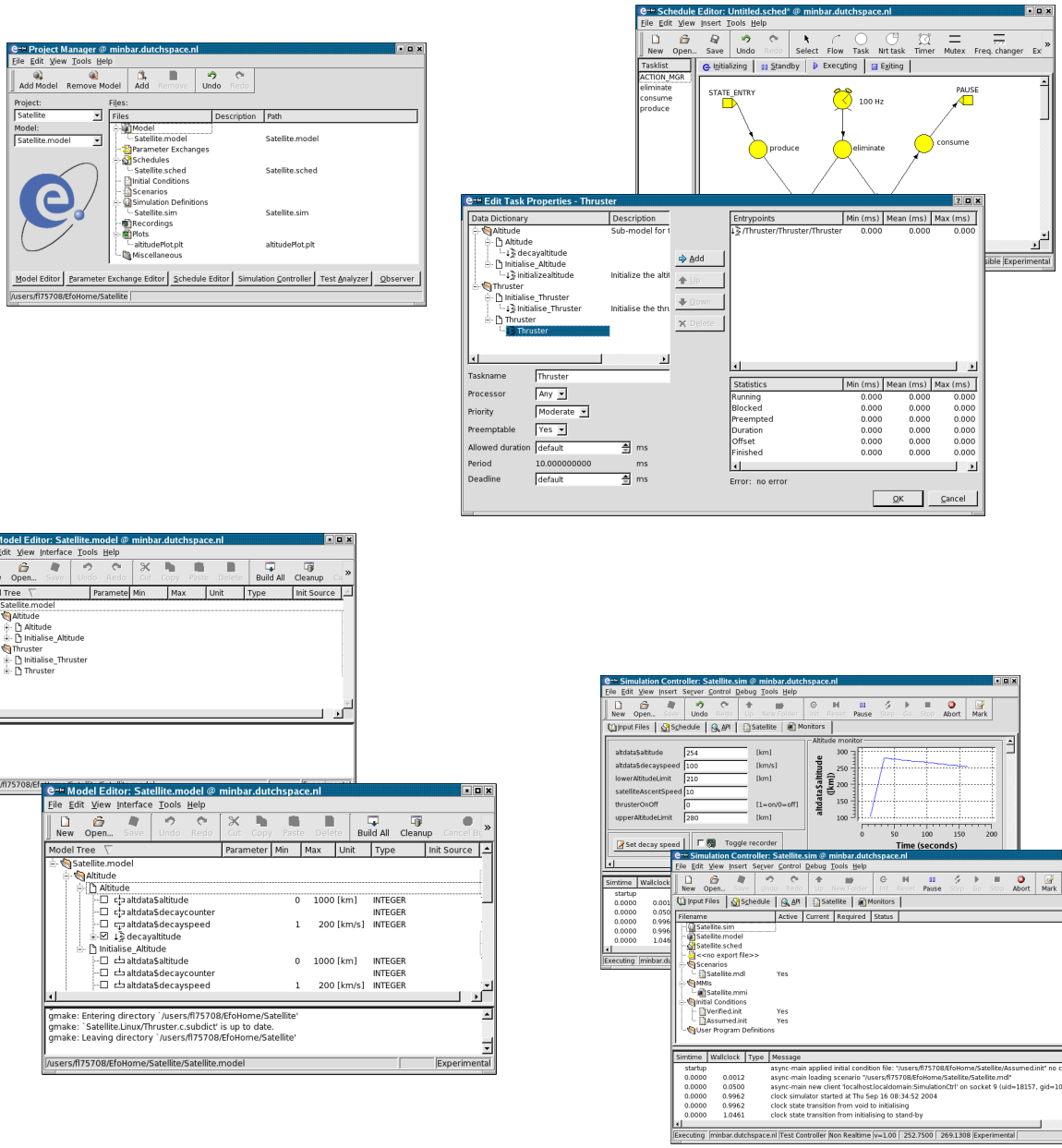
EuroSim Mk5.3
Software User's Manual



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Summary

EuroSim Mk5.3 is an engineering simulator framework to support the quick development of hard real-time simulators. EuroSim provides a reconfigurable real-time execution environment with the possibility of man-in-the-loop and/or hardware-in-the-loop additions. Extensive Graphical User Interfaces assist the user in constructing, using and analysing real-time simulations, resolving the user from the specialist software engineering knowledge required to built hard real-time systems.

EuroSim has been developed initially to support the verification of space (sub) systems defined by ESA programmes of various scales. It's heritage lies in the development of the European Robotic Arm(ERA) project where EuroSim was essential in the development and verification of the large symmetrical arm that can move accross the International Space Station. Up to today, EuroSim installations are still used around the world to support ERA's mission preparation, verification and training. After initial development and application for ERA, EuroSim has been succesfully used in the development, verification and training of the Autonomous Transfer Vehicle (ATV) with multiple installations worldwide. Other space programs where EuroSim has been applied since are Galileo, Herschel & Planck, Gaia to name a few major missions. Currently EuroSim has made its way in to other domains as well, with application in the F-35 Lightning-II Embedded Training program and simulations in support of road tunnel system verification.

This document contains both the User Guide as well as the Reference Guide documentation and consists of five volumes. The User Guide volume provides overview and insight in the toolchain as well as introduction and guidance on the development and usage of real-time simulators. This User Guide volume is recommended reading material for new users of EuroSim. The four Reference Guide volumes provide in detail information on the GUIs, modelling languages, scripting languages and interface capabilities of EuroSim. Experienced users will find these Refence volumes more usefull.

Facility administrators are advised to read [OM14], the *EuroSim Owner's Manual*. More files and documents that contain information related to EuroSim can be found in the bibliography.

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Part I

User Guide

Chapter 1

Introduction

1.1 Purpose

The purpose of this document is to provide a user of the EuroSim facility with an understanding of the functions available and the logical order in which they should be used in order to achieve the objective of developing and executing a simulation model for a particular application.

It is expected that the user has some basic UNIX knowledge and familiarity with simulation in general.

This manual is also available on-line, including hypertext.

1.2 Scope

This document describes the use of the EuroSim Mk5.3.3 facility. It provides details of the functions that are available for the user, and relates these functions to a typical operational scenario. It also provides guidance on the development of the application model itself, including the recommended structure of the model, and the library routines provided by the facility.

In this manual the main functions of the EuroSim facility are described from the user's point of view. The document is divided in five volumes and an appendix:

- Volume 1: User Guide: An introduction into the concepts and features of EuroSim, followed by a Tutorial and Troubleshooting guide to get familiar with the toolset.
- Volume 2: GUI Reference Guide: A detailed description of every GUI in EuroSim to find specific GUI operation details when working with the tool.
- Volume 3: Modelling Reference Guide: A detailed description of the APIs for every supported modelling language, including service libraries in support of model integration.
- Volume 4: Scripting Reference Guide: A detailed description of the languages available for real-time scripting inside the simulation, as well as batch scripting to automate the execution of the simulator.
- Volume 5: Interface Reference Guide: An in depth description of the interfaces provided to connect EuroSim with other applications and integrate hardware in the loop.

Finally, a number of appendices contain the remaining information, generally consisting of reference details only required in special circumstances, such as file formats of the EuroSim configuration files. Furhtermore, abbreviations and terms are defined in Appendix I and Appendix J respectively. The remaining appendices go into more detail on some of the features of EuroSim.

1.3 Where to start

Novice users should start with Chapter 2, and then follow (and possibly re-create) the case study from Chapter 3. The GUIs will generally be self explanatory with tooltips, but it might be necessary to read Chapter 5 to get acquainted with some of EuroSim's user interface aspects.

Users who already have knowledge of EuroSim can immediately proceed to the reference chapters, where each of the EuroSim tools is described in detail.

The table of contents and the index can be used to find certain subjects in the user manual.

Facility managers are advised to read also [OM14], the *EuroSim Owner's Manual*. More files and documents that contain information related to EuroSim can be found in the bibliography.

1.4 Document conventions

The selection of a menu option from the GUI is referred to as for example 'Select the menu option *File:Close*', which means to select from the menu with the name *File* the option *Close*.

Key combinations are shown as 'Alt+Backspace', which means to hold down the key labeled Alt and then simultaneously pressing the Backspace key.

Computer input and output is shown as a `fixed pitch` font. Buttons are referenced with their **label** in bold face.

Chapter 2

Concepts

This chapter introduces the concepts and elements which are common to EuroSim. These include version management and the API interface. Concepts and elements specific to an EuroSim tool or editor are described in the reference chapters for these tools and editors.

First the EuroSim simulation lifecycle concept is introduced, which defines the phases of usage of a EuroSim simulator and thereby provides a first introduction into the work flow of EuroSim. Subsequently the elements in the simulation lifecycle are further elaborated. These elements are then mapped on the tools and services contained in EuroSim. Thereafter more detailed concepts are described such as the API headers, dataflow approach and built in versioning.

2.1 EuroSim simulation lifecycle

EuroSim is a simulator framework which allows the user to construct a real-time simulator by combining model code with the EuroSim libraries into a simulator. This simulator can then be subsequently combined with simulation scenarios into simulations. The results of these simulations can be recorded, which allows the user to analyse these in post processing. This process is called the EuroSim simulation licecycle and is supported with EuroSim tools and services. Figure 2.1 illustrates the phases in this process and the associated Graphical User Interfaces that EuroSim provides to the user.

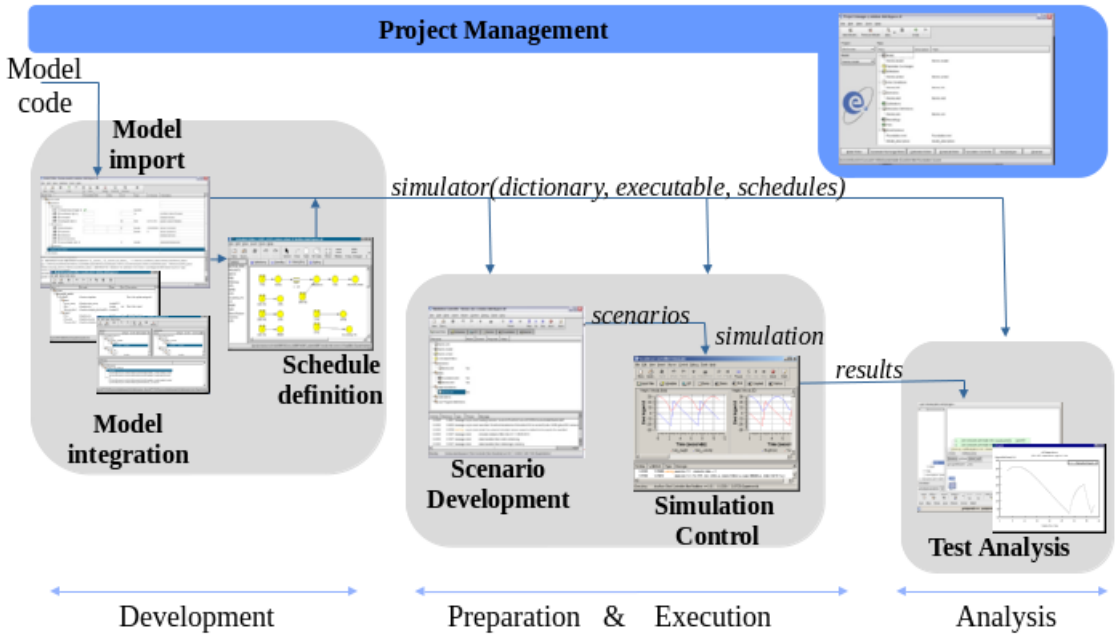


Figure 2.1: EuroSim simulation life cycle

In Figure 2.1 the following phases are shown:

Development

In the Development phase the simulator is constructed in the steps. First model code is imported. It is assumed that model code exists, although it is very well possible to construct model code or elaborate with the EuroSim tools. Model code is assumed to be source code in a variety of languages, and depending on the language different mechanisms exist to define the functions and variables that are of interest within EuroSim. After import, the models need to be integrated. Because EuroSim focusses on hard realtime execution this is achieved via the creation of dataflows between variables of of models. The timing of execution and data transfer is then finally specified with an exection schedule which definines the real-time execution of the simulator.

Preparation

During the Preparation phase, scenarios for a particular simulation are defined. These scenarios including initial conditions, stimuli, recording and on-line monitoring requirements. The scenarios are written in the EuroSim Mission Definition Language, a C-style real-time scripting language. These scripts can be written offline in advance or online during the simulation. The latter is most practicalas writing scripts is an iterarive process. For this reason the Test Preparation and Test Execution phases use the same integrated GUI.

Execution

During the Execution phase the simulator is being executed with the defined scenario. The execution of such simulation is monitored while data is recorded to disk for post analysis. The execution can be performed using a dedicated EuroSim GUI or from batch scripting in a variety of scripting languages such as Tcl, Perl, Python and even from other tools built in for instance Java or C++. Because the execution of EuroSim simulators follows the client-server it is possible to start from a batch script and connect with the GUI in parallel for monitoring purpose. It is even possible to have multiple users connecting simultaneously to the same simulator, one being the operator in charge, the others being observers that can only monitor the simulator execution.

Analysis

During Analysis phase the data recorded during the simulation run can be processed and analyzed. A dedicated GUI allows the user to select the variables to be analayzed from the recorded data and plot the results according to predefined plot definitions. It is also possible to convert data in formats that support analysis with other tools.

During all phases Project Management tools allow the user quick access to the tools and all files in a project.

2.2 Simulator elements

During this life-cycle, a number of objects are used to represent various parts of the simulation. These are:

- A *model*.
- A *schedule*.
- A *data dictionary*.
- The *simulator*.
- A *scenario*.
- A *simulation definition*.
- The *test results*.

Each of these objects is described in more detail in the following sections.

2.2.1 Model

The model (or 'application model') contains all the information needed to describe a real-world system for the purpose of simulation. Using a hierarchical structure, this information comprises of (sub)system descriptions (using any of the languages supported by EuroSim: C, C++, Fortran, Ada-95 and Java[1], and information on parameters and variables which can be modified or monitored during a simulation.

The model hierarchy can be used to group common elements together. To this end, the model hierarchy is a tree-like structure (with the model itself at the top), with the various (sub)system descriptions grouped together by nodes in the tree.

The model hierarchy itself is created with the Model Editor (see Chapter 7). For model integration, the Model Editor supports several sub editors to assist the user in model interface definition, data exchange between the models, error injection and calibration. The products of these sub editors are included as files in the model hierarchy.

2.2.2 Data dictionary

During a simulation, data can be monitored and/or recorded, and parameters can be set. The data elements which should be accessible during the simulation have to be defined in the data dictionary for this purpose. This is done through the use of so-called API headers (see also Section 2.4).

The data dictionary is defined using the Model Editor (see Chapter 7). Browsing the data dictionary can be done using the Dictionary Browser (see Section 12.5) which is available in several of the editors and tools.

2.2.3 Schedule

The timing information of a model is defined through one or more tasks and their execution timing, tied together in a schedule definition. A task is a sequential list of operations provided by the (sub)systems of the model. These operations have to be executed consecutively, starting with the first operation, and ending with the last one. Within a task, there are no timing constraints and/or synchronization points.

The schedule contains information on when and how tasks should be activated in order to:

- achieve real-time, parallel, simulation when executing the simulation, and
- realize a requested change in simulator state (e.g. from executing to standby); see Section 2.2.4 for more information on simulator states.

The tasks and schedule are defined using the Schedule Editor (see Chapter 11), which is available through the Project Manager. Note that a single model could be defined with alternative schedules, each combination creates a different simulator as the schedule defines the activation of model code over time.

2.2.4 Simulator

A simulator is one or both of a hardware device and a computer program built out of model-dependent software (i.e. the model code itself, the schedule and the data dictionary) and the model-independent software for the performance and control of the simulation (i.e. the EuroSim provided software). A simulator together with a simulation definition can be used to start a simulation run.

The simulator is always in one of 5 predefined states (see Figure 2.2). These states determine the current phase in the general process of simulation. These same states (except the unconfigured state) are also used within the Schedule Editor to define the schedule.

[1] Java interface is not realtime

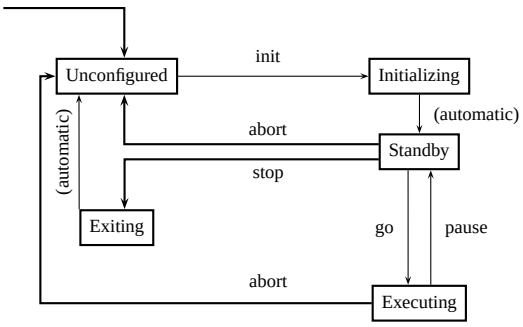


Figure 2.2: Simulator states

State transitions can be triggered by issuing a state transition command, either from the Simulation Controller, the model, or the schedule. The labels in Figure 2.2 correspond to the buttons available in the Simulation Controller (see Section 12.3.1) as well as the MDL commands (see Chapter 21). The only missing state transition is the reset as it is too complicated to put in the drawing. Reset can be issued from standby state and is a combination of a stop and an init command where the simulation is not completely stopped and restarted.
The simulator can be run in one of two modes: *real time* or *non-real time*. When a simulation is started in non-real time, the simulation server will try to run the simulation as close to real time as possible. This means that task timing overruns in the simulation will not generate real-time errors. Also, a simulation running non-real time will not claim a whole simulation server: other simulations can also be running (also non-real time). In non-real time mode, it is also possible to instruct EuroSim to run the simulation as fast as possible (see Section 12.6.5 for more information).

2.2.5 Scenario

Scenarios are lists of scripts functions that can be activated on time or data conditions. The scenario scripts interact in real-time with the model code through the Model API as defined in the data dictionary. Stimuli and Recording definitions are scripts as well in EuroSim, although there creation is supported by dedicated editors to make create of the scrips easier.

2.2.6 Simulation

A simulation definition contains all information required during a simulation: this combines the simulator with initial conditions, scenarios (monitors, simulators, scripts) and MMI definitions.

More than one simulation definition can be defined for a particular model, each resulting in a different simulation result.

Simulation definitions are created using the Simulation Controller, which is described in Chapter 12.

2.2.7 Test Results

When recorders are defined in a simulation definition, the simulation produces teh recorderfile during execution as well as an index file which allows the EuroSim analysis GUI to easily detect which variables are available for plotting

2.2.8 Project

A EuroSim project file contains the references to all files used in the Simulation lifecycle. It consists of:

- a description
- a directory where the files reside (also called the project root)

- a repository where the versioned files reside
- a version control system name

All this information is stored in the project database.

2.3 Services and tools

EuroSim offers users two levels of support:

- The first level of support is through a number of tools which can be used to define the simulation. These tools all have an (often graphical) user interface and include editors such as the Model Editor and the Schedule Editor.
- The second level of support is through a number of services which are available to the model developer. Services are functions in the EuroSim software that can be called from within model code. See Section 2.4 and the services sections of each supported modelling language in the Modelling reference volume.

In the next sections, an overview is given of the available tools.

2.3.1 Project Manager

The Project Manager is used to define new projects. The Project Manager is the main EuroSim window, and is described in detail in Chapter 6.

The list of projects displayed in the project manager is maintained by the user. The projects file is located by default in the `.eurosim` directory in the home directory of the user. The location can be changed by defining the `$EFO_HOME` variable. To use a shared project file, a user has to set the `$EFO_HOME` environment variable to point to a shared projects file.

2.3.2 Model Editor

The Model Editor is used to define a model and its hierarchy together with the definition of the variables and parameters that are available for monitoring, recording, etc. during the simulation run.

The Model Editor is described in detail in Chapter 7. Several sub editors are available to further define the model integration and publication.

2.3.2.1 Model Description Editor

The Model Description Editor is used when integrating several independent models into one simulator without wanting to do the integration explicitly in (model) source code. It is used to describe which model variables should appear in the so called “datapool”.

The Model Description Editor is described in detail in Chapter 8.

2.3.2.2 Parameter Exchange Editor

The Parameter Exchange Editor is used when integrating several independent models into one simulator without wanting to do the integration explicitly in (model) source code. It is used to describe which output variables in the datapool should be copied to which input variables in the datapool.
The Parameter Exchange Editor is described in detail in Chapter 9.

2.3.2.3 Calibration Editor

The Calibration Editor is used to define calibration curves. The calibration curve files can be referenced in the simulation definition file. The calibration definitions can be used using a run-time API.

The Calibration editor is described in detail in Chapter 10.

2.3.3 Schedule Editor

The Schedule Editor is used to define the tasks and the schedule of a model.
The Schedule Editor is described in detail in Chapter 11.

2.3.4 Simulation Controller

The Simulation Controller is used to initially define various simulation definitions and also to execute those definitions during a simulation run. Through the Simulation Controller various Action Editors are available, as well as the Initial Condition Editor.

The Simulation Controller is also used to control the actual simulation. It is described in detail in Chapter 12.

2.3.4.1 Action Editors

To define various actions (stimuli, recorders, interventions, events), a number of Action Editors are available through the Simulation Controller.

The editors are described in detail in Section 12.10.3.

2.3.4.2 Initial Condition Editor

With the Initial Condition Editor, initial conditions can be created and modified. An initial condition is used to initialize the simulator, by providing the simulation variables with initial values. The Initial Condition Editor is described in Section 12.7.4.

2.3.5 Test Analyzer

The Test Analyzer can be used to view and plot the results from a simulation run. Chapter 13 contains more information on the Test Analyzer.

2.4 Application Programmers Interface

The name *Application Programmers Interface* (API) is used within EuroSim to describe the interface between the model and the EuroSim software. This description includes the services available through EuroSim as well as the variables and functions from the simulation model which need to be accessed by EuroSim.

The API for the EuroSim services is relatively simple: it consists of a number of predefined function calls that can be used from within the user's model code. The exact syntax depends on the languages in which the model is implemented, Section 14.4 shows this API for the classic languages (C, Fortran and Ada).

The API for the simulation model is a bit more complicated, as EuroSim does not know beforehand what the user's model code will look like. Therefore, in order for the model code to be used in EuroSim, the user has to add API information to the model code: the API *header*. This API header consists of a number of lines at the top of the model code. As the information is stored as comments, the source code will still be usable outside of EuroSim. Using the Model Editor of EuroSim (see Chapter 7), the user can easily enter the functions and variables in the source code which need to be available to EuroSim.

The information from all the API headers in the model together forms the data dictionary of the model.

The API information required by EuroSim is defined using four keywords (the `'` is part of the keyword):

- `'Global_Input_Variables`
- `'Global_Output_Variables`
- `'Global_State_Variables`

- `'Entry_Point`

The choice of these keywords stems from systems theory, a discipline closely related to the application areas of EuroSim. In systems theory, a classical way to look at systems is from a causal input/output point of view, often referred to as the 'black box' approach to modeling of systems. Inputs are converted to outputs via a so-called black box (Figure 2.3).

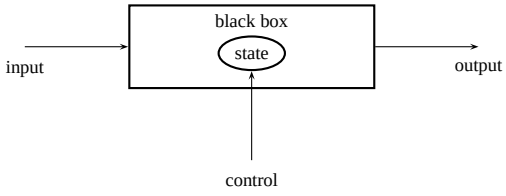


Figure 2.3: The black box approach

An example would be a heater: a current (in Amperes) goes in, a heat flow (in Joules/second) comes out. These inputs and outputs are mapped onto the API-header keywords `'Global_Input_Variables` and `'Global_Output_Variables`.

The next step in the modeling process is to extract (i.e. to model) the memory function of the system. The memory at a certain time is known as the *state* of the system. The state of the system describes in detail how inputs are converted to outputs. Whereas inputs and outputs are the means with which a system communicates to the outside world, there does not exist something like a unique state: the notion of state is very much a mathematical modeling tool.

However, as the system has to be implemented in software to be usable in EuroSim, some way has to be found to define this state. The memory portion of the state is defined using so-called *state variables*. These map onto the keyword `'Global_State_Variables`. The part of the state that determines exactly how to transform input to output using the current state is defined by the functions (or subroutines, or procedures) in the source code. EuroSim assumes that one source code file (i.e. C, C++, Fortran, Ada-95, or Java file) contains one black box.

Note: as far as EuroSim is concerned, it doesn't really matter whether a variable is tagged input, output or state. Each tag will allow EuroSim to access the variable during the simulation. There's only one case where it does make a difference, and that's for the Schedule Editor. This editor can check for data overlap between two tasks, but it will only consider the input and output variables of the tasks' entry points in this check.

As EuroSim needs a way to "run" the black box (i.e. to trigger it at the right times) there is a need for a certain amount of control on the black box. This control is given to EuroSim by declaring a number of functions to be an `'Entry_Point`, which means that these functions can be called by EuroSim when necessary.

An additional bonus of specifying all the variables is that it allows the user define some additional attributes, such as description, unit, etc., which might be useful to the Test Conductor and Observer when running the simulator. Also, the variables can be monitored, recorded, or changed during a simulation run if they are defined in the API header.

There are a number of constraints on the model code in order for this API information to be used correctly. Within EuroSim C, Fortran, Ada-95, C++ and Java[2] can be used as languages to build the model. Further, programming language specific constraints are described in the chapters on the specific programming language usage in the Modelling Reference volume.

[2]Note that EuroSim currently only supports creation of the API headers for C and Fortran code. For Ada-95 code, the user should create the API header by hand. To publish C++ and Java variables and entrypoints, a different style of APIs is provided. See appendix G, API *header layout* for more information on the details of the API header. See Chapter 15 and Chapter 17 for more information on the C++ and Java APIs

For standalone development of models, stubs are provided in the etc directory of the EuroSim distribution. These stubs are provided for C and C++ and are delivered in source code.

2.5 Version management

Developing a EuroSim simulation is a continuously moving process. Files are frequently being changed and updated. Especially when more than one person is involved at any one time, it can be difficult to keep track of different versions of a model. In order to assist the user, EuroSim has a number of *version management* facilities built in.

Each of the files used within a simulation can be versioned by the user. Each version of a file can be given an annotation (a short description of the file). Versions are identified by a version number.

When a file is versioned, a *requirement* on that file can be specified: if EuroSim needs access to that file (i.e. when compiling a source file) it then requires a specific version of that file. This could mean that EuroSim needs a version of a file which has since been updated. Therefore a history of the file version is maintained by EuroSim (for versioned files only). For files which are still under development, no requirement should be set. On the other hand, for files that need to be in a stable or predictable state, a version requirement could be used.

The *repository* is the top of a central directory tree where all versions of files for a project are stored[3]. This location is defined when creating a new project (see Section 6.4.4). The project root (which is also defined when creating a new project) contains the *current (working) version* of the files being used for the simulation. When a group of users is accessing the model through the same project directory, they are all working with the same current version. If each user has a project description file of his/her own, or if *tilde expansion* is used for the project root (using the ~ in a path to represent the users home directory), more than one project root can be defined, which effectively gives each user a private version of the model files.

A copy of any version can be modified at will (e.g. adding new files, or changing existing ones), and when it is decided that a specific file is as it should be, it can be brought under version management by creating a new version. This new version is then the new requirement for the file. Other users can either update their model (by changing the file requirement) or keep using an older version.

Note that *all* files that can be saved from within EuroSim can be put under version management. This includes the simulation model itself, which contains the requirements on the other files. By versioning a model file, a simulation model can be *baselined*, i.e. it can be frozen as a "working simulation".

By versioning all files used for a simulation run, the simulation can be made traceable or reproducible: at any given point in time the simulation can be re-run to recreate simulation results, as the exact version of the model, schedule, initial condition, etc. are stored in the repository.

Although the repository can be stored in the same location as the project root, when more than one person is working on a simulation, it is best to keep the repository separate from the project root, so that more than one person can share the same repository, but also keep their own work version.

All versioning actions are done through the *Tools:Version* menu (see Section 5.6.4).

If an existing software repository, created using the RCS or CVS tool, is to be used within EuroSim, this can be accomplished by setting the 'Repository' to the RCS or CVSROOT directory. The 'Project root' should point to an appropriate working directory, with the restriction that the RCS or CVS repository tree has the same structure as the project tree.

[3] Actually, storage is more efficient: only differences of a file with the previous version are stored.

Chapter 3

Tutorial

In this chapter, a complete pass through the EuroSim life-cycle is described. An example is used to describe all steps necessary to create a successful simulation with EuroSim. The user is advised to check the reference part of the user manual (Chapter 6, and onwards) for more information on menu items and the various objects in the EuroSim environment.

3.1 The case study

Throughout this user guide, a complete ready-to-run simulator is developed. A simple model of a satellite that hovers above a planet, without having it in a geostationary orbit, is used. The altitude of the satellite decays by perturbations and by the gravity pulling it to the planet surface. The thruster is switched on when the altitude reaches a lower limit and is switched off when the satellite reaches an upper limit.

3.2 Starting EuroSim

3.2.1 Linux

To run EuroSim on a Linux platform, type `esim` at the command prompt.

3.2.2 Windows

To run EuroSim on a Windows platform, select *EuroSim* from *Start Menu:Programs*, or double-click on the EuroSim icon on the desktop.

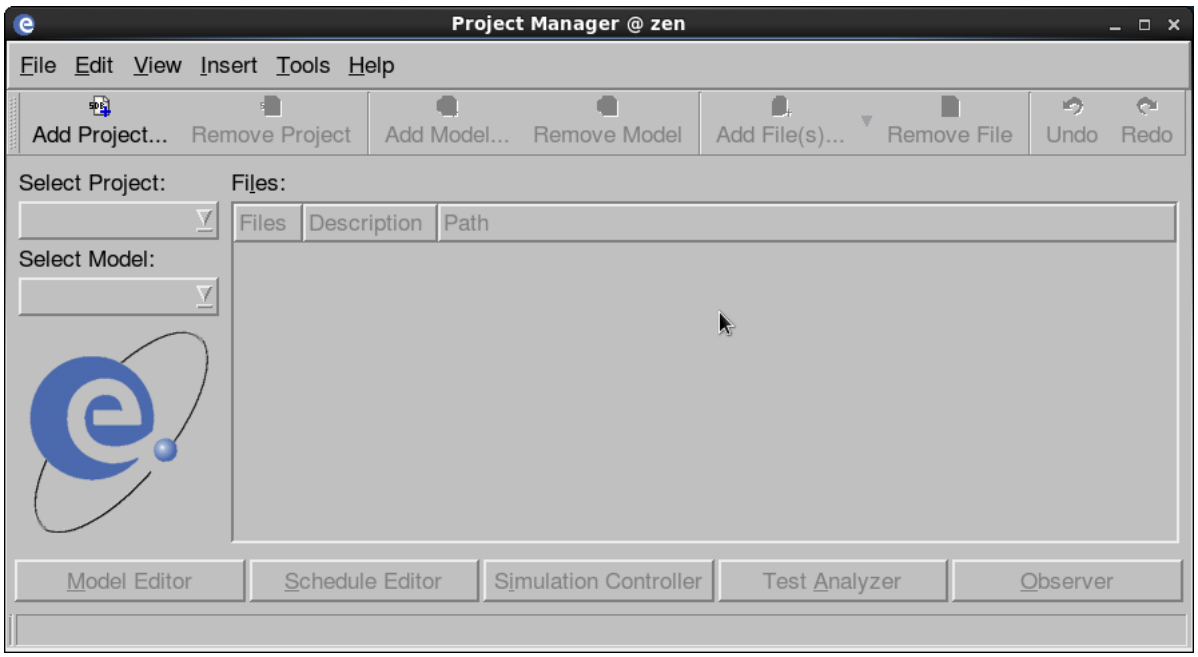


Figure 3.1: The main EuroSim window

After a short while, the main EuroSim window will appear (see Figure 3.1). This window will display the projects to which you have access. If no project is shown ask the EuroSim facility manager to create one for you, or alternatively, create your own project, as described in the next section.

3.3 Creating a project yourself

Press the Add Project button in the toolbar or select Insert:Add Project to start the Add Project dialog window . To create a new project, enter the project name, choose the project directory and version control system. The 'Description' and 'Repository Root' fields are optional.
For the remainder of this chapter, the name '`SUM`' is assumed.

3.4 Creating a shared project

Instead of using a project created by yourself, you can create shared project(s) and database managed by the EuroSim facility manager. This can be achieved by doing the following, *before* starting EuroSim as described in the previous section.

- The EuroSim Facility Manager creates a directory where the shared project database can be stored.
- Set the environment variable `EFO_HOME`[1] to this directory.
- Start EuroSim (see Section 3.2).

3.5 Creating a model

In the main EuroSim window, select the project to be used for this case study from the **Project** combobox and press the **Model Editor** button to create a new model. The Model Editor will show.

When creating a new model a basic model structure consisting of the root node will appear. When editing an existing model select *File:New* to create this basic model structure (see Figure 3.2).

[1] On a Windows platform, environment variables are defined in the file `$EFOROOT/bin/esim.bashrc`.

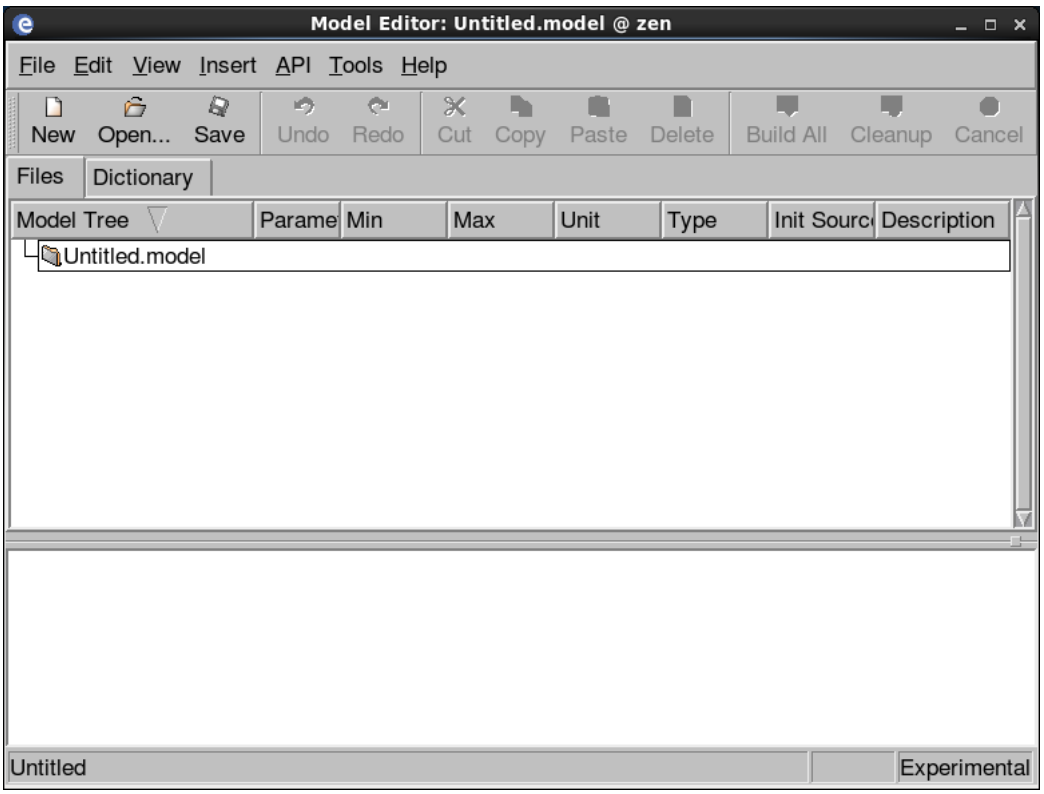


Figure 3.2: A new model

3.5.1 Model

The model for this simulation is divided into four parts:

- a sub-model that decreases the altitude of the satellite;
- a sub-model that lifts the satellite to a higher altitude by usage of a thruster;
- a sub-model that initializes the altitude decay sub-model;
- a sub-model that initializes the thruster sub-model.

The two initialization sub-models will initialize all the variables of the model.
The thruster sub-model will monitor the altitude and keep it within limits. These limits are between 210 km and 280 km respectively. When it is below the lower limit the thruster will increase the altitude until it reaches the upper limit. At that point it will wait until the altitude has decayed to the lower limit and the process starts all over again. In Figure 3.3 the flowcharts of the two main sub-models are shown. These flowcharts could be compared to a first version of the design. Later on in the case study, more optimized code will be used.

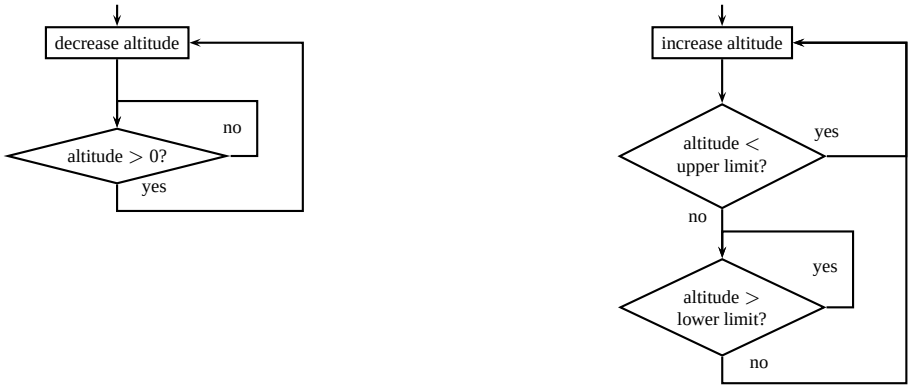


Figure 3.3: The altitude (left) and thruster models

3.5.2 Adding the sub-models

In order to add the four sub-models to the model, select the root node (the left-most node), and choose *Edit:Add Org Node* from the menu. In the window that appears, enter as name `Altitude`. Add another org node (after first selecting the root node again, if necessary), and this time use the name `Thruster`.

The next level of the model hierarchy will consist of four source files, each corresponding to one of the four sub-models. Start by selecting the 'Altitude' node and then do an *Edit:Add File Node*. In the window that appears, enter as file name `Initialize_Altitude.f`, or use the file selection dialog if you already have the tutorial source files. EuroSim will recognize this file as a Fortran source file. A new file node will be added to the model hierarchy.

Repeat the process for the three other file nodes: attach a file node with file name `Altitude.f` to the `Altitude` node, and add two file nodes with names `Initialize_Thruster` and `Thruster` respectively to the `Thruster` node (using files `Initialize_Thruster.c` and `Thruster.c`).

By now, the model should look like Figure 3.4. Notice that after making changes to the new model, as asterisk (`*`) is shown in the title bar of the window to indicate that there are changes to be saved.

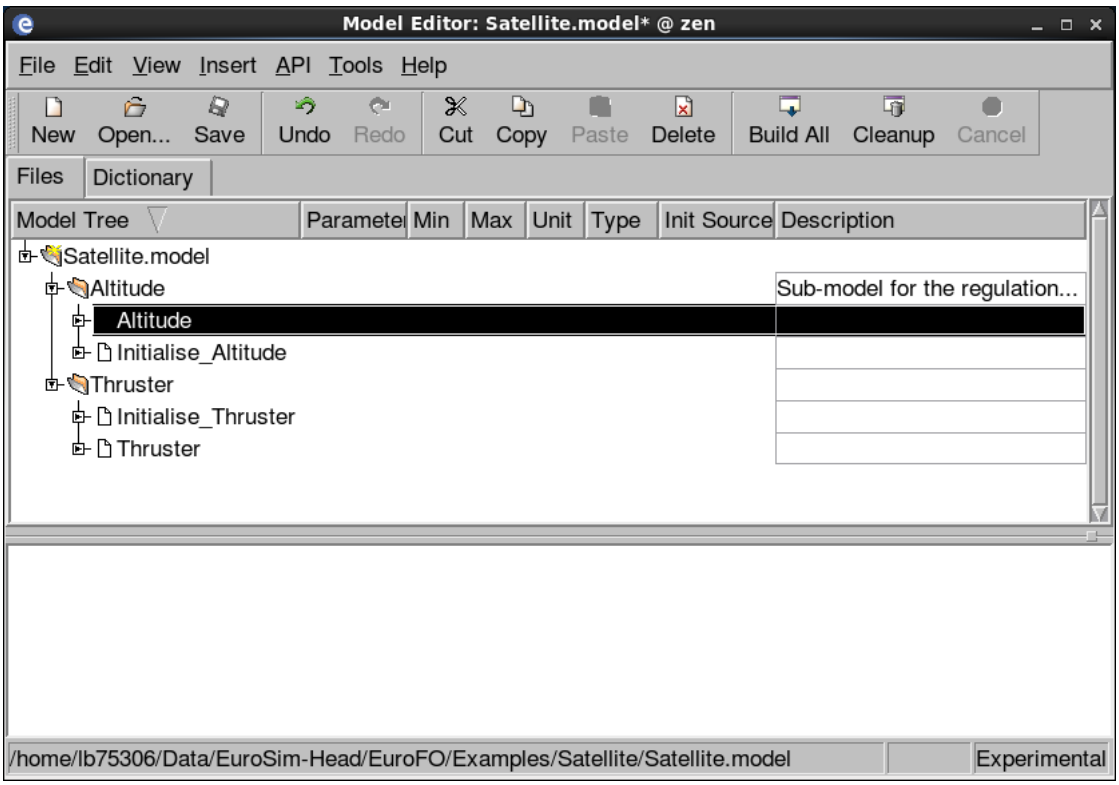


Figure 3.4: Model with the file nodes

Save the model by selecting *File:Save*. As model name, enter `SUM.model` in the file selection window. This file selection is shown because the new model has not been saved before. The next time the model is saved, no file selection window is shown.

3.5.3 Adding the source code

Next, the actual source files have to be created[2]. Do this by selecting the `Altitude` file node, and choosing *Edit:Edit Source* from the menu. An editor[3] will show, in which the following source code should be entered. Beware that Fortran wants to have 6 spaces before the first character on the line (except for the comment lines starting with 'C' in column 1). This is a left-over from the times that programs were entered using punch cards.

Listing 3.1: Source `Altitude.f`

```
C-----------------------------------------------------------
C File: Altitude.f
C
C Contents: The Fortran routines that simulate the gravity
C pull of a planet.
C
C-----------------------------------------------------------
      SUBROUTINE DECAYALTITUDE

C     Global Variable definition.
      INTEGER ALTITUDE
      INTEGER DECAYSPEED, DECAYCOUNTER

C     COMMON Block Definition.
      COMMON /ALTDATA/ ALTITUDE, DECAYSPEED, DECAYCOUNTER
```

[2] If the files have already been selected with the file selection dialog, this step can be skipped.

[3] Set teh EDITOR environment before launching EuroSim to yoru favorite editor if you don't like the standard editor

```
      DECAYCOUNTER = DECAYCOUNTER + 1
      IF (DECAYCOUNTER .GT. DECAYSPEED) THEN
        DECAYCOUNTER = 0
        IF (ALTITUDE .GT. 0) THEN
          ALTITUDE = ALTITUDE - 1
        ENDIF
      ENDIF

      RETURN
      END
```

Save the source file, and close the editor. Repeat the process for `Initialize_Altitude` with the source file:

Listing 3.2: Source `Initialize_Altitude.f`

```
C-----------------------------------------------------------------
C File: Initialize_Altitude.f
C
C Contents: Initialize the altitude decay simulation model.
C
C-----------------------------------------------------------------
      SUBROUTINE INITIALIZEALTITUDE

C     Global Variable definition.
      INTEGER ALTITUDE
      INTEGER DECAYSPEED, DECAYCOUNTER

C     COMMON Block Definition.
      COMMON /ALTDATA/ ALTITUDE, DECAYSPEED, DECAYCOUNTER

C     Parameter Definition.
      PARAMETER (DECAYSPEEDDEFAULT = 100)

      ALTITUDE = 0
      DECAYCOUNTER = 0
      DECAYSPEED = DECAYSPEEDDEFAULT

      RETURN
      END
```

Listing 3.3: The C source code for the `Thruster` file node

```
/*
  File: Thruster.c

  Contents: The C routines that simulate the thruster module
  of the satellite.
*/

#define On       1
#define Off      0

extern int altitude;
int thrusterOnOff;
int speedCounter = 0;
int satelliteAscentSpeed;
int lowerAltitudeLimit;
int upperAltitudeLimit;

void Thruster(void)
```



```
{
  if (thrusterOnOff == On) {
    if (speedCounter++ > satelliteAscentSpeed) {
      speedCounter = 0;
      altitude++;
      thrusterOnOff = (altitude < upperAltitudeLimit);
    }
  }
  else {
    thrusterOnOff = (altitude < lowerAltitudeLimit);
 }
}
```

Listing 3.4: The source file for the `Initialize_Thruster` node

```
/*
  File: Initialize_Thruster.
  Contents: Initialize the thruster simulation model.
*/

#define SPEED_DEFAULT 10
#define On        1
#define Off       0

extern int speedCounter;
extern int satelliteAscentSpeed;
extern int thrusterOnOff;
extern int lowerAltitudeLimit;
extern int upperAltitudeLimit;

void Initialize_Thruster(void)
{
  satelliteAscentSpeed = SPEED_DEFAULT;
  speedCounter = 0;
  thrusterOnOff = On;
  lowerAltitudeLimit = 210;
  upperAltitudeLimit = 280;
}
```

3.5.4 Adding the API headers

3.5.4.1 The Altitude sub-model

The next step is to add the API headers to the model. Expand the `Altitude` file node by pressing the '+' symbol, or use *View:Expand All*. EuroSim will parse the expanded file(s) and display the available entries and variables in the code. First, the `decayaltitude` entry point will be added to the API header. Click the checkbox left to `decayaltitude` to add this entry point to the API header.

We will also add two of the variables from this entry point to the API header: tick the checkboxes in front of the `altdata$altitude` and `altdata$decayspeed` variables under the `decayaltitude` entry point.

When added to the API header (checkmark used), additional information on entry points and variables can be entered (such as a description). Select the `decayaltitude` entry point and click the 'Description' field on the right. Enter the description `The altitude decay operation`. Select the `altdata$altitude` variable. The 'Type' and 'Init Source' fields cannot be changed, as they are extracted from the source file. Enter a description of `The altitude of the satellite`. Enter as 'Unit' the string `[km]`, as 'Min' the value 0 and as 'Max' the value 1000. Repeat this for the `altdata$decayspeed` variable, using the values:

Description	`The speed with which the altitude decays`
Unit	`[km/s]`
Min	1
Max	200

The model should now look like Figure 3.5.

Repeat the above steps for the three remaining sub-models, using the values from the next sections.

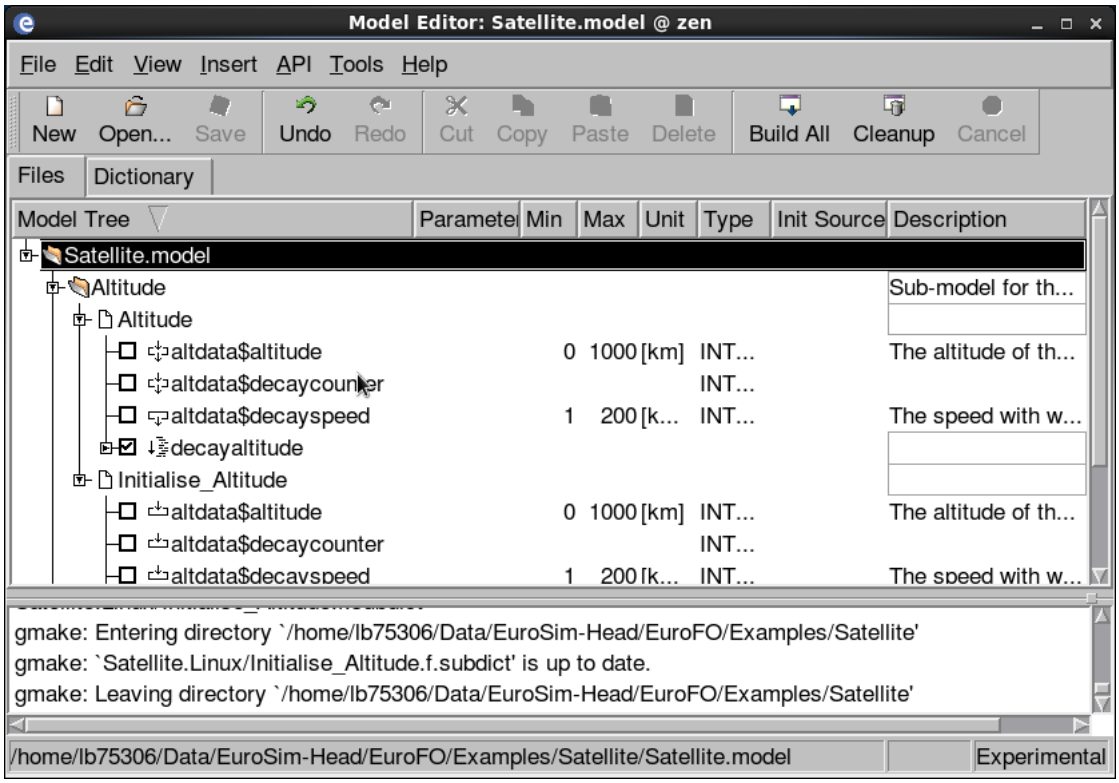


Figure 3.5: The expanded Altitude node

3.5.4.2 The `Initialize_Altitude` sub-model

Add the entry point in `initializealtitude` with a description `Initialize the altitude decay operations`.

3.5.4.3 The Thruster sub-model

Add the entry point `Thruster` with a description `The thruster brings the satellite to the correct altitude`. Add the following variables by selecting them from the list to the right of the `Thruster` entry point:

Variable	Min	Max	Unit	Description
`lowerAltitudeLimit`	0	1000	`[km]`	`Below this limit, thruster must be turned on`
`satelliteAscendSpeed`	1	200	`[km/s]`	`The ascent speed of the satellite`
`thrusterOnOff`	0	1	`[1=On/0=Off]`	`Thruster on/off indicator`
`upperAltitudeLimit`	0	1000	`[km]`	`Above this limit,thruster must be turned off`

3.5.4.4 The `Initialize_Thruster` sub-model

Add the entry point `Initialize_Thruster` with a description `Initialize the thruster.`

3.6 Building the simulator

Select *Tools:Build All* from the menu in the Model Editor. In the output window, all commands executed are echoed, as well as their outputs. Things to look out for are lines starting with `*** Error`, which indicate that an error has occurred during building. Usually directly above a more descriptive error message is given. You can ignore the file version warnings, but there should be an error message like:

```
Satellite.Linux/Thruster.pub.o: In function 'Thruster':
Satellite.Linux/Thruster.pub.o(.text+0x2b): undefined reference to 'altitude'
Satellite.Linux/Thruster.pub.o(.text+0x31): undefined reference to 'altitude'
Satellite.Linux/Thruster.pub.o(.text+0x4e): undefined reference to 'altitude'
collect2: ld returned 1 exit status
gmake: Leaving directory '/home/jv75763/work/Satellite'
gmake: *** [Satellite.Linux/Satellite.exe] Error 1
*** Errors during build ***
```

The meaning of this message is that the compiler can not find a declaration with the name `altitude`. Inspection of the source files indicates that the C function `Thruster` uses an external declaration of a variable with the name `altitude`. Although the Fortran source has a variable with the name `ALTITUDE` it is not possible to connect these two variables in the way the current satellite model has been written. This is a general problem with linking Fortran and C code. It arises from compiler conventions, not from the EuroSim tools.

To solve the problem, change the `altitude` variable in the file `Thruster.c` to the following `struct` declaration:

```
extern struct altitudeDataStruct
{
 int ALTITUDE;
 int DECAYSPEED;
 int DECAYCOUNTER;
} altdata_;
```

And change the use of the variable `altitude` to:

```
altdata_.ALTITUDE
```

Note that the `altitude` variable is used in three places. Be sure to change them all. The `Thruster.c` source file should now look like:

```
/*
  File: Thruster.c

  Contents: The C routines that simulate the thruster module
  of the satellite.
*/

#define On       1
#define Off      0

extern struct altitudeDataStruct
{
  int ALTITUDE;
  int DECAYSPEED;
  int DECAYCOUNTER;
} altdata_;
```

```
int thrusterOnOff;
int speedCounter = 0;
int satelliteAscentSpeed;
int lowerAltitudeLimit;
int upperAltitudeLimit;

void Thruster(void)
{
  if (thrusterOnOff == On) {
    if (speedCounter++ > satelliteAscentSpeed)  {
      speedCounter = 0;
      altdata_.ALTITUDE++;
      thrusterOnOff = (altdata_.ALTITUDE < upperAltitudeLimit);
    }
  }
  else {
    thrusterOnOff = (altdata_.ALTITUDE < lowerAltitudeLimit);
  }
}
```

When the changes to the source file have been made, try rebuilding the simulator. If the build was successful, the messages `SUM.exe MADE` and `all DONE` should be displayed in the status window.

Save the model and exit the model editor. In the EuroSim main window choose *Edit:Add Model* and select `SUM.model` to add the created model to the project.

3.7 Creating the schedule

The schedule of a simulation defines which tasks need to be activated at which time. A task is a set of entry points which are executed sequentially. Task and schedule can be created using the Schedule Editor.

Select the EuroSim main window and press the 'Schedule Editor' button.
The schedule contains four tab pages, one for each of the simulator states *initializing*, *executing*, *standby* and *exit*. For the example, three of the four states will be used.
In the initializing state, a schedule will be created which will be triggered by state entry, and which will then initialize the thruster and altitude model. After these have been executed, the schedule will put the simulator in standby state.

For the executing state, a schedule will be created which triggers the thruster and altitude models using two timers, one at 20 Hz and one at 100 Hz.

In the exit state, a schedule will be created which will close down the simulator.

3.7.1 Initializing schedule

Choose *File:Select Model* from the menu. Select the file `SUM.model` to be able to use the created `API` header.

Select the circle symbol from the toolbar for a task[4]. The cursor changes into a circle. Put the circle on the schedule tab page. It will change color to red, indicating an error (in this case: the task has no input and output connectors attached). It will get a default name of `New Task`. Select the arrow tool from the toolbar on the left. Double click on the task, which causes the task properties dialog to open. In this dialog, select the `Initialize_Thruster` entry point on the left Data Dictionary view and press the **Add** button. This will copy the entry point to the entry points list, indicating that this entry point belongs to the task we are defining. Do the same with the `Initialize_Altitude` entry point.

[4]See Section 11.2 for a description of which icon belongs to which item.

When a task is executed, each of the entry points contained in the task will be executed sequentially. For this initializing task the order is not important, but if it is, the up and down arrow buttons can be used to re-order the entry points. Timing information can be entered for each entry point. As we don't have such information at this moment, we will leave it empty. Later on, if the simulation has been executed successfully, it is possible to import a timings file created by the simulator, which contains the various data required here.

Now change the name of the task to `Initialize` by entering the new name in the field Taskname below the Data Dictionary box. Press the **OK** button. The task on the Schedule Editor now also has the name `Initialize`.

Next, from the *Insert* menu, select the menu item *Internal Event*. Select `STATE_ENTRY` from the submenu. Put it on the tab page. Next select a flow (curved arrow) from the tool button bar. Click the left mouse button on the internal event. Keep the left mouse button pressed and move the mouse to the task. Notice how the flow follows the cursor. Release the left mouse button again above the task. The two are now connected.

Finally, add the `PAUSE` output connector to the tab page, and connect a flow from the task to the output connector. The initializing schedule should now look something like Figure 3.6.

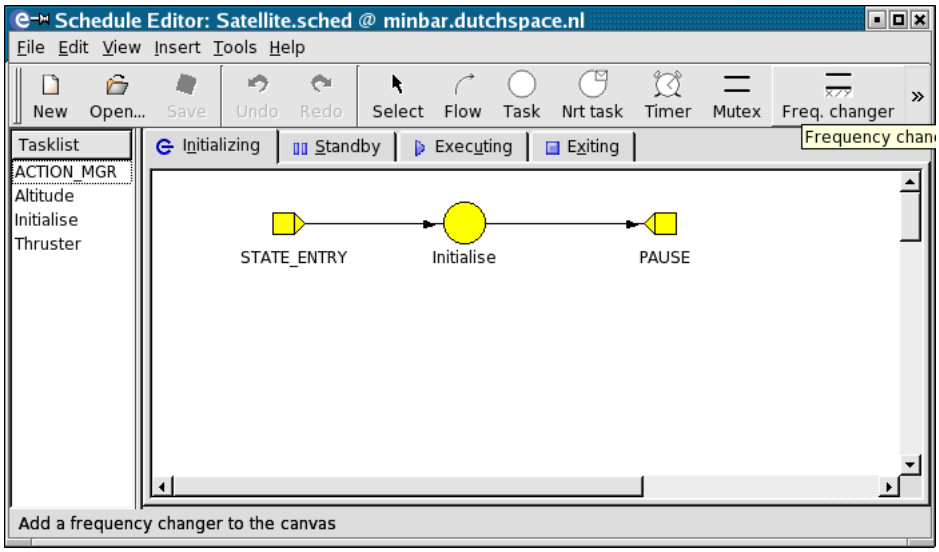


Figure 3.6: The initializing schedule

3.7.2 Executing schedule

First select the *Executing* tab to show the schedule for the executing state. On the tab page, create two more tasks, named `Thruster` and `Altitude`. The `Thruster` task should contain the `Thruster` entry point, and the `Altitude` task should contain the `decayaltitude` entry point.

Next to each task, put a timer. Connect each timer to a task using a flow. As the `Altitude` task should be executed less often than the `Thruster` task, double-click on the timer connected to the `Altitude` task. A timer attribute window will show. In the window, change the frequency to 20 Hz. Close the window with the **OK** button.

Change the frequency of the `Thruster` timer to 100 Hz. On some operating systems this is the default frequency. Other operating systems may have a different default frequency setting.

The executing schedule should now look something like Figure 3.7. With this schedule, the `Thruster` task will be triggered with a frequency of 100 Hz, and the `Altitude` task with a frequency of 20 Hz.

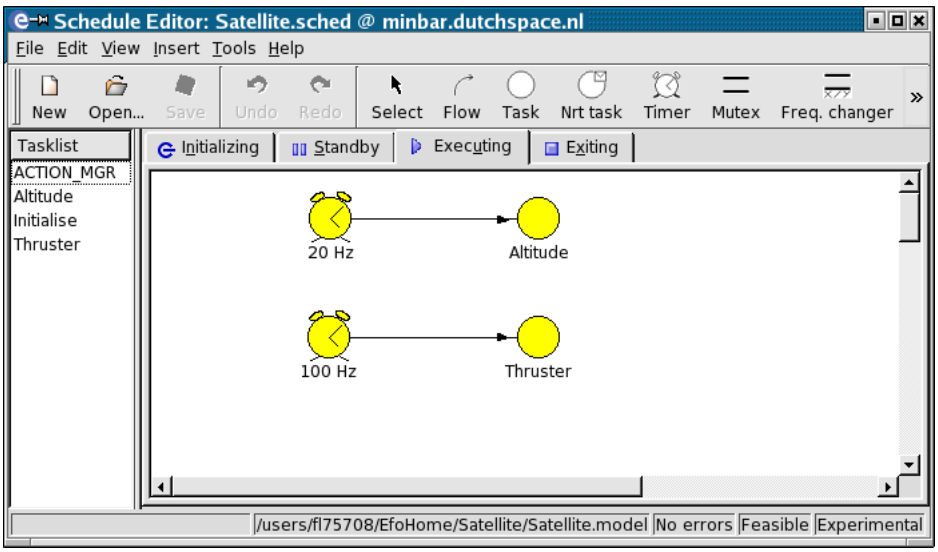


Figure 3.7: The executing schedule

3.7.3 Closing the Schedule Editor

After each of the schedules has been created, select *File:Exit* from the menu and select **Save** when a warning is given about unsaved changes. In the Model Editor, save the model.

3.8 Creating a simulation definition

Now that the model has been created and the simulator has been built, a simulation definition should be created. A simulation definition contains information on the initial values of the variables defined in the API headers, as well as stimuli, recorders and monitors, which can be used to monitor and influence the simulation.

Select **Simulation Controller** from the main EuroSim window. The Simulation Controller will start (see Chapter 12).

In order to create a simulation definition, the Simulation Controller needs to know which particular model and schedule the simulation is intended for (which indirectly gives access to the associated data dictionary). Choose *File:New* to create a new simulation definition. A wizard dialog appears where you can select all files that you want to use in a simulation. Initially you must select the `SUM.model` and the `SUM.sched` files. Use the **Browse...** button to select the model, press the **Next** button to go to the next page of the wizard. If the prefilled schedule file (guessed from the model file) is correct then press **Finish**, otherwise use the **Browse...** button to select the right schedule file and press **Finish**.

3.8.1 Creating a graphical monitor

Select *Insert:New* MMI ... from the menu. You are asked to choose a filename for the new Man-Machine Interface file. Save the file as `Altitude.mmi`. Now you will be asked for the caption of the new tab page. By default the name of the file without the suffix will be chosen. Accept the default.

A blank tab page named *Altitude* appears where you can add monitors. Select this tab and choose *Insert: New Monitor* to add a new monitor. The Monitor Editor will appear (see Section 12.2.5 for more information).

In the Monitor Editor, enter `Altitude monitor` as the caption. Now expand the `decayaltitude` node and double click the variable `altdata$altitude` on the Dictionary Browser. The variable appears in the *Variables* list and is now connected to the monitor.

Change the style from ‘Alpha Numeric’ to ‘Plot against Simulation Time’. By default the X and Y axis will scale automatically when the plot is being created. Select ‘Manual Scaling’ to define the min/max range yourself. As you can see, the first time you select Manual Scaling the min and max values will be determined from the *Variables* list (if possible). The Monitor Editor should now look like Figure 3.8.

Close the editor with the **OK** button. On the Altitude tab page, the new monitor is shown.

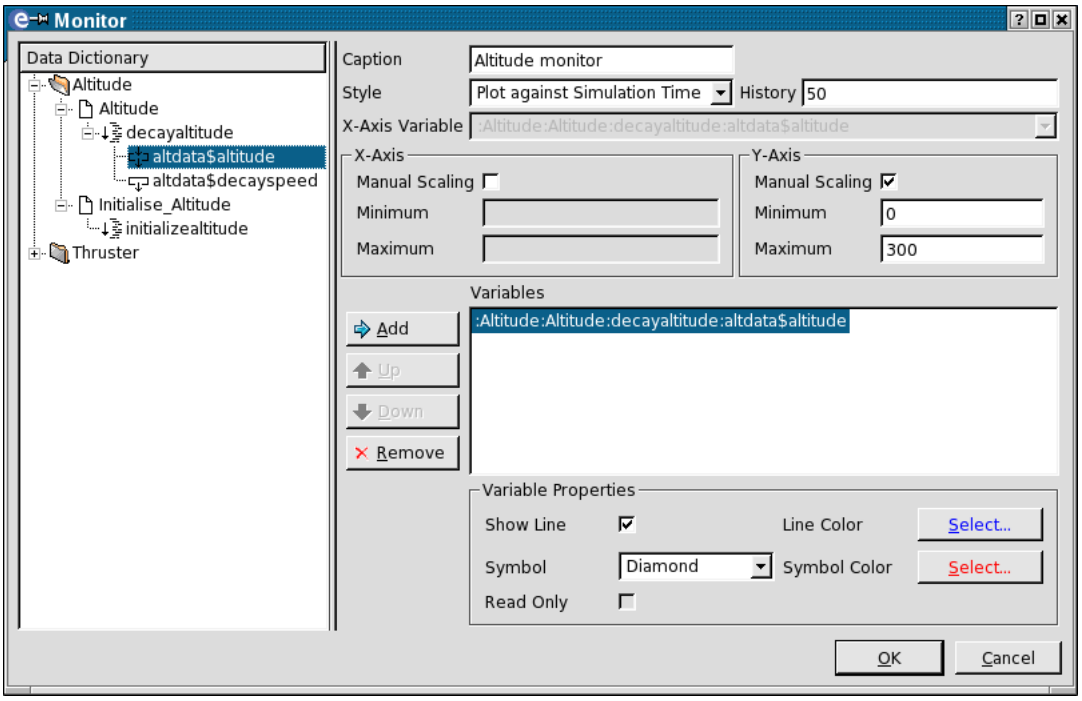


Figure 3.8: The Monitor Editor

3.8.2 Creating an intervening action

In order to create an action which changes a variable during the simulation, you first have to create a scenario file where such actions are defined. Choose *Insert:New Scenario* from the menu. Save the file as `SUM.mdl`. Now you will be asked for the caption of the new tab page. By default the name of the file is used without the suffix. Accept the default.

To add a script choose *Insert:Script* from the menu. Change the name of the action to `Set decay speed to 20`. Select the options ‘Initializing’ and ‘Standby’. Because this action should only be executed if the Test Conductor wants it, the ‘Condition’ field is left blank. Now the action has to be started explicitly by the Test Conductor.

Select the variable `altdata$decayspeed` from the Dictionary Browser using the left mouse button. Whilst keeping the mouse button pressed, drag the name of the variable to the *Action* field. Release the button. The variable is now copied to the Action field. Add `=20` to the same line as where the variable is shown. This statement means to set the variable to a value of 20. Optionally, press **Check Script** to see if any errors were made. The Script Editor should now look like Figure 3.9.

Close the Script Editor with the **OK** button. The new action appears on the Scenario tab page.

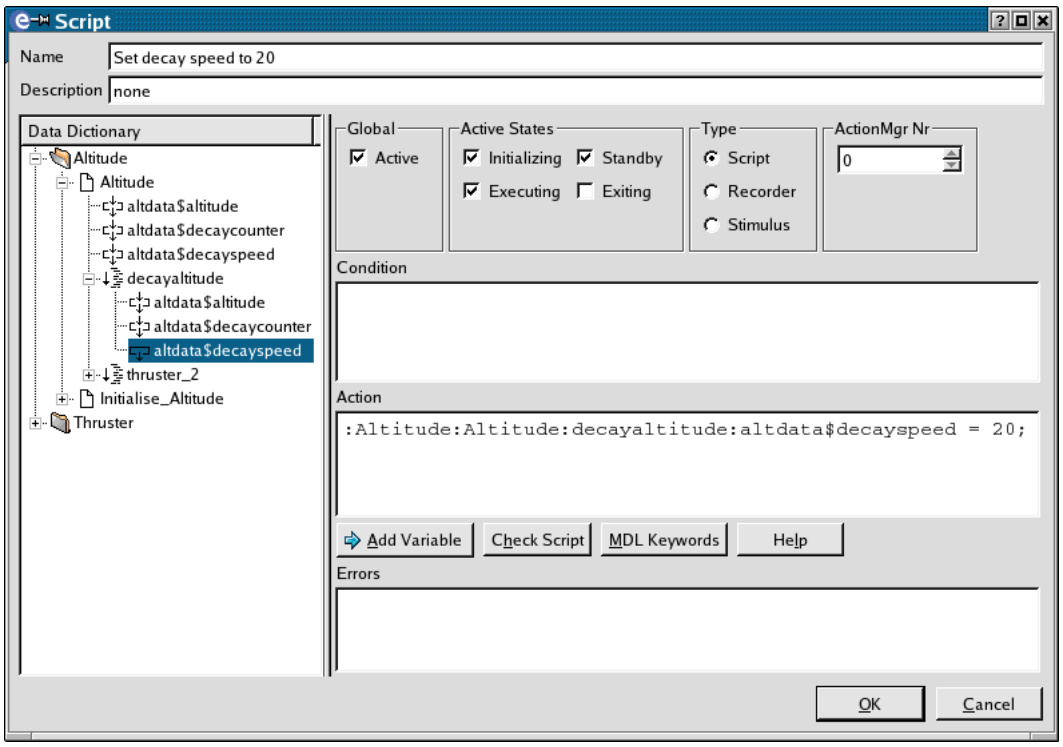


Figure 3.9: The Script Editor

3.8.3 Creating a recorder

In a recorder action, the values of one or more selected variables are saved to a file (in contrast with a monitor, where the values are shown on screen; another difference with monitors is the sample rate: monitors sample at a fixed rate of 2 Hz whereas recorders can sample at a user defined frequency up to the maximum schedule frequency, usually 200 Hz).

Select *Insert:New Recorder* to create a new recorder. In the Recorder Editor, change the name to `Record altitude`. Double click on the `altdata$altitude` variable in the Dictionary Browser. It will be added to the *Variables* list.

For a recorder, a number of extra attributes have to be filled in. Change the name of the recorder file by setting the edit field 'Recorder File' to `altitude.rec`. Optionally, the recording frequency and start/stop times can be entered here as well. The editor should now look like Figure 3.10.

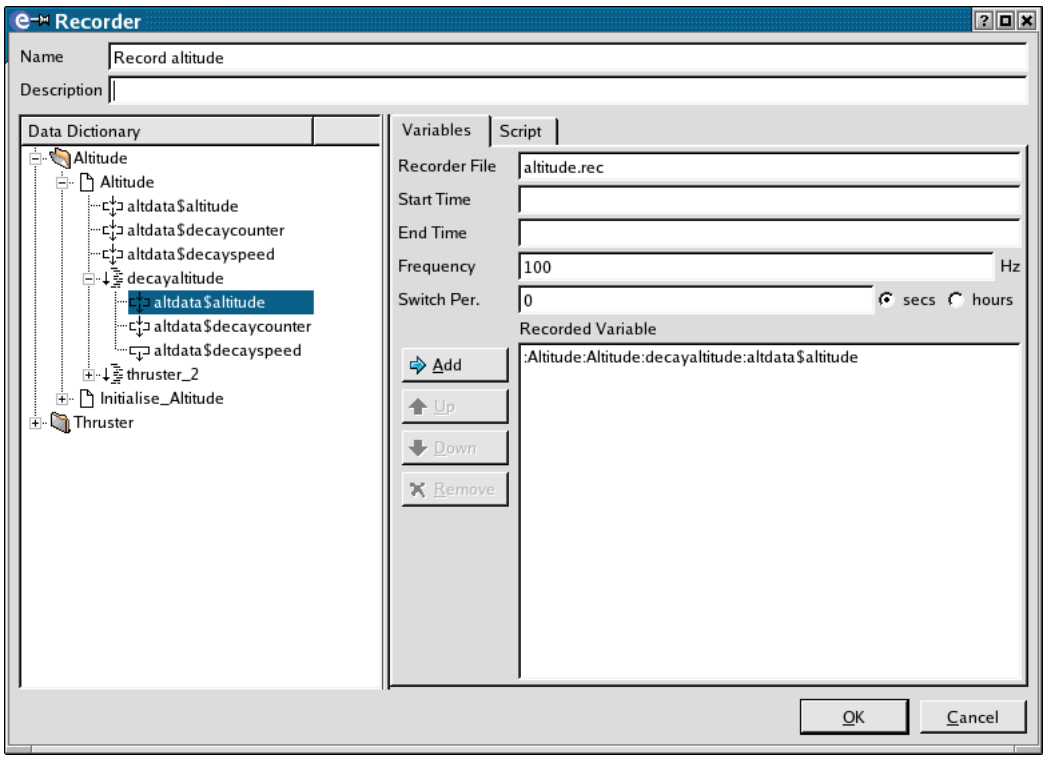


Figure 3.10: The Recorder Editor

The Recorder Editor has two tab pages. Change to the *Script* tab page, and notice that now a 'Condition' has been filled in: at a frequency of 100 Hz, the 'Action' will be executed. Although not used here, the 'Inactive' setting can be useful for temporarily disabling a recording action (or others, e.g. a check on variable values). Active actions are represented by an 'A' in the status column.

The Condition and Action fields are read only, but by checking the **Manual** checkbox you can customize these fields.

Close the Recorder Editor with the **OK** button. A second icon is now visible on the Scenario tab page. The tab page should now look like Figure 3.11.

Save the simulation definition by selecting *File:Save*. Requesting *Save* will cause the *Save As...* file selector to appear as this simulation definition has currently no filename. The simulation definition should be saved as `SUM.sim`.

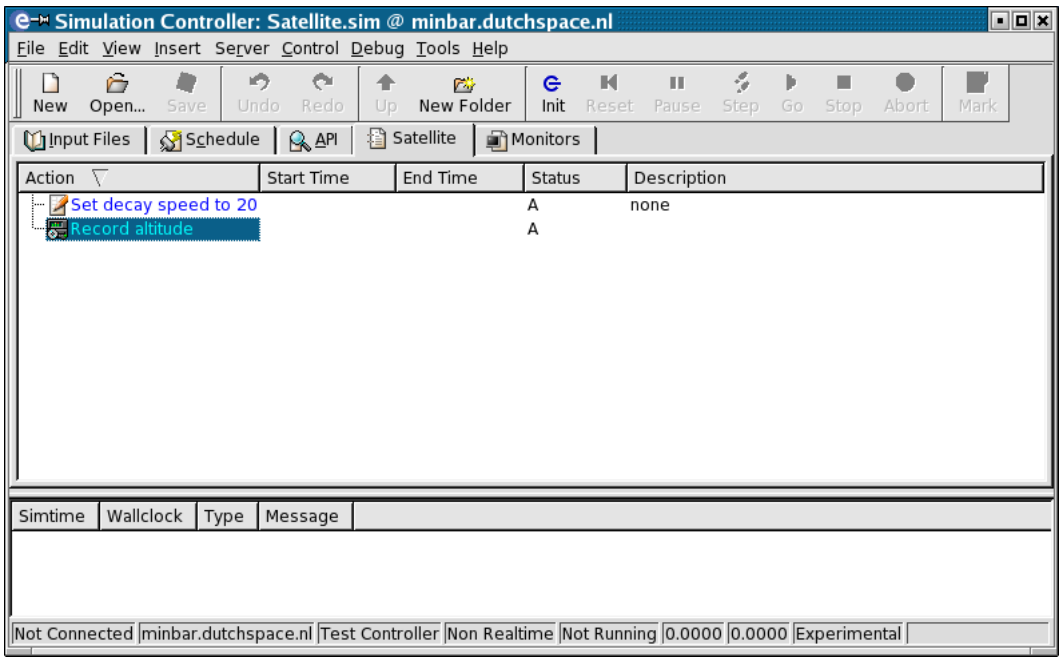


Figure 3.11: The Scenario tab page

3.9 Executing a simulation run

Everything is now set to perform an actual simulation of the model. A simulation runs on a so-called *simulation server*, which is a machine running the EuroSim scheduler. Select *Server:Select server* from the menu, and select one of the servers shown in the list.

Simulations can run either in real time or non-real time. In non-real time mode, the simulation server will try to be as real time as possible, but no real-time errors will be generated (see also Section 2.2.4). By default, non-real time mode is selected.

Initialize the simulation by pressing the **Init** button from the tool bar or from the *Control:Init* menu. After the initialization is completed, the **Init** button will become inactive, and the other buttons will become active. Notice that the wall-clock time will start running.

Now press the **Go** button to start the simulation. On the Scenario tab page, notice that an 'X' appears in the status column for the recorder. This indicates that data is being recorded (the recorder is *eXecuting*). Select the Altitude tab page and notice that the altitude of the satellite is plotted against time in the monitor window. During the simulation, it is possible to change attributes of the monitor (for example the X and Y ranges).

When the satellite starts coming down, double-click on the 'Set decay speed to 20' intervention action. The satellite should now come down more rapidly. Directly after double clicking the intervention action, select *Insert:Mark Journal*. A mark with a number should now appear on the message pane. Afterwards, make a comment with *Insert:Comment Journal Mark* to explain that the mark indicates that the intervention action was executed. For example, enter as comment `Mark 1-tc indicates activation of intervention action.`

After a while, stop the simulation by pressing the **Pause** button and then the **Stop** button. Close the Simulation Controller with the *File:Exit* menu item.

3.10 Analyzing the simulation results

In order to make some plots of the recorded variables, select **Test Analyzer** from the main EuroSim window. Make sure you have PV-Wave or gnuplot installed otherwise this tool will not work. An empty Test Analyzer window will appear.

Now we will load the test results generated during the simulation. Select *File:Select Test Results File*. This will show a file selection window. Now find the recording file generated during the simulation. It will be in a directory like `2001-08-30/15:33:30`. Select the `Altitude.tr` file, which contains a list of all recording files created during the simulation (in this case, just one). Right click on the variable browser window (on the left) and select *Expand All Nodes*. The window should now look like Figure 3.12.

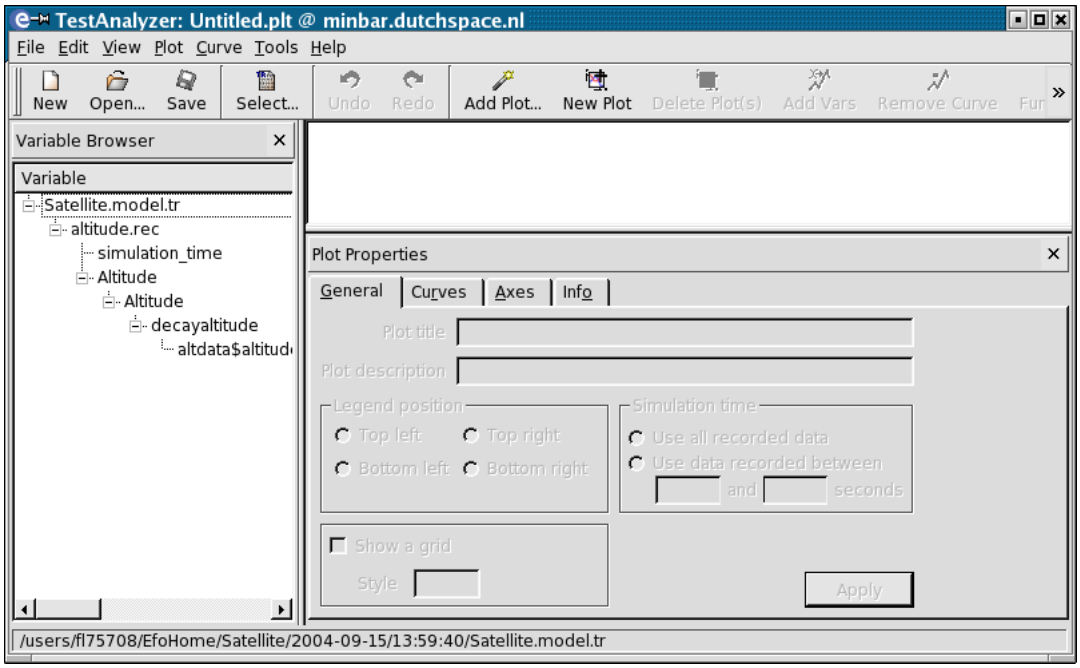


Figure 3.12: The Test Analyzer with the simulation results loaded

Now select *Plot:New Plot*. The plot view (top right) now shows an icon representing the plot. The plot properties tabpages (bottom right) have also become available.

Enter `Altitude` as the plot title and `Plot of altitude against time` as a description. Press the **Apply** button to commit the changes. The text under the plot icon in the plot view will be updated. The window should now look like Figure 3.13.

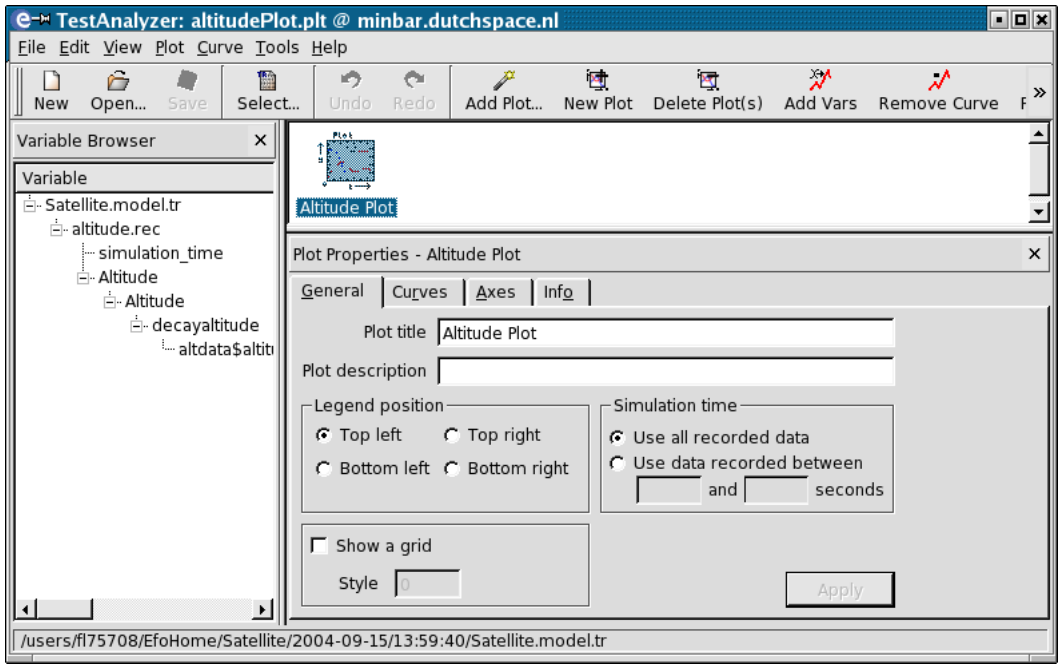


Figure 3.13: A new plot

The next step is to create a curve of the altitude versus the simulation time. Select the variable `altitude$altitude`. Now click on the variables and curves tab of the plot properties tabpages. The curve editor appears. Drag the selected variable from the variable browser to the curve editor. A new curve is created and the window should look like Figure 3.14.

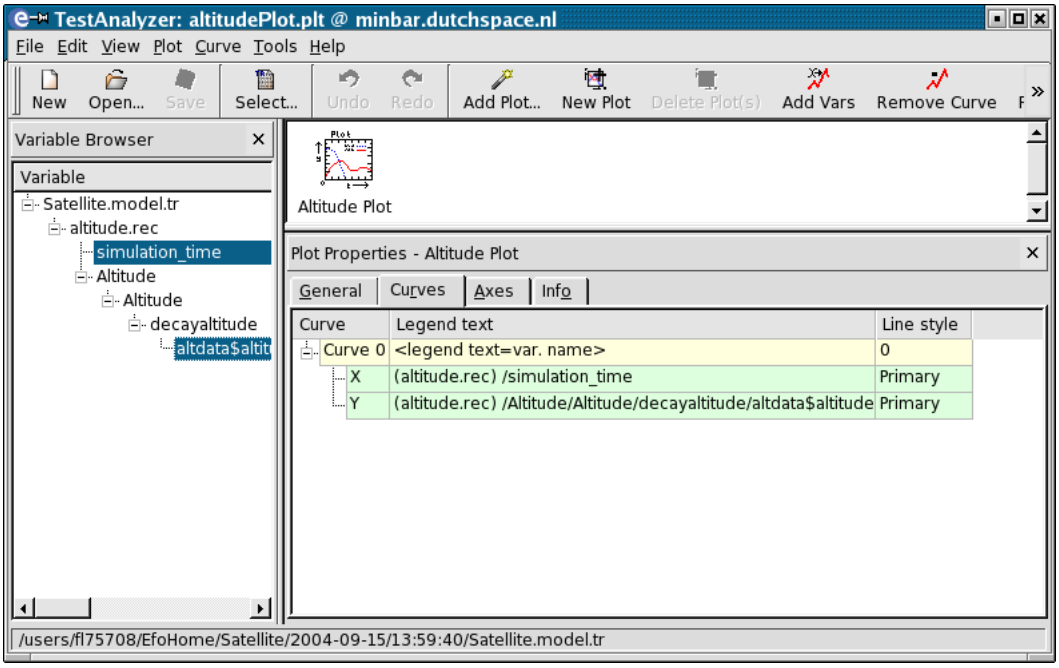


Figure 3.14: A completed plot

This completes the plot. Double clicking the plot icon in the plot view will show the plot.

3.11 Concluding remarks

In this chapter, a complete simulator has been built from scratch. The most important features of EuroSim have been used. However, as EuroSim offers many more functions than can be described in this tutorial, the reader is advised to proceed with the reference chapters, and experiment with the simulator from this chapter.

Chapter 4

Troubleshooting

4.1 Introduction

Building EuroSim simulators requires programming and integrating models, and as consequence a variety of problems that are normal to developing software can occur. Typical examples are:

- Simulation fails to start
- Simulator Controller time-out
- Simulator segmentation fault
- Unexpected model behaviour
- Scheduler event and sequence errors
- Memory allocation messages

When software engineers build their own programs, they know how to engage these problems and use tools like debuggers or print statements to files to get to the cause of the problem. More advanced methods are even to use memory checkers such as valgrind, coverage analysis tools as gcov and profilers such as gprof. Especially under Linux these tools are freely available and can aid to the quality of the software. In addition coverage analysis of the simulator can be used to demonstrate in verification that all code has been checked. (When models are loosely coupled it is possible to verify the models as integrated unit in the simulator by only scheduling the execution of the specific model code.)

Similar features are also available to the Simulator Developer under EuroSim. This chapter explains how to find the cause of problems using the various facilities in EuroSim.

4.2 Daemon Log Inspection

The EuroSim daemon collects all standard error and standard output of simulators and stores these messages in the EuroSim daemon log. Generally it should be in most cases be the first item to inspect in case of unexpected crashes.

The EuroSim daemon log catches all messages from the starting simulator executable untill the simulator has set up its message handling services and has been able to log messages to clients and its own log file in its results directory. This includes any messages generated by model code through the esimReport (messasge, warning, error, fatal) service routines that were generated in such early stage. This could for instance be caused by model code activated from the CPP interface setup function. Besides catching messages in an early stage of the launching the simulator, all writing to stdout or stderr, for instance with printf, duing the simulation will also be caught in the daemon log.

The location of the EuroSim daemon log depends on the operating system:

- On Linux systems, the daemon log is by default created at `/var/log/esimd.log`. Note that the file collects the messages of all simulators, hence it can grow considerably. It is recommended to use the tool `less` to view the file. Use the command `Shift-G` to jump to the end of the file and scroll back to find the messages of your simulator execution.
- On windows systems, the daemon log is created in the Windows system log. Open the Windows Control Panel. Select Administrative Tools and then Computer Management. In Computer Management, unfold Windows Log and then App[lication. Browse to the information items from esimd.

4.3 Core file analysis

If in the exection of the simulator a fatal code in the error is encountered, a segmentation fault is raised and a core file is generated. The latter may be dependent on ulimit settings (set this to unlimited) and potentially compilation with the -g flag that needs to be set in the Model Editor Build Options.

Assuming that a core file is generated, loading this core file in a debugger can in most cases produce a stack trace that can identify in which function the crash occured.. If compiled with -g such that extra symbol information is included in the executable, the exact line in the code can be found. The core file is normally generated in the project directory where also the sim file is located. Using the GNU debugger, the following command will start the debugger with the core file:

```
gdb <modelname>.<os>/modelname.exe <corefilename>

where:
   <modelname>    = Name of the model
   <os>           = Linux or WINNT
   <corefilename> = typically core.<process id number>
```

Note that we have not seen core files being generated on Windows machines yet. On Linux systems the popular GNU debugger front-end ddd can be used instead of gdb. alternatively, eclipse users may use the debugger from within eclipse which is also a GNU debugger front-end.

After the GNU debugger has launched, use the `where` command to get the stack trace.

4.4 Symbolic Debugging

If the simulator is executing, but the model code is not behaving as expected, a first solution is to monitor variables using the monitors that can be made in the MMI tabs of the Simulation Controller. However, it is also possible to step through the code using a symbolig debugger. The only preparation to do this is to set the `-g` flag in the Build Options of the Model Editor and rebuild the model such that it includes additional symbol tables:

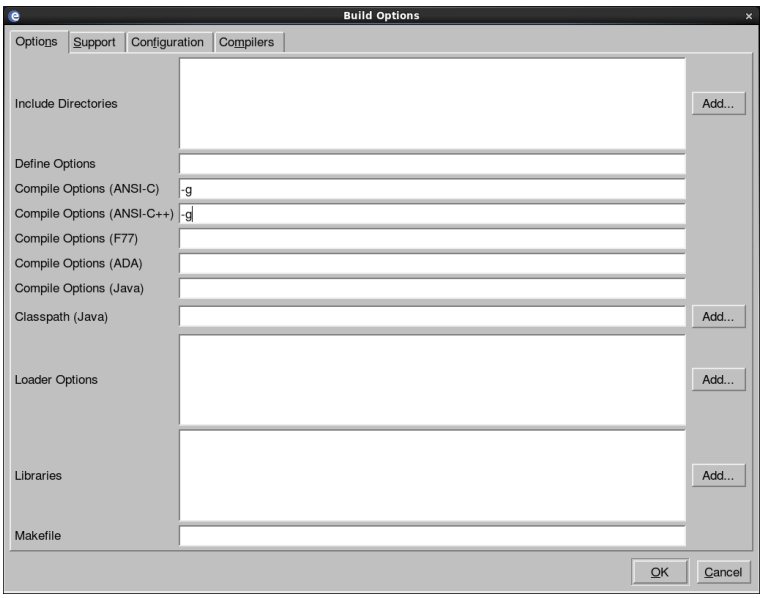


Figure 4.1: Enable symbolic debugging of the simulator model code

The easiest approach to starting the debugger is to launch it from the Simulation Controller when the execution has achieved the point where inspection is desired. Pressing the F5 button the debugger that is selected in the Preferences dialog of the Tools menu of the Simulation Controller is started. The startup is such that the debugger automatically loads the appropriate executable and attaches to the running process. As soon as it is attached the excution of the simulator freezes. The user now has complete control from the debugger. Figure Figure 4.2 shows the debugger hitting a breakpoint in the model code.

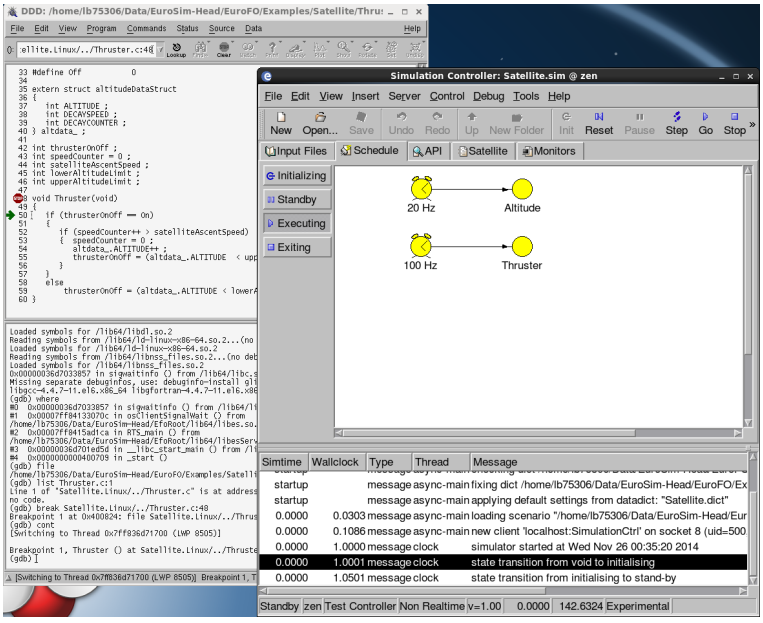


Figure 4.2: Symbolic debugging of simulator model code

Note that a known Software Problem exists on Windows where a console is started with the GNU debugger but the attachment does not occur automatically. Once the debugger is started, look up the process id via the Windows Task Manager (CTRL-ALT-DEL or right moue click on task bar). Select the Performance tab and then press the Resources button at the bottom. The dialog that then comes available has on the Overview tab a listing of os executables with process is. The EuroSim helpdesk is working on the problem.

4.5 Scheduler Debugging

EuroSim has built-in capabilities for schedule debugging. In the context of EuroSim the smallest unit of execution is the entry point. The debugger menu in the Simulation Controller and associated Schedule tab with context sensitive menu options provide a means to debug a the level of tasks and entrypoints. Using these options the user can put traces on the execution of tasks and entrypoints, disable the execution of tasks and step through the execution of tasks.

The Scheduler Debugging features greatest value is in easy ways to get to the point where other means become helpfull. The Scheduler Debugging for instance can help the user to easily break at a specific scheduler entrypointk then hit the F5 button to launch the debugger, and then dismiss the Scheduler Debugger breakpoints and start using symbolig debugging.

4.6 Tuning Memory options

To assure hard realtime execution, EuroSim allocates memory on start-up from which itself and thereafter the user through esimMalloc can claim head memory. This mechanism assures that no page faults occur during simulation. The total amounbt of heap memory that becomes available is defined in the Model Editor via the Build Options dialog. It is not uncommon that large simulators require more heap memory and the default configured setting must be increased. Modern machines have considerable amounts of memory, and allocating large memory of multiple gigabytes is not a problem to EuroSim. Do consider however that on multi-user systems, multiple users can be active. To tune the amount of memory, the EuroSim service interface contains functions to report on heap memory usage and availability. This can also be used to detect memory leaks as the reported memory continues to increase.

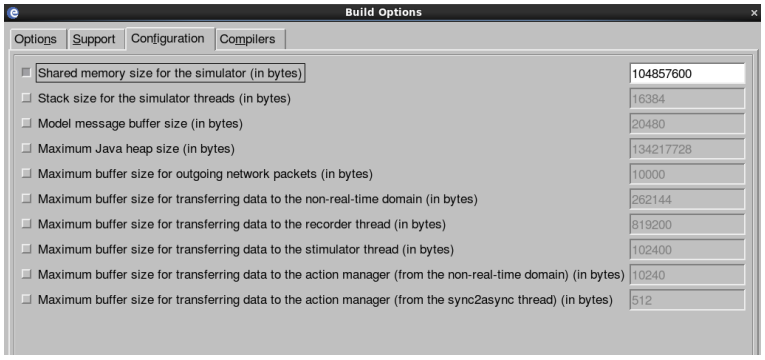


Figure 4.3: Tuning the memory sizes of the simulator

Besides the heap memory tuning, the Model Editor Build Options also allow the sizing of several internal buffers. The most common cause of error messages related to memory problems is the ringbuffer overflow messages. This ringbuffer buffers the echange of message between the real-time domain where the tasks execute and the non real-time domain where for instance the communcation of sockets with clients is arranged. The communication to clients executes on 2Hz and completely drains the buffer of all messages. This however is no match for the real-time excuting processors when the generate high volumes of messages and data (from the Action Manager task to the non realtime domain). Increase the memory settings to allocate more buffer space if the fluctuations in the message volume are high.

4.7 Tuning Simulator Startup time-out

Quite often a Simulation Controller time-out error is related to a problem in the start-up of the Simulator. It is however possible that the start-up takes longer then expected. In particular this can occur with C++ based simulators. The time that the Simulation Controller will wait from launching the simulator until a connection to it becomes available is defined in the Preferences settings of the Simulation Controller

in seconds. Enlarge the value if you think a larger time-out might be needed. Note that the setting is not specific to a simulation (.sim file), but rather is a user specific setting that is stored in the .eurosim directory in the users home directory.

4.8 Execution Timing analysis

EuroSim offers the user two methods of timing analysis: A statistical overview and a timebar overview.

The statistical overview is automatically collected in every simulator run and written to file at the end of a successful simulation run. The log file is called `timings` and can be found in the results directory, which by default is created in subdirectories that identify first the day of the simulation and in that the time of the simulation run. The Simulation Controller also loads the file automatically in the Schedule Tab and is presented to the user if the Statistics button is pressed.

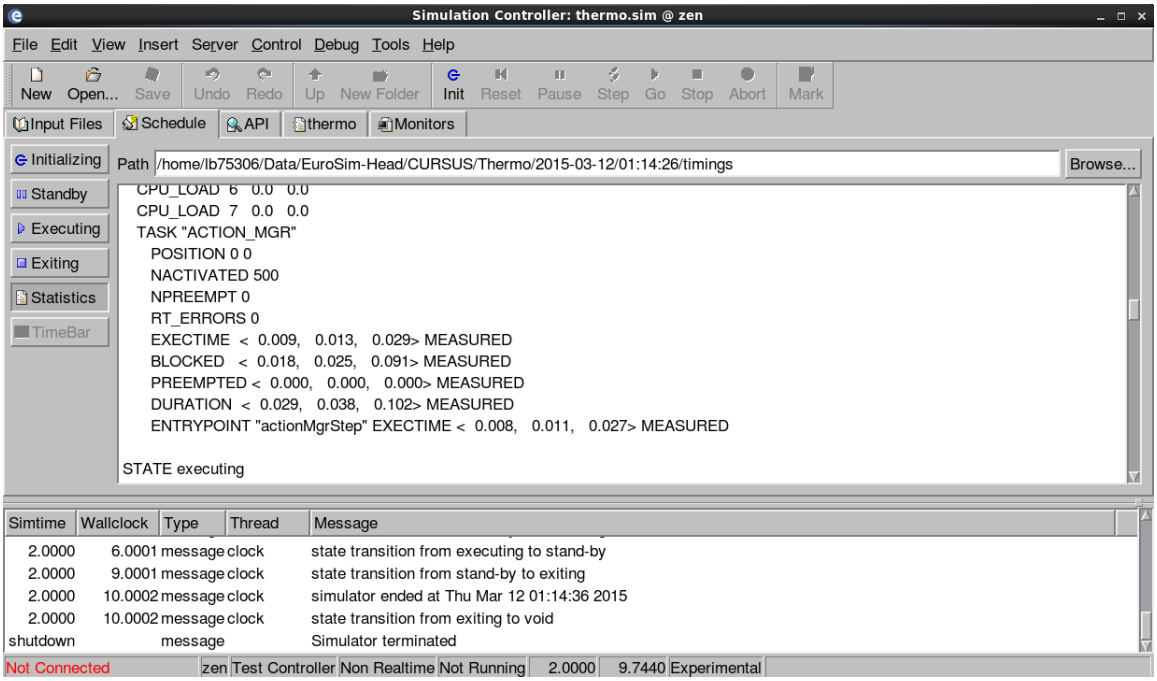


Figure 4.4: Statistics tabs at end of successful simulation run

The file has the same format as a schedule file and clearly lists for every entrypoint in a task the minimum, average and maximum execution time as well as the number of executions of the entrypoint. In addition it shows the number of events and CPU load for every state.

The timebar approach can show the user the execution of the scheduler on a timeline. The scheduler records all events and start-stop times and dumps these in a file. This file to record data to is specified in the the timebar dialog of the Tools menu of the Schedule Editor. Using the same menu the recorded time-bar file that is available after execution can also be displayed using this menu, but an easire method is to start the TimebarViewer from the command line using the command: `TimebarViewer <datafile>`

For more information, see the GUI Reference Schedule Editor section.

4.9 Profiling

Profiling tools assist the user in determining the parts in program code that are time consuming and need to be re-written. This helps make your program execution faster which is always desired.

In very large projects, profiling can save your day by not only determining the parts in your program which are slower in execution than expected but also can help you find many other statistics through which many potential bugs can be spotted and sorted out

In EuroSim the gprof tool can be used in combination with EuroSim to get an overview of the time spent in executing model code. To get the code instrumented for this measuremend, add `-pg` to the Compile Options for your compiler (language) and (re)build your simulator. Only the model code will be recompiled, hence the profiling will only connect information on model code.

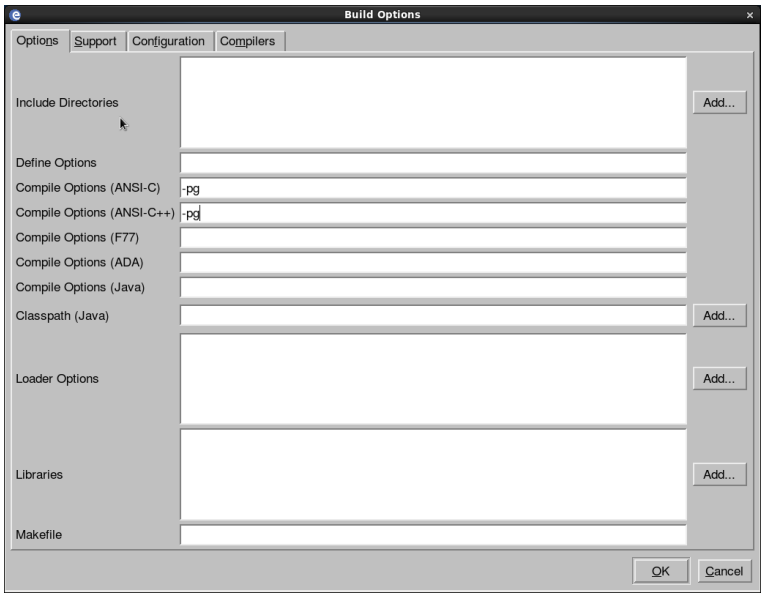


Figure 4.5: Enable profiling of the simulator model code

After the simulation execute the following statement from the command line
`gprof <model>.<OS>/<model>.exe gmon.out`

4.10 Coverage analysis

Coverage analysis tools count how often a program executes a segment of code. In debugging it is helpfull to find if code is executed. In formal verification it may be required to show that code is executed. The tool gcov comes as a standard utility with the GNU Compiler Collection (GCC) suite and can be used in combination with EuroSim.

To instrument the code for collecting the statistics, add fprofile-arcs and ftest-coverage to the Compile Options for your language, and add fprofile-arcs to the link options of the Set Build Options dialog of the Model Editor:

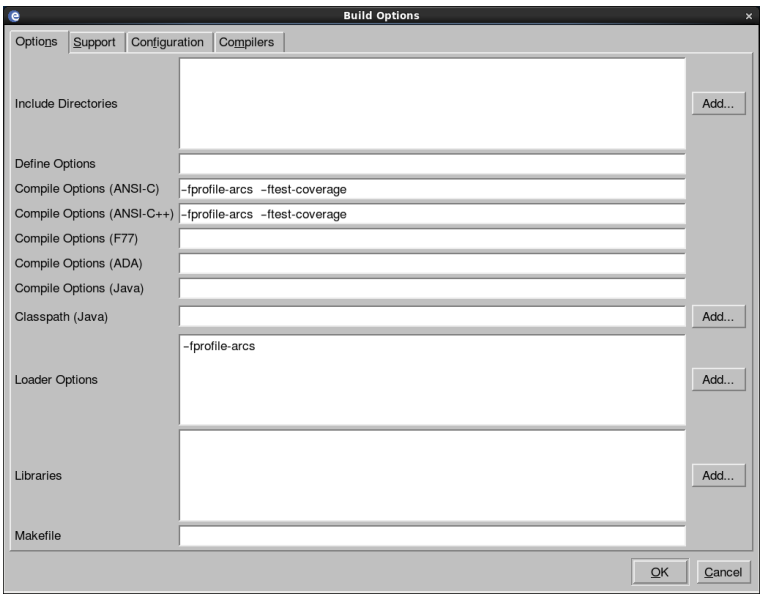


Figure 4.6: Enable coverage data collection on the simulator model code

Build the Simulator and execution remains unchanged, although timing will be affected. On termination the simulator dumps datafiles to the Simulator.¡os¿ directory. These can be post processed with the command

```
gcov o <model>.Linux *.c *.cpp
```


Part II

GUI Reference Guide

Chapter 5

Common GUI reference

EuroSim uses a graphical user interface (GUI) for all tools available to the user. This chapter describes the following elements of the user interface:

- Some of the conventions used throughout the user interface.
- The keyboard shortcuts which can be used to quickly access functions from the menus.
- The menu items that are available in every tool.

5.1 GUI conventions in EuroSim

- An ellipsis is shown after a menu item description when a dialog box is shown to request more information from the user, before an action is performed. E.g. *File:Save As...*
- Menu items and buttons that can not be selected (either due to the context, or because they are currently not implemented in EuroSim) are shown grayed out.
- Where applicable, keyboard shortcuts are shown next to the item. For more information, refer to Section 5.3.

As the EuroSimGUI's are based upon the Qt toolkit, the following elements are used for user input:

- *Checkboxes* (little squares) which can be selected by pressing the box.
- *Radiobuttons* (circles) which behave the same as checkboxes, with the exception that of a group of related radiobuttons, only one can be active.
- *Normal buttons* (rectangles), which have a descriptive label such as 'Save' on top of the button. Pushing the button performs an action.
- *Textfields* (large rectangular areas, sometimes with sliders alongside it), which can be used to enter text. If the field has sliders, they can be used to reveal parts of the field which are not shown on screen.

5.2 Mouse buttons

An item in a window is selected by placing the mouse pointer over it and clicking the left mouse button (MB1). More objects can be selected by holding down the Control or Shift key when clicking MB1. Double-clicking an item with MB1 will activate it (i.e. do the thing the icon represents, e.g. drawing a plot) or fold/unfold it, in case it is an icon in a tree structure.
Pressing the left mouse button over a selected icon allows one to drag the icon and drop it somewhere else (e.g. in a monitor definition, that will then be extended with the new variable name).

5.3 Keyboard shortcuts

The menu items can also be accessed using the keyboard. There are two methods:

- The Alt key can be used to access the menubar. Once selected, menu options can be selected by using the cursor keys followed by Return or by typing the underlined letter for a particular menu option. Escape aborts from the menu traversal.
- Specific, often used, menu items can also be selected directly using a short cut. These shortcuts are usually combinations of the Ctrl and Alt keys and a character key, and are shown next to the menu item.

In textfields, the usual editing keys such as Tab, Enter, arrow keys, Home and End are available. Besides these keys, the following keys have special meaning:

- Prior (or PageUp) scrolls down a page
- Next (or PageDown) scrolls up a page
- Ctrl+a moves to the beginning of the line
- Ctrl+b moves the cursor backwards a character
- Ctrl+c copies the selected text to the clipboard
- Ctrl+d deletes a character
- Ctrl+e goes to the end of the line
- Ctrl+f moves the cursor forward a character
- Ctrl+h backspace a characters
- Ctrl+k deletes to the end of the line, or removes an empty line
- Ctrl+n moves to the next line
- Ctrl+p moves to the previous line
- Ctrl+v inserts text previously cut or copied
- Ctrl+x cuts selected text from the field
- F2 starts editing a selected label in a tree view

On systems running the X Window System (UNIX platforms), the second mousebutton inserts the Xbuffer selection at the cursor location.

5.4 Common dialog buttons

There are a number of buttons that are used throughout EuroSim.

OK Acknowledges the question, or accept the changes made in a window and close the window.

Cancel Abort the operation and all entered data is ignored.

Apply Accept the changes made in a window, but do not close the window.

Dismiss Close the dialog window.

Browse Open a dialog to select an item from a list. Often used to select a file.

5.5 Common toolbar buttons

There are a number of toolbar buttons that are used throughout EuroSim.

Undo Undo the last action.

Redo AbRedo the last undone action.

Cut Cut the selected item(s).

Copy Copy the selected item(s).

Paste Paste the cut item(s).

Delete Delete the selected item(s).

5.6 Common menu items

Throughout EuroSim, a number of menus appear with every tool. These menus have a number of 'standard' items, which are described in this section. Note that each tool can add a number of tool-specific items to these menus - these tool-specific items are described in the sections on these tools.

5.6.1 File menu

New A new file will be created. If there are any unsaved changes in the current file, a warning dialog box will pop up and ask whether you want to save the changes first.

Open Pop-up a file selection dialog box in which a file to be opened can be selected. If there are any unsaved changes to the current file, first a warning dialog box will appear (see *New*).

Save Save the current file without closing it. If the current file has never been saved before (an 'Untitled' file), a file selection dialog box will pop-up asking the user to enter the name of the file. Note that this item cannot be selected if there are no unsaved changes. Note that a window title will have an asterisk appended to the name of the file in the title if the file needs to be saved.

Save As Save the current file with a different name. The newly created file will become the current file.

Print Print the current file in an appropriate form.

Exit Close the tool and all windows associated with it. If there are any unsaved changes, a warning dialog box will pop up.

5.6.2 Edit menu

Undo Undo the last action performed by the user.

Redo Redo the last undone action.

Cut Move the selected portion of data from the tool window to the clipboard.

Copy Copy the selected portion of data from the tool window to the clipboard.

Paste Move the contents of the clipboard to the tool window. Depending on the tool, the location where to paste can be selected.

Delete Remove the selected portion of data from the tool window.

5.6.3 Tools menu

Shell Start a command line session (also known as 'xterm' on X Window Systems (UNIX platforms), or 'Command Prompt' on Windows platforms).

5.6.4 Tools:Version menu

Add... Add the selected file to the repository. A dialog appears where you can enter a text describing the change. See Figure 5.1 for an example.

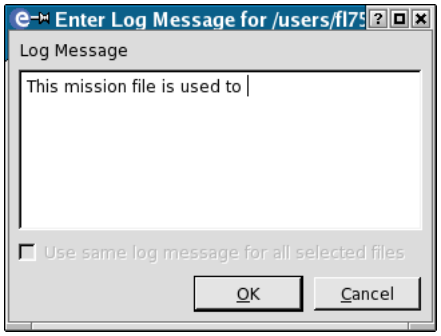


Figure 5.1: The Log Message

Update Update the selected file with the latest version from the repository.

Get... Get a specific version of the selected file from the repository. If the checkbox **Remove file before update** is checked, then before the selected version is retrieved, the old file is removed. Otherwise the selected version is merged with the current version. The version with a checkmark in front is the required version.

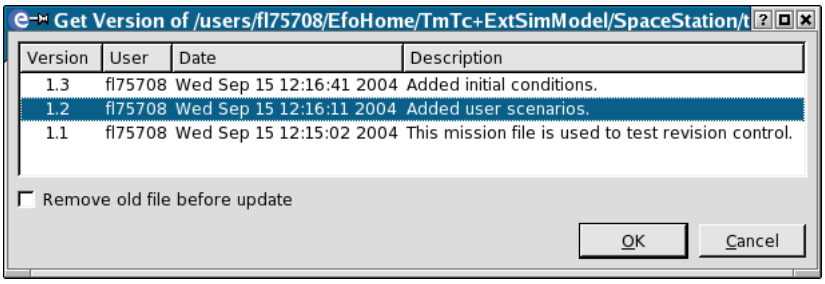


Figure 5.2: Get Version

Detailed...
Show the detailed version history of the selected file. The version with a checkmark in front is the required version.

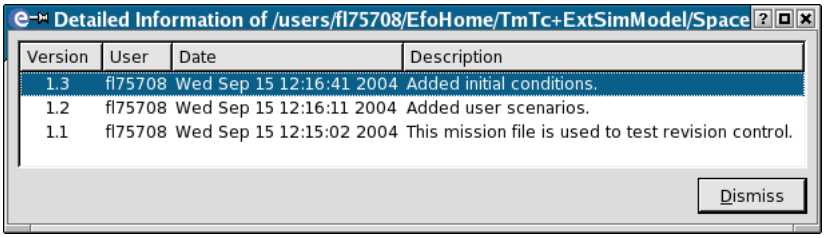


Figure 5.3: Detailed Information

Set Required...
Select a required version of the selected file. The version with a checkmark in front is the current required version.

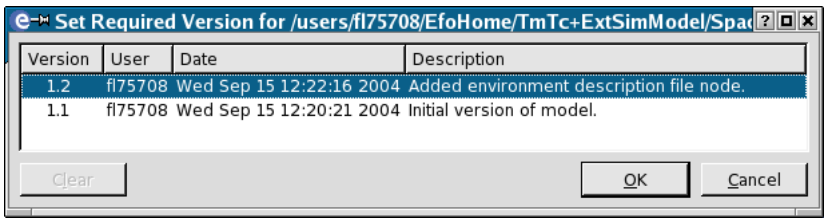


Figure 5.4: Set Required Version

Diff with...

Show the differences of the selected file with another version of that file. The version with a checkmark in front is the required version.

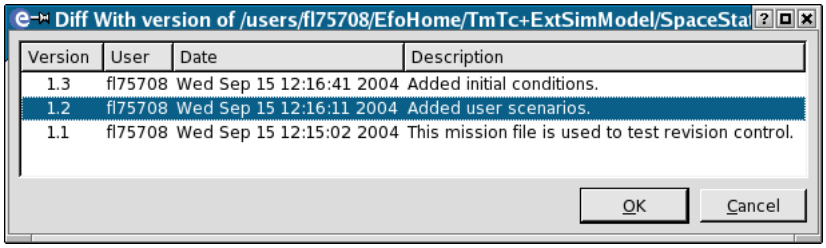


Figure 5.5: Difference With

5.6.5 Help menu

Online Help...

Provide a short description of the tool.

About EuroSim

Show the version of EuroSim.

Chapter 6

Project Manager reference

This chapter describes the top-level interface of EuroSim (`esim`), the Project Manager. For a description of the various EuroSim components, such as the Model Editor and Schedule Editor, refer to the next chapters.

6.1 Introduction

The project Manager provides a quick access to EuroSim projects and the files contained in these projects. For this purpose the Project Manager maintains a list of projects in a file called projects.sdb which is located in the the `.eurosim` directory of the user. It is also possible to share this list with other users by setting the environment variable `EFO_HOME`, in which case Project Manager will maintain the `projects.sdb` in the location that this environment variable points to.

The projects database contains a reference to a directory for each project. In this directory the Project Manager stores a project specific database with the name `project.sdb`. This project specific database contains relative files for all the files in the project. The `project.sdb` file can thus be shifted to other locations or handed over the other users and reconnected to their list of projects. The `project.sdb` database organises the files per model file. Every file depends on the .model file, and thus a project consists of multiple file trees with the .model files as root of each tree, if multiple .model files occur.

When you start one of the EuroSim editors from the Project Manager to create a new file (f.i. a new schedule file), the Project Manager will automatically add the new file to the current project when you save it to disk. Depending on the settings in the preferences dialog, you will be prompted with a question if the file should be added to the project or not. In the preferences dialog you can also disable this feature.

Note that files other than model files are always added in the context of the currently active model file in the current project. Each project can have multiple model files. If you have not yet selected a model file for the current project, the automatic addition of other files is disabled.

6.2 Starting the EuroSim Project Manager

The EuroSim environment is started with the esim command. This will pop-up the Project Manager window of EuroSim (see Figure 6.1).

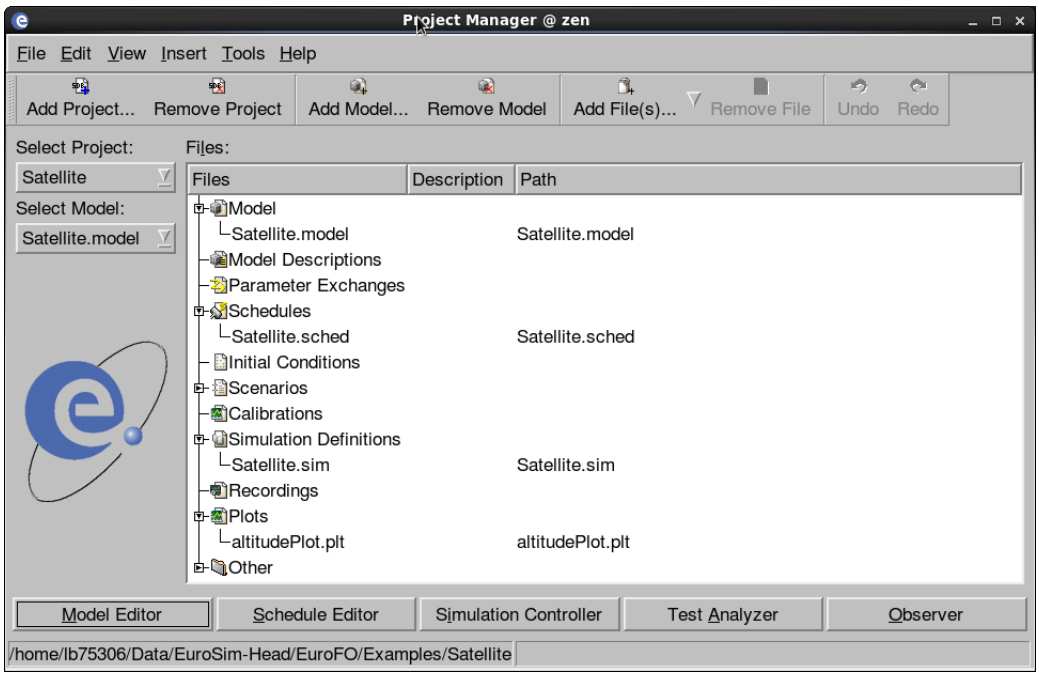


Figure 6.1: EuroSim start-up window

With the Project Manager the various editors can be started.

Before starting EuroSim, make sure that the environment variables `PATH`, `DISPLAY`[1], `EFOROOT` and `EFO_HOME` [2] are set correctly. On the RedHat Enterprise Linux platform these environment variables are set automatically. On Windows platform environment variables are defined in the file `$EFOROOT/bin/esim.bashrc`. See also Section 3.2.

The Project Manager will use the global project database file `projects.sdb` in the directory pointed to by the `EFO_HOME` environment variable. If `EFO_HOME` has not been set before starting EuroSim, EuroSim will use the subdirectory `.eurosim` in your home directory. The file `projects.sdb` contains all project references. If `projects.sdb` does not exist, EuroSim will create a new file.

EuroSim can be terminated by selecting the *File:Exit* menu option.

6.3 Views in the Project Manager

When the Project Manager has been started, a window similar to the one in Figure 6.1 is shown. This window is divided into three parts:

Selection pane
: This pane contains two drop down boxes allowing the user to select the project and model for which the files will be displayed in the Files pane.

Files pane
: The files pane shows the files for the selected Project and Model, categorized into the various types of files for the EuroSim specific file types.

Button pane
: The Button pane provides quick access to the main editors. If the user prefers direct access to additional editors then this can be configured as part of the Preferences in the Tools menu. If an editor is started it will load with the selected file in the Files pane, or with a new file if no selection is made.

[1] On the Windows platform, the `DISPLAY` environment variable will not be used by EuroSim
[2] This variable only needs to be set to override the default value (`$HOME/.eurosim`)

In addition the toolbar provides quick access to the functions of the Insert menu ((see Section 6.4.3)), and the status bar displays the project location for the project selected under Select Project.

6.4 Menu items

6.4.1 File menu

There is only a single projects.sdb file that is automatically loaded and updated, hence no file menu items apply.

6.4.2 Edit menu

Set Description...
: Adds a file description to a selected file.

Edit File...
: Opens the associated editor for the currently selected file. This is the same as double-clicking a file in the files list.

Project Settings...
: Opens a dialog for changing various project description items. A project description contains a number of elements, each of which can be set in this dialog (see Figure 6.2).

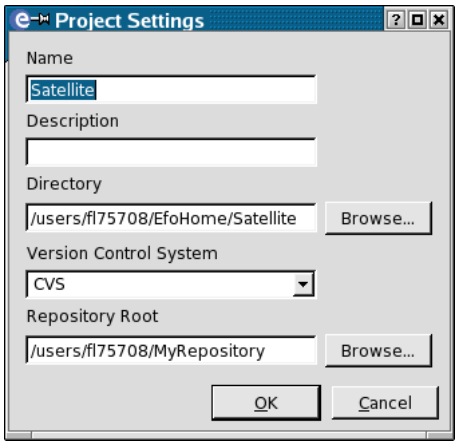


Figure 6.2: Project Settings dialog

Name The project name is the name that appears in the project list of the Project Manager, as well as in various other places, such as the name of the root node of the model hierarchy in the Model Editor.

Description
: The project description is a free-text field that can be used for a more precise description of the project.

Directory
: The project directory is the top of the directory tree in which all project related files will be stored. The **Browse** button can be used to search for an existing directory. Use the operating system file protections to protect project files against unauthorized use. Under UNIX one could for example create a UNIX group for each EuroSim project and make the project files writable by group members only. Depending on the security level required, the project files can be made world readable or not[3].

[3]Making UNIX groups and assigning members requires 'root' privileges and hence is a system administrators/facility managers job. Implementing a good protection strategy is not easy, but is assumed to be within the knowledge of the system administrator.

Version Control System

Defines which version control system will be used for this project. Currently EuroSim supports the CVS and Cadese[4] version control systems.

Repository Root

The repository root is the top of the directory tree in which the version management of the various model files will be stored. Refer to Section 2.5, for a discussion whether the repository can best be kept separate from the project root or not. The **Browse** button can be used to search for an existing directory. If an existing RCS or CVS repository is to be used within EuroSim, make sure that the tree under the project root has the same structure as the repository tree. The repository root field is optional and can be left empty. See Appendix F on how to set-up a repository root.

6.4.3 Insert menu

Add Project...

Opens a dialog for adding an existing project or for creating a new project (see Figure 6.3).

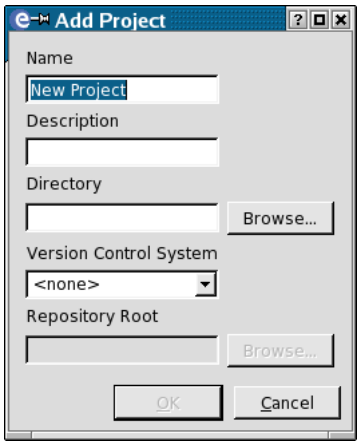


Figure 6.3: Add Project dialog

Fill in the various project description items of the window. For the dialog field descriptions refer to Section 6.4.4, item "Project Settings...".

Remove Project

Use this option to remove the current project from the projects list. The actual project files (such as the model file, the schedule, etc.) are not deleted.

Add Model...

Opens a dialog for selecting the model to add to displayed project (see Figure 6.4).

[4]Not supported in the Windows version.

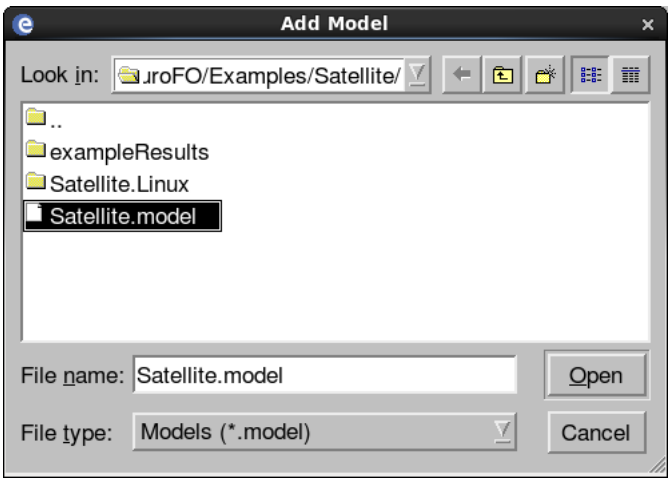


Figure 6.4: Add Model dialog

The model will appear in the drop down list under Selected Model.

Remove Model
Use this option to remove the model from the current selected project. The actual model file will not be deleted from disk by this action.

Add File(s)...
Allows opening a dialog for selecting a file to add to the selected project and model combination. A list of different types can be selected, the difference being the setup of the filter of the file selection dialog that will be popped-up.

Remove File
Use this option to remove the selected file in the Files list from the project for the specified model. The dialog that follows will allow the user to choose between cleaning the file from disk or only removing the reference to the file.

6.4.4 Tools menu

Shell...
Opens a new command shell (e.g. xterm or a DOS command prompt).

Model Editor...
Starts the Model Editor.

Model Description Editor...
Starts the Model Description Editor.

Parameter Exchange Editor...
Starts the Parameter Exchange Editor.

Calibration Editor...
Starts the Calibration Editor.

Schedule Editor...
Starts the Schedule Editor.

Simulation Controller...
Starts the Simulation Controller.

Test Analyzer...
Starts the Test Analyzer.

Observer...
Starts the Simulation Controller in Observer mode.

Preferences...

Opens a dialog to set the preferences. The following items can be set.

Do not prompt to add files automatically

When you start one of the EuroSim editors from the Project Manager and create a new file, you are prompted whether the new file should be added to the current project. If you check this item, you will not be prompted and the decision whether to add the file to the current project depends on the value of the next item.

Never add files automatically

If this option is checked, new files that are created by one of the EuroSim editors will not be added to the current project automatically. If you want to add a newly created file afterward, then use the appropriate menu command.

Show additional editor buttons

If this option is checked, buttons are displayed for sub-editors that are normally controlled from within the main editors. In particular this applies to the Model Description Editor, the Parameter Exhange Editor and the Calibration editor.

6.4.5 Help menu

Online Help

This menu option will start the 'Netscape' HTML-browser for UNIX and the 'Internet Explorer' for Windows which will load the on-line version of the user manual.

About EuroSim

This will pop-up a window displaying the copyright information for EuroSim.

Chapter 7

Model Editor reference

This chapter provides details on the Model Editor. The various objects which can be added to the model tree, the menu items of the editor and their options are described. For menu items not described in this chapter, refer to Section 5.6.

7.1 Starting the Model Editor

The Model Editor can be started by selecting the **Model Editor** button in the EuroSim start-up window (see Figure 6.1). Alternatively, the Model Editor can be started by typing `ModelEditor < filename.model>` on the command line. This will pop-up the Model Editor window of EuroSim (see Figure 7.1.

Figure 7.1: Example Dictionary view

7.2 Views in the Model Editor

When the Model Editor has been started, a window similar to the one in Section 12.12 is shown. This window is divided into two main parts, separated by a splitter:

Tab pane
: This pane contains two tab pages that are used for selecting and parsing files to be included in the simulator and the dictionary after building a simulator.

Message pane
: Shows the output from the build process for creating a simulator executable.

At the top is the menu bar and a tool bar. At the bottom a status bar provides additional state information.

7.2.1 The toolbar

The tool bar provides easy access to the following functions, beyond the standard buttons already described in section Section 5.5

New Create a new Model definition. The same as the *File:New* menu item.

Open
Open an existing Model Definition. The same as the *File:Open* menu item.

Save Save the current Model Definition. The same as the *File:Save* menu item.

Build All
Build the simulator (executable, dictionary). The same as *Tools:Build All*.

Cleanup
Cleanup the simulator and all files generated in the build process. The same as *Tools:Cleanup*.

Build Cancel
Cancel the ongoing build of the simulator. The same as *Tools:Cancel*.

7.2.2 The tab pane

The tab pane consists of the following tab pages:

Files In the Model Editor tree view the structure of the model is created using a hierarchical, tree structure. Elements in the tree are called *nodes* and have a specific function. The API (properties of variables and entry points available to the rest of EuroSim) can be edited in the Model Editor. In Figure 7.2 an example model tree is shown.

Figure 7.2: Example model tree

Note that only org nodes and file nodes can be directly added to the model hierarchy (using the menu options *Edit:Add Org Node*, *Edit:Add File Node* or *Edit:Add Directory*). The other nodes are put into the model hierarchy indirectly, e.g. by parsing the files. Informational messages are written to the logging window while parsing the files.

Dictionary
The Dictionary tab displays the EuroSim Dictionary after a complete EuroSim build. For classical EuroSim usage, this tab will be the same as the import tab after building the dictionary. For the Object Oriented language interfaces such as the EuroSim native C++, and Java API and SMP2 standard support, this tab will show all the objects and their child nodes in the hierarchy dictated by their ownership relations. In Figure 7.3 an example model tree is shown.

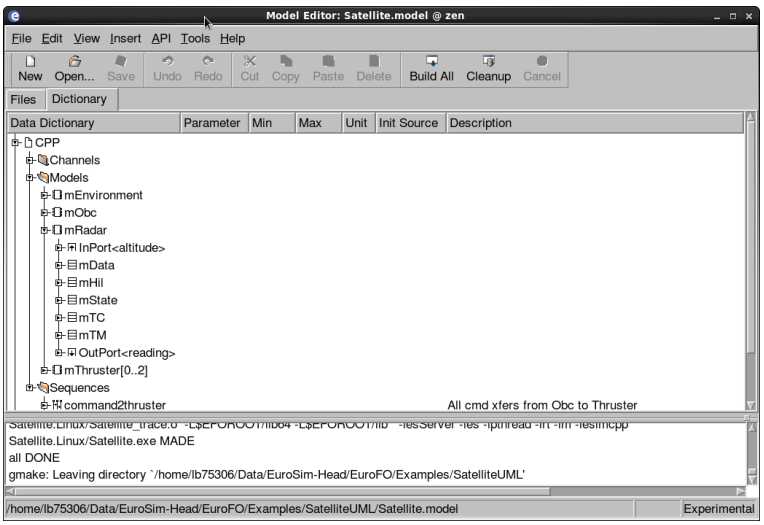


Figure 7.3: Example Dictionary view

7.2.3 The message pane

The message pane displays the output of the make process, either as a consequence of pressing Build (make all) or Clean all (make clean). The Build process generates a makefile ¡modelname¿.make by running the ModelMake tool as: `ModelMake <modelname.model> <modelname.make>`

After generation of the make file it executes the make file using `gmake (mingw32-make on Windows).`

7.2.4 The status bar

The status bar displays the model that is loaded and the status of the model. The latter refers to the versioning of files using the build in versioning capability fo the Model Editor to assure Traceable Simutions. It is not required to use this feature to have traceable models. Many users find it preferable to version files outside the Model Editor, in which case the Model Editor lists the model as Experimental. The versioning in EuroSim is now considered a deprecated feature.

7.3 Objects in the Model Editor

This section describes each of the nodes that can occur in the Import and Dictionary tabs of the ModelEditor. The default icon for the node is shown in the left margin. If more than one icon is used, all are shown.

7.3.1 Root node

The root node represents the complete model. It is a special type of org node (see next section) and therefore shares the same attributes of org nodes. The name of the root node in the attributes window is the name of the model file. The name displayed on the Model Editor window is the (file)name of the model, or *Untitled.model* if a new model is started and has not been saved yet. Double-clicking the root node folds or unfolds the node.

7.3.2 Org node

Org nodes are used to structure the model. By using org nodes, two or more related sub-models can be grouped together by connecting them to the same org node. Both other org nodes as well as file nodes (representing the sub-models) can be attached to an org node.

The name of the org node can be changed by clicking a selected node. A description can be entered in the description field.

7.3.3 SMP2 lib node

SMP2 lib nodes organise the files that compile into an SMP2 library. SMP2 catalogues, a package, and a folder containing generated C++ code and a Makefile can be attached to an SMP2 lib node. Refer to Chapter 16 for more information.

7.3.4 File node

There are various types of file nodes. They will be discussed in the sections below.

The name of the file node can be changed by clicking a selected node. The filename cannot be changed. A description can be entered in the description field.

The file attached to a file node can be viewed and edited through the menu options *Edit:View Source* and *Edit:Edit Source* respectively. Depending on the type of file, the correct viewer or editor is started. When a file is being edited or viewed the file icon with lock is shown.

The viewer/editor of SMP2 Artefact file nodes (catalogues, packages, and Assemblies) can be defined by the user in the `SMP2EDITOR` environment variable. If that variable is not set by the user, EuroSim falls back to the `EDITOR` environment variable. If no SMP2 modelling environment is available on the user's system, it is recommended to use an XML viewer as SMP2 Artefact file node viewer/editor.

The properties of a filenode can be shown with *Edit:Properties* (see Figure 7.4). You can select another file using the *Browse* button. For non-source files the type of the file can also be modified. As different file types have different attributes and functions, it is important to correctly enter the file type.

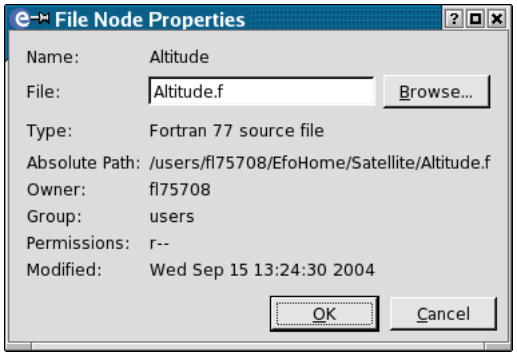


Figure 7.4: File Properties

See Section 5.6.4 for information on how to change the version requirement.

7.3.4.1 Environment file node

The environment node of a model is used to store information on the current development environment and the required target environment. It is used during build to check whether the current environment matches the required environment. The options *Edit:View Source* and *Edit:Edit Source* start the environment viewer and editor respectively. Refer to Section 7.6 for more information.

7.3.4.2 Source file node

Currently supported source file nodes are for the classic languages C , FORTRAN and Ada-95, as well as the Object Oriented languages C++ and Java. For more information on the restrictions on those languages, refer to the Limitations sections for each specific language in the Modelling Reference volume.

Note that it is not possible to have more than one file node referring to the same source filename, even if these files are in different directories.

Double-clicking on a source file node will start the source code editor defined by the EDITOR environment variable, or the editor defined in the esim_conf file.

For the classical languages, the files whil have the option to unfold or fold. Unfolding C and Fortran files will start the EuroSim parser to show the API information of a source file. For Ada there is no code parser, but if the user writes the API manually the unfolding will show the API defined by the user. If the source file cannot be parsed, due to a syntax error, the broken file icon  is shown. If the API information is changed, i.e. attributes of variables or entry points are changed, and the file is not yet saved the file icon gets an asterisk  .

A variable or entry point is part of the API if its checkbox is checked. See the *decayaltitude* entry node in Figure 7.2.

Use the mouse or the **space** bar to change the state of the API check box on the current selection, which can contain multiple items.
Interface:Save API writes this information to the source file.

For C++, Java and SMP2 files there are no parsers as there is not a direct relation between the file that implements a class and the creation of objects. For these languages the simulator is build and executed, but instead of activating the scheduler, the dictionary is written to file. The dictionary for each of the languages and interfaces are then merged with the dictionaries created for the classical languages and the result is displayed in the Dictionary tab. For the OO languages, there is thus no unfold capability on a single file, but its published items should be looked up in the Dictionary tab.

For more information on how to add SMP source code see Chapter 16. For more information on the use of the native C++ API see section Chapter 15. For More information on the Java API see section Chapter 17

Note that warnings and errors that occur during parsing and saving of files are shown in the logging window at the bottom of the Model Editor.

7.3.4.3 Model Description file node

Model Description files together with Parameter Exchange files and Calibration files togheter specify the integration of models using the EuroSim SimInt library.

Model Description file nodes can be added to the model file to generate a so called “datapool”. See Chapter 8 for a description on the datapool and how to create a Model Description file. During the build process (make), which can be started from the Model Editor, Model Description files that are part of the model will be read to generate the variables and entry points for the datapool.

7.3.4.4 Parameter Exchange file node

Paremeter Exhange files use the ModelDescription files and calibration file scontained in the ModelEditor as input and can be used to interconnect models via their datapool variables.

Parameter Exchange file nodes can be added to interconnect Model Description output nodes with Model Description input nodes. See Chapter 8 for a description on the datapool and how to create a Model Description file. During the build process (make), which can be started from the Model Editor, Parameter Exchange files that are part of the model will be processed into code that performs the code with option calibration.

7.3.4.5 Calibration file node

The calibration editor allows the user to define their calibration curves based on values and possible interpolation or polygon definitions.

The curves can be associated with a parameter exchange in the Parmameter Exchange editor. See Chapter 10 for more information.

7.3.4.6 SMP2 Assembly file node

SMP2 Assembly file nodes can be added to the model file to generate a file that creates instances of the models and data flows between them, according to the SMP2 Assembly specification. Refer to Chapter 16 for more information.

7.3.5 Entry nodes

An entry node represents a schedulable function or method. In the classical API (C,Fortran) the entry point is a function that has no parameters and no return value. In the Object Oriented API the entry point can be either a published method or function that has no arguments or return value. Some system generated entry points exist in thenew OO API to support dataflow scheduling.

7.3.5.1  Entry node

An entry node represents an entry point in a source file. For the classical API, it is part of the API of the model if its checkbox is checked (see Section 7.3.4.2).

The description is the only attribute of an entry point.

 If the API information in the file contains entry points that are no longer available in the source code, a red cross is drawn through the icon.

In the OO API, an entry node represents a published method or function in the API. These entry nodes only appear in the Dictionary tab after a succesfull build.

The description is the only attribute of an entry point.

7.3.5.2  Transfer node

In the OO API, a Transfer (xfer) node represents a schedulable entry node that performs the transfer of data from an Output put port to an Input port. A dataflow transfer is thus controller by schedulig this node. Transfer nodes only appear in the Dictionary tab after a succesfull build.

The description of a transfer node is generated and contains the output and input port path.

7.3.5.3  TransferGroup node

In the OO API, a TransferGroup node represents a schedulable entry node that performs the transfers that are listed as its direct child nodes in the dictionary. The TransferGroup node thus allows the user to group a list of tranfers in a single schedulable entry point, reducing the amount of work to specify the scheduling of the individual transfer nodes.

The description is the only user definable attribute of a transfer group point.

7.3.6 Variable nodes

A variable node represents a variable in a source file. It is listed under the file where it is used and also under every entry point that uses it. It is part of the API of the model if its checkbox is checked. (See Section 7.3.4.2 above on API editing.)

The initial value and type of a variable are determined by parsing the source code.

Compound variables, such as arrays and structures, are shown as children of the variable node. Some attributes of the variable node can be edited at variable node level in the tree view of the Model Editor, while others must be edited at the variable base level (f.i. *min* and *max*). You can only edit attributes of variables when the API flag on the left of the variable is checked. Use the mouse or the **space** bar to change the state of the API check box on the current selection, which can contain multiple items.

A grey box around an attribute indicates that it is editable. Start editing by clicking in the box with the mouse or press the **F2** key to start editing the first editable attribute in the current selection. The **Tab** key moves to the next editable attribute in the current selection, while the **Enter** key finishes editing without moving to another attribute. The **Esc** key lets you leave edit mode without making any changes.

The user can specify:

- *parameter*: a variable set as a parameter may only be changed at initialization time by an initial condition.
- *unit*: the unit of the variable, e.g. *km*. It is for informational purposes only and written to the dictionary for use by other EuroSim tools, such as the API tab of the Simulation Controller.
- *min*: the minimum value of the variable.
- *max*: the maximum value of the variable.

The latter two (*min* and *max*) are checked at run-time when f.i. a user changes the value through the API tab of the Simulation Controller.

 If the API information in the file contains variables that are not available in the source code a red cross is drawn through the icon.

Note that the entry point and variable information is extracted from the file after the language specific pre-processor has processed the file. In particular, if compile flags determine which entry points are available the API may show conflicts when compile flags change.

In order to avoid problems with globals that only have a local ‘extern’ declaration in entry points, the `extern` keyword will be emitted by EuroSim when creating the data dictionary. In particular this means that for externals with function scope no API information can be generated.

7.3.6.1  State variable

For the classical APIs (C, Fortran) these nodes refer to variables which have filescope and are read and written by entry points in the file.

For Object Oriented APIs (C++) this is the default for member variables that are published to the dictionary.

7.3.6.2  Read Access variable

For the classical APIs (C,Fortran), these nodes refer to variables that are read by the entrypoints. When using the classical APIs (C, Fortran) the parser detects whether entrypoints read the variables and set the input state accordingly. The icon shows that the data is read by an entrypoint from the variable. At global (file) scope, the sum of all access is shown. A variable that is read in one entrypoint and written in another entrypoint thus shows up as read access variable in the first entrypoint, write access variable in the second entrypoint and combined read write access at filescope level.

7.3.6.3  Write Access variable

For the classical APIs (C,Fortran), these nodes refer to variables that are written by one or more entrypoints. When using the classical APIs (C, Fortran) the parser detects whether entrypoints read the variables and set the output state accordingly. The icon shows that the data is written by an entrypoint into the variable. At global (file) scope, the sum of all access is shown. A variable that is read in one entrypoint and written in another entrypoint thus shows up as read access variable in the first entrypoint, write access variable in the second entrypoint and combined read write access at filescope level.

7.3.6.4  Read/Write Access variable

For the classical APIs (C,Fortran), these nodes refer to variables that are read and written by entrypoints. When using the classical APIs (C, Fortran) the parser detects whether entrypoints read or write the variable and set the input, output or input/output state accordingly. The icon shows that the data is read and written by an entrypoint when occuring inside an entrypoint. At global (file) scope, the sum of all access is shown. A variable that is read in one entrypoint and written in another entrypoint thus shows up as read access variable in the first entrypoint, write access variable in the second entrypoint and combined read write access at filescope level.

7.3.6.5  Input variable

For the Object Oriented C++ API the developer sets the input state explicitly via an API call instead of access detection via Parsers. In the context of C++ objects the icon therefore has a different meaning then the access denotation of the classical API. Setting the input state of a variable denotes visually that this is a variable that the user may set. An example is a thermostat temperature setting. The default variable notation is then used for an internal variable that is relevant for a simulation developer, but not for a simulation user (simulation controller). This is a suggested usage for the C++ API, it has no further effect.

7.3.6.6  Output variable

For the Object Oriented C++ API the developer sets the output state explicitly via an API call instead of access detection via Parsers. In the context of C++ objects the icon therefore has a different meaning then the access denotation of the classical API. Setting the output state on a variable denotes visually that this is a monitor node, a variable that the user may want to monitor or record. An example is the temperature that is measured by a sensor. The default (State) variable notation is used for an internal variable that is relevant for a simulation developer, but not for a simulation user (simulation controller). This is a suggested usage for the C++ API, it has no further effect.

7.3.6.7  Input/output variable

For the Object Oriented C++ API the combined input/ouput variable node visualises that the developer considers this node to be both an input that the user may change via initial conditions or even during the simulation, as well as suggest to the user that this variable is suitable to monitoring or recorinding.

7.3.7  Object node

The object nodes are introduced in EuroSim Mk5 and appear only in the Dictionary Tab of the editor where they reflect an instance of a class. The entry nodes and variables that are children of the object node are to be viewed as methods and member variables of the instances.

Object nodes can have other object nodes as child nodes. This reflects an ownership relation, where the parent node created the child node. However, please beware that in the CPP API there is a lot of

flexibility in shaping the dictionary. The visual presentation may be constructed by the user even if when it is not actually present in any class definition.

7.3.8 Model node

7.3.9 Device node

7.3.10 Port node

The In- and Out ports are introduced with the C++ API in Mk5. The C++ API contains functions to create dataflows that connect outports to inports. The port nodes only appear in the Dictionary Tab of the ModelEditor.

7.3.10.1 Inport node

Inport nodes can have other object, entrypoint or variable nodes as children in teh tree. These child nodes reflect properties of the inport related to the value in the port that is filled by a dataflow, the possible scheduling of data transfer from the port variable to its associated instance variable, and error injection control variables. See the C++ API reference documentation for more information.

7.3.10.2 Outport node

Outport nodes can have other object, entrypoint or variable nodes as children in the dictionary tree. These child nodes reflect properties of the outport related to the value in the port that is extracted by a dataflow, the possible scheduling of data transfer from the instance variable to the port variable and error injection control variables. See the C++ API reference documentation for more information.

7.3.11 Channel node

7.3.12 Sequence node

7.4 API Selection

7.4.1 Selecting API Variables and Entrypoints

The File tab of the Model Editor provides the user the capability to parse model files using the EuroSim model parsers for C and Fortran. These parsers provide an easy method to identify to EuroSim which elements in the source code are relevant in the context of building and using the simulator and simulations. The parser analyzes the code and shows what could be included in the EuroSim dictionary. The EuroSim user selects from these available resources which are relevant. On Save EuroSim then writes this selection in a so called API header as comment at the top of original source file.

7.4.2 Selection within a sub-model

When selecting a variable for inclusion within the API header, a variable can sometimes appear twice, because the parser sees the variable being used not only at file level, but also at the level of the function that uses it. See for example `altdata$altitude` in Figure 7.2.

In principle, there is no difference between selecting one or the other: both variable nodes are different representations of the same variable and hence point to the same memory address. The default situation can be taken as tagging variables at the level of their file scope. However, there can be sometimes reasons for tagging the variables beneath 'their' entry point:

- if there are a lot of API variables within a particular sub-model (source code file), then selecting variables which appear below their relevant entry points gives you an additional level of hierarchy which can ease identification and manipulation of API variables later on

- if there is a significant amount of data dependency between entry points which needs to be taken into account during scheduling, then again, the variables beneath entry points should be selected, as this relationship is used when determining tasks which share data (see also Section 11.3.5, on intersection)

7.4.3 Selection from two or more sub-models

Where variables are used by two or more functions, they will appear in more than one sub-model. An example is the `altdata$altitude` variable seen in Figure 7.2, which also appears in the listing of variables for the `Initialise_Altitude` source file.

Again, there is no difference between selecting one or the other, as both representations point to the same memory address. The general guideline is to tag (and annotate) the variable belonging to the code which will be active during the executing scheduling state. In the example given above, this means that `altdata$altitude` would be tagged for the `Altitude` source rather than for its one-off use in the `Initialise_Altitude` source.

7.5 Menu items

7.5.1 File menu

New Creates a new empty model.

Open Opens a model.

Save Save the current model.

Save As If the model file is saved to a different directory, the file nodes are updated so that the newly saved model file shares its files with the original model file. If you want a copy of the model file with the relative pathnames of file nodes unchanged, thus possibly referring to non-existing files, use the UNIX `cp` or DOS copy command from the command line of a shell.

Exit Exit the Model Editor.

7.5.2 Edit menu

Undo/Redo
Undo/redo actions.

Cut/Copy
When cutting or copying an org node, the whole subtree, including the selected org node, will be copied for later pasting.

Paste Paste cut or copied data. Nodes are pasted into the currently selected node.

Delete Delete the current selection.

Edit Source
For file nodes, this option will start an editor with which the file attached to the node can be modified. For program source files by default the 'vi' editor will be started on UNIX platforms and NotePad on Windows platforms. If the environment variable `EDITOR` is set, that editor will be used. For environment file nodes, the environment editor (see Section 7.6) will be started.

View Source
For file nodes, this option will start (if applicable) an external program to view the contents of the file attached to the node.

Find Node

With the Find Node option, it is possible to search through the model hierarchy for a certain node. (see Figure 7.5).

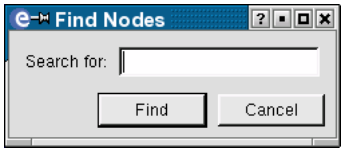


Figure 7.5: Search window

Rename Node

Rename the currently selected file or org node.

Properties

Shows the properties of a file node (see Figure 7.4) and allows specifying another file name for this file node.

7.5.3 View menu

Expand To Files

This menu option will show file nodes.

Expand All

This menu option will show all nodes of the tree. All source files will be parsed and entry points and variables will be shown.

Collapse All

This menu option will close all nodes of the tree.

7.5.4 Insert menu

New Org Node...

When an org-node is selected in the model hierarchy, this menu item can used to attach a new org node as a child to the selected node. The name and description of the new node can be entered.

New SMP2 Lib node...

When an org-node is select in the model When an org-node is selected in the model hierarchy, or when the root node is selected, this menu item can be used to attach a new SMP2 lib node as a child to the selected node. The name of the new node can be entered. This will be the name of the SMP2 library that is produced by the files that will be attached to the SMP2 lib node. Refer to Chapter 16 for more information.

New Source Node...

When an org-node is selected in the model hierarchy, or when the root node is selected, this menu item can be used create a new C, Fortran, Ada, C++, or Java source or header file node from the EuroSim template and insert it in the model hierarchy.

New Model Description Node...

When an org-node is selected in the model hierarchy, or when the root node is selected, this menu item can be used create a new Model Description file and insert it in the model hierarchy.

New Parameter Exchange Node...

When an org-node is selected in the model hierarchy, or when the root node is selected, this menu item can be used create a new Parameter Exchange file and insert it in the model hierarchy.

New Calibration Node...

When an org-node is selected in the model hierarchy, or when the root node is selected, this menu item can be used create a new Calibration file and insert it in the model hierarchy.

New Text Node...
When an org-node is selected in the model hierarchy, or when the root node is selected, this menu item can be used create a new flat text file and insert it in the model hierarchy.

New Document Node...
When an org-node is selected in the model hierarchy, or when the root node is selected, this menu item can be used create a new Document file and insert it in the model hierarchy.

New Environment Node...
hen an org-node is selected in the model hierarchy, or when the root node is selected, this menu item can be used create a new Environment file and insert it in the model hierarchy.

Add Directory...
When an org-node is selected in the model hierarchy, this menu item can be used to recursively add a complete directory tree to the selected node. The directory can be selected using a directory selector. Each directory found in the selected directory will be added as an org-node. The files that are found will be added as children to their respective parent node. This command automatically filters out the `CVS` and `.svn` directories, if any.

Add File Node...
When an org-node is selected in the model hierarchy, this menu item can be used to attach a new file node as a child to the selected node. The file can be selected using a file selector. The name of the node can be changed into a more descriptive name by clicking in the selected node name after the file node has been added to the node tree. When adding a non-existing file, a dialog box will pop-up asking whether to create a new file or not. Templates for new files can be found in the `lib/templates` sub-directory of the EuroSim installation directory.

Add SMP2 catalogue...
When an SMP2 lib node is selected, this menu option can be used to attach an SMP2 catalogue file to the SMP2 lib node. Refer to Chapter 16 for more information.

Add SMP2 package...
When an SMP2 lib node is selected and no SMP2 package file has yet been attached to it, this menu option allows to attach an SMP2 package file to the SMP2 lib node. The SMP2 package file is required to have the same name as the SMP2 lib node, which is the name of the library that is the target of the SMP2 lib node. Refer to Chapter 16 for more information.

Add Generated C++ Code
If an SMP2 package file node is selected or if an SMP2 lib node is selected and a package file node is present in the SMP2 lib node, this menu option allows the user to attach a tree of files and folders that has been generated from the package and is present on the file system. The files and folders making up the tree of generated code will be attached to the SMP2 lib node in a hierarchy. Refer to Chapter 16 for more information.

7.5.5 API menu

Parse File(s)
Parse the selected file(s) to discover it's API and/or find items that can be added to the API of the sub-model.

Save API
Writes the API information to the sub-model source file.

Clear API
Removes the API information from the sub-model source file.

Include Add variable or entry point to the API.

Exclude
Remove a variable or entry point from the API

Exclude all undefined...
Remove all variables and/or entry points that are still in the API but no longer available in the sub-model source code.

Clear Min
Clears the minimum value(s) of a variable node.

Clear Max
Clears the maximum value(s) of a variable node.

7.5.6 Tools menu

Build All
Build the simulator and data dictionary.

Build Clean
This menu option will remove all generated files from the model directory. This includes the data dictionary, and compiler generated object files. Use this option to force a rebuild of the model. This option is generally used when a new version of EuroSim has been installed, when the filesystem has had integrity problems, or when EuroSim does not behave as expected.

One specific case where a clean up is required is when you add a new file to the model hierarchy (e.g. a C source file) which is older than the already existing target file (e.g. add a file `file.c` whilst there still is a newer `file.o`). The `make` which is used to build the simulator will then not know that the target should be recreated. The same applies when deleting a file node from the model tree.

Set Build Options...
When in source files external functions are used (such as arithmetic or string functions), the libraries containing these functions can be specified in the options dialog shown by this menu option (see Figure 7.6).

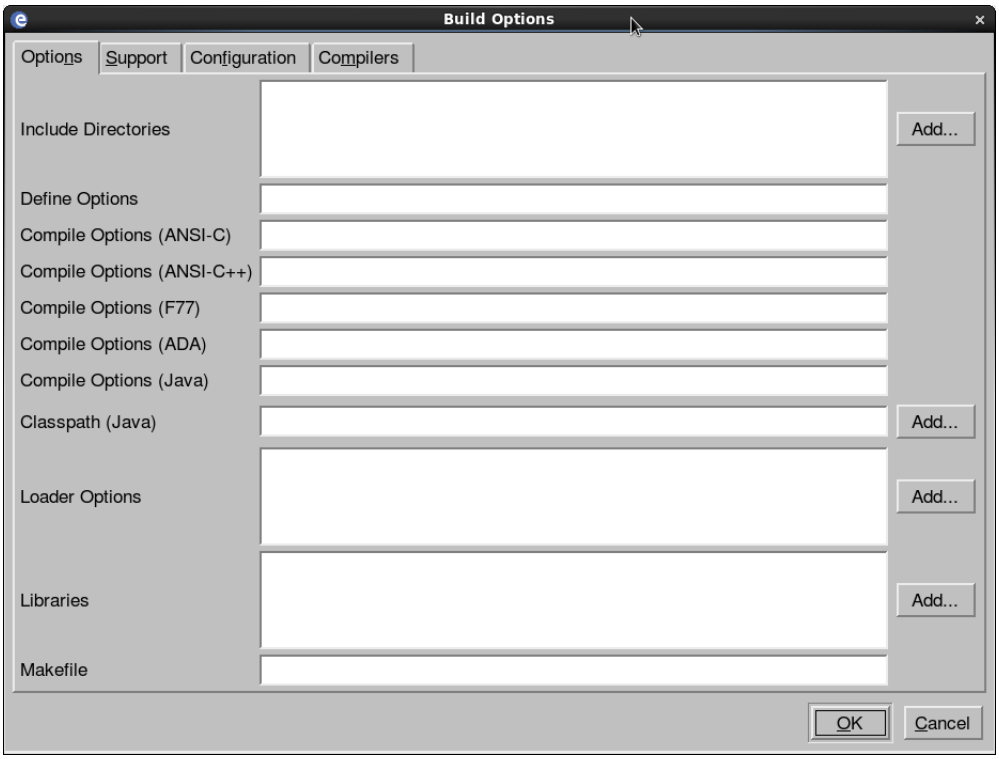


Figure 7.6: Model Build Options dialog: Options tab page

Also, specific compiler options can be specified, including directories where the compilers should look for include files. In the libraries field, libraries which need to be linked to the

simulator should specified in the form `-l`*libraryname*. One of the more often used libraries is ‘m’, the math library.

The Makefile field allows you to define the Makefile that is executed by the ModelEditor when you push the Build All and Cleanup buttons. This option is for instance usefull if you have to assure that libraries are rebuild before the EuroSim build links them to the simulator. When nothing is specified in the Makefile field, the ModelEditor will issue the command `gmake -f <modelname>.make -C <project directory> <target>` where ¡target¿ is either ’all’ or ’clean’ based on the button you pressed. The name of the file specified in the Makefile field will replace the `<modelname>.make` part in this command. Your user defined Makefile should accept the all and clean targets, and execute the original EuroSim make command at the appropriate time.

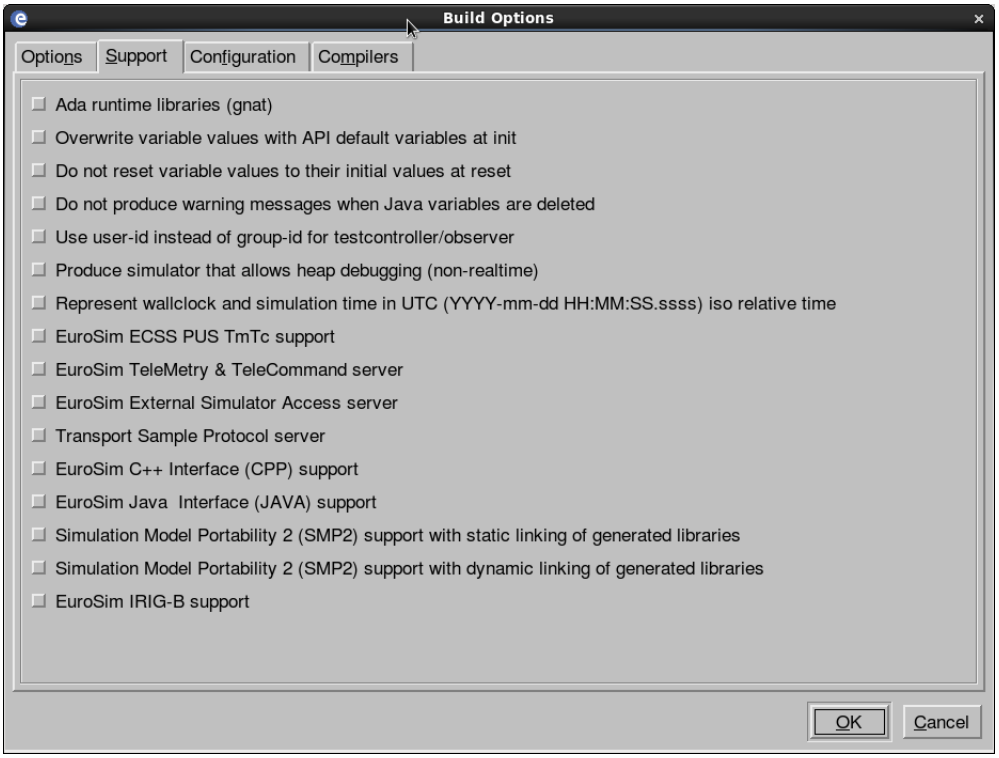


Figure 7.7: Model Build Options dialog: Support tab page

Figure 7.7 shows the available pre-defined build support options for the simulator. Selecting one or more of these options causes libraries such as ‘external simulator’ or ‘telemetry and telecommand’ to be linked in, augmenting the simulator with extra runtime functions. Usage of Ada-95 n runtime libraries requires explicit selection of the appropriate options. Options are described in the EuroSim.capabilities manual page, and can be listed using the `esimcapability` command.

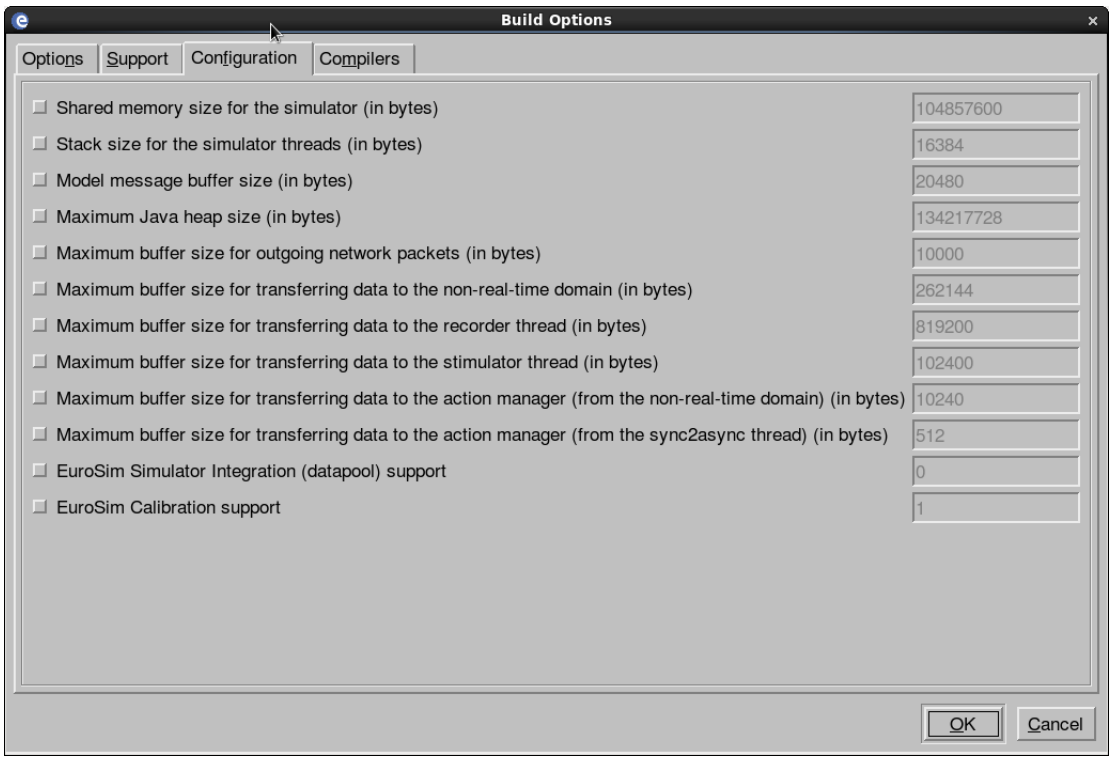


Figure 7.8: Model Build Options dialog: Configuration tab page

Figure 7.8 shows the available configuration options for the simulator. Selecting one of the options allows you to change the default value. It is possible that during run-time you exceed one of the buffer sizes or need more heap or stack memory. In that case change the appropriate size so that the simulator runs without exceeding the sizes.

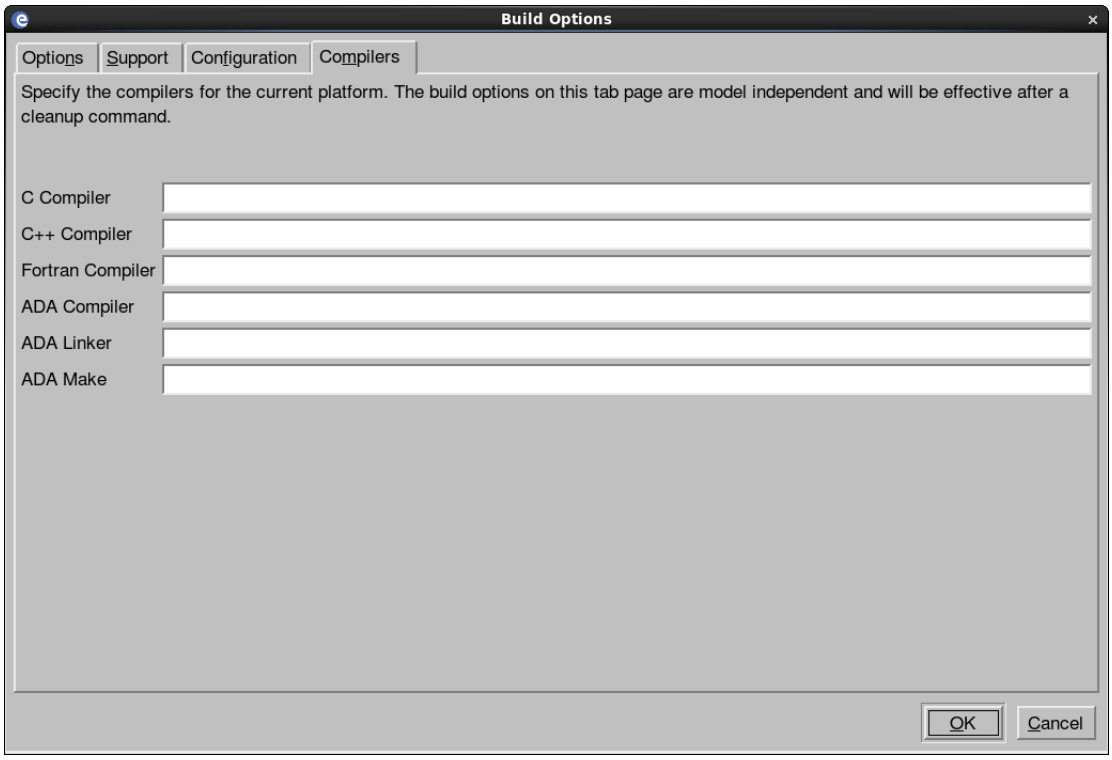


Figure 7.9: Model Build Options dialog: Compilers tab page

The Compilers tab page (see Figure 7.9) allows you to specify which *compiler(s)* and related

utilities to use to build the simulator. When specifying a command, the default used by the build command will be overruled. Leaving a field blank in the dialog will cause the build command to use the default command.

You can specify just the command (provided its directory can be found in the PATH environment variable) or the full path, for example:

```
/usr/bin/gcc
```

You can also specify additional command line options for a specific command, for example:

```
g77 --no-second-underscore
```

The commands specified on this tab page dialog are not stored in the model file, but in a global resource[1]. Therefore, the command specifications are model independent. The specifications are read by the ModelMake utility when generating the makefile that is used to build the simulator executable. They are effective after the *Tools:Cleanup* command.

Clear Logging
Clears the logging window at the bottom of the Model Editor.

Save Logging
Opens a file dialog where you can select or specify the name of the file to save the contents of the logging window.

Preferences
Shows a dialog where you can specify Model Editor specific preferences and preferences related to version control. Examples are as always saving API information to files and saving the changes to the .model file or automatically clearing the logging window, before starting a build. Note that the system wide preferences can be found in the `$EFOROOT/etc/esim_conf` file. See Section 7.7

7.5.7 Tools:SMP2 Tools menu

Install SMP2 Library
If an SMP2 lib node is selected, this menu options builds a library for the files attached to the SMP2 lib node and installs it in the directory where EuroSim will install its executable simulator. The SMP2 lib node must contain an org node with the same name as the SMP2 lib node and an SMP2 package lib node with the same name. The org node contains the generated C++ code and it must contain a Makefile.

It is not required to use this menu option, as the SMP2 Library will also be build when selecting the *Build All* command. It may however be useful to build an SMP2 library in isolation of the rest of the model tree if the model tree is not yet completely finished and the user is editing the generated C++ code of the SMP2 library. Moreover, if a change is made in the generated C++ code for the SMP2 library, the user must apply this function to install an updated version of the library. Refer to Chapter 16 for more information.

Cleanup SMP2 Library
Under the conditions described above, this menu options removes all generated binary files from the directory containing the generated C++ code. If a library was installed, it is removed as well. Use this option to force a rebuild of the model, e.g. when the source code of the library has been modified, when a new version of EuroSim has been installed, when the filesystem has had integrity problems, or when EuroSim does not behave as expected. Refer to Chapter 16 for more information.

[1] Located in the `.eurosim` sub-dicrectory of your home directory (Unix systems) or in the registry (Windows systems)

Validate SMP2 Artefact

If an SMP2 file node is selected (catalogue, Assembly or package), this menu option validates the SMP2 artefact and reports the result. Refer to Chapter 16 for more information.

Generate Default package

If an SMP2 catalogue file node is selected that has the same name as the SMP2 lib node that it is attached to, or if an SMP2 lib node is selected that has a catalogue attached to it with the same name, this menu option generates an SMP2 package and attaches it to the SMP2 lib node. The SMP2 package contains an implementation for all types in the catalogue that need an implementation. Refer to Chapter 16 for more information.

Generate C++ Code

If an SMP2 package file node is selected, or an SMP2 lib node with a package attached to it, this menu options allows the user to generate C++ code from the package. The generated code is a hierarchy of files that is attached to the SMP2 lib node inside an org node with the same name as the SMP2 lib node. If generated C++ code was already attached, this menu options generates the code and integrates any existing implementation by the user in the new version of the code. Refer to Chapter 16 for more information.

Generate Makefile Template

If an SMP2 package file node is selected, or an SMP2 lib node with a package attached to it, and a Makefile is not yet present on the file system in the directory associated with the SMP2 library, generate a Makefile template that can be completed by the user to contain the correct installation command for an imported SMP2 library. The ”install” target of the Makefile should install the shared object that is the result of SMP2 library building in the central installation directory of the EuroSim simulator. The ”clean” target of the Makefile should remove an installed shared library. Refer to Chapter 16 for more information.

7.6 Environment editor and viewer

The environment editor is started by selecting the environment node in the model tree and selecting the *Node:Edit Source* menu option. The viewer is started using the menu option *Node:View Source* when the environment node is selected.

7.6.1 The environment viewer

The environment contains information on the target hardware required for the simulator being developed. The environment viewer (see Figure 7.10) shows at the right the current environment, and at the left the target environment, as it is stored in the environment file. If there are any differences between the two, these are indicated with unequal signs (<>).

If a field from the environment is too long to fit in the text area, the middle mouse button can be used to scroll the text area to reveal the remainder of the field.

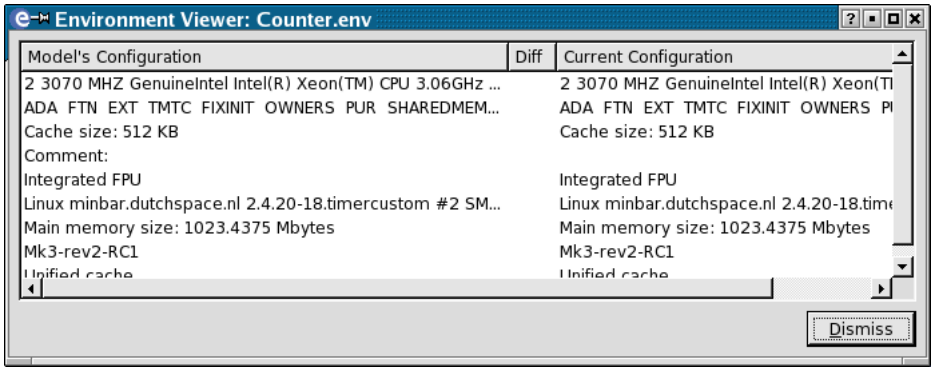


Figure 7.10: The environment viewer

7.6.2 The environment editor

The environment editor allows the user to retrieve the current environment and save it to the environment description file, as well as adding a comment to the environment file. Use the button *Get Current Environment* in the Environment Editor to retrieve the current environment.
To put the file under configuration control use the same procedure as for source code files.

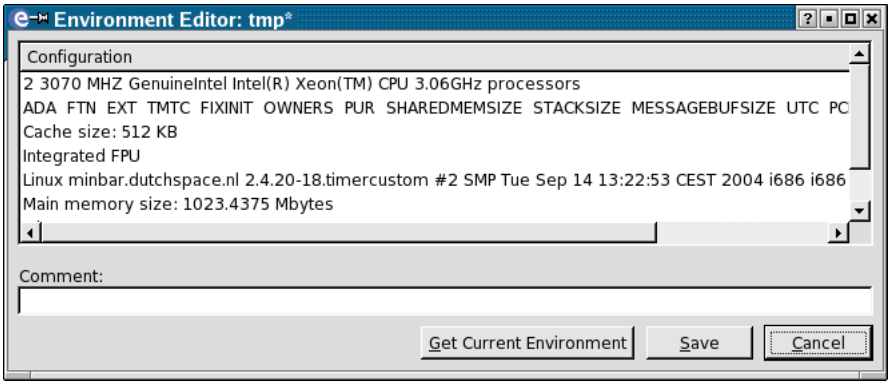


Figure 7.11: The environment editor

7.7 Configuring File Associations

The Model Editor allows the user to define which editor to start when double clicking a file in the File tab, or selecting Edit or View source from the context menu after a right click. These file associations are configured in the file esim_conf that can be found in the etc directory of the EuroSim installation tree. The file shows that by default the editor that is named in the EDITOR environment variable is started. If that is empty the ModelEditor defaults to vi for Linux and notepad for Windows.

The easiest approach to configure a different editor is to set the EDITOR environment variable to your favorite editor. For instance on Linux gedit is a good candidate and for Windows we advise notepad++. You should then also assure that the path up to the directory that the executable is located at is in your PATH variable. You may need your system administrator to handle this.

The alternative approach to configuring different editors is to modify esim_conf. Note that changing this file in the ets directory of the EuroSim installation will affect all EuroSim users. To make personal customizations, one can overrule any setting with an `esim_conf` file in your home directory.

The esim_conf file currently does not accept spaces in path names, thus assure that the PATH variable for the system is amended with the directory where your editor is stored rather than writing out the complete path.

Chapter 8

Model Description Editor reference

This chapter provides details on the Model Description Editor (MDE). The menu items that are specific to the MDE will be described in separate subsections of this chapter. For menu items not described in this chapter, refer to Section 5.6.

8.1 Introduction

The use of the MDE is optional, but Model Description files are typically used when integrating models into one simulator without wanting to do the integration explicitly in (model) source code. Use Model Description files in combination with Parameter Exchange files (see Chapter 9) to exchange data between models. The combination of Model Description files and Parameter Exchange files serve as input to functions of the Simulator Integration Support library, which is described in detail in Chapter 18.

The MDE can be used to create one or more Model Description files that describe copies of API variables[1] that exist under a special node called "datapool" in the data dictionary. The data dictionary itself is built by the build process (make) that can be started from the EuroSim Model Editor, see Section 7.5.6.

The copies of the variables can have names that are different from the ones in the data dictionary. This is especially useful when the data dictionary contains API variables with ambiguous names (f.i. when the source code of the model is generated by a software generation tool) or when you address an index in an array variable and wish to give it a more descriptive name, for example:

```
model description      data dictionary

sun/update/input/X     sun.c/vector[0]
sun/update/input/Y     sun.c/vector[1]
sun/update/input/Z     sun.c/vector[2]
```

The MDE also supports creation of user defined variables in the datapool. User defined variables are variables that do not have a relation with a model API variable. Typical use of user defined datapool variables is with EuroSim External Simulator Access, see Chapter 30. The user defined variables in the datapool are f.i. updated by an external client.
All variables created by the MDE (i.e. the copies of the API variables) will be added to a special node in the data dictionary, the so called "datapool". In order to update these variables in the datapool, special entry points are automatically generated. These entry points contain the source code to copy the values of the variables of the model to the copies in the datapool (in case of output variables) or vice versa (in case of input variables). The datapool and the generated entry points are merged into the data dictionary during the last step of the build process so that the datapool variables and entry points are available to the EuroSim simulator.

The automatically generated entry points must be called by the scheduler at the appropriate time steps, see Figure 8.1 for a very simple example of a datapool and model source code. At step 1 the automatically

[1] An API variable is a model variable that is marked in the Model Editor to be exported to the data dictionary.

generated entry point takes care of copying the value of the X variable in the datapool to the X variable of the model code. Step 2 calls the actual entry point in the model to update the X variable. At last, step 3 copies the updated model variable X back to the datapool. This last step is also performed by automatically generated code. Use the Schedule Editor to specify when the generated entry points should be called. The generated entry points are also placed under the datapool node in the data dictionary. The names of the entry points are based on the names of the input and output group nodes.

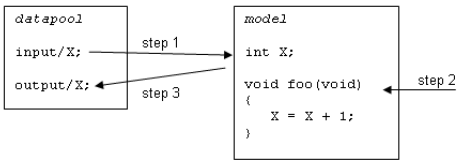


Figure 8.1: Example of data transfer between datapool and model

The Model Description Editor leaves it up to the user to decide at what constitutes a model and whether step1 and step3 apply to a single or multiple entrypoints of the model. For instance if the above example would have had two entrypoints foo1 and foo2, the datapool could contain `foo1/input/x`, `foo1/output/x` and `foo2/input/x`, and `foo2/output/x`. The entrypoint is then viewed as a submodel by itself and it state must be stored in the datapool. The user would schedule the step1 and step3 around the execution of foo1, and a similar step4 and step6 around foo2. Conceptually the communication between foo1 and foo2 if needed would pass through the datapool. This gives great flexibility and power in terms of timing, but can often be overcomplicating and surpassing the users goal.

Alternatively the user can prefer to see the datapool reflecting the model. `model/input/x`, `model/output/x` are the counterparts in the datapool of the model variable x. Step1 and step3 transfer data from the datapool into the model and vice versa, but they don't have the specific relation to the entrypoints foo1 and foo2. If in this approach there would be multiple variables, say x1 and x2, where x1 is only used by foo1 and x2 is only used by foo2, the step1 and step2 would have to transfer both x1 and x2. There is thus a trade-off between conceptual ease of use against performance and timing requirements.

8.2 Starting the Model Description Editor

The Model Description Editor (MDE) can be started from the Model Editor. When the model tree contains a file with the appropriate extension (see Appendix A), then the MDE is automatically started when the Edit command is selected on the model description file node in the Model Editor.

The MDE needs a data dictionary as input. When the MDE is started from the Model Editor, the Model Editor first runs the build process (make) in order to ensure that the data dictionary is up to date. This means that there may be some delay when starting the MDE if there are a lot of outstanding changes since the last build command was given.

It is possible to start the acroMDE directly from the Project Manager GUI or from the commandline (type ModelDescriptionEditor). An empty acroMDE will appear as shown in Figure 8.2.

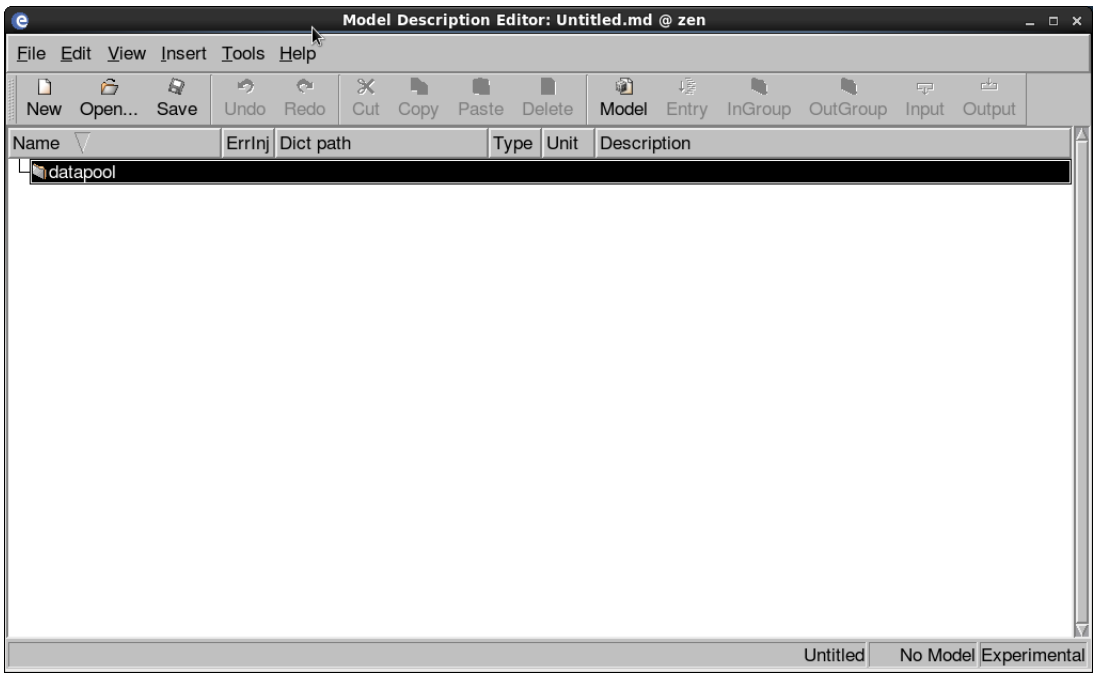


Figure 8.2: Model Description Editor

In this case, when the user opens a model description file, the editor requires a reference to the model file that it belongs to. If not set via the Select Model item from the File menu, the model description editor will ask the user via a model selection dialog.

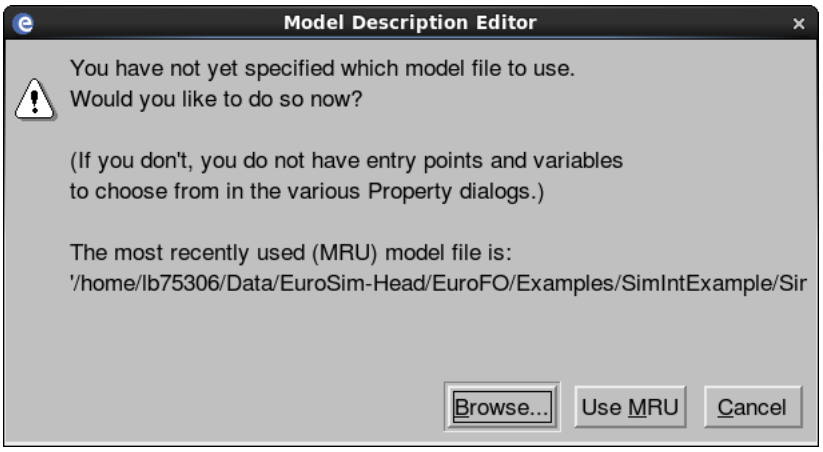


Figure 8.3: Model Description Editor model selection dialog

The Most Recently Used (MRU) model is a convenience feature that works well after once a selection has been made.

8.3 Views in the Model Description Editor

The Model Description Editor features a single view in which the user constructs a leave of the datapool tree in the dictionary. The main functions that operate on the view are included in the Insert menu and are also conveniently available via the tool bar buttons and context sensitive menus that appear on a right click on tree nodes.
The Model Description Editor tree view starts with an empty tree with root node ”datapool”. Below this root node the use can add models. A model description file can cover a single model or multiple models. This is entirely up to the user’s preference. The advantage of multiple files is that it is easier to re-use over

different model files in different combinations. An example could be that the onboard software is first executed as a model in EuroSim and removed at a later stage when the onboard computer is connected as HIL In this case a split in two model description files could be usefull. It could also be argumented that every model should have its own model description file to allow each different model developer to maintain his own model description file. The choice is related to the needed flexibility in the project, weighed against the higher complexity of multiple files.

Below the model node the user has the choice of creating an Input- or Output group, or an Entrypoint. This relates to the view of the user whether input- and output date transfer is to be conducted at the model level or at the level of the entrypoints within that model.

Underneath the groups the variables can be selected for input or output. Whether a variable is input or output in the datapool is determined in solely at this point. The input- and output group division is required to deconflict variables that are both input- and output.

8.4 Objects in the Model Description Editor

In the Model Description Editor tree view the model description is created using a hierarchical tree structure. Elements in the tree are called *nodes* and have a specific function.
In Figure 8.4 an example model description tree is shown.

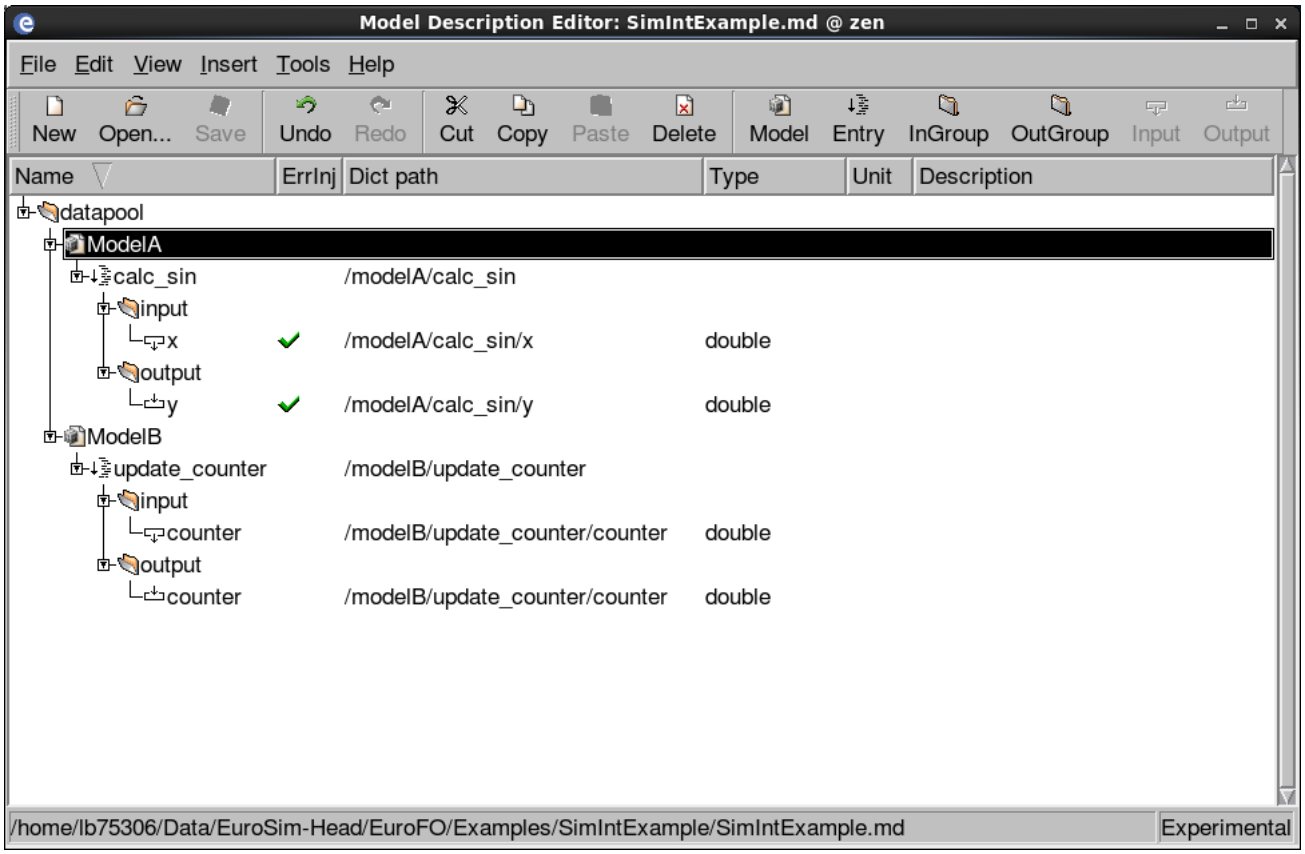


Figure 8.4: Example model description tree

8.4.1 Root node

Each model description has one root node. It represents the complete model description and it has the base name of the model description file. The root node can hold one or more Model nodes.

8.4.2 Model node

Model nodes are used to structure the model description and will usually (but not necessarily) refer to the model(s) as specified in the Model Editor. Model nodes are children of the root node and can hold one or more entry point nodes.

8.4.3 Entry point node

Entry point nodes are also used to structure the model description and refer to an entry point in the model code. Entry point nodes are children of a model node and can hold inputs and outputs group nodes.
When you create a new entry point node, you are presented with a dialog box to select an entry point from the data dictionary.

8.4.4 Inputs and Outputs group nodes

Inputs and Outputs group nodes are used to logically group the input and output variables of an entry point. Inputs and outputs group nodes are children of an entry point node. An inputs group node can hold input nodes and an outputs group node can hold output nodes.

8.4.5 Input and output nodes

Input and output nodes refer to API variables of the model code (i.e. variables in the data dictionary) or they are user defined (i.e. the node holds an ANSI-C variable declaration). Input and output nodes cannot have children, i.e. they are the leaves of the model description tree.

When you create a new input or output node, you are presented with a dialog box to select the API variable from the data dictionary or enter an ANSI-C variable declaration when defining a user defined variable. In the latter case, the name of the node is derived from the entered variable name.

8.5 Menu items

Note that most common commands are also available in context sensitive menus that pop-up when clicking the right mouse button. Some commands also have keyboard short-cuts and are available via the tool bar.

8.5.1 File menu

Select model

Select the model file that will be used to get the data dictionary. The model file (and hence the data dictionary) defines which entry points and variables you can choose from in the dialogs when adding and entry point node or a variable node.

8.5.2 Edit menu

Toggle Error Injection

Toggle the error injection flag for the selected inpt and output nodes, see Chapter 19.

Properties

This pops up the the properties dialog box, see Figure 8.5, which is used to edit the properties of entry point, input and output nodes. Depending on the type of the node, some of the elements in the dialog box are shown.

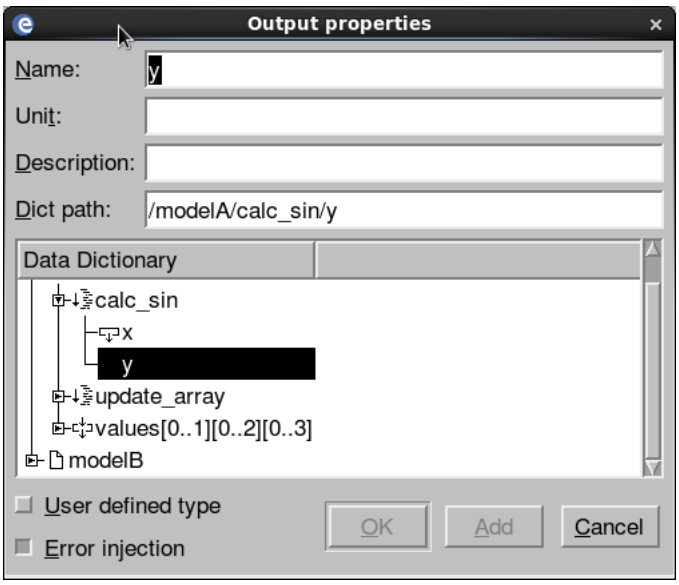


Figure 8.5: Properties Dialog Box

The Name field contains the name of the entry point or variable. In case of a variable node, the fields Unit and Description are shown. The Unit defines the physical unit of the variable. The Description is the textual description of the variable. The Data Dictionary field allows you to select the Dict path of an entry point or variable. In case of a variable to check boxes are available for User defined type and Error injection. If you check the User defined type box, the Dict path field is changed to User defined variable declaration. That declaration must be a valid variable declaration in C syntax. The type can be any basic C type or array. If you check the error injection box the error injection function is enabled for that variable.

8.5.3 Insert menu

Model Node

Add a model node to the root node, see Section 8.4.2.

Entry Point Node

Add an entry point node to a model node, see Section 8.4.3.

Inputs Group Node

Add an inputs group node to an entry point node, see Section 8.4.4.

Input Node

Add an input node to an inputs group node, see Section 8.4.5.

Outputs Group Node

Add an outputs group node to an entry point node, see Section 8.4.4.

Output Node

Add an output node to an outputs group node, see Section 8.4.5

8.5.4 Tools menu

Check Model Description for errors

Checks the model description for any errors. The model description is also automatically checked on each save to disk. This feature can be disabled through the Tools:Preferences menu.

Chapter 9

Parameter Exchange Editor reference

This chapter provides details on the Parameter Exchange Editor (PXE). The menu items that are specific to the PXE will be described in separate subsections. For menu items not described in this chapter, refer to Section 5.6.

9.1 Introduction

The use of the PXE is optional, but Parameter Exchange files are typically used when integrating several independent models into one simulator without wanting to do the integration explicitly in (model) source code. Use Parameter Exchange files in combination with Model Description files (see Chapter 8) to exchange data between models. The combination of Model Description files and Parameter Exchange files serve as input to functions of the Simulator Integration Support library, which is described in detail in Chapter 18.

The PXE can be used to create one or more Parameter Exchange files that describe which output variables in the datapool should be copied to which input variables in the datapool (see Section 8.1 for a brief description on how to create the datapool using the EuroSim Model Description Editor). Optionally a calibration cureve can be applied during the actual exchange of the parameter from one model to the other. This is limited to variables of type double. Calibration curves can be constructed using the Calibration Editor (see Chapter 10).

The actual copy of the variables is performed by automatically generated entry points. These entry points are placed in a special node of the data dictionary, called “paramexchg”. The entry points have the same name as the exchange group. Exchange groups are described later on in this chapter. There is no need to re-build the data dictionary in the EuroSim Model Editor, since the entry points are generated at run-time by reading the appropriate Parameter Exchange files. Either include the Parameter Exchange files in the model tree or load them via the *File* menu in the EuroSim Schedule Editor to make the Parameter Exchange entrypoints avialable for scheduling. See Section 11.3.1.

A simple example of scheduling an exchange group entry point is given in Figure 9.1.

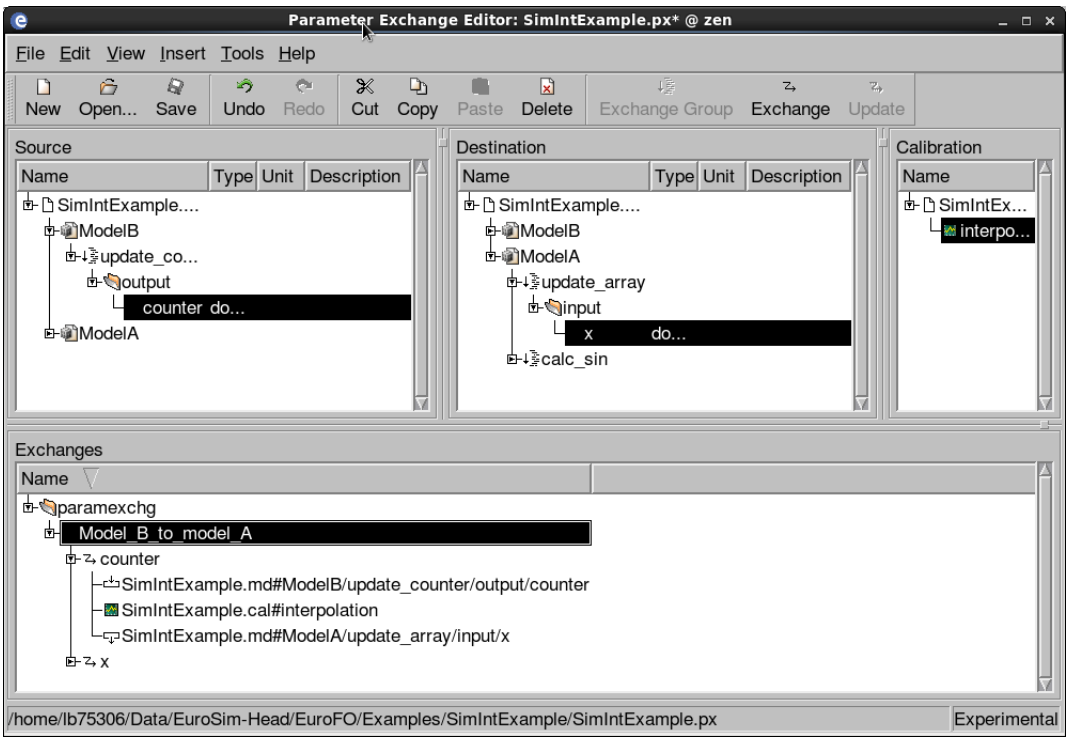


Figure 9.1: Example of data transfer between models

After model A has been updated and its output variable in the datapool is set (see Scheduling datapool updates in Section 8.1), the parameter exchange can take place between model A and model B. This also shows that scheduling the exchange has to be done at the appropriate point in time, i.e. *after* all models have updated their output variables and *before* the (other) models need the updated data on their respective input variables.

9.2 Starting the Parameter Exchange Editor

The Parameter Exchange Editor (PXE) can be used from within the ModelEditor in the same manner as the Model Description Editor. This is the most convenient way as when started from the Model Editor, the (PXE) is provided with all the Model Description files that are in the Model Editor file tree and the latest data dictionary. This prevents the need to select the model and model description files via the File menu items of the (PXE).

In Figure 9.2 an example parameter exchange tree is shown in the bottom view.

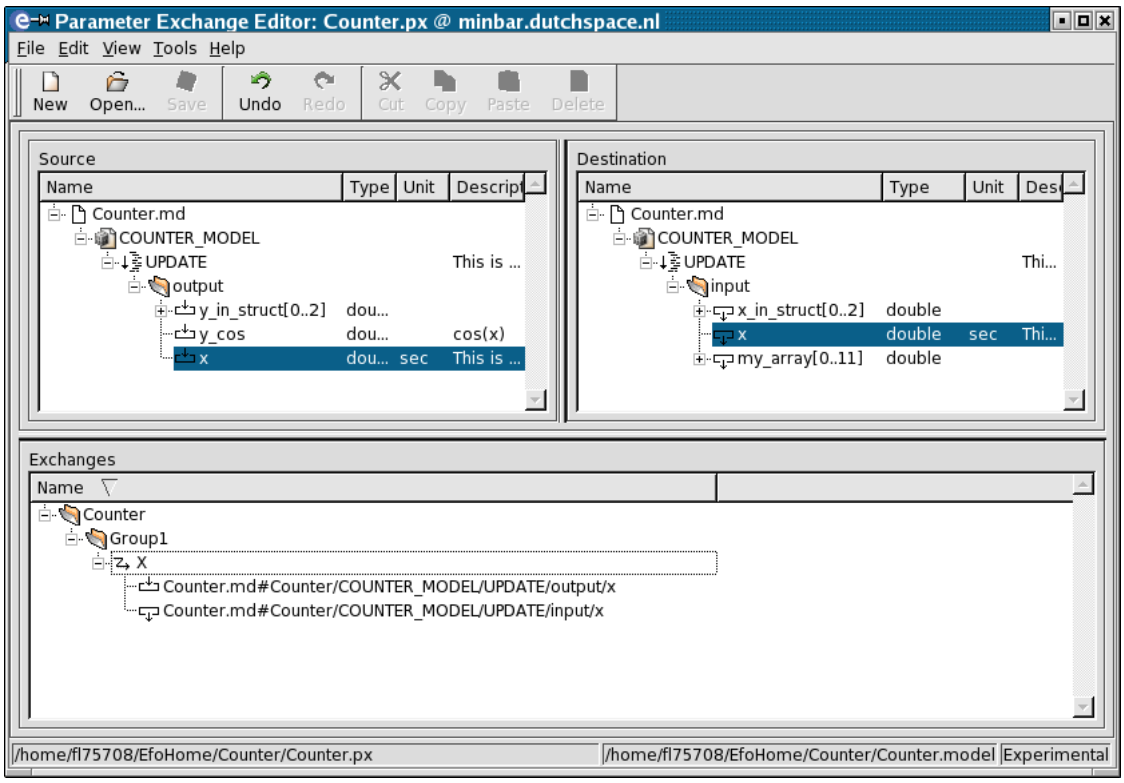


Figure 9.2: Example parameter exchange tree

Alternatively, the (PXE) can be started by selecting the **Parameter Exchange Editor** button in the EuroSim start-up window (see Figure 6.1) or by typing ParameterExchangeEditor on the command line. In these case the user must select the model and add the Model Description files via the File menu items.

9.3 Views in the Parameter Exchange Editor

The Model Description Editor features a single view in which the user constructs a leave of the datapool tree in the dictionary. The main functions that operate on the view are included in the Insert menu and are also conveniently available via the tool bar buttons and context sensitive menus that appear on a right click on tree nodes.
The Parameter Exchange Editor features four views from which items are selected as input to the Parameter Exchange definition. The main functions to create such definitions are located in the Insert menu, which items are also available via the tool bar and context sensitve menus.

9.3.1 Source view

The Source pane in the PXE shows all the Model Description files that are loaded in the PXE. From these files the Source pane shows only the output variables as the parameter exchanges flow from an output variable in the datapool to an input input variable in the datapool.

9.3.2 Destination view

The Destination pane in the PXE shows all the Model Description files that are loaded in the PXE. From these files the Destination pane shows only the input variables as the parameter exchanges flow from an output variable in the datapool to an input input variable in the datapool.

9.3.3 Calibration view

The Calibration pane shows all the Calibration files that have been loaded and the Calibratiaon Curves that they contain. Calibrations can only be applied for variables of type double. At runtime the calibration is then applied when the parameter is tranfered from output to input in the datapool

9.3.4 Exchange view

The Exchanges pane shows the defined Parameter Exchange Groups and the Parameter Exchanges they contain. An Exchange Group is an entrypoint that can be scheduled in the Schedule Editor. WHen activated the Exchange Group entrypoint performs the transfers that it contains.

The root node of the Exchange group is named paramexchg, this is also the node where the parameter exchange group entrypoints can be found in the data dictionary as is visible in scheduling and simulation definition.

9.4 Objects in the Parameter Exchange Editor

The Source, Destination and Calibration panes are read-only and show the contents defined in the Model Description Editor and Calibration editor. For more information on the contained nodes, see Chapter 8 and Chapter 10. This section focusses on the Parameter Echange specific nodes that are constructed with the Parameter Exchange Editor as shown in Figure 9.3.

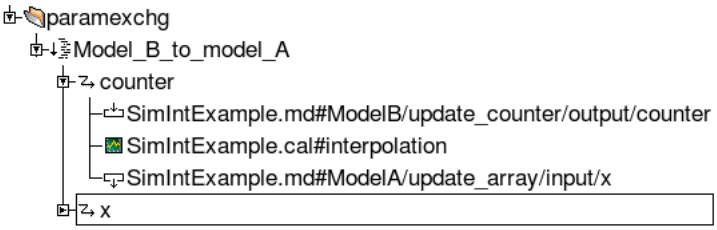


Figure 9.3: Example of parameter exchange definition

9.4.1 Exchange group node

An exchange group is used to organize a logical group of exchanges for which the exchange (copy) of variables can be scheduled as one step. For each exchange group an entry point will be generated with the same name as the exchange group under the “paramexchg” node in the data dictionary. An exchange group node contains the actual exchange parameters.

9.4.2 Exchange parameter node

An exchange parameter specifies which output variable from the datapool - as specified by a Model Description file - should be copied to which input variable in the datapool. Optionally with performing a calibration during the copy.

The value of the output variable is copied to the specified input variable by an automatically generated entry point that has the name of the parent exchange group node. You must specify when to schedule this entry point using the EuroSim Schedule Editor.

An exchange parameter is a child of an exchange group node and it cannot have children, i.e. it is the leaf of the parameter exchange tree.

9.5 Menu items

Note that most common commands are also available in context sensitive menus that pop-up when clicking the right mouse button. Some commands also have keyboard short-cuts and are avialable via the tool bar.

9.5.1 File menu

Add Model Description
: Add a Model Description file to the source and destination views. This is only required when the PXE is started from outside the Model Editor.

Add Calibration File
: Add a Calibration file to the Calibration view to allow Parameter Exchange definitions to include calibrations.

Select model
: Select the model file that will be used to get the data dictionary. The data dictionary is used to check if a parameter exchange is valid, i.e. it checks the type and size of the source and destination variable. This is only required when the PXE is started from outside the Model Editor.

9.5.2 Edit menu

Exchange Update
: Update an exchange parameter with currently selected input and output variables in the destination, source and optionally calibration views, respectively.

9.5.3 Insert menu

Add Exchange Group
: Add a Parameter Exchange Group node to the root node in the Exchanges pane. This is the same as the tool bar button Exchange Group. The item is only enabled when the root node in the Exhanges pane is selected. The result of the action is an exchange group entrypoint that can be scheduled in the schedule editor.

Add Exchange Parameter
: Add an exchange parameter to an exchange group node, see Section 9.4.2. You will be prompted with a dialog box to enter a name (a sensible default is provided). The name is purely informational. In order to add an exchange parameter you must first select an output variable in the source view and an input variable in the destination view. Then select the appropriate exchange group and select the *Add Exchange Parameter* command in the Edit menu. If a calibration is to be applied on the exchange to convert the parameter from raw to engineering and vice versa, a calibration should be selected as well in the Calibration view

9.5.4 Tools menu

Check Parameter Exchange for errors
: Checks the parameter exchange for any errors. The parameter exchange is also automatically checked on each save to disk. This feature can be disabled through the Tools:Preferences menu.

Check Coverage
: Check if all output and input variables are covered by exchanges.

Chapter 10

Calibration Editor reference

This chapter provides details on the Calibration Editor (CE). The menu items that are specific to the CE will be described in separate subsections. For menu items not described in this chapter, refer to Section 5.6.

10.1 Introduction

The use of the CE is optional, but you would typically use Calibration files when you need to interface with external hardware such as electrical front-ends.

Calibration files serve as input to functions of the Calibration library. There are two methods in which Calibrations can be applied. First, the calibration library provides an Application Programmers Interface which allows the user to calibrate values based on a calibration curve that is defined using the Calibration Editor. The calibation library is described in detail in Chapter 20.

Second, the calibrations can be automatically applied on a parameter exchange defined with the ParameterExchange editor. In this case the calibration occurs automatically after copying of the value from the source and before writing it to the destination of the exchange. In this case there is no need for performing the calibrations in the code, but the calibration file should be included in the ModelEditor.

The CE can be used to create one or more Calibration files that describe the transformation from engineering values to raw values and vice versa.

There are three types of calibration:

- polynomial equation
- interpolation
- lookup table

The polynomial equation is a continuous function of the format

$$y = ax^4 + bx^3 + cx^2 + dx + e \tag{10.1}$$

The constants a,b,c,d,e are coefficients which, when correctly chosen, approximate any correlation function closely enough for the intended purpose.

The interpolation method uses point pairs to create a continuous function by performing a linear interpolation between these points.

The lookup table method creates a discrete correlation function using a lookup table to convert the input to the output value. If the input value is not present in the lookup table, an error condition is raised. (Thus similar to point pairs, but without linear interpolation).

Figure 10.1 shows the different calibration types in a plot:

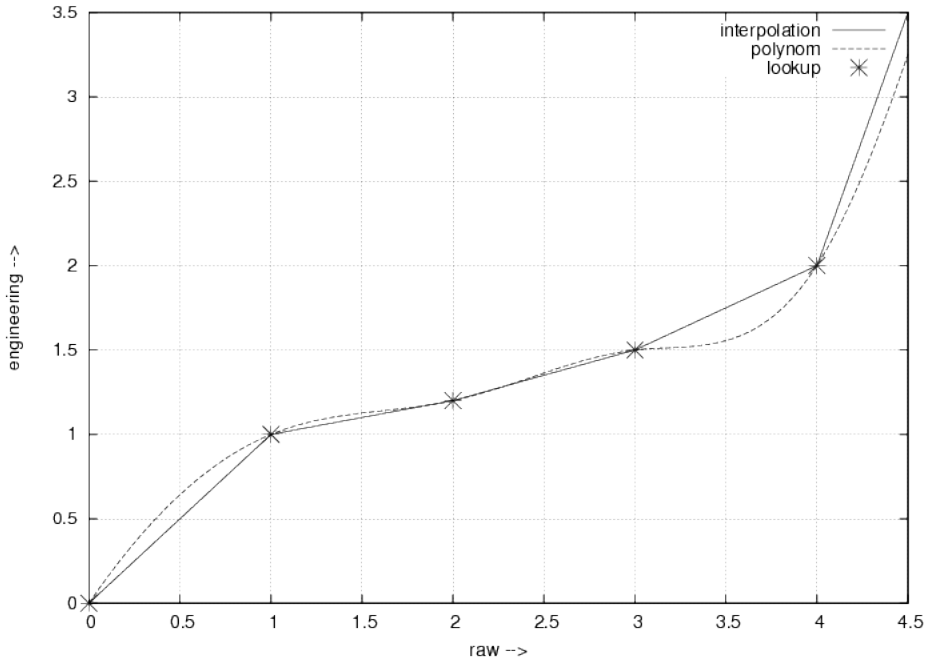


Figure 10.1: Calibration types

The following restrictions are applicable to data elements in each curve:

- No duplicate In/Power/Index values
- The lookup table must contain at least one entry
- The polynom must have at least one coefficient
- The interpolation must have at least two point pairs

10.2 Starting the Calibration Editor

The Calibration Editor (CE) can be started either from the Model Editor, or by selecting the **Calibration Editor** button in the EuroSim start-up window (see Figure 6.1 as it may require enabling this button to become visible), or by typing calibrationEditor on the commandline.

The preferred solution is to include the Calibration files in the ModelEditor, specifically if the ParameterExchange files are also included in the model tree and calibration are applied on parameter exchanges. In this case the Calibration Editor can be started by double clicking the calibration file or execute it via the (context) menu items.

If the Calibration files are not included in the ModelEditor, the calibration files must be included in the Simulation Controller to force their loading at the start of the simulation. If the files are included in the ModelEditor it is still allowed to also incude them in the Simulation Controller GUI for quick access to users of the Simulator.

The result of starting the CalibrationEditor is shown in Figure 10.2:

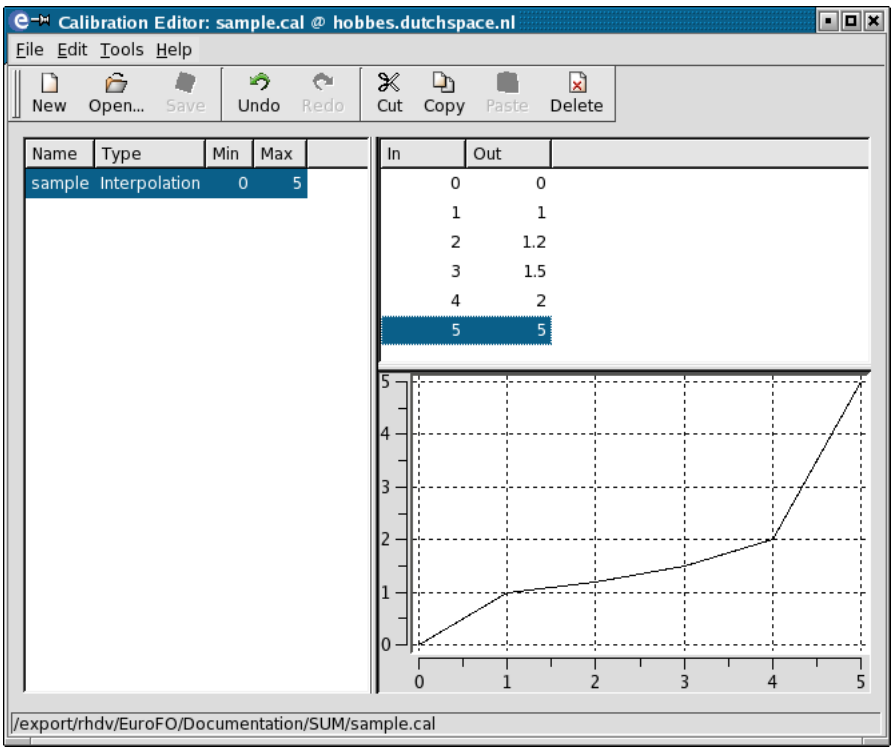


Figure 10.2: Calibration Editor

10.3 Views in the Calibration Editor

The calibration Editor contains three views, which are elaborated in the following sections. Context sensitve menus and tool bar buttons provide easy access to the functions in the menus that operate on these views.

10.3.1 Calibration view

The calibration pane provides an overview of the calibrations in the opened Calibration file.

10.3.2 Data rows view

The table view shows the data for a single calibration curve in tabular form. Each row is a data point that defines the Calibration curve according to the selected curve type.

10.3.3 Graph view

The graph view shows the data for a single calibration curve in a graphical form as a 2D curve.

10.4 Menu Items

Note that most common commands are also available in context sensitive menus that pop-up when clicking the right mouse button. Some commands also have keyboard short-cuts and tool bar buttons.

10.4.1 Edit menu

Delete Delete the selected rows in the currently active view. This can be either the Calibration view or the Data row view.

Select All
Select all rows of the currently active view.

10.4.2 Insert menu

New Calibration...

Add a new calibration curve. This will show a dialog box to enter the name, type and min/max values of the new calibration curve.

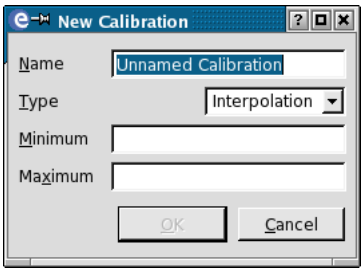


Figure 10.3: New Calibration dialog box

Add Data Row

Add a new data row to the currently active calibration curve.

Rename

Rename/start editing the first column of the row which has focus.

Chapter 11

Schedule Editor reference

This chapter provides details on the Schedule Editor. The various items which can be placed on the schedule tab pages, all menu items of the editor and their options are described. For menu items not described in this chapter, refer to Section 5.6.

11.1 Starting the Schedule Editor

The Schedule Editor can be started by selecting the 'Schedule Editor' button in the Project Manager window or by choosing the *Tools:Schedule Editor* menu item. If no schedule file is selected in the Project Manager tree view, the Schedule Editor starts with a new schedule. It is recommended to use a filename of the form *modelname*`.sched`. The Schedule Editor can also be started by double clicking a schedule file in the 'Files' list of the Project Manager. When creating a new schedule, the Schedule Editor automatically uses the name of the model file that is currently selected in the Project Manager.

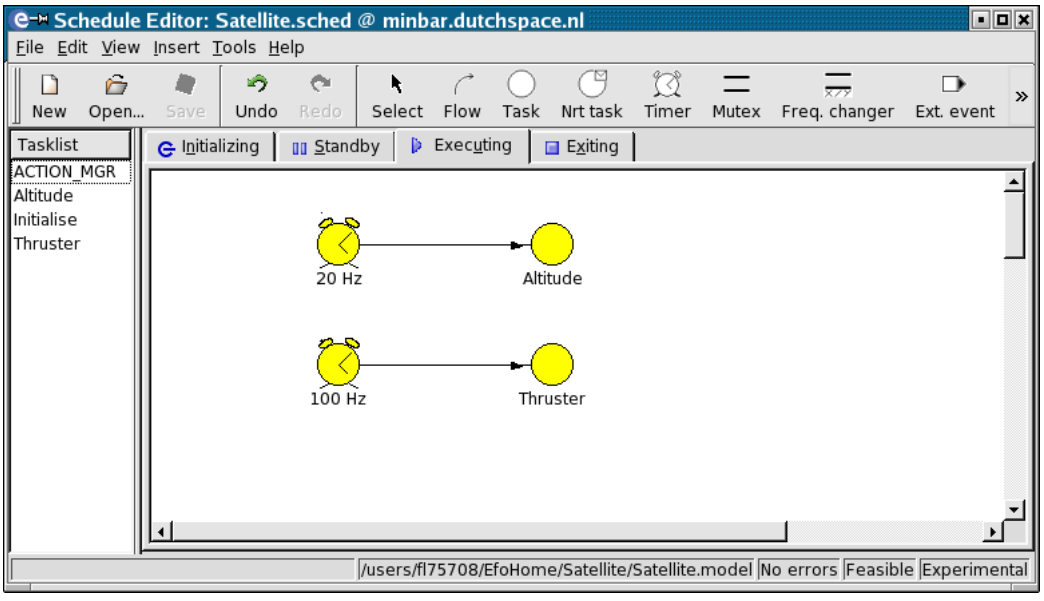


Figure 11.1: Schedule Editor window

11.2 Schedule Editor items

In the Schedule Editor tab pages, a schedule can be created by positioning schedule items (tasks, mutual exclusions, frequency changers, internal and external events, output events, timers) and connecting them with flows. A schedule is a set of attributed tasks, timers, scheduling events and their respective dependencies. The overall behavior of a schedule is deterministic, whereas that of a single task need not be.

When an item is placed in the tab page, it is given some default values for the properties of the item. These can be changed by double-clicking the item, or by selecting the item and activating the menu item *Edit:Properties* (or pressing Alt-Enter on the keyboard). When the item is shown in a color other than yellow, there is an error for the item. The error message can be viewed alongside the properties of the item. For a list of possible error messages, refer to Appendix E.

Items in the tab page can be repositioned by selecting the item with the left mouse button and, whilst holding the button pressed down, moving the item to another location on the tab page. All flows to and from the item will remain connected.

Labels can also be repositioned in the same way. This allows you to move the label out of the way if a flow passes through the label. The position of the label remains relative to the item it belongs to.

In the next sections, each of the items is described, together with the properties which can be modified. The graphic representation of the item in the tab page of the Schedule Editor is shown on the left.

11.2.1 Tasks

A task item represents a list of one or more entry points. Each task represents a single execution unit during the simulation. Grouping entry points within a task will ensure that the operations (represented by the entry points) are executed sequentially. In a schedule, tasks can be activated by:

- a simulator execution state transition (STATE_ENTRY connector on entering and STATE_EXIT connector on leaving a state)
- completion of another task
- periodically, using a timer which triggers the task at a given frequency
- through an input connector that is triggered from an operation that has ended execution
- a frequency changer

Tasks have an AND relation on their input flows. Only after all connected inputs have been activated will the task become active.

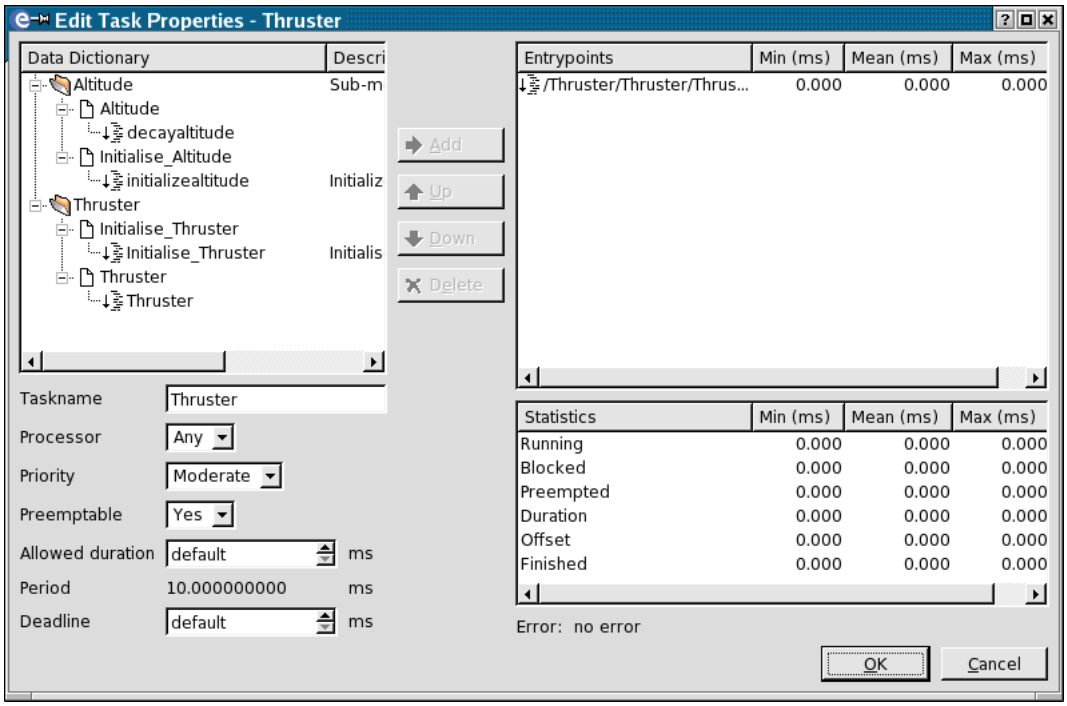


Figure 11.2: Task dialog

The following properties can be modified in the Edit Task Properties window (see Figure 11.2):

Entry Points
: This list shows all entry points that are associated with the task. The 'Data Dictionary' list contains all known entry points, the 'Entry Points' list shows the entry points selected for the current task. The list can be modified by pressing the buttons in-between the two listboxes. An entry point can be copied from the 'Data Dictionary' list to the 'Entry Points' list (right arrow), or removed from the task list (the 'Delete' button). The up and down arrow buttons can be used to re-order the entry points. For editing the entry point list a model file should be selected, so a data dictionary will be loaded into memory (see also Section 11.3.1): the data dictionary file of the model must have been build, otherwise the list will be empty and no entry points can be selected.

  Timing information for the selected entry point is shown next to the 'Entry Points' list. Timing information can be modified by clicking on the entry point timing values. Timing information can also be imported into the scheduler using the *File:Import timings...* menu item. The latter is only possible if you have already performed a simulation run with this schedule, which produces the timings file.

  Beneath the entry point values the total timings for the current task are displayed. Entry points in a task are executed sequentially, so the timing information is calculated by adding the values for the individual entry points in the task.

Taskname
: The name of the task.

Processor
: The processor on which the task should be executed. The default is 'Any'.

Priority The priority with which the task should run. Default is 'Moderate'.

Preemptable
: Set this to 'No' if the task may not be interrupted by another task.

Allowed Duration
: The maximum allowed task duration in milliseconds, with microsecond resolution. The duration is checked after task completion and results in a warning when exceeded. By default the duration is unchecked. For Periodic tasks the maximum is the tasks' input period. For Non Periodic tasks the maximum is unlimited.

Deadline
: The time period after which the task must have finished. The deadline is relative to the start of task execution and can be specified with a 'basic cycle' period resolution. For Periodic tasks the default and maximum deadline values are equal to the tasks' input period. For Non Periodic tasks the deadline is unchecked by default. The maximum is the main cycle period. As soon as a deadline is exceeded a real-time error is raised and the scheduler inserts basic cycles until the task finishes (in the 'Executing' state this means the Simulation time is effectively halted).

Times (for *Allowed Duration* and *Deadline*) are always in multiples of the basic clock cycle (see Figure 11.8).
Task statistics are shown in the window below the entry points:

Running
: The time that the code in the entry points was actually executing.

Blocked
: The time between task activation and start of execution.

Preempted
: The time the task was preempted by a higher priority task.

Duration
The total time to execute the task entry points.

Offset The start of execution measured from the start of the current cycle.

Finished
The end of execution measured from the start of the current cycle (Offset + Duration).

The last item, *Error*, shows the status of the item.

11.2.2 Non real-time tasks

Non real-time tasks are the links between the real-time domain and the non real-time domain. A non-real-time task can be raised by a completed task, by an internal event or by an external event.

When the schedule is executed by the scheduler, all tasks (seen as a set of entry points) connected to a non real-time task will be executed in the non-real time domain. For each activation of the non real-time task this will be done once, unless the buffer overflows because tasks in the non-real time domain can not be executed fast enough.

Non-real-time tasks have an OR relation on their input flows. As soon as one of the connected inputs has fired, the non-real-time task is activated. If an AND relation is needed, this can be easily created by inserting a real-time task between the connected input items and the non-real-time tasks. The real-time task then assures the AND relation on the input flows, and subsequently activates its output flow to the non-real-time task.

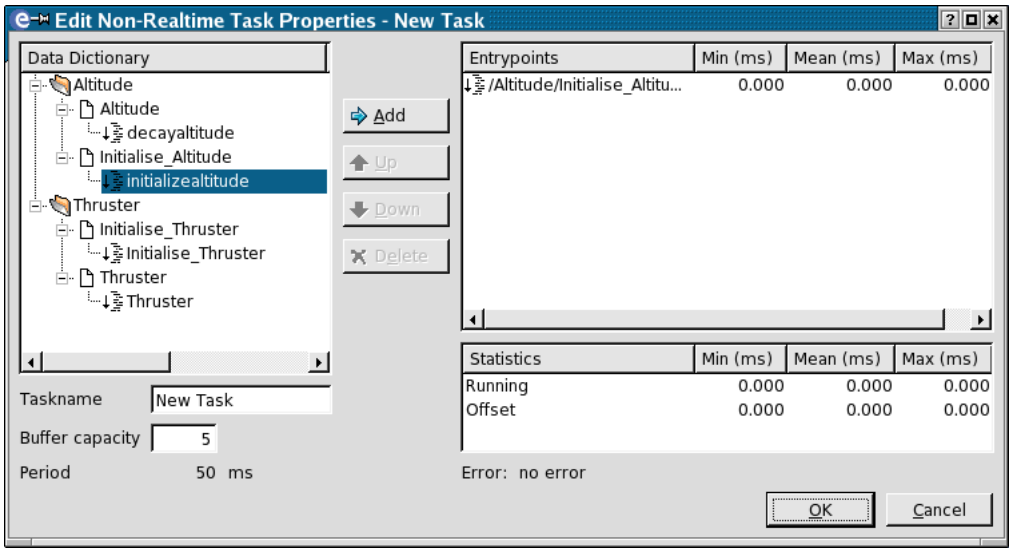


Figure 11.3: Non Real-time Task Dialog

The following properties can be modified in the properties dialog (see Figure 11.3)

Entry Points
This field indicates the entry points that will be triggered by this non real-time task. This list can be modified just like real-time tasks (see Section 11.2.1).

Taskname
The name of the non real-time task.

Buffer Capacity
This indicates the buffering capacity of the non real-time task.

The *Period* field is inherited from the schedule. *Timingsfile* shows the selected timingsfile. *Error* shows the status of the non real-time task.

11.2.3 Mutual exclusions

Mutual exclusions are used for asynchronous stores. Independently of the direction of a connected flow, only one task (of those connected to the store) will be executed at a time. The sequence of execution is done on a first-come first-serve basis.

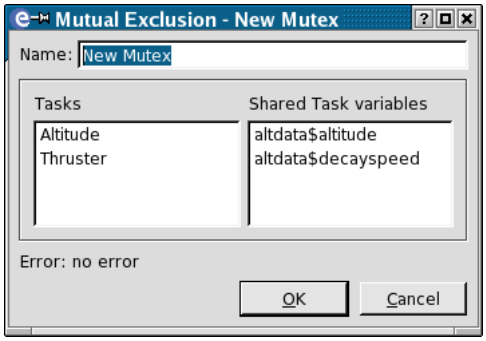


Figure 11.4: Mutual Exclusion Dialog

The following properties are shown in the properties window (see Figure 11.4):

Tasks This list shows all tasks currently connected to the mutual exclusion.

Shared Task Variables
The Shared Task variables box shows a list of the variables that are shared by the listed task(s).

The last item, *Error*, shows the status of the item.

11.2.4 Frequency changers

Frequency changers, or synchronous stores, are used for multiple frequency dependencies, meaning that they transform the frequency of the incoming triggers into the store to another frequency going out of the store. Only one input connector is allowed for a frequency changer.

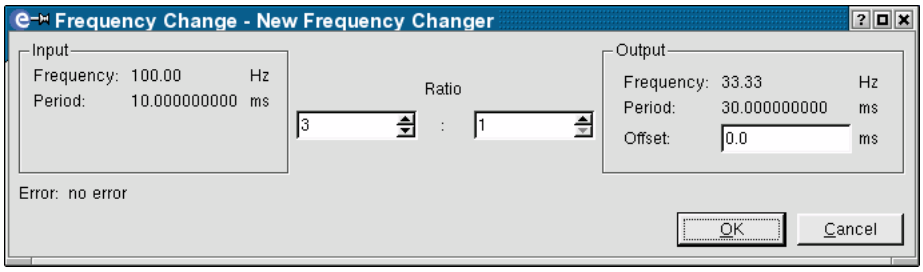


Figure 11.5: Frequency Change Dialog

The following properties can be modified in the properties window (see Figure 11.5):

Input Ratio and Output Ratio
show the ratio between the input and output frequencies. Only M:1 or 1:N ratios are allowed. An 1:N store (e.g. 10Hz/50Hz) means that upon activation of the frequency changer the output flows of the store are activated N times (5 in the example) directly one after another. To achieve a more regular task activation (50 Hz in the example), the task after the output flow should also be connected to a 50Hz timer. An M:1 store will activate the output flow only once every M input activations.

Offset The delay of the output activation in milliseconds. Only valid for M:1 ratios. It must be a multiple of the basic clock cycle (see Section 11.4.7). A value of zero (0) means that the output will be activated on the first input activation. The default activates the output after M input activations.

Note that the output side of the synchronous store runs mutually exclusive with the input side. See also Section 11.4.3 and Section 11.4.4.

The *Output Frequency* and *Output Period* are updated when the ratio changes.
The last item, *Error*, shows the status of the item.

11.2.5 Internal and External events

Internal and external events, both input connectors, represent events in the non-real time domain. An input connector activates its output flow when the event occurs. This may in turn execute a task or activate an output event. An internal event represents a predefined event related to simulator state changes and real-time errors. An external event is an event explicitly raised by the user from an MDL script or by an external event handler.

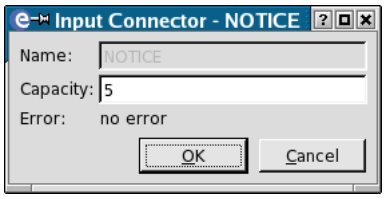


Figure 11.6: Input Connector Dialog

The following properties can be modified in the properties window (see Figure 11.6):

Name The name of the input connector. Predefined events cannot be renamed, only user defined input events can be renamed. The name must be unique.

Capacity
This indicates the buffering capacity of the connector.

Raised by
This indicates the sources of the event. An event can be raised internally by model code, a script or the event connection. An event can also be raised by an External Event Handler, e.g. a handler connected to a HW device or a signal handler (see section Section 11.3.5: external event handler).

Error shows the status of the item.

11.2.6 Output events

An output connector can be raised by a completed task or by an input connector. It represents an event related to simulator state changes and scheduler mode switches.

A user defined output event activates the user defined input event that matches its name.

Output connectors have an OR relation on their input flows. As soon as one of the connected inputs have fired, the output connector will raise the output event. If an AND relation is needed, this can be easily created by inserting a real-time task between the connected input items and the output connector. The real-time task then assures the AND relation on the input flows, and subsequently activates its output flow to the output connector to raise its event.

No properties can be modified. Only user defined output events can be renamed.

11.2.7 Timers

Timers activate their output at the specified frequency and can be used to activate f.i. tasks. The maximum allowed frequency can be defined in the Schedule Configuration tool (see Section 11.3.5). The system uses 100 Hz as default value.

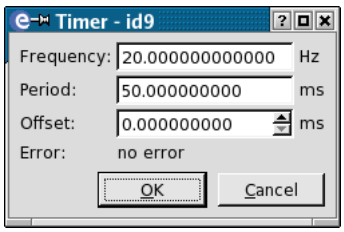


Figure 11.7: Timer Dialog

The following properties can be modified in the properties dialog (see Figure 11.7):

Frequency and Period
: Use either of these to set the frequency of the timer. If one is modified, the other is updated automatically. The maximum and default frequency is 100 Hz (Linux, Windows). The frequency range allowed is 0.001 Hz up to and including the maximum frequency, with a step 0.001 Hz.

Offset
: The delay of the output activation in milliseconds. This must be a multiple of the basic period (see Section 11.4.7).

Error shows the status of the timer.

11.2.8 Flows

Flows are used to connect items in the schedule. They represent triggers going from one item to another.

11.3 Menu options

11.3.1 File menu

Select Model
: With this option, a different model file can be selected from a file selection window. If the model does not have a data dictionary built, then it is not possible to specify entry points for tasks and non real-time tasks.

Parameter Exchange files
: Opens a dialog to view, add or remove Parameter Exchange files for the current schedule, see Chapter 9 on how to create parameter exchange files.

Import timings
: With this option, a timings file can be imported into the schedule. A file selection window will be shown in which a file can be selected. Timings files are generated automatically by the simulator and importing one will overwrite any manually entered timing settings.

11.3.2 Edit menu

Rename
: Opens an in-place line edit to rename the currently selected item.

Properties
: Pop up a dialog in which the properties of the currently selected node can be edited. The same effect can be reached by double clicking on an item in the schedule tab page.

11.3.3 View menu

In this menu, the state whose schedule tab page should be raised to the top can be chosen. There are four possible states: *Initializing*, *Standby*, *Executing* and *Exit*.

Enlarge drawing area
Enlarges the drawing area so that more items can be placed. Note that printing the drawing area will resize it to fit all items on one page.

Shrink drawing area
Shrinks the drawing area.

Refresh Reads in the new data dictionary that is associated with the currently selected model. This option is useful if you have an instance of the Model Editor open and update the model - and data dictionary by building it - while you are also editing the schedule.

11.3.4 Insert menu

In this menu, an item can be found for each of the items described in Section 11.2. For the internal events and output events, a cascading sub menu is available, from which various predefined internal and output events can be selected. For an explanation of the predefined events, see Section 11.3.4.2 and Section 11.3.4.3.
When an item has been selected from this menu, the cursor will change to the selected item, after which the item can be positioned on the tab page. If a flow is chosen, click on the item from which the flow should go, keep the left mouse button pressed, move to the target item and release the mouse button.

11.3.4.1 External events

External event handlers that are of type 'automatic' automatically add their input connector to this menu. See Figure 11.3.5 on how to create an external event handler.

11.3.4.2 Predefined internal events

The following internal events are predefined:

NOTICE
This event is raised when the `esimMessage()` or `esimReport()` with the `esimSeverity` parameter set to `esimSevMessage` is called.

WARNING
Idem for a warning.

ERROR Idem for an error.

FATAL Idem for a fatal message.

STATE_ENTRY
This event is raised when the state is first entered.

STATE_EXIT
This event is raised when the state is exited. Beware that the task connected to this connector is executed in the new state.

REAL_TIME_ERROR
This event is raised in case of a real-time error.

REAL_TIME_MODE_ENTRY
This event is raised at the transition to real-time mode, and at STATE_ENTRY when in real-time mode.

NON_REAL_TIME_MODE_ENTRY
This event is raised at the transition to non real-time mode, and at STATE_ENTRY when in non real-time mode.

SNAPSHOT_END
: This event is raised after loading a snapshot and applying the values to the variables. Restoring a snapshot is performed asynchronous. This means that when the user issues the command, the snapshot is not applied when the command finishes. Instead this event is raised to indicate that it has finished.

11.3.4.3 Predefined output events

The following output events are predefined:

INIT Requests transition from 'Unconfigured' to the 'Initializing' state.

GO Requests transition from 'Standby' to the 'Executing' state.

RESET System reset. Requests transition from 'Standby' to the 'Initializing' state.

PAUSE Requests transition from 'Executing' to the 'Standby' state.

ABORT System abort. Requests transition from 'Standby' or 'Executing' to the 'Unconfigured' state.

STOP Request transition from 'Standby' to the 'Exiting' state.

QUIT Requests transition from 'Exiting' to the 'Unconfigured' state.

REAL_TIME_MODE
: Requests transition to the real-time mode.

NON_REAL_TIME_MODE
: Requests transition to the non real-time mode.

11.3.5 Tools menu

Schedule Configuration...
: This menu item will show the Schedule Configuration dialog (see Figure 11.8).

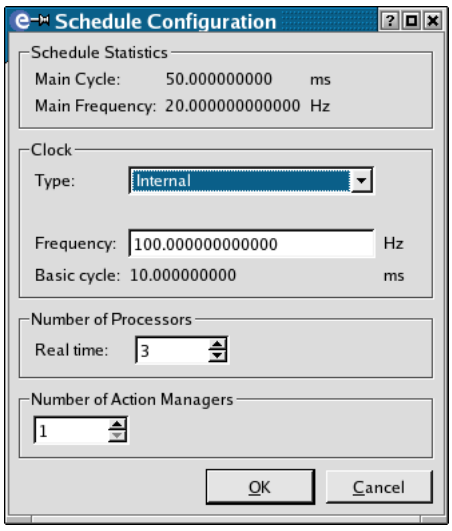


Figure 11.8: Schedule Configuration Dialog

In this dialog, the following properties of the schedule can be set:

Type This determines which clock is used by the scheduler. The availability of clocks depends on the selected model and target platform (see Section 11.4.9).

Period / Frequency

The desired period or frequency at which the scheduler should operate. The default is 100 Hz, but this can be raised up to 1000 Hz, depending on the clock type. The requested frequency is converted to a period in milliseconds. This period is used as the basis to calculate simulation time, so round numbers are in favour. Note that on some platforms it is possible to specify external clock sources. In that case it is important that you specify the right frequency for correct simulation time calculation.

Real time

The number of processors to be allocated to the scheduler. The maximum number of real-time processors is 10. The default value is 3 processors.

Number of Action Managers

The number of action managers which can be explicitly scheduled in each simulator state. The default value is 1.

External Event Handlers...

This menu item will show the list of External Event Handlers (see Figure 11.9). Here External Event Handlers can be added, deleted or modified. The user has to specify the processor that handles the external event. With 'exclusive' use of the specified processor, the scheduler excludes the processor from the 'any' pool for task execution[1]. Event handlers that have an 'automatic' handler type, automatically add an input connector to the *Insert:External event* menu (see Section 11.3.4.1). The external event gets the same name as the event handler. Event handlers of handler type 'user defined', need additional code to handle the event and optionally raise one or more user defined input connectors, see Section 26.3.

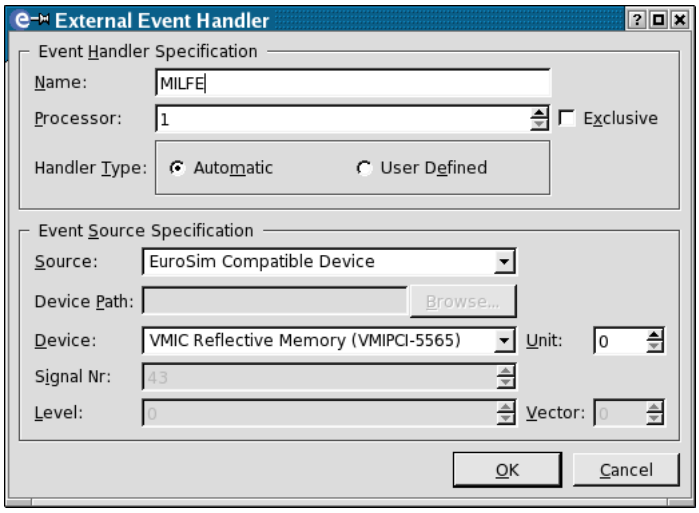


Figure 11.9: External Event Handler Dialog

Intersection...

This item will show the Intersection dialog (see Figure 11.10). The Intersection window shows all variables that are shared by all the selected tasks. This way, it is easy to see if there are any (possibly unwanted) interactions between tasks.

[1] This setting has no meaning on single CPU machines.

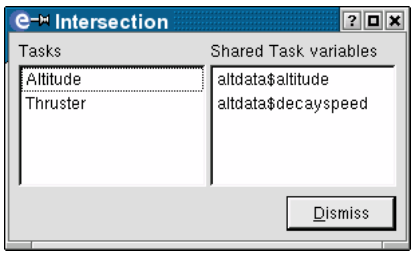


Figure 11.10: Intersection Dialog

CPU *load...*

The fields of this window show the processor load for each of the processors per state of the schedule (see Figure 11.11). The processor load is calculated using the *mean* duration (execution) fields of the tasks. Timings for tasks assigned to 'Any' processor are split among all processors. If any of the processors has a load of more than 50%, this will result in a non-feasible schedule.

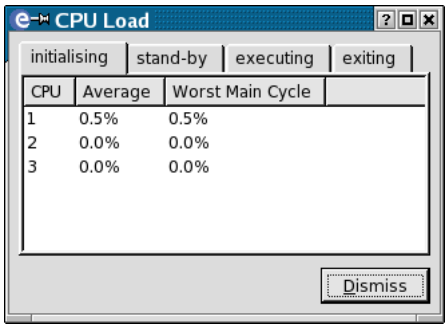


Figure 11.11: CPU Load Dialog

Timebar...

With the timebar dialog the scheduler trace file can be specified (see Figure 11.12). When the filename is specified the scheduler will log all scheduler events and execution times to this file.

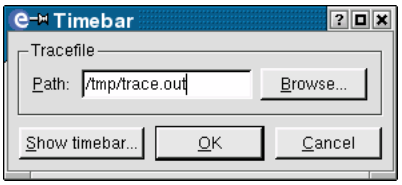


Figure 11.12: Timebar Dialog

From the timebar dialog it is also possible to visualize the resulting trace file. An example of the resulting timebar visualization is shown in Figure 11.13.

Figure 11.13: Timebar View

The viewer can also be started from the command line by typing:

```
TimeBarViewer </path../trace_file_name>
```

The timebar visualizes the trace data for each state in a seperate tab, with each tab drawinng the data in three categories. The ITEMS category visualizes the data from the perspective of the items on the ScheduleEditor canvas, resulting in the subcategories of tasks, timers, inputs etc. When data is found line items are added to the subcategory, making it unfoldable to show the details. The color coding shows on which scheduler executer the item was executed. A task scheduled on Any Processor in the Schedule Editor will likely show its execution therefore with different colors as the task can be executed by the first available processor.

The PROCESSOR category visualizes the date from a processor usage perspective. The processor number refers to the executer selected in the Schedule Editor, with NRT as special item for the Non realtime task execution, and Other for all processors above 7. For each processor both the acutal processing time used by EuroSim as well as the actual execution of user code is shown. This allows the user to see the overhead of EuroSim with respect to the execution of the users model code.

The SYSTEM catefory catches all remaining items, such as messages from the scheduler relevant to tracing, or the clock tich interrupt timing. specific EuroSim executer because they are at a System wide level.

Note that the trace file can grow substantially very quickly. Internal buffering is applied to prevent that the writing to disk affects the execution of the system, but nevertheless there is a small overhead introduced. Also it is advised to specify the location (path) of the trace file somewhere on a local drive, thus avoid using a networked drive. In addition the user can use the esimTracePause, esimTraceResume and esimTraceMask functions (see man page) to limit the data by only logging when of interrest and only logging the events and processors that the user is interested in.

11.4 Advanced Scheduler topics

In this section some examples are given that will give more information on mutual exclusion behavior, the activation of user tasks according to mutual exclusions, dependencies, performing I/O in the non-

real time domain, time requirements, how the scheduler will handle state transitions between different simulation states, and how to schedule the ActionMgr.

11.4.1 Scheduler mutual exclusion behavior

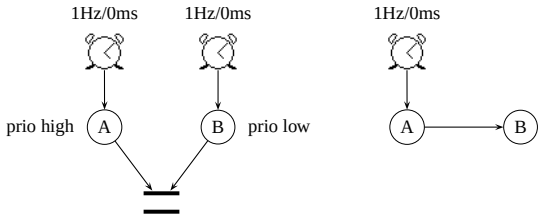
11.4.1.1 Effect of mutual exclusions

A mutual exclusion, or asynchronous store, in the Schedule Editor represents a 'mutual exclusive' run-time behavior between tasks. The task that captures the store first is allowed to continue running while all other tasks that are attached to that store, are prevented from starting until the store becomes available again (only one task can capture the store at any one time).

11.4.1.2 Effect of task priorities

Using priorities on tasks implies that when the task with the lowest priority is running and a task with a higher priority is activated, the task with the highest priority will preempt the lower priority task when that lower task is preemptable and no other processor is available.

Thus in the case that two tasks are connected to a mutual exclusion, using a higher priority for a task does not imply that that task will capture the mutual exclusion first, as it is the starting time that is of importance. If such a dependency is required, then it can be better specified using the following construction:

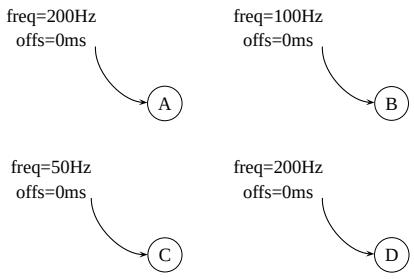


Wrong approach *Correct approach*

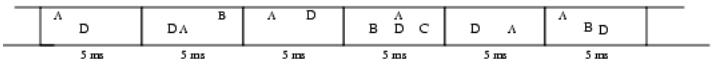
Note that even in the example above the starting time is never exactly the same, one of A or B will start slightly earlier than the other (the difference might be in nanoseconds). Which one in this case runs first depends on system internal behavior.

11.4.2 Dependencies, stores and frequency changers

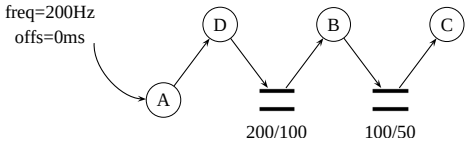
Dependencies, stores and frequency changers are used to define a sequence of tasks. Suppose that we have the following schedule:



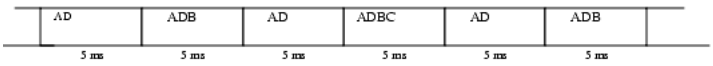
With this schedule it is defined that task A and D must be activated each 5 ms, task B must be activated each 10 ms, and task C must be activated each 20 ms. The maximum frequency on which the scheduler can activate tasks is for all states default 200 Hz. This means that the "real-time" is split up in time slots of 5 ms. For the example, the scheduler will activate tasks A and D in slot 1,2,3,..., task B in slot 2,4,6,..., and task C in slot 4,8,12,...



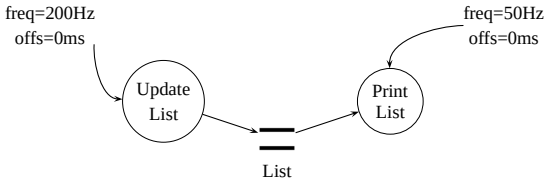
In the previous example, the sequence of tasks within the slots, is not defined. To define the sequence between tasks within the slots, dependencies (between tasks with the same frequency) and frequency changers (for tasks with different frequencies) can be used. In the following example the sequence of tasks within the time slots is defined with dependencies and frequency changers.



Note that the frequency of task D is still 200Hz, the frequency of task B is still 100Hz and the frequency of task C still 50Hz. These frequencies are now defined in the output frequency of the frequency changer. With these frequency changers it is defined that the time slots and sequences of tasks, within these slots, will be:

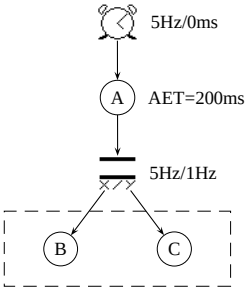


In the previous example we used frequency changers to define the sequences of tasks. With the defined sequence it is implicitly defined that tasks do not run simultaneous. If we do not want to define a sequence, but we only want to define that tasks are not executing simultaneous, we can use mutual exclusions. Tasks that read or write from the same mutual exclusion, are never executed by the scheduler simultaneous. For example, if we have a “printing” task that prints the contents of a linked list on 50 Hz, and a “updating” task that is changing the list at 200 Hz. It is obvious that the updating task may not run simultaneous with the printing task. To solve this problem, we can use a frequency changer.



11.4.3 Frequency changers and mutual exclusive execution of tasks

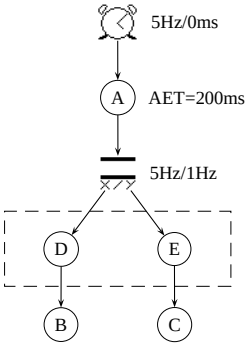
The frequency changer takes care of mutual exclusive execution of the tasks that write to it with the tasks that read from it. In case of a N:1 frequency store, this can severely limit the allowed execution time of the reading tasks. This is explained using the drawing below:



In this figure, the frequency changer must guarantee that task A will run mutual exclusive with tasks B and C. The allowed execution time of task A is limited to a maximum of 200 msec as a consequence of the frequency of 5Hz.

After 5 activations of Sync Store, the store will activate tasks B and C, *before* releasing task A for the next activation. However, task A must be released in 200msec (its AET), or else it will cause real-time errors. The total allowed execution time of the combination of task B and task C is therefore limited to a maximum of 200msec. In practice, the duration of task A will be larger than zero, which further reduces the allowed execution time of B+C.

If the execution of B+C is more than allowed, a solution might be to store the part of the code that needs the mutual exclusive behavior in a separate task. For instance:



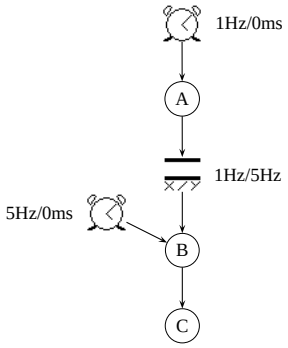
The part of the code of B and C that needs to be executed mutually exclusive with A (because it accesses the same variables) is stored in D and E. The remaining code is still in tasks B and C.

Now only the code in D and E must have a combined duration that is smaller than 200msec.

Note: D and E do not run mutually exclusive. If that is required, this can be accomplished by connecting these two tasks to a mutual exclusion (see Section 11.3), or even simpler by combining the code contained in D and C in one task.

11.4.4 Timing the output frequency of a frequency changer

Although a frequency changer has an output frequency, tasks reading from a frequency changer will only be activated with a frequency that approximates the specified output frequency. If more accuracy is desired, the frequency of the activations can be made exactly the one specified in the output frequency of the frequency changer by adding a timer. This is explained in the figure below:



Without the 5Hz timer, B is activated 5 times in rapid succession after each activation of A. Therefore the frequency of B would not be exactly 5 Hz, but would be determined by the execution duration of B. This is sufficient if only the ratio between A and B is of importance. However if it is required that B must be executed with an exact frequency of 5Hz, then the 5Hz timer should be added, which forces B to wait

200msec between the successive executions of B. The advantage of not adding a timer is that execution time is more efficiently used.

11.4.5 Example of using an output connector for I/O

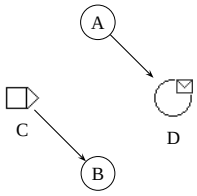
I/O is non-deterministic in time and thus calls must be issued from the non-real-time domain. In the Schedule Editor this can be achieved by connecting the task that performs the I/O to an output-connector. There are two ways to synchronize your non-real-time tasks with the real-time tasks:

1. You can synchronize explicitly in the Schedule Editor, using the schedule items available
2. You can use a 'flag' variable in memory to pass the status information about the I/O.

Both are explained below:

11.4.5.1 Using Schedule Editor items for synchronization

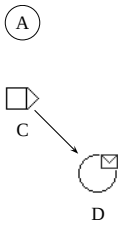
The following figure explains the first approach.



Task A performs some action. When finished, the non real-time task D is activated which performs the task D containing entry points that do the I/O actions. Within task D, when it has performed its I/O actions, a call to the function `esimRaiseEvent` is made (in this case with argument "C"). This function call activates the Input Connector C which in turn will activate Task Item B. Data read by task D can now be used by task B.

11.4.5.2 Using a variable for synchronization

Approach 1 implies that D is activated each time A was activated. Using a synchronous store a relation can be established (like for every N times A was activated D is activated once). You may want a more parallel behavior where tasks A and D run in parallel, and A uses the data read by D when available. This is described below:



When task A needs to perform I/O, it sets a variable (e.g. `io_request`) and activates the input connector C by calling `esimRaiseEvent(C)`. Task A keeps on running.

The activation of C will cause an activation of D. Task D connected to non real-time task D will perform its I/O and will set a variable (for instance `io_handled`) when the I/O operation is ready.

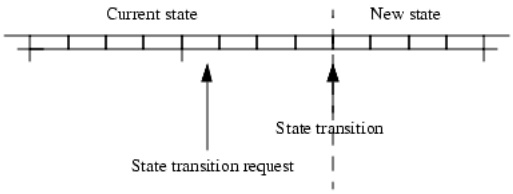
While running, task A scans variable `io_handled` to verify if I/O has completed. When it detects that this variable has been set, both `io` variables can be reset, and data read in the I/O action can be used.

Note that, within this approach, it is also possible to activate input-connector C from a MDL script instead of a task. Using this feature, D can be activated from the Simulation Controller.

11.4.6 State transitions

A state transition can only occur at a main cycle boundary. A main cycle has a period equal to the least common multiple (LCM) of the periodic tasks computed over all states of the simulator in the schedule. In the current implementation, the main cycle is taken as the LCM of the periods of all periodic tasks (over all states), instead of the LCM of the periods of active tasks in the current running state. This, for reasons of simplicity, is still correct, although it may make the main cycle somewhat larger than strictly necessary.

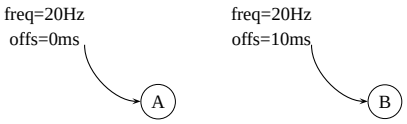
In the previous example we had a main cycle "AD:ADB:AD:ADBC"of 20 ms duration. This means that state transitions can only occur at each "4 slots" boundary. For this reason the scheduler will delay the user's state transition request until the end of slot 4, 8, 12, ... etc.



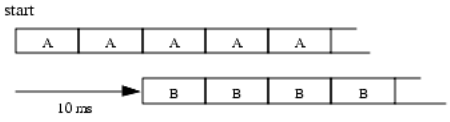
NB. If in the period between the request and the transition more state requests are given, these requests are buffered by the scheduler (up to 32) and applied on FIFO basis at the next main cycle boundaries, with one at a time.

11.4.7 Offsets

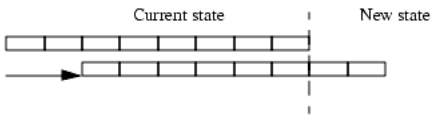
Offsets are used to "delay" tasks to following time slots. Suppose we have the following schedule:



The 10 ms offset of timer B will delay all activations of task B by 10 ms.



When offsets are used, state transitions will still be on the main cycle boundaries. This means that task B must still be activated (according to the current executing schedule), in the first two slots of the new state. This guarantees that the number of activations for each tasks are always the same. I.e. a functional model will always complete leaving the system in a deterministic state.



Note that no synchronization whatsoever is performed between the schedules in the 'old' and 'new' state: this is omitted under the assumption that there is only one nontrivial EuroSim state (state EXECUTING), and that any other state is to perform simple procedures, such as initialization or keeping hardware alive. Supporting state synchronization would unnecessarily add to the complexity of the scheduler. The user must however be aware of a possible overlap in execution of the schedules of two states 'just after' a state transition when offsets are used.

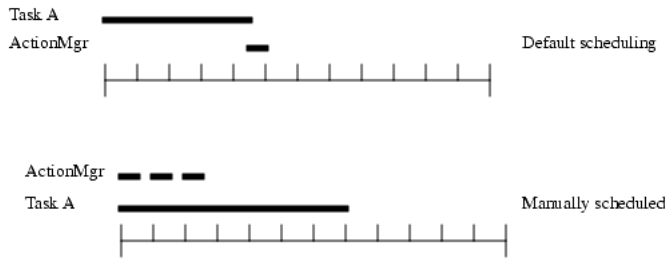
Note: One exception is made for the transition to ABORT. An abort transition does not wait until the main cycle boundary, but is directly done by the scheduler. This means that all tasks, inclusive tasks with an offset, are directly stopped.

11.4.8 Scheduling the action manager (ACTION_MGR)

The action manager is a special task provided by the EuroSim environment. Although it is a special task, the action manager must be scheduled just as any normal task. As with any normal task, how it is scheduled is of importance to its performance. For instance, if variables are to be logged just after performing a certain task, then the action manager could best be scheduled after this task using a flow (dependency relation).

When the action manager is not scheduled explicitly, i.e. not placed on the tab page in the Schedule Editor, the action manager is added to the schedule with a default frequency that is equal to the Basic Frequency of the scheduler and with a priority of Low. In many cases this will be sufficient, as this will activate the action manager with a high frequency, and after all other tasks have been activated.

However, there are cases where the action manager should be scheduled more carefully using the Schedule Editor. One such case has already been mentioned: to provide logging of variables on a specific moment in the overall schedule. Another example is the case in which only one real-time executor is available on which a low frequency task with long duration is running. Due to its long duration some time slots are filled completely, leaving no time to run the action manager. In this case the default Low priority will lead to real-time errors. Scheduling the action manager in the Schedule Editor with a higher priority may be the solution. This is illustrated below:



Default vs Manual scheduling of the ActionMgr, when having a long-duration task

11.4.8.1 Multiple action managers

There are situations where a single action manager does not allow you to execute the actions at the appropriate place in the schedule. For that situation it is possible to specify more than one action manager task. The number of action managers can be configured in the Schedule Configuration dialog box (see Section 11.3.5).

Each action manager can be scheduled individually at different frequencies in each scheduler state.

When there is only a single action manager it has the name ACTION_MGR. In the case when there is more than one action manager, the names are ACTION_MGR_0, ACTION_MGR_1, etc. The number corresponds to the action manager number you can specify for each individual action in the script dialog box in the Simulation Controller (see Section 12.10.3.1).

Messages printed by actions are labeled with the name of the action manager that executes them. The label has the form of actionmgr*n*, where *n* is the number of the action manager.

11.4.9 Clock types

Depending on the platform the simulator will be running on, the developer can choose from a number of clock types (or clock 'sources') to drive the Scheduler. The type of clock to be used can be configured in the Schedule Editor (see Section 11.3.5). Note that for all external clock sources it is important that you

specify the right frequency/period for correct simulation time calculation. The Scheduler will receive the heartbeat and assume that it in between the amount of time specified by the period will have passed.

The following clock types are available on Linux:

Internal
: Represents the internal clock of the computer running the simulation.

Plugin The clock that is glued via the plugin library identified with the library path in the selection dialog.

IRIG-B The IRIG-B clock related to the option in the Model Editor. Note that the new clock plugin solution is prefered, this option will likely become deprecated with EuroSim [6].

RCIM clock
: Selecting this clock will read the time from the RCIM card, allowing GPS and RCIM chain synchronized clocks.

Posix Signal
: Signals in the range RTMIN to RTMAX can be routed to the EuroSim master clock to drive the scheduler

RCMI interrupt
: Ticking the EuroSim clock on the basis of the external interrupt input on the RCIM card

EuroSim Compatible Device Type 1
: Cicking the EuroSim clock on the basis of a EuroSim Compatible driver of type 1. These devices provide specific ioctl functions which EuroSim uses to wait for interrupts.See the Exter Hardware interface chapter on how to make a driver EuroSim compatible.The plugin is preferred, this option is however still available.

Chapter 12

Simulation Controller reference

This chapter provides details on the Simulation Controller. The panes and tab pages of the editor, the various objects that can be created, all menu items of the editor and their options are described. For menu items not described in this chapter, refer to Section 5.6.

12.1 Starting the Simulation Controller

The Simulation Controller can be started by selecting the **Simulation Controller** button in the EuroSim start-up window (see Figure 6.1), by selecting the **Observer** button in the start-up window, or via the command line.
When the Simulation Controller is started from the command line, the user can provide the following command line options:

-observer
: Start the simulation controller in observer mode

-connect hostname:prefcon
: Connect at start-up to an already running simulator running on host *hostname* on connection *prefcon*.

See also the manual page for the Simulation Controller *SimulationCtrl(1)*.
Example:

```
hobbes:~$ SimulationCtrl -connect minbar:0
```

Before components for a new scenario can be defined in the Simulation Controller editor, a model and a schedule should be selected. The model is needed for the definition of the scenario actions and the initial condition files using the data dictionary specific for that model. The schedule is required in order to actually run a simulation. By selecting the *File:New* menu item a wizard will appear that helps you select the files you need.

If the Simulation Controller is started by selecting the **Observer** button, then the number of options will be limited, as the outcome of the test cannot be affected in any way. This means that some menu options (e.g. debugging) and some activities (e.g. using a script to update a data value) are not available.

Before a simulation can be started through the Simulation Controller, a simulation definition file has to be loaded (using the normal *File:Open* menu item), or should be created (using the normal *File:New* menu item).

12.2 Input Files of the Simulation Controller

The Simulation Controller allows the Test Conductor to create different simulation definitions for executing a model in the simulator, each testing e.g. a particular aspect of the model. Such a definition consists of the following components:

Reference to a model
: This is a link to a model definition. This link is necessary to collect all required information about a model.

Reference to a schedule
: This is a link to a schedule definition. This link is necessary to actually run a simulation.

Reference to an export
: This is a link to an export definition. This link is optional and specifies the exports file that describes which variable nodes will be exported to external clients, see file formats in Section A.5 for a description on the exports file format. Chapter 30 describes in more detail how an exports file is used.

Reference to an alias file
: This is a link to an alias definition file. This link is optional and specifies the alias file that describes which variable aliases will be created. See file formats in Section A.6 for a description on the alias file format. Section 12.7.3 describes in more detail how aliases work.

Reference to a TSP *map file*
: This is a link to a TSP map file. This link is optional and specifies the TSP map file that describes which variables will be exported by the TSP provider in EuroSim. See file formats in Section A.8 for a description on the TSP map file format.

Initial conditions
: These are used to change the initial state of the model. The initial conditions override the initial values of the variables defined in the code.

Scenarios
: These are used to create events and actions, e.g. to introduce malfunctions in the simulation. A scenario contains script, recorder and stimulus actions. Several scenarios can be loaded at one time.

Stimuli files
: Stimuli are used to replace external data inputs which would be present in the real world. Time-series stimuli have their values taken from a file, for example to feed in values representing an operator's input. Functional stimuli have their values generated from a mathematical function.

MMI *Definitions*
: MMI definitions describe where monitors are placed on the MMI tab page and which data they monitor. Monitors on an active MMI page collect data during a simulation run. They do not store the information in a file, but display the data directly on screen. It is also possible to execute scenario scripts and activate/deactivate recorders and stimulus actions by placing buttons or checkboxes on the MMI tab page. In order to reduce required bandwidth between the simulator and Simulation Controller, you can deactivate an MMI file.

Image Definitions
: The simulation definition can contain information about one or more image definitions. Once the simulation has been initialized, an image definition can be "launched" as a separate client.

User Program Definitions
: A user program definition is used to launch a program as a separate client. That program can connect to the simulator and provide additional functionality.

Not all of these components have to be present in one simulation definition. Only the references to the model and schedule are required.

12.2.1 Initial Condition

A particular simulation is often required to be executed several times, each one starting from a different state i.e. a different initial condition definition. Instead of creating different simulation definitions for

each of these possibilities, it is easier to reference all the possible initial conditions within a single simulation definition, and then to ensure that the required initial conditions are selected prior to initializing the simulator.

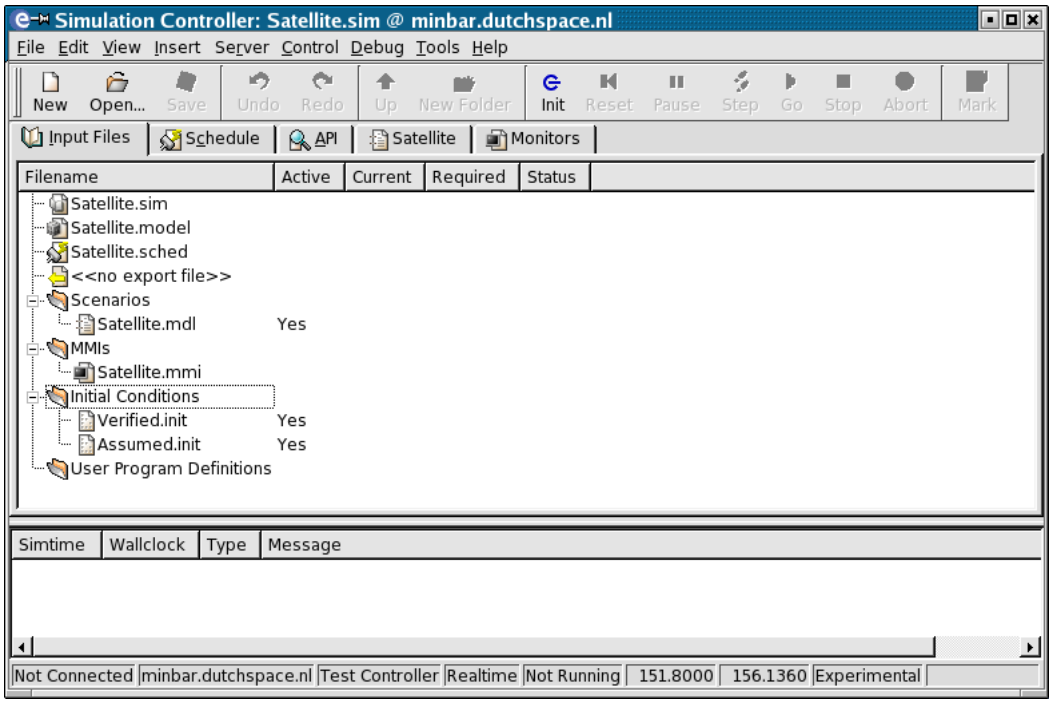


Figure 12.1: Simulation Controller with multiple Initial Conditions

The required (active) initial conditions are indicated in the Input Files tab page: the initial conditions marked *Active* form the set of values that will be applied if you request "Init" or "Reset" from the Simulation Controller. Values which have been updated are then used in tasks scheduled for the "initializing" state. The set of active initial conditions can be updated by activating or deactivating the appropriate file in the Input Files tab page.

Alternatively, you can request *Control:Apply Initial Condition...* from the Simulation Controller to cause the data values within the file to be applied directly to the current simulation. In this case, the values are used to override the current simulation values. The simulation state is not affected when this option is used.

12.2.2 Script Action

This type of action contains a Mission Definition Language (MDL) script. A script is the basic building block from which all actions can be made. For ease of use, EuroSim provides special-purpose interfaces for recorders and stimuli. However, any actions which require more complex activation conditions (e.g. a recorder which is to record when a particular data value is between predefined boundaries) can only be made by defining the script directly.
MDL is a simple yet versatile language for simulation scripting. It allows users to write control scripts in a limited free-text, C-like language. Chapter 21 contains a comprehensive overview of MDL.
A script action is made up from four parts:

name Used to reference the action.

attributes
Which determine how the action looks on the scenario tab page, in which state it should be executed, etc.

execution condition
Which contains the condition (written in MDL) under which the action will be executed.

action to be executed
Which contains the actual MDL script which will be executed when the condition is true.

All of these items can be modified with the Action Editor, which is described in more detail in Section 12.10.3. The Action Editor is started when creating a new action, or when modifying an existing action.

12.2.3 Stimulus Action

The stimulus action is a special case of the script action, and can be used to easily create actions that provide stimuli to the simulator, using data from a specified file to update the values of the selected variables, at a certain frequency and for a certain time period. Using the *Variables* tab page in the Action Editor, there is no need for the user to write the MDL script himself. However, if needed, users can still access the raw MDL script, allowing the editor to be used for the creation of the basic stimulus action and then be customized.
See Section 12.10.3.3 for a more detailed description of the stimulus Action Editor.

12.2.4 Recorder Action

The recorder action is also a special case of the script action, and can be used to easily create actions that record the values of one or more selected variables, at a certain frequency and for a certain time period. Using the *Variables* tab page in the Action Editor, there is no need for the user to write the MDL script himself. However, if needed, users can still access the raw MDL script, allowing this editor to be used for the creation of the basic recorder action, and then be customized.
See Section 12.10.3.2 for a more detailed description of the recorder Action Editor.

12.2.5 Monitors

While it is possible to create a monitor script action, this type of monitor has become obsolescent. Generally you only come across a monitor action when loading an old (EuroSim Mk2 or earlier) `.mdl` scenario file or when you explicitly create a script action containing a monitor.

When an obsolescent monitor action is triggered a new tab page *Script Monitors* will appear that contains the created monitor.

In EuroSim Mk5.3 a monitor is no longer a script action. Instead monitors are defined in a `.mmi` file and can be edited in the corresponding MMI tab page. You can create multiple MMI tab pages, each containing a set of monitors.

In order to reduce required bandwidth between the simulator and Simulation Controller, you can deactivate an MMI file. When and MMI file is inactive, its monitors will not be subscribed for updates from the simulator. You can activate or deactivate an MMI file when the simulator is running. The monitors will then subscribe or unsubscribe for updates as appropriate.

Monitors on the scenario tab page can be converted to an MMI tab page by using *Tools:Convert Old Monitors*.
There are two built-in monitor types: alpha-numerical and graphical monitors.

With alpha-numeric monitors, a window will be shown in the MMI tab page in which the current value of one or more variables will be presented. The window will be updated when the value changes.

Graphical monitors use one of three types of graphs to display the values of variables:

XY Plot one or more variables against an independent variable.

Simulation Time
Plot one or more variables against the simulation time.

Wall Clock Time
Plot one or more variables against the wall clock time.

See Section 12.11.4 for a more detailed description of the Monitor Editor.
For user-defined monitors, a special plugin type can be used. This type uses shared libraries to load plugins. For a more detailed description and examples see Section 12.11.5.

12.3 Windows of the Simulation Controller

When the Simulation Controller has been started, a window similar to the one in Section 12.12 is shown. This window is divided into two main parts, separated by a splitter:

Tab pane
: This pane contains several tab pages that used for editing, debugging and viewing a simulation.

Message tab pane
: Shows the messages from the simulator.

At the top is the menu bar and a tool bar. At the bottom a status bar provides additional state information.

12.3.1 The toolbar

The tool bar provides easy access to the following functions:

New Create a new Simulation Definition. The same as the *File:New* menu item.

Open
: Open an existing Simulation Definition. The same as the *File:Open* menu item.

Save Save the current Simulation Definition. The same as the *File:Save* menu item.

Up Go up one level in the folder hierarchy. Available when the scenario is represented using icons. The same as the *View:Up* menu item.

New Folder
: Create a new folder. Available in the scenario tab page. The same as the *Insert:New Folder* menu item.

Init Initialize the simulator. The same as the *Control:Init* menu item.

Reset
: Reset the simulation. The same as the *Control:Reset* menu item.

Pause
: Pause the simulation. The same as the *Control:Pause* menu item.

Step Advance the simulation through one executing cycle. The same as the *Control:Step* menu item.

Go Put the simulation in executing state. The same as the *Control:Go* menu item.

Stop Stop the simulation. The same as the *Control:Stop* menu item.

Abort
: Abort the simulation. The same as the *Control:Abort* menu item.

Mark
: Place a mark in the journal file. The same as the *Insert:Mark Journal* menu item.

12.3.2 The tab pane

The tab pane consists of the following tab pages:

Input Files
: Shows all files used by the Simulation Definition.

Schedule
: Used to debug a simulation run.

API Show the data dictionary and quickly monitor and/or change the value of a variable.

Scenario
: View and edit all actions in a scenario. One tab page appears for each scenario in the Simulation Definition.

MMI The Man-Machine Interface. One tab page appears for each MMI file in the Simulation Definition. The MMI tab page allows you to monitor variables and to execute scripts, recorders or stimuli.

To start the simulation controller with a specific tab page, you can make one of them the default by using the menu item *Edit:Set Default Tab Page*.

12.3.3 The message pane

On the message pane all messages are displayed. This includes messages generated by the simulator (e.g. when starting the simulator, or when pausing it), errors from the scheduler (see Appendix E). as well as marks and comments created by the test conductor. Comments are marks with an extra item of text attached. See Section 12.12 for some examples. Marks and comments can be created with the *Insert:Mark Journal* and *Insert:Comment Journal Mark* menu items. All messages appearing on the pane are also logged into the journal file, see Section 12.4.

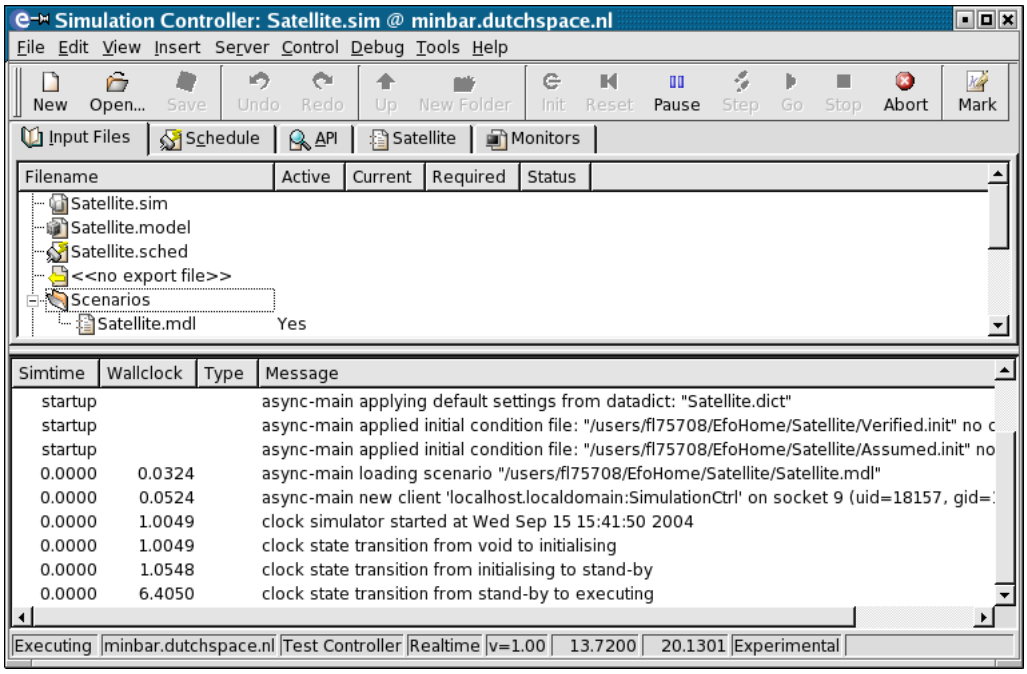


Figure 12.2: The Simulation Controller

Messages generated by the simulator include messages about:

- Change of state
- Problems encountered, such as real-time errors

- Manual activation of actions
- Updates to the action definitions

Simulation message logging can be customized by creating additional message tabs. For each message tab a message filter can be created to filter (out) messages based on their types. There are four standard EuroSim message types (message, warning, error, fatal). Additional user defined message types can be created in the simulator using EuroSim library functions. Message tabs can have filters on built-in EuroSim message types and user defined message types. For more information see Section 12.12.

12.3.4 The status bar

In the status bar a number of items about the current simulation are displayed:

- The current simulation state.
- The simulation server.
- The current user role (Test Conductor or Observer)
- The simulation mode (real-time vs. non-real-time vs. debug)
- The simulation speed.
- The simulation time (it is expressed in seconds or as an absolute time displayed as YYYY-mm-dd HH:MM:SS.ssss if the simulation uses UTC).
- The wall clock time (elapsed time since start-up or the UTC time if the simulation uses UTC).
- Traceability: experimental or traceable. If the simulation of a versioned simulation definition is requested, then various checks will be carried out to assess whether the execution will be traceable at a later date or not. If so, then the status bar will state that the simulation is *Traceable*, if not, then the simulation is *Experimental*.

'Traceability' means that all source files involved in the simulation definition can themselves be traced at a later date. This is only possible if a) the source files (i.e. simulation definition, scenarios, initial conditions, executable, MMI files, data dictionary and schedule (the latter deriving from the model file)) are (generated from) non-modified repository versions (e.g. `1.2` not `1.2+`) and b) the versions on disk match the required versions.

12.4 Output files of the Simulation Controller

During a simulation run, a number of files are generated:

journal file
: This file contains all messages generated by the simulator, as well as all entered marks and comments. There are two variants of this file. A human readable version and a machine readable version. The file name of the human readable file is `EsimJournal.txt`. The file name of the machine readable file is `EsimJournal.xml`.

timings file
: This file contains timing information which can be used in a schedule (see Section 11.3.1 of the Schedule Editor). This file has the name `timings`. See also Section 11.4 for information on task timings.

recording files
: These are the files that result from the recording actions as defined in the scenario definition. For each recorder a file is created with the name *recordername*`.rec` if the default name was chosen in the scenario definition.

test result file
: This file contains a list of all recordings performed during the simulation run. This file will have the extension `.tr`.

All these files are created in a directory with a name like `2001-12-14/15:33:30`, which includes the date and time of the simulation run.

12.5 Dictionary Browser

The Dictionary Browser allows the Simulation Controller and other programs to look at which variables and entry points have been defined in the API headers of the model, and therefore are available in the data dictionary.

The browser shows a tree hierarchy of the available nodes, files, entry points and variables. If you try to expand a very large array, then you will be asked for a confirmation first. The selected items can be dragged and dropped to the destination. Double clicking on a single item will also add that variable to the destination. There is also a button **Add** to add the selected variables to the destination.

You can switch between a full view and a condensed view where all unnecessary nodes are left out by pressing the *F3* key or by choosing *Condensed View* or *Full View* from the context menu that you get when pressing the right mouse button in the Dictionary Browser.

If you want to find a variable you can either choose *Find* from the context menu or start typing immediately while the Dictionary Browser has the input focus. For every key you type the browser will be updated to show only those variables that match the text you've typed. The browser uses a case-insensitive substring search. So any variable name that contains the text without regard to upper or lower case will match. When no variables match the browser is empty. Use backspace to delete the last character from the search string until the search string is empty, and then you return to the original state of the browser.

Note that the search string is also displayed in the caption of the first column of the dictionary browser.

The context menu also contains a *Expand All* item to expand all nodes and a *Collapse All* item to collapse all nodes in the tree.

Finally, there is a *Info* menu item in the context menu that appears when you click with the right mouse button on a node in the dictionary. Selecting this menu item will pop up a window that shows type information about the selected node.

12.6 Menu Items

This section describes the menu items that are not tied to a specific tab page and that do not belong to the group of common menu items that are described in Section 5.6.

Menu items that are only enabled when a specific tab page is on top are described in the section for that tab page.

12.6.1 Edit menu

Set Default Tab Page
: Make the current tab page the default one on start-up. This setting is saved in the .sim file and will be restored the next time the .sim file is loaded. This is only applicable for the tab pages on the top portion of the screen, and not for the message tabs.

12.6.2 View menu

Input Files
: Raise the Input Files tab page to the top.

Schedule
: Raise the Schedule tab page to the top.

API Raise the API tab page to the top.

Script Monitors
: Raise the Script Monitors tab page to the top.

MMI A sub-menu with all MMI tab pages. The selected tab page will be raised to the top.

Scenarios
: A sub-menu with all Scenario tab pages. The selected tab page will be raised to the top.

Toolbar Button Labels
: Show text below the toolbar buttons. This setting is saved in a settings file and will be restored the next time the Simulation Controller is started.

Large Toolbar Buttons
: Show large icons for the toolbar buttons instead of the default small icons. This setting is saved in a settings file and will be restored the next time the Simulation Controller is started.

Tabbar Labels
: Show text on the tab-bar. Disabling this setting can be useful if your Simulation Definition file contains a lot of MMI and/or script files. This setting is saved in a settings file and will be restored the next time the Simulation Controller is started.

Refresh If the data dictionary or schedule file have been changed, then reload these files.

Clear Log
: All the messages (if any) in the message tab pane currently on top are deleted.

12.6.3 Insert menu

New Scenario
: Add a new Scenario file to the Simulation Definition. This will automatically create a new Scenario tab page where this file can be edited. You will be asked to enter the caption of the new tab page.

Add Scenario
: Import an existing scenario file into the Simulation Definition. A new tab page will be created where this file can be edited. You will be asked to enter the caption of the new tab page.

New MMI
: Add a new MMI file to the Simulation Definition. A new MMI tab page will appear where you can add monitors, etc. You will be asked to enter the caption of the new tab page. By default the new MMI file will be marked as *Active* in the Input Files tab page.

Add MMI
: Import an existing MMI file into the Simulation Definition. A new tab page will be created where this file can be edited. You will be asked to enter the caption of the new tab page. By default the imported MMI file will be marked as *Active* in the Input Files tab page.

New Initial Condition
: Add a new Initial Condition file to the Simulation Definition. By default the new initial condition file will be marked as *Active* in the Input Files tab page.

Add Initial Condition

Import an existing Initial Condition file into the Simulation Definition. By default the imported initial condition file will be marked as *Active* in the Input Files tab page.

New User Program Definition

Create a new User Program Definition. This is basically a user defined program that will be launched when you select *Edit:Launch*. The User Program Definition window is very simple (see Figure 12.3). In the *Definition* input field the program to start is specified and any arguments that are needed. The `%h` sequence will be replaced with the hostname of the running simulator, and the `%c` sequence will be replaced with the preferred connection number. If you need to run `.bat` batch files (Windows version only), then you have to precede the User Program Definition with `'cmd /C '`. Similarly for shell scripts (`.sh` files); precede the User Program Definition with `'bash '`. If the shell script file is located in the same directory as the `.sim` file and you do not specify the full path to it, then you may need to prefix the name of the shell script file with a `'./'`, depending on whether the current directory (dot) is in your search path or not (environment variable PATH). Examples: `'bash -c ./myscript.sh'` or `'cmd /C mybatch.bat'`.

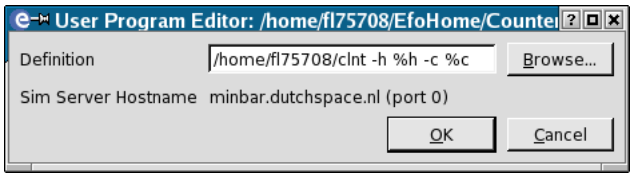


Figure 12.3: Example User Program Definition

Add User Program Definition

Import an existing User Program Definition.

Make Mark

Use this menu item to make a mark in the simulation log. The mark is also displayed on the message pane. The idea behind marks is to allow you to tag some interesting/unexpected event quickly. Each mark is allocated a unique number which can also be used for adding explanatory comments later on.

Make Comment

Use this menu item to enter a comment in the simulation log. The comment is also shown on the message pane. When this menu item is selected, a window shown in Figure 12.4 will pop up, in which the comment can be entered.

By default, the comment 'belongs' to the last mark made, but you can add comments to earlier marks by manually editing the number in the Mark field.

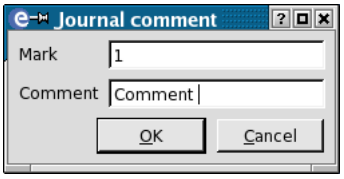


Figure 12.4: The Comment Journal Mark window

New Message Tab

Use this menu item to create a new message tab to customize simulation message logging. For more information see Section 12.12.

12.6.4 Server menu

Select Server

Before a simulation can be started, a computer on the network has to be selected which can act as the simulation server. By default the host on which you started EuroSim is assumed to be the simulation server, and so this option is only necessary if you wish to use another host. When this menu item is selected, a window similar to the one in Figure 12.5 is shown. This window lists all currently available servers on the network. Use the *Server:Show Current Simulations* menu item to check the status of each of those servers.

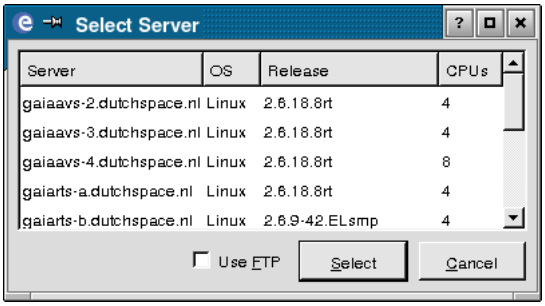


Figure 12.5: Select Server window

If the checkbox **Use FTP** is enabled, as in Figure 12.6, the dialog allows a host to be specified where the simulation should be started. At that time the relevant simulator files will be uploaded using FTP to that host. This functionality is required for starting simulators on the Phar Lap ETS platform (see Appendix G).

Figure 12.6: Specify FTP Server window

Show Current Simulations

Use this menu item to check the status of each of the available simulation servers with respect to the number of simulations running on those servers. An example is shown in Figure 12.7. The **Show Paths** button can be used to show the exact path of each the simulation running on the servers. When the paths are shown, the button will change into a **Hide Paths** button, which reverses the action. The **(Re)Connect** button can be used to connect to one of the simulation servers shown. The **Kill Sim** button can be used to kill a simulation if a run is hanging for any reason and is no longer responding to the Simulation Controller.

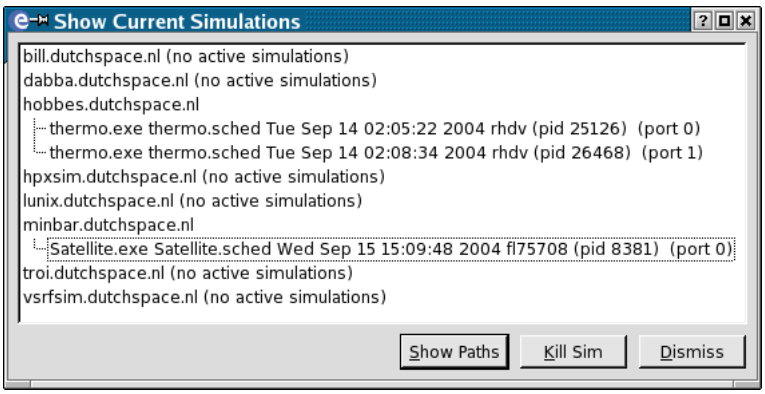


Figure 12.7: Show Current Simulations window

Reconnect to ETS Simulation

If the **Use FTP** option has been enabled in the *Server:Select Server* dialog, this menu item will be enabled. It allows to reconnect to the specified Phar Lap ETS simulator. (These simulators cannot be selected using the *Server:Show Current Simulations* menu item, as no EuroSim daemon can be run on Phar Lap ETS.)

Only use this action to reconnect to a simulator that corresponds with the selected model, otherwise results will be unspecified. (Most likely establishing the connection will be succesful, but the parameters between the expected model and actual simulator will not match.)

Disconnect From Server

This menu option will disconnect the Simulation Controller from the simulation server. The simulation will remain on the server, and the Simulation Controller can be reconnected to the server using the *Server:Show Current Simulations* or *Server:Reconnect to ETS Simulation* menu items.

In case the **Use FTP** option is enabled, the intermediate results are retrieved from the server (using FTP) and stored in the appropriate result directory.

12.6.5 Control menu

Set Realtime

This menu item acts as a toggle with which the simulation can be set to real-time mode or non-real-time mode. This can only be done before initializing the simulator.

Speed Control

Use this menu item to get the Speed Control Window as shown in Figure 12.8. When the simulation is running non real time the user can speed up or slow down the scheduler clock with the slider. The 'as fast as possible' button selects a mode where the scheduler is boosted to maximum speed without internal clock overhead. The actual speed can be lower than the requested speed, since the scheduler slows down if tasks do not complete in time[1].

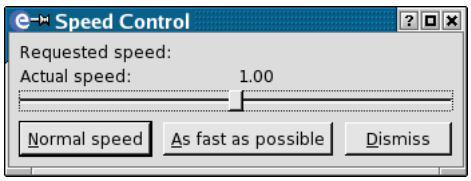


Figure 12.8: The Speed Control window

Init This will initialize the simulator. Standard this process comprises of the following steps:

[1] Speed Control has no effect if an external clock is used whose frequency cannot be changed by EuroSim.

1. Load the application model associated with the current simulation definition.
2. Use the data dictionary information to set initial values.
3. Use the Initial Condition files (if active) to update initial values.
4. Execute the task from the initializing schedule through the scheduler.
5. Execute the actions that are tagged as active during the initializing state. Once the initialization is complete, the simulator will be in the standby state at simulation time 0.0000 seconds, or the simulation time set by a script or model code.

If **Use FTP** has been enabled in the *Server:Select Server* dialog the following steps are executed before the default steps:

1. Check if no model is running on the selected host. If there is, an error is displayed and the **Init** action is aborted.
2. Collect the application model files and transfer these to the selected Phar Lap ETS host using FTP.
3. Collect the required "stub" DLL files for the model and transfer these as well.
4. Generate and transfer a "run.cmd" file that specifies the model with the correct runtime parameters.

... Rest of the steps.

Reset This will reset the simulation (i.e. perform steps 2 through 5 of the initialization process). Note that if the schedule contains an output connector connected to ABORT, the simulation cannot be reset.

Step This will advance the simulation through one executing cycle. If the schedule contains a low frequency task, then this could be a significant period of time.

Go This will put the simulator in the executing state.

Pause This will temporarily stop the simulation (put it in standby state). The simulation is not necessarily completely inactive however, as tasks and actions specified for the standby state will be still executed.

Stop This will stop the simulation gracefully. The simulator will be transitioned to the exit state, all open files will be properly closed and the connection to the simulation will be disconnected.

If the simulation was run on the Phar Lap ETS platform using the **Use FTP** option from *Server:Select Server* dialog, the result files from the simulation will be retrieved using FTP and stored in the result directory.

Abort This will abort the simulation instantaneously. Open files will not be closed by EuroSim, but rather by the operating system, which results in loss of data as data still in memory is not saved.

If a test execution has resulted in a simulator hang, or remaining executables from previous simulation runs, use the *Server:Show Current Simulations* menu option and select the offending simulation and request **Kill Sim** to remove the remaining executables.[2]

Raise Event

Show a list of available user defined events. Select an event and raise that event by either double clicking the event or pressing the **Raise Event** button. This menu item is only available when the connection to the simulator is active and if at least one user defined event is available.

[2] As a last resort, use the `efoKill` command from a UNIX shell or Windows command prompt to remove the remaining executables, see Section 22.7.2. The `efoList` command can be used to list the simulator runs currently executing on the host machine, see Section 22.7.1 or the UNIX manual pages for more information.

Suspend/Resume Recording

This menu option allows the user to activate/deactivate all recording actions in the simulation via a single request. This can be useful for temporarily suspending recording during a simulation run.

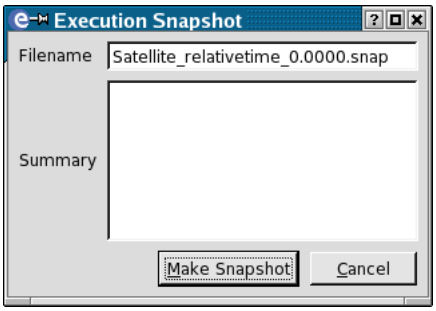


Figure 12.9: Take Snapshot window

Take Snapshot

This menu option will pop-up a window (see Figure 12.9) with which a snapshot of the current state of all simulation variables can be made. In the same window a comment can be added to the snapshot. The file created has a default extension of `.snap`. Snapshot files can be used as initial condition files (see Section 12.7.4).

Apply Snapshot

This menu item will have a sub-menu showing all available initial condition and snapshot files, i.e. all files referenced within the current simulation definition. Select one of the initial conditions to override current simulation values with the values in that file.

Apply Initial Condition

Apply the selected initial condition file to the currently active simulation to override the current simulation values with the values from the selected file.

Check Health

Check whether the connection to the simulator is working correctly. A message appears in the log pane describing the health status of the simulator.

12.6.6 Tools menu

Preferences

This option shows the Simulation Controller preferences dialog for editing user specific global settings as show in Figure 12.10.

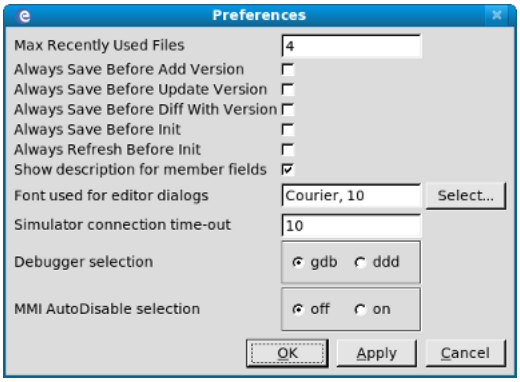


Figure 12.10: The Simulation Controller preferences window

Settings in this dialog allow you to specify how the Simulation Controller GUI behaves. This is independent from the project that is loaded. Settings that can be specified define for instance

the maximum number of Simulation Definition files that are stored in the most recently used files list in the *File* menu. You can also select whether all changes are always automatically written to disk when the stimulator is started, or which debugger will be launched when you use the Start Debugger (F5) option from the *Debug* menu. The MMI Auto Disable option forces the Simulation Controller to automatically disable any non visible MMI tab. This mode should only be used when large number of MMI tabs and monitors are used, and the user experiences that the Simulation Controller becomes unresponsive. In such extreme case the responsiveness can be improved by disabling tabs. Switching the MMI Auto Disable mode on automates the disabling, leaving only the visible MMI tab active.

CPU *Load*

This option enables or disables a CPU load monitor as shown in Figure 12.11.

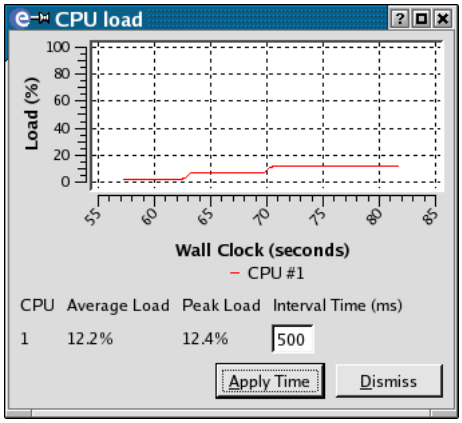


Figure 12.11: The CPU load window

The average and peak load percentage readings are shown for each CPU. The loads are measured over the time interval specified in the line edit in the last column. The average load shows the average of the measured loads over a 500 milliseconds period. The graphical plot shows the maximum of the measured loads over the 500 milliseconds period. The peak load reading shows the maximum measured load encountered during the simulation.

The load measurement time interval can be set in a range from 1 to 9999 ms. If you edit values in the last column you should press the **Apply Time** button to actually use the changed value. If the measurement interval is larger then 500 milliseconds, then the average load will be equal to the actual load in the plot as the time measurement interval is larger then the 500 msec interrogation period used by the Simulation Controller.

This CPU load monitor is only available if a connection to a simulator is active and the simulator is running in real time.

Rec/Stim Bandwidth

This menu item will show in a window (see Figure 12.12) the runtime bandwidth (in bytes/second) for the recorders and stimuli defined in all scenarios in the Simulation Definition. There are two estimates: one for all actions and one for all *active* actions. These estimates do not take into account start and stop times of these actions, or any other conditions (such as a test like `if varx >100 record ...`). The *actual* bandwidth values are only available during a simulation.

The *Time before disk full* item is an estimate based on the bandwidth of the active recorders and does not take other file actions into account. It also assumes that all recorder files are written to the results directory as displayed in this window.

Press the Rescan button to perform a new calculation based on the most actual bandwidth and free disk space values.

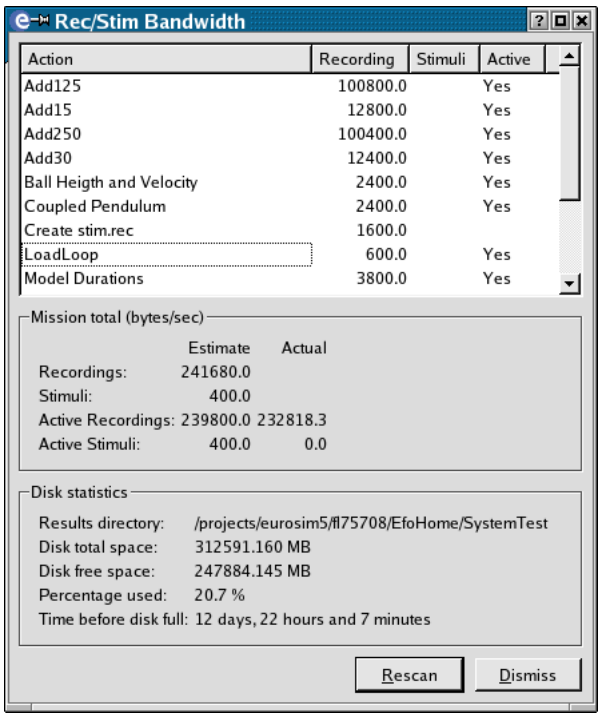


Figure 12.12: The Rec/Stim bandwidth window

Configuration

This menu item will display a window in which various information on the current simulation is given (see Figure 12.13). In the top half of the window the names of the files currently in use as model, schedule, export, alias file, TSP map file, data dictionary, initial condition and scenario are displayed, as well as any stimuli data files referenced so far. Finally, the actual stimuli throughput (in bytes/sec) is given. In the bottom half of the window any recording data files in use and the recording throughput are given. Also (prior to requesting Init), the user can change here the directory in which all results files should be stored, as well as whether additional date and time subdirectories should be created where the results files are placed. The **Show Paths** button can be used to view the full path of each of the file names. The **Rescan** button can be used to get the latest information on the throughput rates.

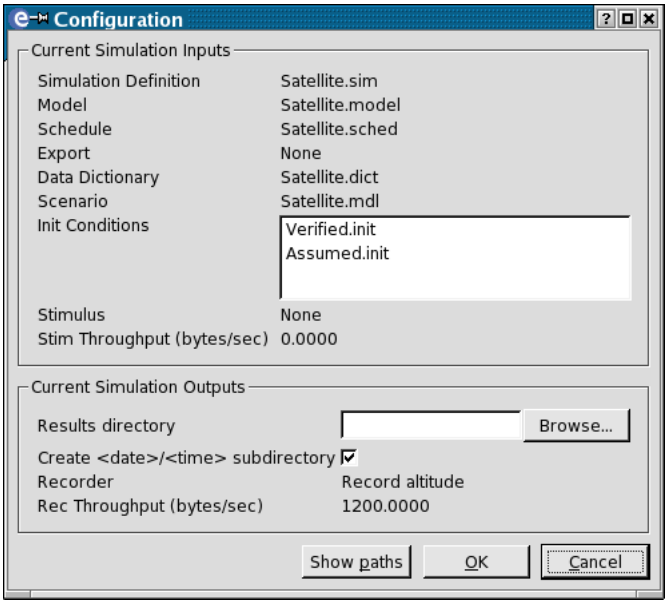


Figure 12.13: Sample Configuration

12.7 Input Files tab page

This tab page lists all files used in the Simulation Definition. These files can be removed through *Edit:Delete*, new files can be added through the *Insert* menu and the contents can be edited (where applicable) through the *Edit:Properties* menu.

The tab page consists of a tree structure that organizes the files by type:

Top Level
: Shows the used simulator definition (`.sim`), model (`.model`), schedule (`.sched`), export (`.exports`), alias (`.alias`) and TSP map (`.tsp`) files.

Scenarios
: Shows all scenario (`.mdl`) files.

MMI*s*
: Shows all Man-Machine Interface (`.mmi`) files.

Initial Conditions
: Shows all initial condition (`.init`) files.

Calibrations
: Shows all Calibration files (`.cal`) files. This is mandatory if the calibration files are not included in the Model Editor and are loaded via the programming API. If they are included in the Model Editor tree, it is still allowed to also include these in the Simulation Controller to provide easy access to end users.

User Program Definitions
: Shows all User Program Definition (`.usr`) files.

You can reorder the scenario or MMI tab pages. To do that you drag and drop a scenario or MMI file to before or after another scenario or MMI file.

To reorder the Initial Condition files (and thus the order in which these files are applied) you can also use drag and drop to move then around.

12.7.1 Menu items

The following *File* menu items are available in the Input Files tab page:

Select Model
: Select another model file for this Simulation Definition.

Select Schedule
: Select another schedule file for this Simulation Definition.

Select Export
: Select an exports file for this Simulation Definition.

Select Alias
: Select an alias file for this Simulation Definition.

Select TSP *map*
: Select a TSP map file for this Simulation Definition.

Save File As
: Save the selected file to another location.

The following *Edit* menu items are available in the Input Files tab page:

Properties
: Allows you to edit the properties of the selected file. For scenario and MMI files the corresponding tab page will be raised to the front. For Initial Condition and User Program Definition files a dialog will appear.

Delete Remove this file from the Simulation Definition. Note that the actual file is not deleted, the entry is only removed from the Simulation Definition.

Activate
Only valid for Scenario, MMI and Initial Condition files. Mark this file *Active*, i.e. this file will be used when the simulator starts.

Deactivate
Only valid for Scenario, MMI and Initial Condition files. Mark this file *Inactive*, i.e. this file will not be used when the simulator starts. Inactive scenario, MMI and initial condition files are ignored by the simulator.

Launch Only valid for User Program files. This will launch the program definition.

If the launch User Program produces output and/or error messages then a window will pop up that shows those messages.

The following *Control* menu item is available in the Input Files tab page:

Apply Initial Condition
The currently selected initial condition file will be applied to the running simulation.

Double clicking on the file name has the same effect as selecting *Properties* from the *Edit* menu. There are a few exceptions: double clicking on a User Program Definition file when a connection to the Simulator is active will *Launch* the program.

12.7.2 Context menus

Two context menus are available in the Input Files tab page depending on where you click the right mouse button. If you click on a file item in the tree then a context menu with the following items appears (see Section 12.7.1 for a description of the menu items):

- Properties
- Delete
- Activate
- Deactivate
- Launch
- Apply Initial Condition
- Select Model
- Select Schedule
- Select Export
- Select Alias
- Select TSP map

The other context menu appears when you click outside the tree area to the right of the last column or below the last row (see Section 12.6.3 for a description of the menu items):

- New Scenario
- Add Scenario
- New MMI

- Add MMI
- New Initial Condition
- Add Initial Condition
- New User Program Definition
- Add User Program Definition

12.7.3 Data Dictionary Aliases

The alias file defines aliases for individual data dictionary variables. A variable is defined through its data dictionary path. It is possible to create an alias for a composed variable such as an array or structure or to create an alias of an individual element of that variable.

Aliases are placed in a special /alias sub tree of the data dictionary at run-time. It is possible to refer to aliases using their short name through the client-server protocol to set and get individual variables (dtSetValueRequest or dtGetValueRequest) or using the TSP protocol.

The aliases placed in the /alias sub tree are accessible as if they were normal data dictionary variables (which they are).

12.7.4 Initial Condition Editor

The Initial Condition editor allows the specification of a particular state to which the model should be initialized prior to execution, e.g. locations of payloads or the state of hatches. It is only necessary to specify values in the initial conditions if these values override the initial value specified in the API header. The initial conditions are set prior to execution of the code, and a simulation can be re-initialized during a run.

The validity of the initial condition cannot be checked by EuroSim. However, the Initial Condition editor will only allow values of the correct type to be entered which are the range that was specified in the API headers of the model.

The initialization sequence is as follows:

- first the simulator is loaded and the variables will get the values as they are hard coded in the source file.
- next the model is loaded and the variables defined in the API headers will get their designated default values
- finally, the initial conditions are used to set the variables specified in the Initial Condition files, with their values. The order of appearance in the *Input Files* tab page determines the order of initialization. I.e., the top-most Initial Condition file is applied first, followed by the second file, etc.

12.7.4.1 Starting the Initial Condition editor

The editor is started by double-clicking with the left mouse button on an Initial Condition file in the *Input Files* tab page, or by selecting an Initial Condition file and then selecting *Edit:Properties*. A dialog appears that uses the Dictionary Browser to represent the dictionary and to edit the initial conditions.

You can set initial values by left-clicking on the line containing the variable that you want to edit or by selecting the line and pressing F2.

Values that are out of bounds are rejected. If you want to set the initial value for a variable designated as a parameter then a window appears asking for confirmation.

You remove an initial value by clearing the contents. However, clearing a member of a structure or array will only reset the value to the default value. If you want to clear the initial value of the whole compound variable, then right click on the top variable node and select *Clear* from the context menu.

If the initial value that you entered is equal to the default value, then the initial value is cleared and removed from the set of initial condition values. As indicated above, this does not apply to the members of compound variables.

Any variable that has an initial value is marked with a small asterisk ( ). Also all entry point and org nodes that contain variables that have an initial value are marked the same way.

12.7.4.2 Context menu items

If you right click on a node or on the background a context menu appears with the following items (besides the menu items that are described in Section 12.5):

Clear The initial value is removed for the selected variable.

Show Modifications Only/Show All
This menu item toggles between showing all variables or only those that have an initial value. You can also use the key *F4* as a shortcut.

Undo Undo the last change.

Redo Redo the last *Undo* action.

12.8 Schedule tab page

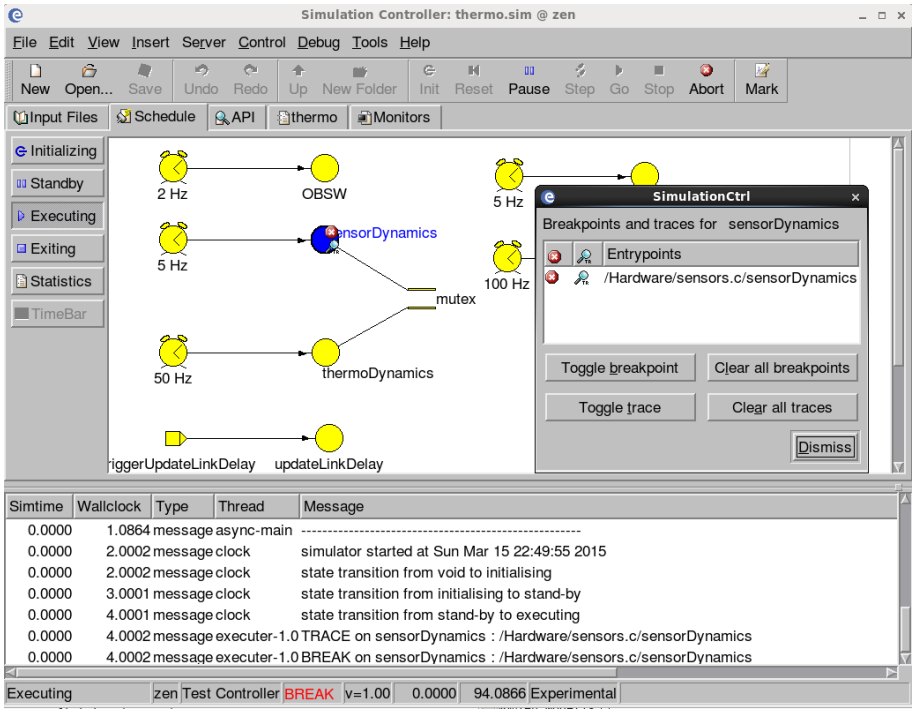


Figure 12.14: The Schedule Tab Page

The schedule used by the simulation definition can be debugged in the Schedule tab page (see Section 12.8.1). The upper fours buttons on the left allow switching between the schedule states. In these views the user can set traces and breakpoints, as well as disable and enable tasks prior to a simulation run. The lower two buttons `Statistics` and `Timebar` are related to displaying the timing results after a simulation run.

The Debugging concepts and operations are elaborated in the sections Section 12.8.1 up to Section 12.8.4. The timing analysis views are further elaborated in section Section 12.8.5.

12.8.1 Debugging Concepts

Debugging a simulation run (or software in general) is a means to investigate why the simulation run is not running as intended. In EuroSim this is done by allowing the user to run the simulation entry point for entry point. Thus, instead of going through the whole of the simulation, the Debug Control window allows the user to stop at any entry point he wishes, or even, to stop at every entry point before executing it. This process is called *single stepping* through the simulation code. However, as it can be rather tedious to single step through all entry points, *breakpoints* are available. A breakpoint is a kind of stop sign next to an entry point. Whenever the simulator encounters such a stop sign, it will hand over control back to the user.
Also, in order to assist the user in debugging the simulation run, entry points can be traced and complete tasks can be disabled or enabled at will (note that if a task is disabled, all tasks connected to it 'downstream' in the schedule will also not be called).

Single stepping, breakpoints and disabling of tasks are all easily controlled through the schedule tab page. The schedule tab shows the schedule as defined by the Schedule Editor. You can set breakpoints, traces and enable/disable tasks using the *Debug* menu or by right-clicking on a task to show the context menu.

If you are in debugging mode, then the simulation state is 'executing', even if you are paused at a breakpoint. In such a case, the main window will say 'executing' whilst the simulation time is stopped. In order to return to normal executing, you need to clear all breakpoint tags and continue using the **Continue** button.

If you set a breakpoint of a task in Initializing state, then that breakpoint will not work because the list of breakpoints is passed on to the simulator *after* the Initializing tasks have been called. This is a known limitation.

12.8.2 Debug Control objects

12.8.2.1 ○ Enabled task

These are the tasks as defined in the schedule of the simulation. An enabled task will be executed by the simulator.

12.8.2.2 ⊠ Disabled task

A disabled task will not be executed by the simulator. Note that any task connected to a disabled task will also not be executed.

12.8.2.3 Current task

The current task (shown in green) is the task currently being executed by the scheduler. If the simulation is run on more than one processor, more than one current task can be present in the schedule view.

12.8.2.4 Breakpoint

This is used to indicate the entry point(s) which have a breakpoint attached.

12.8.2.5 Trace

This is used to indicate the entry point activation will be traced. A traced entry point writes time-tagged messages in the Simulation Controller log window. If an entry point has both a trace and a breakpoint, only the breakpoint is shown.

12.8.2.6 Color coding

The tasks are color coded:

blue indicates the selected task.

green indicates the currently executing task/breakpoint.

12.8.3 Menu items

The following *Debug* menu item is available in the scenario tab page:

Item Debug Settings...
Open the Debug Settings window to set and clear breakpoints and traces for the selected task.

Clear All Breakpoints
Clear all breakpoints in the schedule.

Clear All Traces
Clear all traces in the schedule.

Toggle Task Activity
Enable or disable the task.

Continue
Let the simulator run until a breakpoint is encountered. Note that the **Go** button on the main Simulation Controller window cannot be used for this purpose. If **Continue** is requested after all breakpoints have been cleared, then this puts the simulation run back into a normal, non-debugging mode. You can use the function key F8 to quickly access this menu item.

Step Advance the simulation to the next entry point to be executed. This button should not be confused with the **Step** button on the Simulation Controller window itself. You can use the function key F10 to quickly access this menu item.

12.8.4 External debugging facilities

There are two options for debugging model code within EuroSim. The first option is to use the debug control window in the Simulation Controller (see Section 12.8.1). This is useful for tracing which tasks and entrypoints get executed. It also offers an integrated interface with EuroSim itself.

However, when the model code is not behaving as expected, a symbolic debugger may become more practical. In these cases, it is possible to attach an external (symbolic) debugger. The only precaution to be taken is to set the usual `-g` flag in the Build Options of the simulator to include the symbols required by the debugger in the exectutable code. Because EuroSim uses the GNU compilers, the usage of the GNU Debugger (gdb) or graphical front-ends for it such as ddd or eclipse are advised. Of course symbolic debugging is not usefull with a real-time executing simulator as the timing will no longer be correct.

The Simulation Controller supports symbolic debugging by launching the debugger when pressing F5 or selecting Start Debugger from the Debug menu.[3]. Which debugger is to be launched can be configured in the Preferences menu item of the Simulation Controller. When the debugger is launched by the Simulation Controller it will automatically load the correct symbols and attach to the simulator executable. The execution of the simulator will come to a halt, the time displayed at the bottom of the Simulation Controller will no longer increase. At this point the user can type the `where` command to see the stack trace, set breakpoints, step or continue with the execution.

The use of symbolic debugging can be combined with the scheduler debugger capabilities in the Simulation Controller. First use the scheduler debugger capabilities to stop at the entrypoint that you want to start debugging. Then attach the symbolic debugger, set your breakpoint in the code and allow the scheduler debugger and symbolic debugger to continue.

[3]In EuroSim for Windows the debugger currently may not attach, but does get started. You can find the process id (pid) via the Task Manager's Performance Monitor after clicking Resource. Type `attach <pid>` to connect to the running simulator

An alternative approach for launching the symbolic debugging is for the user to start the debugger independently with as argument the simulator executable which can be found in the ¡modelname¿.WINNT or ¡modelname¿.Linux directory that is generated by the ModelEditor. The last argument should be the process id ((which can be obtained with the `ps` command). This approach is more likely for eclipse users as eclipse takes long to start.

Because the Simulator executable uses signals, the GNU debugger will get interrupted when attached and continuing the simulation. To avoid this, create a file `.gdbinit` in your home directory containing the following lines:

```
handle SIG34 nostop
handle SIG34 noprint
handle SIG35 nostop
handle SIG35 noprint
handle SIG36 nostop
handle SIG36 noprint
handle SIG37 nostop
handle SIG37 noprint
handle SIG38 nostop
handle SIG38 noprint
handle SIG39 nostop
handle SIG39 noprint
```

You can copy this file from `$(EFOROOT)/etc/gdbinit^`.

12.8.5 Timing analysis

EuroSim provides two approaches to record the timing characteristics of simulations for post analysis purposes. The first approach is a statistics recording, produced at the end of every successful simulation run. The second approach is a detailed recording of every event and execution over time.

12.8.5.1 Statistics view

The statistics view provides a text display of the timings file as produced at the end of a simulation run. The view is automatically loaded, but in offline mode the user can also load files via the browse button. Figure 12.16 shows the statistics view:

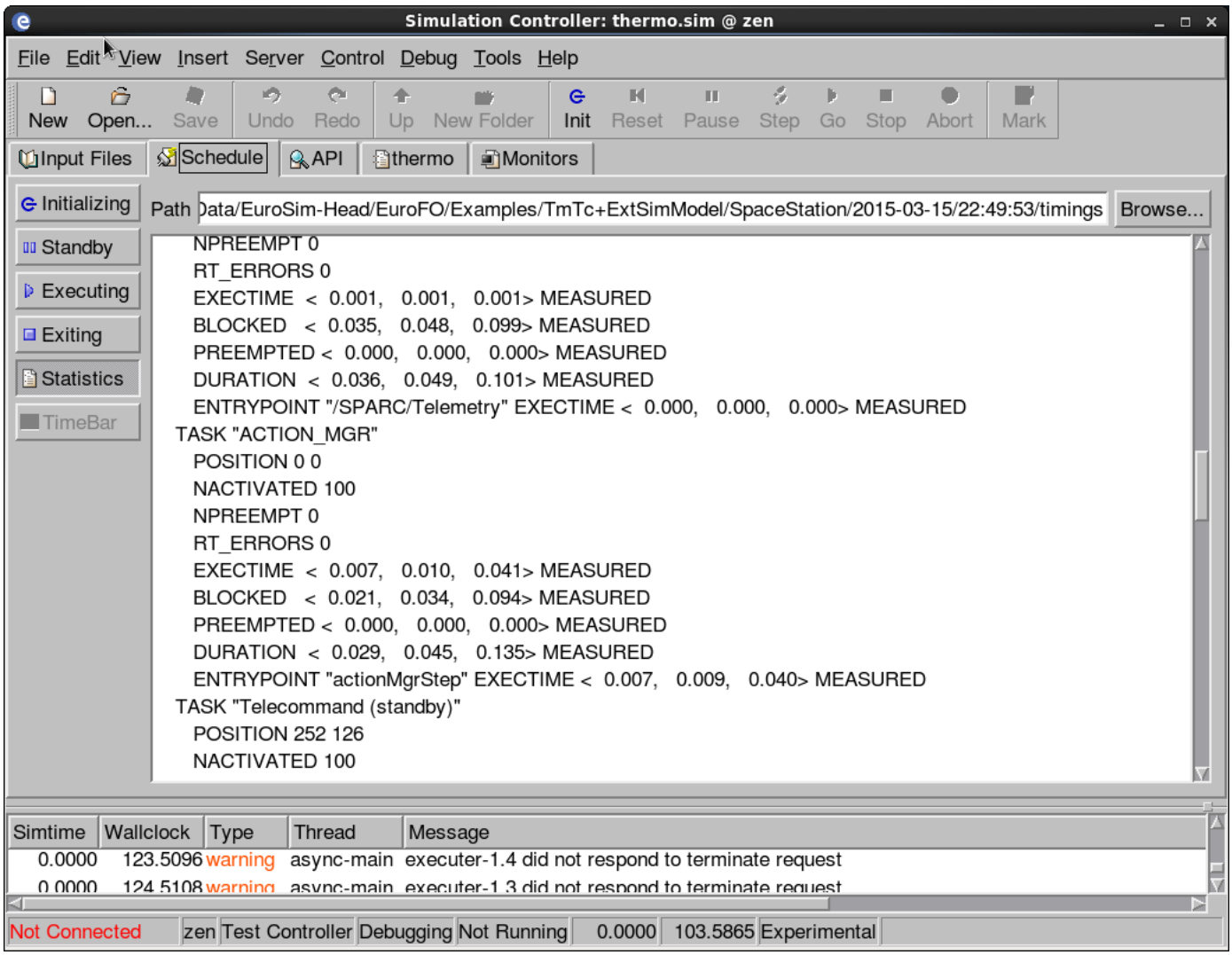


Figure 12.15: The API tab page

The Statistics view shows for most items the number of times it has been activated. For the tasks it provides also a detailed overview of the execution timing of the task and entrypoints:

Running
: The time that the code in the entry points was actually executing.

Blocked
: The time between task activation and start of execution.

Preempted
: The time the task was preempted by a higher priority task.

Duration
: The total time to execute the task entry points.

Offset The start of execution measured from the start of the current cycle.

Finished
: The end of execution measured from the start of the current cycle (Offset + Duration).

12.8.5.2 Statistics view

This section is for future versions. Currently the only display mechanism for timebar recordings are either to start the Timebar viewer from the command line or luanch it via the Schedule Editor Tools

menu.
To start the Timebarviewer from the command line type: `TimebarViewer.exe <timebar recording fil`

12.9 API tab page

The API tab page is a Dictionary Browser (see Section 12.5) with some extra functionality. When no simulation is running it just shows the dictionary with a few extra columns to show the minimum and maximum values, the unit of the value, and the description of the variable.

The column *Value* is empty until a simulation is started. As long as a connection to the simulator is active this column will show the current value of that variable just like a monitor in an MMI tab page. By clicking on the value or by selecting the line and pressing F2 you can edit it and set the variable to a new value. Parameter variables cannot be set as they are read-only. Basically the API tab page is a quick monitor facility.

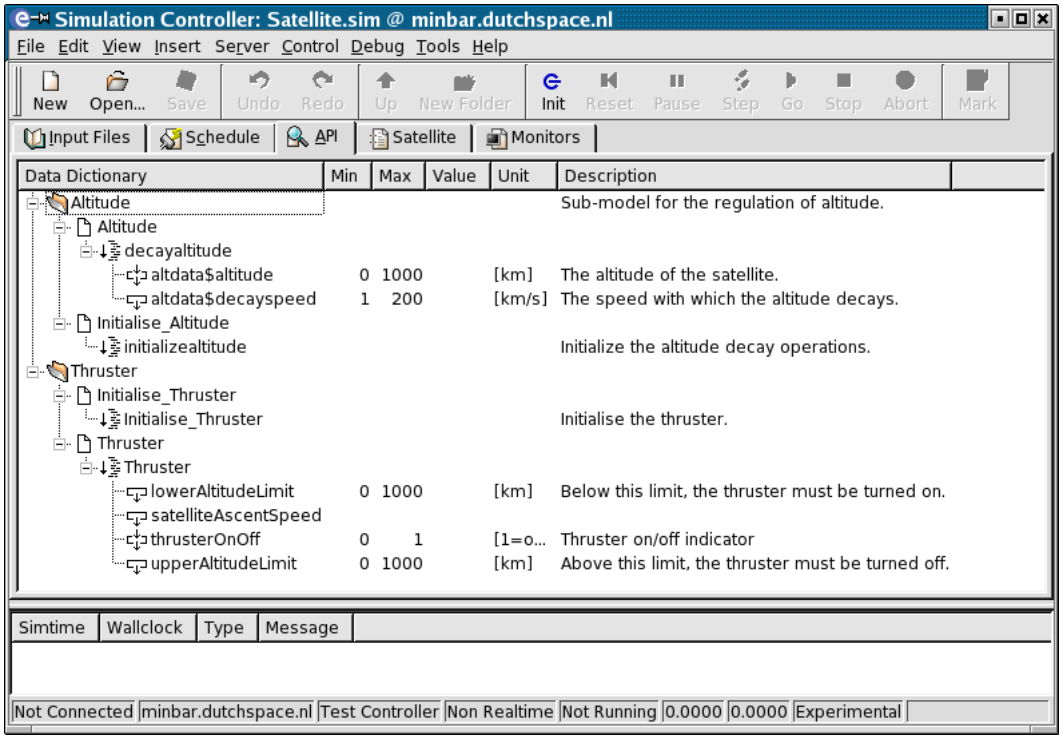


Figure 12.16: The API tab page

12.10 Scenario tab page

For each scenario file a separate Scenario tab page is created. When the scenario file is opened or created you are asked to provide the caption that appears as the name of the tab page.
The scenario can be presented either as a tree view (see Figure 12.17) or as an icon view (see Figure 12.18). In both cases the actions in the scenario can be organized in folders.

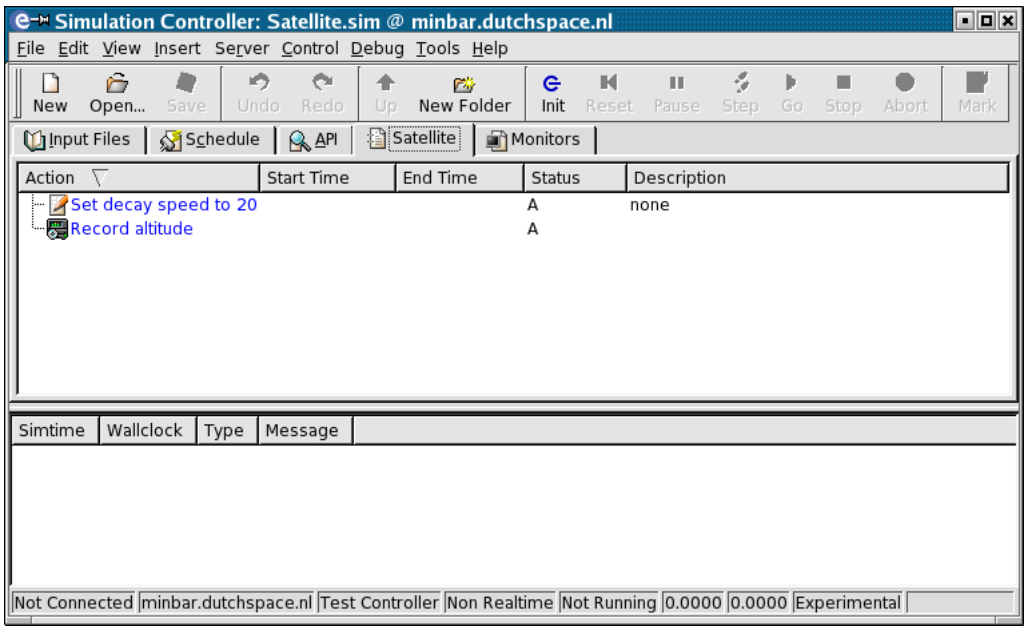


Figure 12.17: The Scenario tab page (tree view)

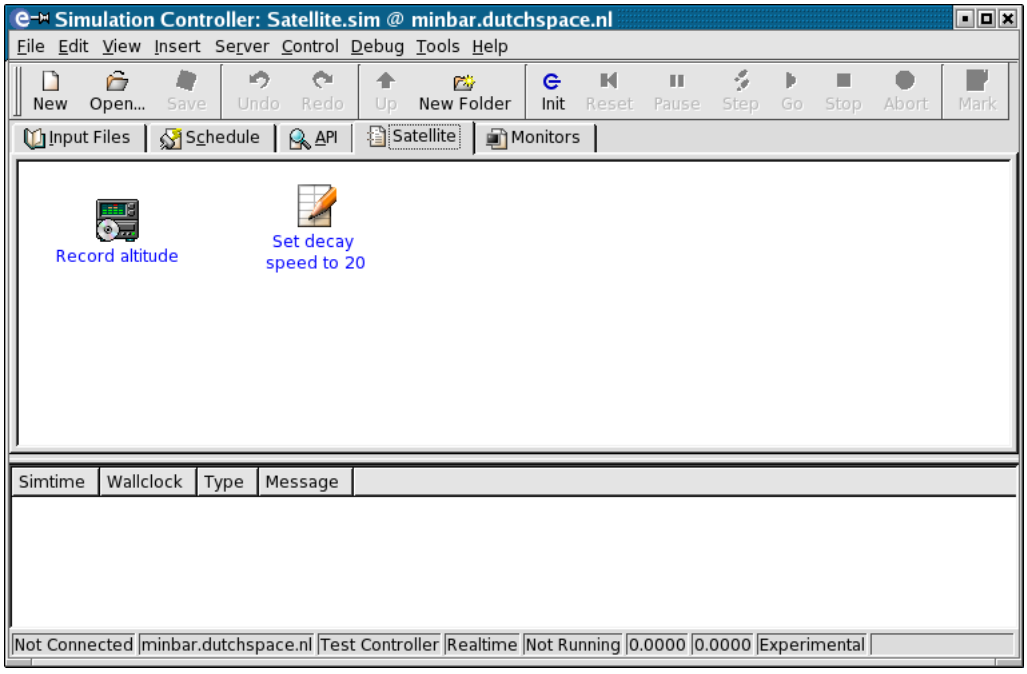


Figure 12.18: The Scenario tab page (icon view)

Actions in the scenario tab page can be either active or inactive (indicating whether it will be automatically checked against its run condition during a simulation run). For active actions the action name is shown in blue instead of black and (for the tree view only) the last column *Status* is marked with an '*A*'. By toggling the *Active* checkbox in the Action Editor dialog you can change the initial Active state.

During a simulation you can activate an inactive action or deactivate an active action. This does *not* modify the *Active* property of the action. When the simulation ends the Active status returns to its original setting.

When an action is actually executing, the *Status* column is marked with an '*X*' (for the tree view only) and the action name is shown in green instead of blue (active action) or black (inactive action).

Icons are used to represent actions (stimuli, recorders, monitors, scripts) or folders. The following icons are used in the scenario tab page:

 *Recorder*
this icon is used for recorder actions (defined using the Recorder Editor)

 *Stimulus*
this icon is used for stimulus actions (defined using the Stimulus Editor)

 *Monitor*
this icon is used for monitor actions (can only appear in old pre-Mk.3 scenario files)

 *Script*
this icon is used for script (free format MDL) actions

 *Folder*
this icon is used for folders that can contain other actions or folders.

Double clicking on these actions when a simulation is running will have the following effect depending on the type of action:

Recorder
activate or deactivate this recorder

Stimulus
activate or deactivate this stimulus

Monitor
start this monitor (it will show up on the *Script Monitors* tab page)

Script trigger this action

You can drag and drop actions and folders from one place to another. In order to rename a folder or action you can click on the item with the left mouse button to select it, then click again to edit the name. You can also press *F2* to edit the name of the selected item.

12.10.1 Menu items

The following *File* menu item is available in the scenario tab page:

Diff with
This menu option will pop-up a file-selection box, in which another scenario file can be selected. The selected scenario file will be compared with the current file, and any differences will be reported. The following symbols are used to identify any differences; these will appear between column listings of components in scenario A (first column) and scenario B (second column): -> means that an item is present in B but not in A <- means that an item is present in A but not in B <-> means that there is a difference in versions between a file in both scenarios <b> means that there is a difference in the body of two actions with the same name <c> means that there is a difference in the condition of two actions with the same name. See Figure 12.19 for an example.

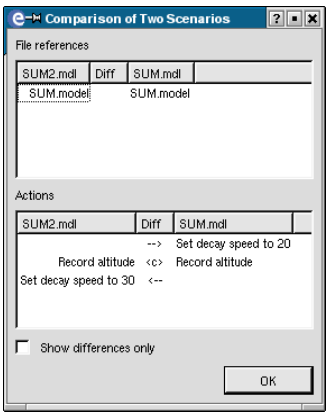


Figure 12.19: Example difference list

The following *Edit* menu items are available in the scenario tab page:

Undo/Redo
: Action changes and changes to the hierarchy structure of a scenario (i.e. actions moved to another folder, folders dragged to another position, folders deleted or added) can be undone and redone.

Cut/Copy/Paste
: Actions and folders support the usual cut, copy and paste operations. An action/folder that is copied or cut from one scenario tab page can be pasted onto the tab page of another scenario.

Activate/Deactivate
: Activate or deactivate the selected action. Only available if a simulation is running.

Properties
: Start the editor for the selected action.

Delete
: Delete the selected action or folder. The action or folder is not placed in the clipboard and thus cannot be pasted.

Edit Scenario Caption
: Change the caption of the scenario tab page.

Delete Scenario Tab Page
: Delete the scenario tab page. You will be asked to confirm this operation.

The following *Edit* menu items are available in the scenario tab page:

Show Icon View
: Toggle between the tree view and the icon view of the scenario.

Rearrange Icons
: Icon view specific: rearrange the icons of the scenario.

Up
: Icon view specific: by double clicking on a folder you move down in the action hierarchy. This menu item moves the icon view to one level up the action hierarchy.

The following *Insert* menu items are available in the scenario tab page:

New Recorder
: Create a new recorder action. See Section 12.10.3.2 for more information.

New Stimulus
: Create a new stimulus action. See Section 12.10.3.3 for more information.

New Script
: Create a new script action. See Section 12.10.3.1 for more information.

New Folder
: Create a new folder called *New Folder* followed by a unique number. You can immediately edit the generated folder name and change it to something more appropriate.

The following *Control* menu item is available in the scenario tab page:

Execute Action
: Execute the selected action. Only available when the connection to the simulator is active.

The following *Tools* menu items are available in the scenario tab page:

Commandline Script
: Quickly enter an action script and execute it. Only available if there is a connection to a simulator.

Convert Old Monitors
: Convert all monitor actions in this scenario to a new MMI tab page. You are asked for the file name of the new `.mmi` file, the caption for the new tab page and if you want to delete the old monitors after conversion.

12.10.2 Context menus

Two context menus are available in the Scenario tab page depending on where you click the right mouse button. If you click on an action item in the tree then a context menu with the following items appears (see Section 12.10.1 for a description of the menu items):

- Properties
- Activate
- Deactivate
- Execute Action
- Delete
- Cut
- Copy
- Paste
- Undo
- Redo

The other context menu appears when you click outside the tree area to the right of the last column or below the last row (see Section 12.10.1 for a description of the menu items):

- New Recorder
- New Stimulus
- New Script
- New Folder
- Up
- Paste
- Undo

- Redo
- Rearrange Icons
- Edit Scenario Caption
- Delete Scenario Tab Page

12.10.3 Action Editor

The Action Editor allows for the creation and modification of action objects, as they are used in the Simulation Controller. For each of the three possible action types, a variation of the Action Editor is used. A number of elements are shared amongst all editor variations, and these are described in the section on script actions (Section 12.10.3.1).

All actions are ultimately defined in MDL and handled at run-time in the same way. The provision of the Action Editors is to allow the most common types of actions to be created with the minimum knowledge of MDL syntax.

12.10.3.1 Script Action Editor

The script Action Editor is shown in Figure 12.20.

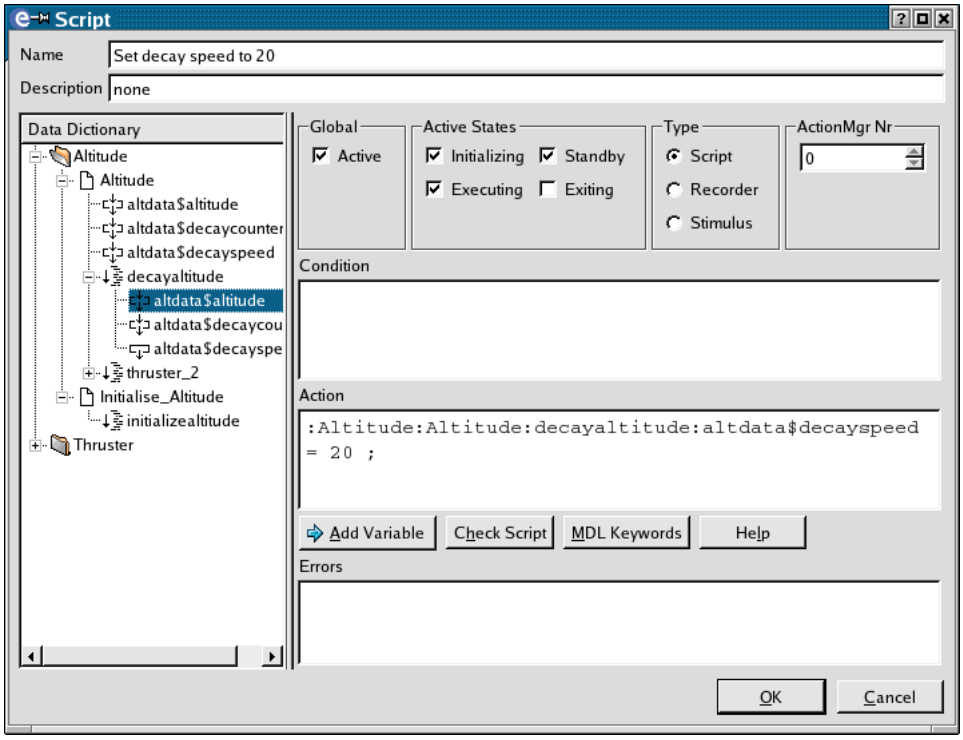


Figure 12.20: The Script Action Editor

The window consists of several parts, each part corresponding to an element of an action, as described in Section 12.2.2. In the first three parts, the following attributes can be entered:

Action name
: This is the name of the action as it appears in the tree or icon view. It should be a unique name within the current scenario.

Description
: A description of the action.

Global & Active States
: These options are used to indicate whether the action should either be active or inactive when the scenario is started; as well as in which of the four simulation states the action should be active.

ActionMgr Nr
: This attribute allows you to specify on which action manager this action will be executed.

The next part of the window is a text entry area where the execution condition of the current action can be specified. The execution condition is specified using the Mission Definition Language (see Chapter 21).

The final part of the window is another text entry area in which the actual action script can be entered. The **Check script** button can be used to check whether or not the entered MDL scripts are syntactically correct.

The MDL **Keywords** button will pop up a small window with a list of all available MDL commands. With the **Add to Clipboard** button (or by double clicking on a command) you can copy the command to the clipboard and paste it in the Condition or Action text entry areas.

The **Events** button will show a window with all input connectors from the schedule. With the **Add to Clipboard** button (or by double clicking on an events) you can copy the events to the clipboard and paste it in the Condition or Action text entry areas. If no user defined input connectors are found, then this button will not appear.

Any errors that are detected in the condition or action text will appear in the *Errors* area at the bottom of the window.

The left hand side of the window contains a Dictionary Browser (see Section 12.5) that you can use to drag and drop variables from the dictionary to the condition or action text areas. You can select more than one variable and they will be inserted into the text as a list of variables, one per line.

Besides drag and drop you can also double click on a variable to add it at the current cursor position, or use the **Add Variable** button to add all selected variable at the current cursor position.

12.10.3.2 Recorder Action Editor

The recorder Action Editor consists of two tab pages. The editor with the first tab page (*Variables*) on top is shown in Figure 12.21. The second tab page (*Script*) is the same as the script Action Editor window (Figure 12.20) except for an extra checkbox *Manual*. When checked the Condition and Action text areas can be edited, and the entry fields in the *Variables* tab page cannot be edited. When unchecked the situation is the other way around.

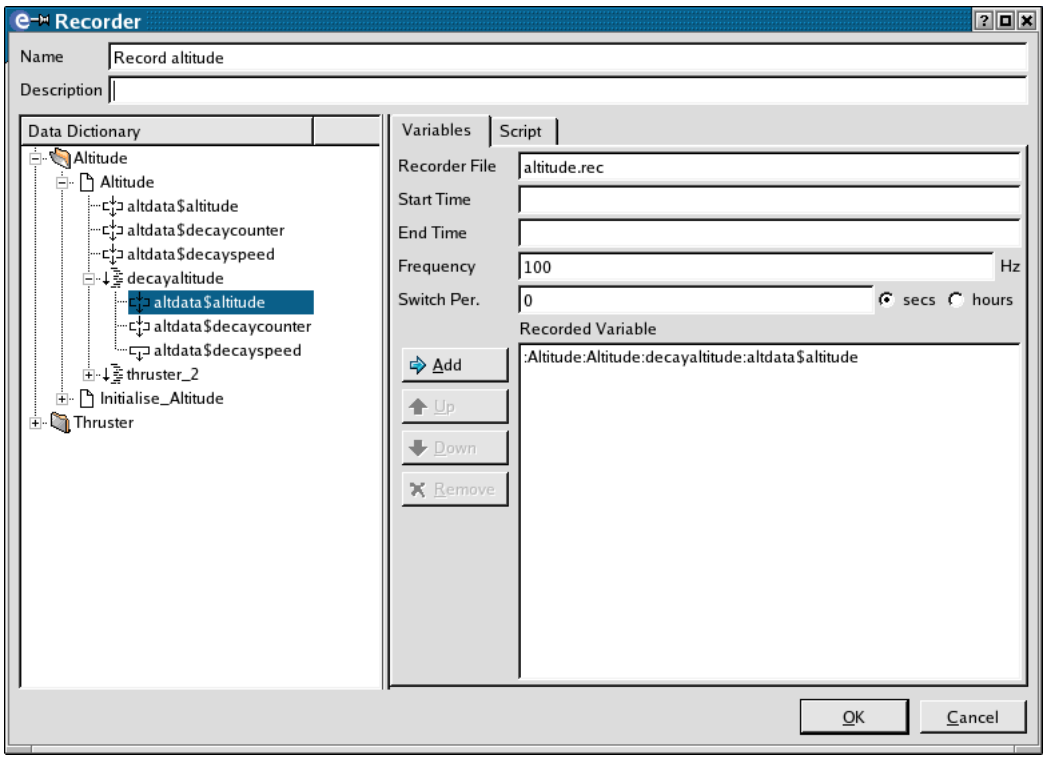


Figure 12.21: The Recorder Action Editor

It should not be necessary to check the *Manual* checkbox when building simple recorders. For more complex recorders you could start with the *Variables* tab page, fill in all the fields, switch to the *Script* tab page, check the *Manual* checkbox and then customize the condition and action.
In the *Variables* tab page, the following information can be entered to define a recording action.

Action name and Description
: As for the script action attributes.

Recorder File
: The name of the file in which the recorded variable values should be stored. The default file name is *actionname*`.rec`.

Frequency, Start Time and End Time
: The three attributes specify when the recording should start and stop, and with what sample rate the variable values should be written to the file. Note: if UTC is selected times should entered as YYYY-mm-dd HH:MM:SS[.sss], e.g. 2001-12-31 16:01:02.400.

Switch Per.
: A switch period can be specified to indicate that the recorder should switch periodically. This value can be given in units of seconds or in units of hours. After each elapsed switch period recorder *actionname-nnn*`.rec` is closed and recorder *actionname-nnn + 1*`.rec` is opened (where nnn is the switch counter).

Below these attributes the *Recorded Variable* listbox is shown. If any variables were added from the Dictionary Browser (see Section 12.5), they are shown here. Variables can be added using drag and drop, by double clicking on a variable in the Dictionary Browser, or by selecting variables in the Dictionary Browser and pressing the **Add** button to add them. To remove a variable from the list, select it, and press the **Remove** button. You can change the order of the variables by selecting variables in the listbox and using the **Up** and **Down** buttons.

The values of the variables in the list are recorded into the specified file at the specified frequency. EuroSim automatically generates an MDL-script for this purpose, which can be viewed in the *Script* tab page. If you want to use a non-numerical start or end time you can change the values manually in that tab. For example, you can use a simulator variable as the end time.

12.10.3.3 Stimulus Action Editor

When the stimulus editor is started you will be asked to select a stimulus file. You can select both a `.stim` file or a `.rec` recorder file.
The stimulus Action Editor consists of two tab pages (see Figure 12.20 and Figure 12.21). The Script Action Editor tab page (see Figure 12.20) is identical for both cases. The first stimulus Action Editor tab page (see Figure 12.21) has the following fields:

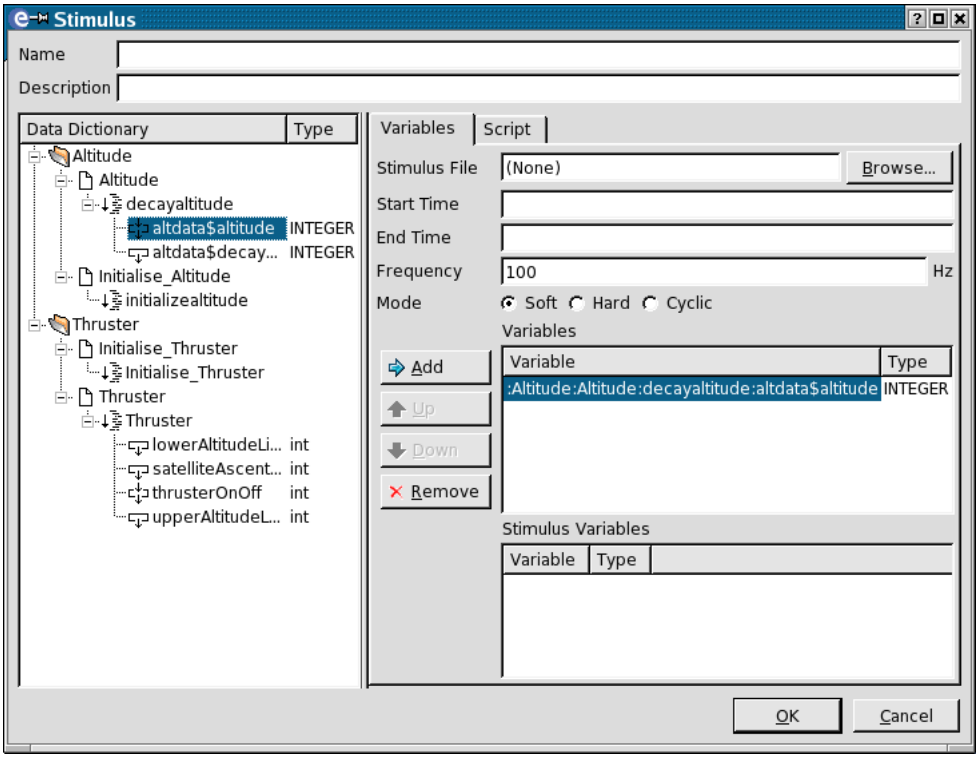


Figure 12.22: The Stimulus Action Editor

Stimulus File
: This should be the name of the input file containing the stimulus data.[4] You can use the **Browse** button to select an input file.

Frequency, Start Time and End Time
: The three attributes specify when the stimulus should start and stop, and with what sample rate the variable values should be read from the file. Note: if UTC is selected times should entered as YYYY-mm-dd HH:MM:SS[.sss], e.g. 2001-12-31 16:01:02.400.

Variables
: If any variables were added from the Dictionary Browser (see Section 12.5), they are shown here. Variables can be added using drag and drop, by double clicking on a variable in the Dictionary Browser, or by selecting variables in the Dictionary Browser and pressing the **Add** button to add them. To remove a variable from the list, select it, and press the **Remove** button. You can change the order of the variables by selecting variables in the listbox and using the **Up** and **Down** buttons.

Stimulus Variables
: The variables you add to the *Variables* list must match with the variables from this list. This list is extracted from the selected stimulus file. The variable types are shown in both lists and in the Dictionary Browser. This makes it easier to find a match. If the *Variables* list is empty

[4] Note that this action editor can only be used to make stimuli actions which read in data from an external source. To update a variable using a function (e.g. to feed a sinusoidal value), this needs to be defined using a script Action Editor with e.g. varZ = sin(varX).

when a stimulus file was selected, then the program tries to prefill the *Variables* list with correct matches.

Mode This can either be set to *soft*, *hard* or *cyclic*. With the first option, the data in the stimulus file is read in sequential order at the specified frequency, and the timestamps attached to the data are ignored. With the second option, only those data from the file are used whose timestamp match the current simulation time (or has the nearest elapsed time) when the data is requested. Data between these points are ignored. With the third option the data in the stimulus file is read in sequential order and after the last data point read, the stimulus file is reread from the beginning. These stimuli data is applied in 'soft' manner.

Consider the following input data file:
Data file:

```
simtime  data
0.9      10
1.9      15
2.9      17
3.9      19
4.9      20
5.9      18
6.9      15
7.9      15
8.9      14
9.9      12
```

If the stimulus action is to update variable 'Z' at a frequency of 0.5 Hz, and the stimulation mode was set to *soft*, then 'Z' would be updated as follows, i.e. every 2 seconds the next value is used from the file:
Simulation:

```
simtime  Z
0        10
2        15
4        17
6        19
8        20
10       18
12       15
14       15
16       14
18       12
20       no more data
```

If the stimulus actions is to update variable 'Z' at a frequency of 0.5 Hz, and the stimulation mode was set to *hard*, then 'Z' would be updated as follows, i.e. every 2 seconds the most 'up-to-date' value is used from the file:
Simulation:

```
simtime  Z
0        0
2        15
4        19
6        18
8        15
10       12
12       no more data
```


If the stimulus action is to update variable 'Z' at a frequency of 0.5 Hz, and the stimulation mode was set to *cyclic*, then 'Z' would be updated as follows, i.e. every 2 seconds the next value is used from the file, and when there is no more data, the data from the file is used again:
Simulation:

```
simtime  Z
0        10
2        15
4        17
6        19
8        20
10       18
12       15
14       15
16       14
18       12
20       10 (start from the beginning)
22       15
```

etc.

12.11 MMI tab page

For each `.mmi` file a separate MMI (Man-Machine Interface) tab page is created. When the `.mmi` file is opened or created you will be asked to provide the caption that appears as the name of the tab page.

The MMI tab page is a large pane on which you can place monitors to monitor variables in the simulation. There are two basic types of monitors: alpha numerical, i.e. each variable is presented as a caption followed by the value, and graphical, where each variable is tracked over time (or possibly against another variable) and plotted on a canvas. See Figure 12.23 for an example. Besides monitoring variables you can also add *Action Buttons* to execute MDL scripts or to enable/disable recorders or stimuli or add user defined plugins that act like monitors.

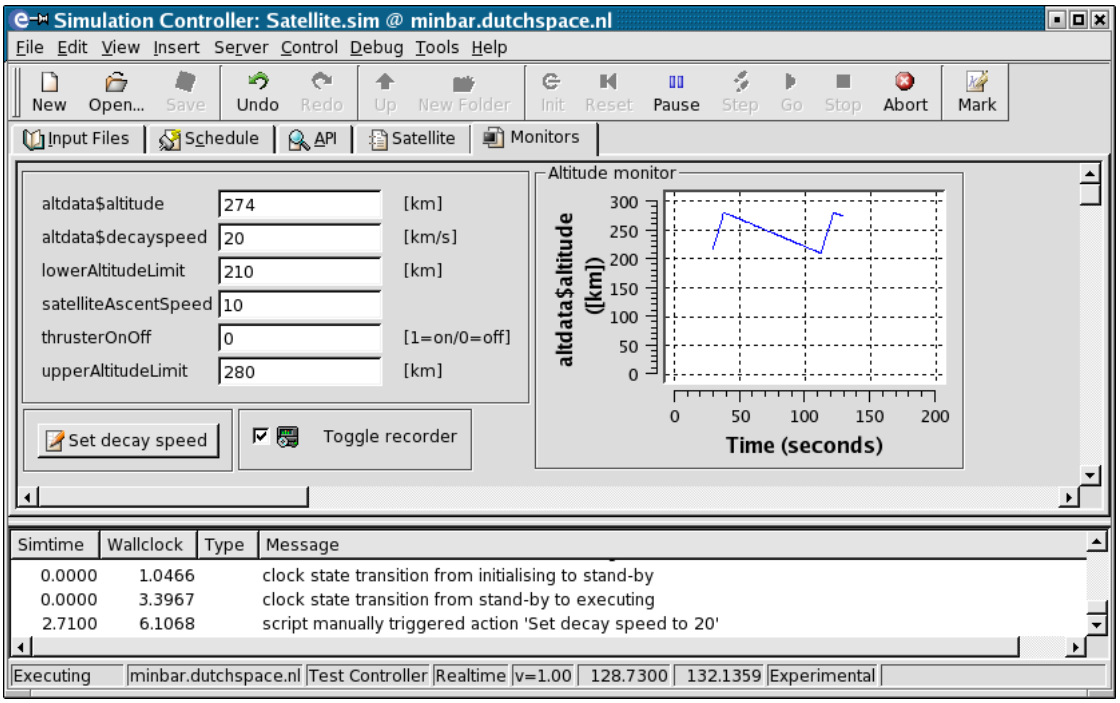


Figure 12.23: The MMI tab page

When you select a monitor by clicking on the monitor window with the left mouse button a rectangle with 'grab handles' appears. By clicking on the handles and moving the mouse around (keeping the left mouse button pressed) you can resize the monitor. If you click inside the rectangle and move the mouse around you can move the monitor to another place.

You can insert a new monitor by using the *Insert:New Monitor* menu item or by double clicking in the MMI tab page. Double clicking on a monitor will open the *Properties* window where you can modify the properties of that monitor.

You can insert a new user defined monitor (custom plugin) by using the *Insert:New Plugin* menu item. Double clicking on plugin monitor will open the *Properties* window where you can modify the properties of that plugin.
You can insert a new action button by using the *Insert:New Action Button* menu item. Double clicking on an action button will open the *Properties* window where you can modify the properties of that action button.

12.11.1 Menu items

The following *Edit* menu items are available in the MMI tab page:

Undo/Redo
: When a monitor or action button is resized, moved, or properties are changed then those changes can be undone and redone.

Cut/Copy/Paste
: Monitors and action buttons support the usual cut, copy and paste operations. A monitor or action button that is copied or cut from one MMI tab page can be pasted onto the tab page of another MMI.

  You can also (as a special case) copy or cut an old monitor action from a scenario tab and paste it onto an MMI tab page. The reverse is not possible since monitor actions are obsolescent.

Properties
: Edit the properties of the selected monitor or action button.

Copy to Desktop
: Copy the monitor or action button as a floating window on the desktop.

Edit MMI *Caption*
: Change the caption of the MMI tab page.

Delete MMI *Tab Page*
: Delete the MMI tab page. You will be asked to confirm this operation.

The following *Insert* menu items are available in the MMI tab page:

New Monitor
: Create a new monitor. See Section 12.11.4 for more information.

New Plugin
: Create a new plugin. See Section 12.11.5 for more information.

New Action Button
: Create a new action button. See Section 12.11.3 for more information.

12.11.2 Context menus

Two context menus are available in the MMI tab page depending on where you click the right mouse button. If you click on a monitor or action button then a context menu with the following items appears (see Section 12.11.1 for a description of the menu items):

- Properties

- Copy to Desktop
- Delete
- Cut
- Copy
- Paste
- Undo
- Redo

The other context menu appears when you click directly on the tab page background (see Section 12.11.1 for a description of the menu items):

- New Monitor
- New Action Button
- Paste
- Undo
- Redo
- Edit MMI Caption
- Delete MMI Tab Page
- Activate MMI Tab Page
- Deactivate MMI Tab Page

The latter two menu items, *Activate* MMI *Tab Page* and *Deactivate* MMI *Tab Page*, are short-cuts to the *Activate* and *Deactivate* menu items that are available in the *Edit* menu of the Input Files tab page (see Section 12.7.1).

12.11.3 Action Button Editor

The Action Button Editor (see Figure 12.24) allows you to add a button or checkbox to the MMI pane to execute MDL scripts or enable/disable recorders or stimuli. The editor has the following properties:

Caption
: This is the text that you want on the button/checkbox. If left empty, then the name of the action is used instead.

Scenario
: Choose the scenario containing the action that you want to use.

Action Choose the action from the scenario selected above.

A script action will now appear on the MMI tab as a button. Pressing the button when simulator is running will execute the action. Recorders and stimuli appear as a checkbox. When checked the recorder or stimulus is active, when unchecked it is not active. Toggling the checkbox will activate/deactivate the recorder or stimulus. See Figure 12.23 for an example.

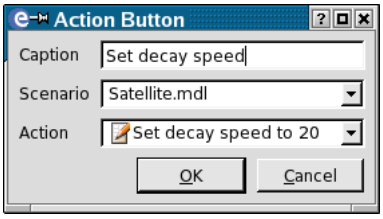


Figure 12.24: The Action Button Editor

12.11.4 Monitor Editor

The monitor editor is similar to the recorder Action Editor (see Figure 12.21) in terms of overall layout, but there are still many differences.

Nevertheless, as can be seen in Figure 12.25, the basics are the same: on the left hand side is the Dictionary Browser (see Section 12.5 for more information), on the right hand side is a *Variables* list and in between are buttons to add to, remove from and rearrange the variables in the list.

If you try to add an array or structure that contains more than 10 elements you will be asked if this is really what you want. Since structures and arrays are expanded in the *Variables* list to their constituent variables this prevents against the accidental selection of large arrays or structures. A monitor of more than 10 variables is generally not very useful.

There are two property areas in the editor: the properties above the *Variables* list are properties of the monitor as a whole, the properties below the list are properties of the currently selected variable in the *Variables* list.

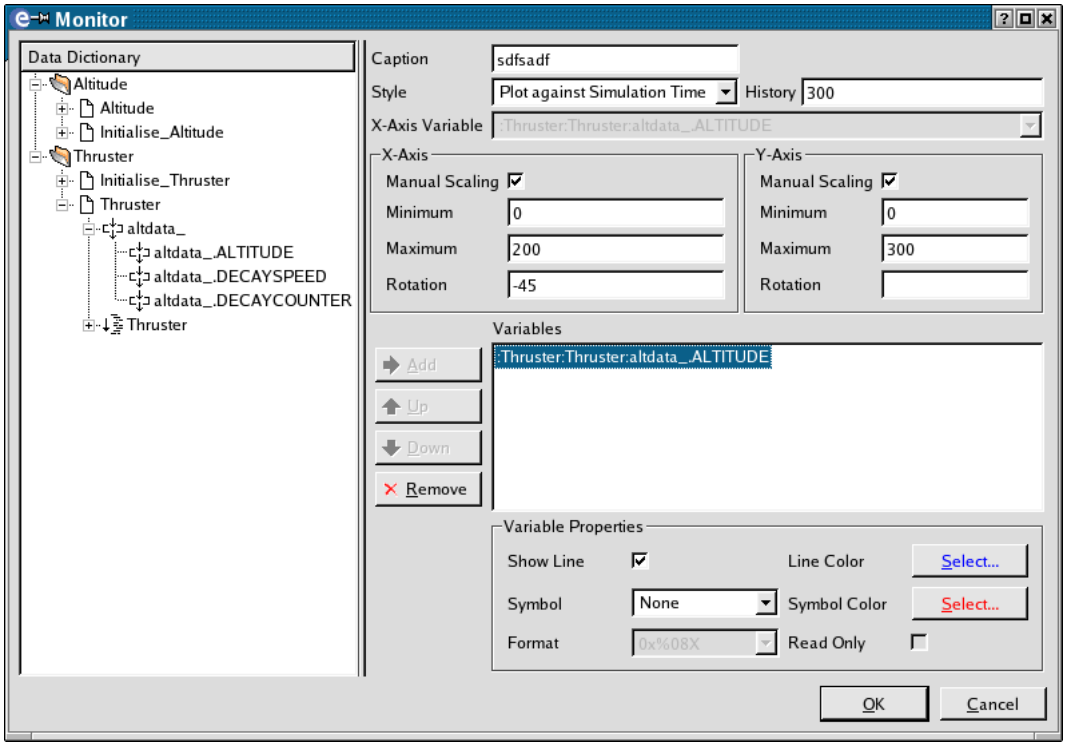


Figure 12.25: The Monitor Editor

12.11.4.1 Monitor Properties

The following properties are always available:

Caption
: Enter the caption of the monitor.

Style
: Select the style of the monitor. The following styles are available:

  Alpha Numeric
  : Give a textual representation of the value of a variable.

  Plot against Simulation Time
  : Use the value of the variable as the Y-axis value and the simulation time as the X-axis value.

  Plot against Wall Clock Time
  : Use the value of the variable as the Y-axis value and the wall clock time as the X-axis value.

XY-Plot Use the value of the variable as the Y-axis value and the value of a designated other variable as the X-axis value.

Depending on the style some of the other properties in the monitor editor become enabled or disabled. For the Alpha Numeric style the *Read Only* checkbox in the variable properties area is only enabled if the variable is an input variable and the *Format* combobox is only enabled if the variable is not a string. For the plot styles all properties are enabled except for the *Read Only* checkbox and the *Format* combobox. The *X-Axis Variable* combobox is only enabled when the *XY-Plot* style is selected.

The following properties are available when one of the plot styles is selected:

History This value indicates how many samples of each variable should be simultaneously displayed. Once the maximum is reached, the older values will be discarded.

Manual scaling
This checkbox can be checked if the user wishes to specify the minimum and maximum values for the axis.

Minimum
The minimum value for the corresponding axis.

Maximum
The minimum value for the corresponding axis.

Rotation
The rotation of the labels on the corresponding axis.

The following property is available when the *XY-Plot* style is selected:

X-Axis Variable
Select a variable from the *Variables* list that provides the X-Axis variable values.

12.11.4.2 Variable properties

The variable properties are disabled if no variable is selected in the *Variables* list. Otherwise they change the representation of the selected variable.

The following properties are available when the *Alpha Numeric* style is selected:

Format Allows you to enter an optional formatting string using the printf style, see Section 12.11.4.3. The drop down list box gives you a few suggestions for representing integer values as hexadecimals.

Read Only
If checked, then this variable cannot be modified in the monitor.

During a simulation run, an alphanumeric monitor can be used as a mechanism for updating the value of the variable(s) it is displaying. You just need to type a new value into the field and press Return. If the *Format* field specifies a conversion, f.i. to hexadecimal, then you must also enter the value in that format. For traceability, this update event is logged. Read-only variables cannot be edited and are displayed as text instead of an edit field. If the variable is a parameter, then that variable is always read-only.

The following properties are available when a Plot style is selected:

Show Line
If checked, connect the data points in the plot with a line.

Line Color
Press the **Select...** button to select the color for the line.

Symbol Choose a symbol to be used for each data point.

Symbol Color
Press the **Select...** button to select the color for the symbol.

12.11.4.3 Variable formatting and conversion

The *Format* field of the Variable properties allows formatting and/or conversion of the monitored variable. When this field is left blank, then a default formatting will be applied that is appropriate for the type of the variable. The *Format* field supports a sub-set of the format string as specified for the *printf* function, see the `printf(3)` man page for more details.

The following length modifiers are supported: **h** (short int or unsigned short int), **ll** (long long int or unsigned long long int). Make sure that the length modifier matches the type of the model variable in the simulator. You can retrieve the variable type by pressing the right mouse button on the variable in the Dictionary Browser and selecting the Info menu item in the context menu. Variables of type int, long int, float and double do not need a length modifier in the format string (note that int and long int are the same on 32-bit platforms).

The following conversion specifiers are explicitly *not* supported: **c** (character) and **s** (string).
Table 12.1 gives a few examples of formatting and conversion of monitored variables. Note that conversion to/from hexadecimal values can only be done on integers, while formatting of floating point numbers only works on float and double types.

Value in simulator	Format	Result in monitor
255	%X	FF
255	%08X	000000FF
255	0x%08X	0x000000FF
3.141592	%.2f	3.14
3000	%.2E	3.00E+03

Table 12.1: Examples of formatting and conversion.

12.11.5 User-Defined Monitors (Plugins)

To accommodate the need to add user-defined monitors to the MMI tab page, it is possible to load custom plugins. These are added as shared libraries during runtime. Section 12.11.5.1 describes the general use of these plugins in the Simulation Controller and explains where example code can be found and how it should be used. Furthermore it describes in more detail what has to be done to implement a plugin and what functionality can be used.

12.11.5.1 Loading Plugins

A plugin can be added to the MMI by using the *insert menu* or the right click *context menu*. A dialog will ask for a shared library file to be selected. Two examples (*pluginThermo.so* and *pluginKnob.so*) are available in the EuroSim *lib/MMIPlugin* directory.

12.11.5.2 Programming Plugins

The source code for the provided examples can be found in the EuroSim *src/MMIPlugin* directory. Plugins are written in C++ and use the Qt library. These are mandatory for plugin development.
Both examples use an extension to Qt, the Qwt library, that provides scientific GUI widgets. The use of Qwt is however not mandatory.
Every plugin will have to include two header files, which are located in the EuroSim *include* directory.

scUserPluginInterface
: interfaces the plugin with the Simulation Controller. All abstract functions of this header file need to be implemented in the plugin code

scMonInterface
: interfaces the Simulation Controller with the plugin. This header file contains methods the plugin can use to interact with the Simulation Controller and the simulation model.

scUserPluginInterface contains three abstract methods and one extern function.

scUserPluginInterface::update
: This method handles update requests by the Simulation Controller. Whenever an update request is sent, this method should update the variables and show them on the screen.

scUserPluginInterface::refresh
: This method is called to paint the monitor when the monitor is constructed or when the simulation is not running. It will usually just contain the paint instructions.

scUserPluginInterface::editProperties
: This method is called when the user requests the properties menu. The minimum functionality of this dialog should be to select variables.

CreatePlugin_t
: This function type is used by the Simulation Control to create a plugin and get a pointer to the object. Without it, the Simulation Controller will not be able to build and control the plugin.

DeletePlugin_t
: this function type is used by the Simulation Control to delete a plugin. Without it, the Simulation Controller will not be able to properly delete the plugin.

The actual plugin can use several methods to communicate with EuroSim. This way Variables can be requested, values changed, names set, etc. These methods are available through *scMonInterface.h*. Detailed descriptions are given in the header files itself.

changeValue
: Change the value of a variable in the model.

getValue
: Request the value of a variable in the model.

setVarlist
: Set the list of used variables.

getVarlist
: Request the list of used variables.

parentWidget
: Request the parent widget of the plugin.

dictWidget
: Request a variable selection dialog.

getPluginPath
: Request the path to the shared library

setCaption
: Set the caption of the plugin monitor

getCaption
: Request the caption of the plugin monitor

addProperty
: Add a custom property.

readProperty
: Request the value of a property.

clearProperty
: Clear all custom properties. Usefull to rebuild the list.

deleteProperty
: Remove a single property.

An example makefile for each plugin example is provided. They are called *plugin.make* and placed with the source code. These should help the user to quickly generate their own makefile for building, installing and testing their plugin.
After a plugin is compiled to a shared library, it can be tested for basic loading functionality. For this purpose a small program called *pluginTest* can be used. It is located in the EuroSim *src/MmiPlugin* directory. It requires the path to the shared library as an argument.

12.12 Message tab pane

All the messages from the simulator are logged in the message tab pane. By default there will be only one message pane without tabs. However, additional message tabs can be created in order to customize the logged messages (see Figure 12.26). Message logging can be customized by creating message filters which can be created by choosing a combination of different message types. Message types could be either EuroSim defined (by default) or user defined message types you created in your currently running simulation.

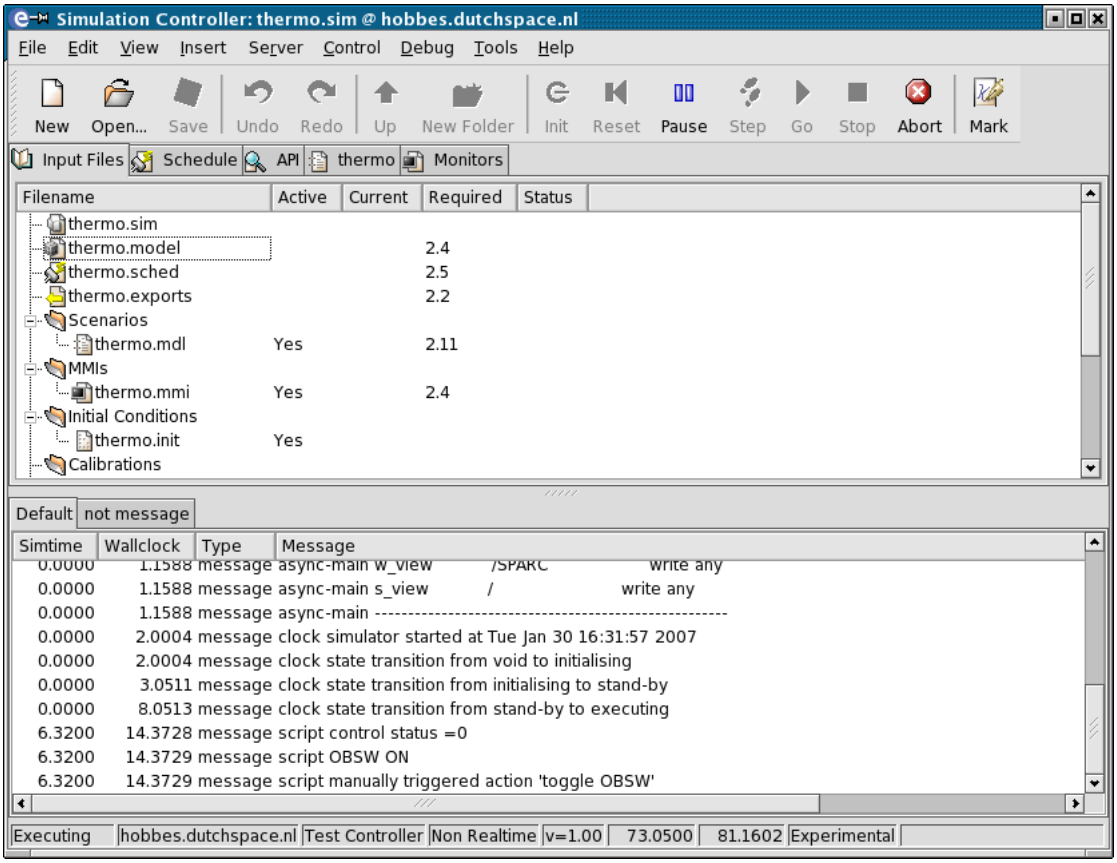


Figure 12.26: The Simulation Controller with message tabs

A new message tab can be created either by choosing *Insert:New Message Tab* menu item or by double clicking on the empty space (to the right of the last message tab) in the Tab header. A dialog box to edit the message tab properties appears (see Section 12.12.1).

Note: *i)* The message tab with title ”Default” is the default message tab. This title does not appear if this is the only message tab.

ii) The default message tab cannot be edited or deleted. However, the messages can be copied and cleared if necessary.

12.12.1 Editing message tab properties

The dialog box to edit the message tab properties has the following fields:

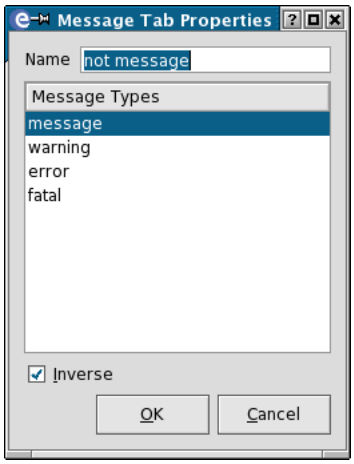


Figure 12.27: Message Tab Properties Dialog

Name Enter the name of the message tab (which appears in the tab header).

Message types
A list of all message types in the model, in the currently running simulation session and the built-in EuroSim defined message types (message, warning, error and fatal). If a message type appears in gray color it means either a simulator is currently disconnected (not running) or that the message type is not defined in the currently running simulation session. Even if some message types appear gray, they can be selected to create a message filter.

Inverse Check this check box to indicate that the selected message type messages should *not* be logged in this message tab.

12.12.2 Menu Items

The following *Edit* menu items are available when a message tab page is in focus:

Copy Copy the selected message in the currently visible message tab pane to the clipboard.

Copy All Messages
Copy all messages in the currently visible message tab pane to the clipboard.

Delete Delete the currently visible tab pane.

Message Tab Properties...
Change the properties of the currently visible message tab. A dialog box to edit the message tab properties appears (see Section 12.12.1).

Undo/Redo
Undo/Redo a message tab deletion.

12.12.3 Context menus

If you click the right mouse button anywhere on the message tab pane the following items appear (see Section 12.12.2 for a description of the menu items):

- Copy

- Copy All Messages
- Clear Log
- New Message Tab...
- Message Tab Properties...
- Delete
- Undo
- Redo

12.12.4 User defined message types

You can create your own message types using the EuroSim library function `esimReportAddSeverity()` in your simulation (see Section 14.4.4. When you initialize the simulator, all the message types that you have created appear in the message tab properties dialog box.

Chapter 13

Test Analyzer reference

The Test Analyzer can be used to create and display plots of the generated test results. It uses PV-WAVE[1] or gnuplot to display and print the plots. For most plots the user interface of the Test Analyzer is sufficient, but it is also possible to send commands to the PV-WAVE or gnuplot back-end directly.

The purpose of this chapter is to provide a detailed reference of the Test Analyzer.

The first part of this chapter describes how to start and use the Test Analyzer (Section 13.1 - Section 13.2). The second part can be used for reference (Section 13.4 - Section 13.7).

13.1 Starting the Test Analyzer

The Test Analyzer can be started by selecting the Test Analyzer button in the EuroSim start-up window (see Figure 6.1).

The Test Analyzer can also be started from the command line by issuing the `TestAnalyzer` command.

13.2 Using the Test Analyzer

The next sections describe how the Test Analyzer can be used without going into too much detail. For a complete description of a particular part of the user interface please refer to Section 13.4 - Section 13.7.

13.3 Test Analyzer main window

The main window of the Test Analyzer is shown in Figure 13.1. The main window contains the following elements:

[1] Not supported on the Windows platform.

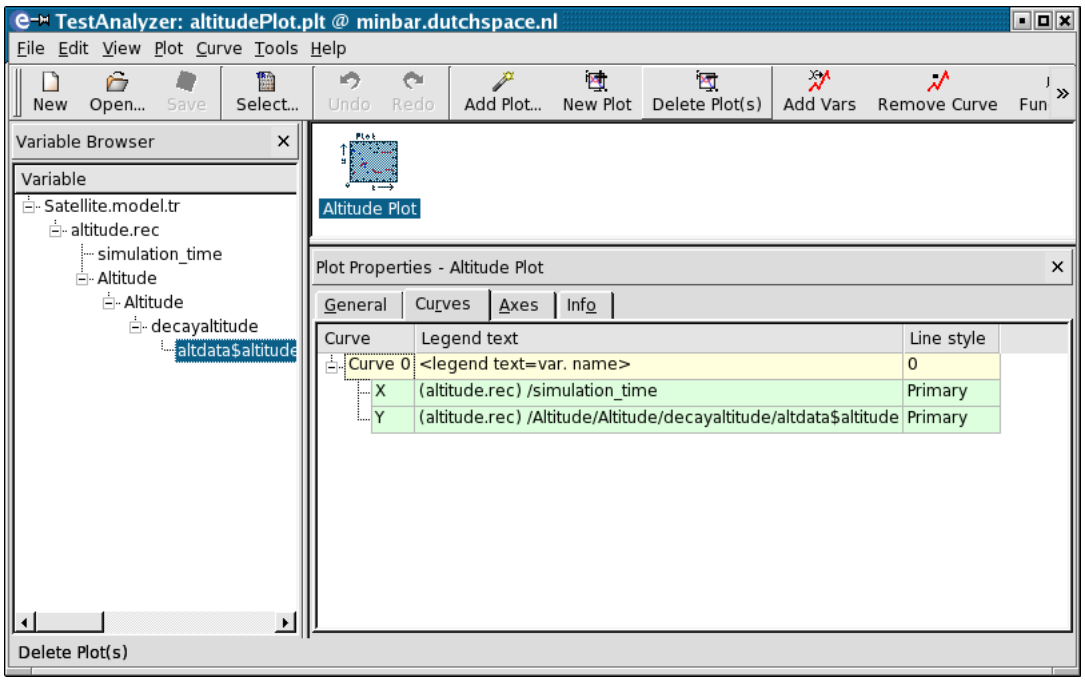


Figure 13.1: The Test Analyzer main window

Menu bar
: For a detailed description of the menu items see Section 13.7.

Toolbar A description of the action the toolbar button performs is displayed if the mouse is left above the button for a short period of time. The toolbar provides a shortcut to many often used menu items like undo, redo, add plot, etc.

Plot view
: The plot view holds the icons representing the plots that are defined.

Variable browser
: The variable browser contains the variables found in the test results that are loaded. You can use these variables to create or edit curves in the plots.

Plot properties
: The plot properties pane contains three tabpages. The first page deals with the general plot properties like plot title and description. The second page is dedicated to the curves of the plot (*curve editor*). The third page is used to change axes related settings like scaling (linear/logarithmic) and axis range.

Statusbar
: The status bar displays the location of the currently loaded test results file on the right. The rest of the statusbar is used to show short (status) messages.

13.3.1 Opening a plot file

The Test Analyzer works with plot files. A plot file contains one or more (often related) plots. Previous versions of the Test Analyzer worked with plot definition files (pdf). This file format is no longer in use. Instructions on how to convert old pdf files can be found in Section 13.3.2.

To open a plot file, select *File:Open...* from the menu or click on the button on the toolbar. The plot view now shows the plots defined in this file. To be able to show the plots, test results need to be loaded as well.

13.3.2 Importing old plot definition files

To import old plot definition files, select *File:Open*. In the dialog that appears, select the "Plot definition files (*.pdf)" from the file filter selection area (see picture below).

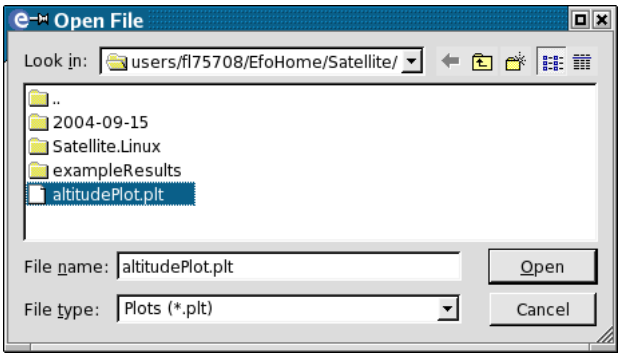


Figure 13.2: Importing plot definition files. Click on the "File type" combobox to switch between file formats.

Next, browse to the plot definition file that needs to be imported and click on the **OK** button. A warning message will appear stating that the pdf file will be converted. Press **OK** to convert the pdf file.

The Test Analyzer now contains the converted data. If you wish you can save the converted file with *File:Save* or with *File:Save As...* in case you wish to save the file under a different name.

13.3.3 Selecting the test results file

Plots cannot be shown until a matching set of test results is loaded. A matching set of test results is a test results file that contains the same variables as used in the plot(s). If the selected test results do not match (some of) the plots, these plots will be marked with a big red X.

To select a test results set, select *File:Select Test Results File...* and the test results file will be loaded into the variable browser. It is not possible to have multiple test results files selected at the same time.

13.3.4 Using recorder files

Usually, the recorder files used are the ones related to the selected test results file. Plots use the data from that specific test results set.

Sometimes however, it is desirable to be able to create a plot from a specific recorder file. For example, to compare the results from a certain test run to a reference run. This can be achieved by adding recorder files to the variable browser (*File:Add Recorder File...*).

Curves created with variables from this specific recorder file always display with the data in that specific recorder file.

Switching test result files has no effect on these curves. The variables in the curves from such a manually inserted recorder file are labeled with "[A]" (absolute).

13.3.5 Creating a new plot

To create a new plot, either select *Plot:New Plot* to create an empty plot or select *Plot:Add Plot Wizard...* to start the wizard that will guide you through the various needed steps to create a plot from information you provide.

13.3.6 Changing a plot

A plot is changed using the *plot properties* part of the user interface. To show the plot properties select a plot on the plot view and choose *Plot:Properties...*

Adding curves

Curves can be added to a plot in many ways. The easiest way is to use drag and drop. Select the variables you would like to add as curves in the variable browser and drag them to the curve editor or on the desired plot icon in the plot view. More information can be found in Section 13.4.2.

Changing curves

To change a curve or one of its properties, click on it in the curve editor. An edit field will appear depending on where you clicked. For example, clicking the variable name in one of the curves axis will show a selection box with the variables used (or recently used) in the plot.

A more detailed list of the possibilities can be found in Section 13.4.2

Removing curves

To remove a curve, select it in the curve editor and press the delete key, use the toolbar or menu ( *Curve:Remove Curve*).

Changing other plot settings

General plot settings can be changed on the "General" tab page of the plot properties area. This includes settings like plot title, description, legend position etc. A more detailed list can be found in Section 13.4.1.

Settings related to the axes like scaling and range can be changed on the "Axes" tab page of the plot properties area. Detailed information can be found in Section 13.4.3

13.3.7 Showing and printing plots

After a plot has been properly set up it is shown by selecting *Plot:Show Plot* from the menu (or double-click the plot icon). A new window appears containing the plot. If gnuplot is selected as the plot back-end, the window can be closed like any other window or by selecting *Plot:Close Plot* from the menu. If PV-WAVE is the current back-end the window can only be closed by selecting *Plot:Close Plot* from the menu.

To print one or more plots, select them and choose  *File:Print*. The print dialog appears.

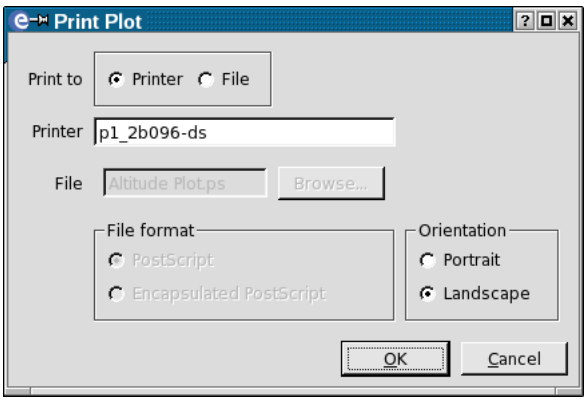


Figure 13.3: Printing plots.

It is possible to print to the printer or to print to file(s). Printing to the printer will print each plot on a separate page, while printing to file will print each plot in a separate file.

13.4 Plot properties reference

The next three sections describe the plot properties area. This area can be used to alter the plot's properties. It is divided into three parts: general properties, the curve editor and the axes properties.

13.4.1 General plot properties

Figure 13.4 shows the tab page with the general plot properties.

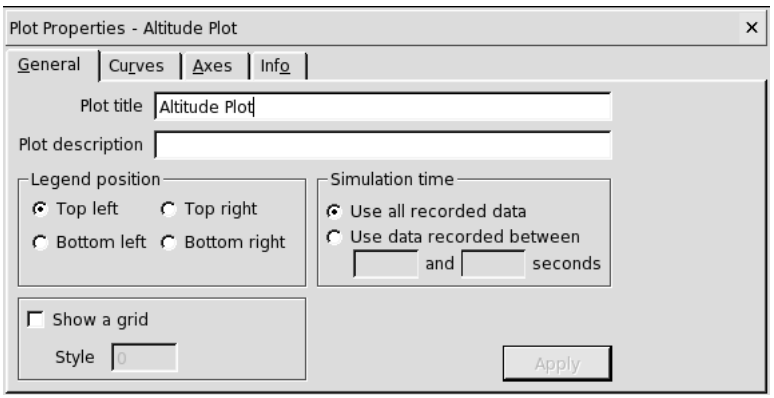


Figure 13.4: General plot properties.

Plot title
: The title of the plot is shown on the plot view as well as on the plot itself.

Plot description
: This can be a more elaborate description of the plot and is shown on the plot.

Legend position
: The legend is placed on the specified position.

Simulation time
: The simulation used in the plot can be set to either all data or to a specified time range.

Grid
: To display a grid check the “Show grid” option. Optionally, a grid style can be entered. The effect of the grid style depends on the back-end. In gnuplot for example, this influences the line style of the grid.

Note that the apply button must be pressed after you have made your changes.

13.4.2 Curve editor reference

The curve editor is the tool to make, change or remove curves from a plot. It displays the curves of the plot selected on the plot view.

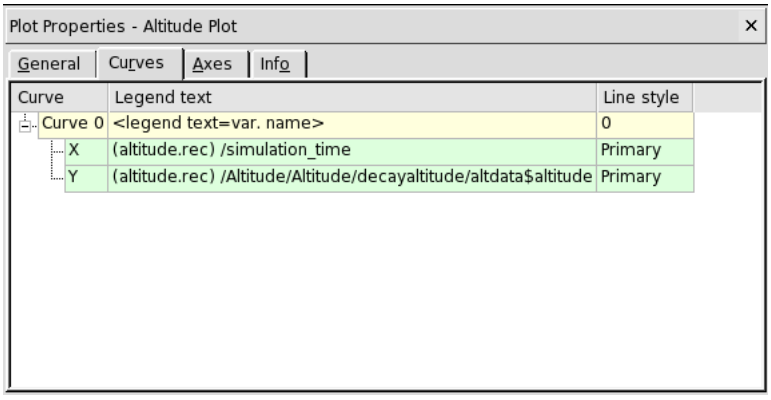


Figure 13.5: The curve editor.

About curves
As shown in Figure 13.5, a variable or function must be specified for the X and Y in each curve[2].
Some of the fields in the curve editor can be edited by clicking them. For example, to change the line style of a curve click on the last column of the curve's row and type in the desired style.

Legend text
The legend text can be specified manually by typing in a legend text or it can be generated automatically. In that case, one of these formats can be chosen:

- variable name
- variable path
- variable description

Line style
The effect of the line style depends on the back-end and the output media (screen or printer). With gnuplot, for example, the decimals specify the linetype as specified in the gnuplot documentation and the hundredths specify the style. Up to nine gnuplot styles are supported. Example: the value "100" will give you the gnuplot "points" style.

Variable
The axis variable can be changed in two ways. The drop-down list contains the recently used variables in this plot and can be chosen the normal way. It is also possible to drag a variable from the variable browser and drop it on the desired axis.

Axis The axis can be set to "Primary" or "Secondary". The primary axis is on the left for X and at the bottom for Y. The secondary axis is the right axis for X and the top axis for Y.

Adding curves
Curves can be added in many ways:

- Double click a variable in the variable browser. The selected variable is added as a curve. Initially, the variable is plotted against simulation_time so do not forget to change this if necessary.
- Drag the variables selected in the variable browser to an empty spot of the curve editor. If there is a variable with "time" or "x" in its name it is used as the x-axis variable. The curves created are all other variables plotted against this curve (or against the first variable if no such variable could be found). This is probably the easiest method.
- Select *Curves:Add Curve* from the menu. The result is the same as dragging the selected variables from the variable browser to the curve editor.

13.4.3 Axes properties

The plot's axes can be configured with the last tabpage. Figure 13.6 shows this tabpage. On the left the axis can be selected. On the right, the settings for the current axis are shown.

[2]This is different from previous versions of the Test Analyzer, where there could be only one x-axis variable or function in a plot.

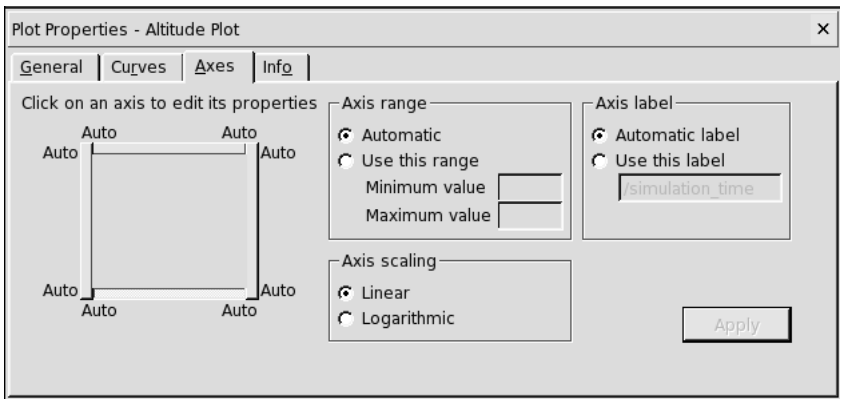


Figure 13.6: Axes properties.

The axis properties that can be set include axis range, scale and label. “Automatic axis range” calculates a default range from the data values. “Automatic axis label” creates a default label for the selected axis based on the variable names.

13.5 Variable browser reference

The variable browser displays the variables present in the currently loaded test result and recorder files. By default, all nodes are collapsed. To expand all nodes to the variable level, right-click the variable browser and choose *Expand All Nodes*.

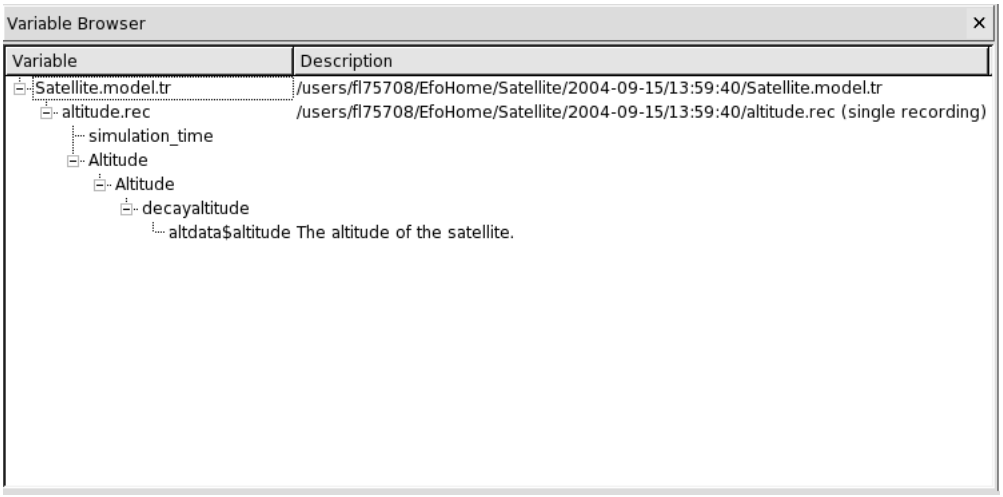


Figure 13.7: The variable browser.

The variable browser has two columns. The first column contains the variables, the second column contains the variable descriptions.

13.6 Plot view reference

The plot view shows all defined plots. The plot view can be switched between three modes:

- Large icons
- Small icons
- List

Figure 13.8 shows the default large icons.

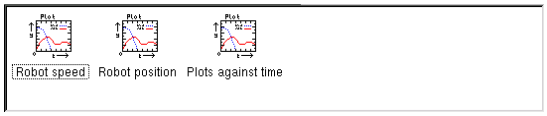


Figure 13.8: The plot view.

In small icons and list mode, the plot icon is small and the plot title is shown right of the icons instead of below them.
The difference between small icons and list mode is the order of display. In small icons mode the icons are ordered left to right while in list mode the icons are ordered top to bottom.

13.7 Menu items reference

The next sections describe each of the menus and their menu items. Some of these menu items also have a toolbar button that performs the same action. These are described in Section 13.8.

13.7.1 File menu

New Starts a new, empty .plt file.

Open...
Opens an existing .plt file. Can also be used to import old .pdf files.

Save Saves the current .plt file.

Save As...
Saves the current .plt file under the specified name.

Close Closes the current .plt file. Asks to save changes if there are unsaved changes.

Select Test Results File...
Switches the current test result set (.tr file). The variables used in the plots must be present in the new test results file, otherwise (some of) the plots will be marked as invalid. See also Section 13.3.3.

Add Recorder File...
Adds a recorder file to the current test results. See also Section 13.3.4 for more information about this feature.

Close Recorder File
Closes the recorder file selected in the variable browser. This is only possible for recorder files added with *File:Add Recorder File...*

Print...
Prints the selected plots.

Recent files
The four most recently used .plt files can be opened quickly from here.

Exit Exits the program. Asks to save changes if there are unsaved changes.

13.7.2 Edit menu

Undo
Undoes the last action if possible.

Redo
Redoes the last undone action if possible.

Cut Cuts the selected item from the document and places it on the clipboard.

Copy Copies the selected item from the document and places it on the clipboard.

Paste Inserts the item on the clipboard into the document.

13.7.3 View menu

Toggle Variable Browser...
Shows/hides the variable browser.

Large icons
Toggles the plot view to large icon mode. The icons are large, the plot title is shown below the icon and icons are initially placed right to left.

Small icons
Toggles the plot view to small icon mode. The icons are smaller, the plot title is shown next to the icon and icons are initially placed right to left.

List Toggles the plot view to list mode. The icons are small, the plot title is shown next to the icon and icons are initially placed top to bottom.

13.7.4 Plot menu

Add Plot Wizard...
Starts the wizard. The wizard allows you to create a plot step by step. All information needed to create a plot is gathered in several pages.

New Plot
Creates a new, empty plot.

Delete Plot(s)
Deletes the plots selected on the plot view.

Show Plot(s)
Shows the plots selected on the plot view.

Close Plot Window
Closes an open plot window for the selected plot. If you are using gnuplot the plot window can also be closed as usual. However, if you are using PV-WAVE you must close the plot window this way.

Print...
Prints the selected plots.

Add Selected Variables as Curves
Adds the variables selected in the variable browser as curves to the current graph. If a variable is found containing 'x' or 'time' it is used as the X-axis variable. Otherwise, the first variable is used as the X-axis.

f(x) Edit Functions
: Shows the function editor dialog box for this plot. It contains all variables and user defined functions for this plot.

Properties
: Shows/hides the plot properties area.

13.7.5 Curve menu

Add Curve
: Adds a new curve to the current plot. See also the remarks in Section 13.4.2 about adding curves.

Remove Curve
: Removes the current curve from the current plot.

13.7.6 Tools menu

Select Plot Backend
: Shows a dialog in which the plot back-end can be selected. See Figure 13.9 below.

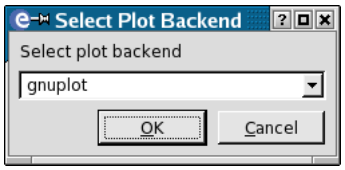


Figure 13.9: Plot back-end selection.

Plot Backend Interface
: Shows the interface to the plot back-end. The interface allows you to see the responses from the plot back-end and send commands to the back-end manually. See Section 13.10.1 or Section 13.11.1 for more information.

13.7.7 Help menu

Online Help
: Starts the help browser.

About EuroSim
: Shows a dialog with information about EuroSim.

13.8 Toolbar reference

Many of the menu items described in the previous section are also present on the toolbar. The toolbar provides shortcuts to these menu items as toolbar buttons.

The toolbar is shown in Figure 13.10. A description of the action of each toolbar button is provided in Section 13.7. The icons on the toolbar are shown next to the menu items.

Figure 13.10: The Test Analyzer toolbar.

13.9 Using User Defined Functions

User defined functions can be specified in the function editor (see Section 13.9.1). How format and validation of these functions is handled is described in Section 13.9.2.

13.9.1 The function editor

The function editor allows you to specify a function that uses one or more of the variables of the test results. The function editor is displayed if you select $f(x)$ *Plot:Edit Functions* or if you press the "Add a function of variables" button in the curve editor.

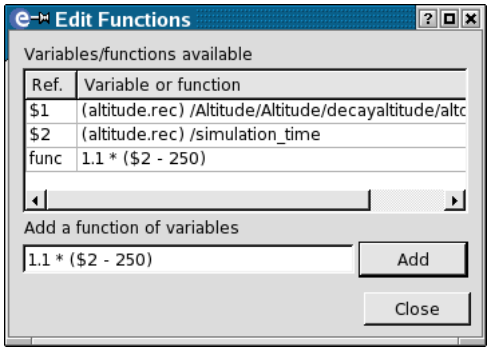


Figure 13.11: The function editor.

By default, the function editor displays the variables already in use by the selected plot. If a variable is required that is not yet listed, it suffices to drag and drop the variable from the variable browser onto the function editor.

To add a user defined function, type it in the edit field below the list and press the add button. User defined functions are added to the bottom of the list and are tagged as "func". They can be edited by clicking on the function. An edit field will then appear.
To use a function in a plot, drag and drop the function from the function editor to the desired axis of the desired curve in the curve editor. It is also possible to click on the variable or function field of the desired axis of the desired curve and then select the function from the list.

Note that unused functions and variables are removed between sessions. That is, if you save the .plt file and load it again unused variables and functions are no longer listed.

13.9.2 Format and Validation

The entry for the function is free format, allowing you to build functions using standard mathematical operators and expressions. To reference data from another variable (or from another user defined function), refer to the reference tag shown in front of the variable (in the "Ref." column), e.g. sin($1) will give the sine of the variable tagged as "$1" in the list. Functions are tagged as "func" in the list. Note that it is no longer possible to reference functions (i.e. it is no longer possible to nest functions).

The function typed in is sent to the plot back-end "as is". No checks are performed to see if the function is correct because each back-end has its own format for functions.

If there is an error, then the plot will not appear when *Plot:Show Plot* is requested. Common errors are recognized and the plot back-end interface window will appear. Since not all errors are recognized, it is recommended that the plot back-end interface window is kept open when plotting user defined functions (at least for the first few times), so that any errors can be quickly identified and corrected.

13.10 PV-WAVE interface

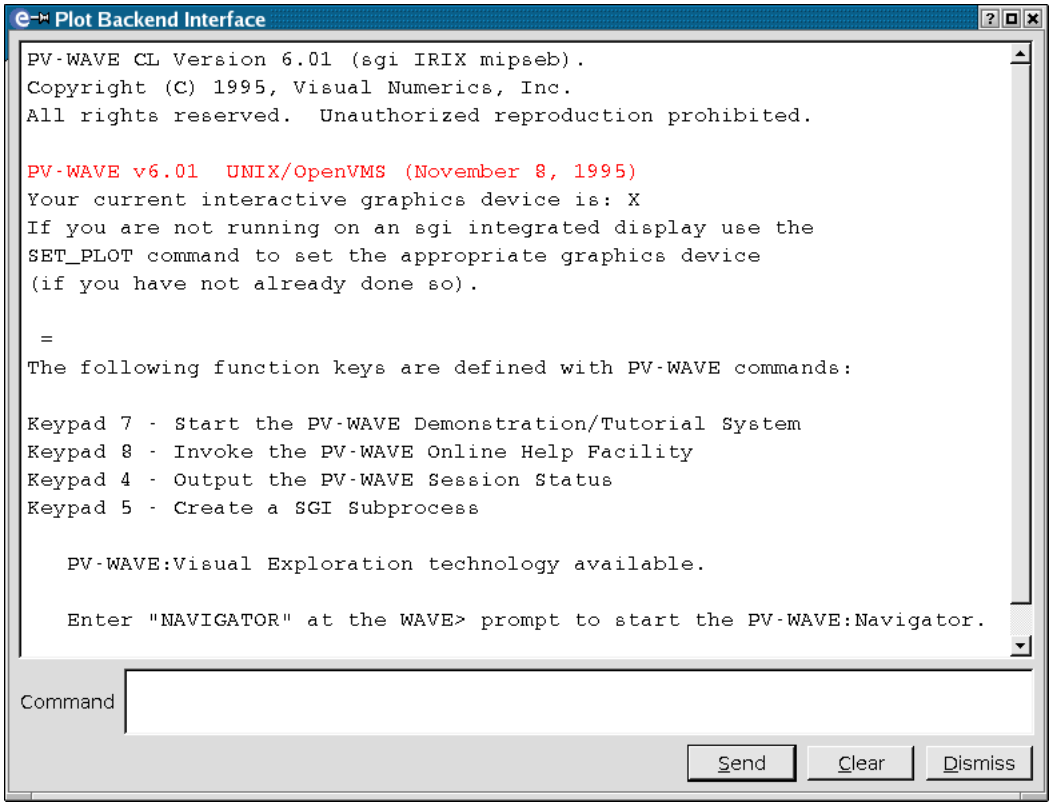


Figure 13.12: The plot back-end interface window, showing PV-WAVE output.

13.10.1 PV-WAVE Operators and Functions

There are many PV-WAVE functions which can be used; the main criteria is that the function should return an array. The following are examples of valid functions (assuming that the variables tagged with $1 and $2 exist in the list of variables).

- sin($1)
- $1 ^ 2
- $1 * exp(0.1)
- $1 + (3 * $2)
- !Dtor * $2

The last example shows the use of the PV-WAVE system variable “deg to rad”; this and other possibilities are described in Section 13.10.2.
PV-WAVE has various operators and functions available, including the following:

- * / + - ^
- sin, cos, tan, sinh, cosh, etc
- alog, alog10, exp, sqrt, abs

PV-WAVE Programmers Guide (Chapter 3): describes expressions and operators
PV-WAVE Reference Volume 1 (Chapter 1): gives an overview of all the available routines; of particular relevance are the General/Special/Transcendental Mathematical Functions.

When referencing two vars within a function, e.g. "$4 - $6", the function is applied in turn to each of the values within the two datasets, e.g. the difference between the first two values, and then between the second values and so on. In the case of the two datasets having different number of recording entries, then the function is applied until the smaller set of values is exhausted.

Warning: a comparison of datasets produced by plotting *$1* and *$2* requires that */simulation_time* variables[3] from both of the source recording files are referenced, with the resulting comparison being actually an overlay of the two graphs, each using a separate time base. However, if you use a single diff function instead (e.g. *$1 - $2*) then only one timebase is possible. This is taken from the first file that is referenced (in this example, the *$1/simulation_time* values). For this to give the intended result, the two datasets should have the same recording characteristics (i.e. have been recorded at the same frequency and be in "synchrony" (either due to the same timestamps within the recording, or because both recording files begin after the same event).

13.10.2 PV-WAVE Variables

PV-WAVE has various system variables available, of which the following may be useful:

- !Pi: The floating-point value of *pi*: 3.14159
- !DPi: Contains the double-precision value of *pi*: 3.1415927
- !Dtor: Contains the conversion factor to convert degrees to radians. The value is *pi*/180, which is approximately 0.0174533
- !Radeg: A floating-point value for converting radians to degrees. The value is 180/*pi* or approximately 57.2958

PV-WAVE Reference Volume 2 (Chapter 4): gives an overview of all the available system variables (although the majority are concerned with plot appearances/defaults and are not relevant for function definitions).

13.10.3 Accessing recorded data

After a plot has been activated, the plot back-end interface window will show the exact commands sent to PV-WAVE (in blue). If we inspect this output, we can see that the variables used in our plot ($1, $2, etc.) are available as V1, V2, etc. The dollar sign ($) of the variable reference is replaced with a "V". We can access these variables in PV-WAVE as usual. For example, to check the number of data values for $1 we can give the command:

```
info, V1
V1 DOUBLE = Array(307)
```

Which means that V1 is an array of 307 elements.
To actually see the values in the array we could issue a print command:

```
print, V1
0.0029616649 0.0059233298 0.0088849947 0.011846660
0.014808325 0.00092749497 0.0038891599 0.0068508248
0.0098124897 0.012774155 0.015670285 0.0018549899
.......
```

13.10.4 Examples of using PV-WAVE commands directly

PV-WAVE provides many options for presenting/filtering data. These can be used by typing the commands in the back-end interface dialog window and sending them to the PV-WAVE process.

Some examples of the use of these commands on recorded data are presented below.

[3] It is assumed that `simulation_time` is used for the x axis variable, but it could be some other variable of course.

13.10.4.1 Creating a table

To create a table of the data from a recorder file, the following commands could be used:

```
simtime = V1
temp1 = V2
temp2 = V5
temp3 = V6
tempTable = build_table("simtime, temp1, temp2, temp3")
```

Now, to select and display a subset of the data the following commands can be used:

```
subsetTable = query_table(tempTable,
  " * Where simtime > 10.0 and simtime < 12.0")
print ,"time celltmp[1][1] celltmp[1][2] celltmp[1][3]"
for i=0, N_ELEMENTS(subsetTable)-1 do begin PRINT, subsetTable(i)
```

This will result in output similar to:

```
time celltmp[1][1] celltmp[1][2] celltmp[1][3]
{ 10.005000 193.298 169.990 260.438}
{ 10.015000 193.298 169.990 260.438}
......
```

To export the selected data, and store it in a file (as ASCII), use the following command:

```
status = DC_WRITE_FIXED('table.dat',subsetTable.simtime,
subsetTable.temp1,subsetTable.temp2,subsetTable.temp3,/Col )
```

13.10.4.2 Data analysis

On the recorded data, analysis functions such as a Fast Fourier Transform (FFT) can be performed. An example would be:

```
xd = simtime
yd = temp1
n_sample = N_ELEMENTS(xd)
samp_rate = (n_sample-1)/(xd(n_sample-1) - xd(0))
x = FINDGEN(n_sample) - (n_sample/2.)
x_ind = WHERE(x GE 0)
x(x_ind) = x(x_ind)+1.
x_freq = x * samp_rate/ FLOAT(n_sample)
y_proc = ABS(FFT(yd, -1))
PLOT, x_freq, SHIFT(y_proc, n_sample/2.)
```

A FFT plot should then appear. Plots generated with the `plot` command can be removed again by using the command `wdelete,0` (for plot number 0)

Also, various statistical analysis functions are available through PV-WAVE. For example:

```
print, "min= ", min(yd)
print, "max= ", max(yd)
print, "mean= ", avg(yd)
print, "median= ", median(yd)
print, "std dev= ", stdev(yd)
```


13.10.5 User defined functions

It is possible to define user defined functions which can later be used interactively in the dialog box which shows the interface with the plot back-end. To create a new user defined function you must first create a file containing the commands. From the Test Analyzer menu *Tools:Shell...* a shell window can be opened where you can create a file using your favorite editor. The filename should be the name of the function and the filename extension should be 'pro', e.g. user_func.pro. Type the PV-WAVE commands in the file and save it. In the Test Analyzer select *Tools:Plot Backend Interface...* A dialog box appears where you then can enter your command in the Command box as follows: ".run user_func". Click Send to execute the command.

13.10.6 PV-WAVE help

This can be accessed from the back-end interface dialog window by sending the command help.

13.10.7 The PV-WAVE process

As soon as the current plot back-end is set to PV-WAVE, an attempt is made to start PV-WAVE. Depending on the number of PV-WAVE licenses available in the local environment however, this might not succeed. If the start-up fails, then the user's request for a license is placed in a queue. All the Test Analyzer edit functions are still available however and the user can make/edit plot definitions as required: the only difference is that the "activate" (display graphical plot) request will not be immediately executed.

If the Test Analyzer appears unresponsive to requests to display a plot, then the back-end interface window should be checked for this situation and/or other error messages.

13.11 gnuplot interface

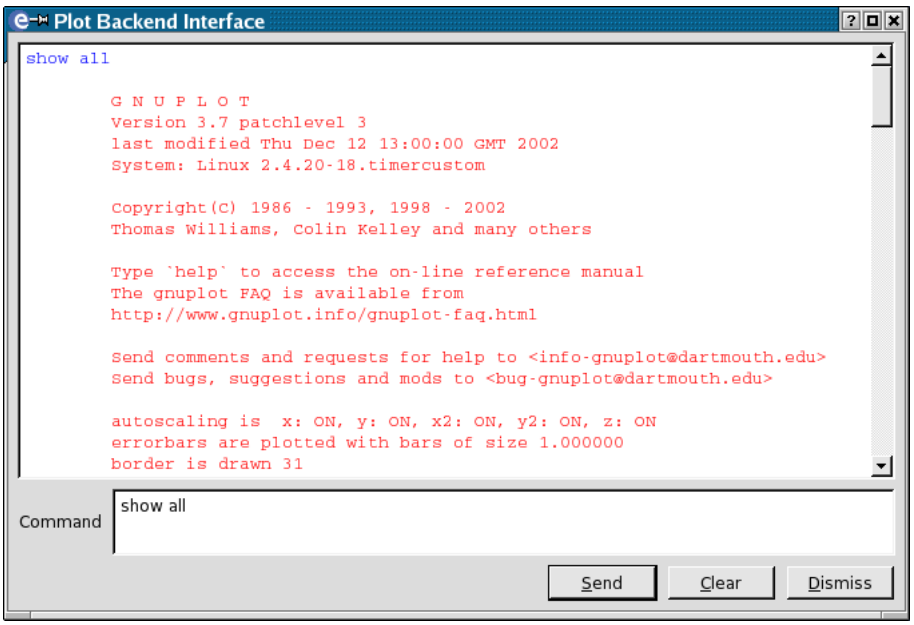


Figure 13.13: The plot back-end interface window, showing gnuplot output.

13.11.1 gnuplot operators and functions

According to the gnuplot documentation, the expressions accepted by gnuplot can be any mathematical expression that is valid in C, FORTRAN, Pascal or BASIC. The precedence of operators is the same as in the C programming language.

The functions supported by gnuplot are about the same as those present in the UNIX math library. A complete list is available in the gnuplot documentation. Examples:

- sin($1)
- log10($3)
- $1**2 *[this means $1 squared]*
- $1 * exp(0.1)
- $1 + (3 * $2)

13.11.2 Accessing recorded data

Showing a plot causes a temporary file to be written containing the variables used in the plot. This file will be deleted when the Test Analyzer is closed or when the back-end is set to something else than gnuplot. In the meantime, the data in this file remains accessible.

The name of the data file can be obtained from the plot back-end interface window. After showing a plot, the name of the datafile is shown on the line containing the plot command, for example:

```
plot "/var/tmp/gnuAAAa0Y093" using ($1):(1.1 * ( $2 - 250 )) axes

x1y1 title "just a plot'' with lines lt 0
```

The name of the file is shown in bold. The data can be accessed using gnuplot's **using** command, as shown in the plot command above. See the gnuplot documentation for more information.

13.11.3 gnuplot help

The gnuplot help interface can be accessed by sending the "help" command from the back-end interface window. Note that you should press enter a few times to leave help mode.

Part III

Modelling Reference Guide

Chapter 14

C, Fortran, Ada interface reference

14.1 Introduction

In this chapter we first show the setup of EuroSim for usage of the

14.2 Setup procedure

The C API is fully integrated and does not require any setup. For Fotran and Ada the linking of the Fortran or Ada runtime library must be seleced in the Model Editor build options. See Figure 14.1.

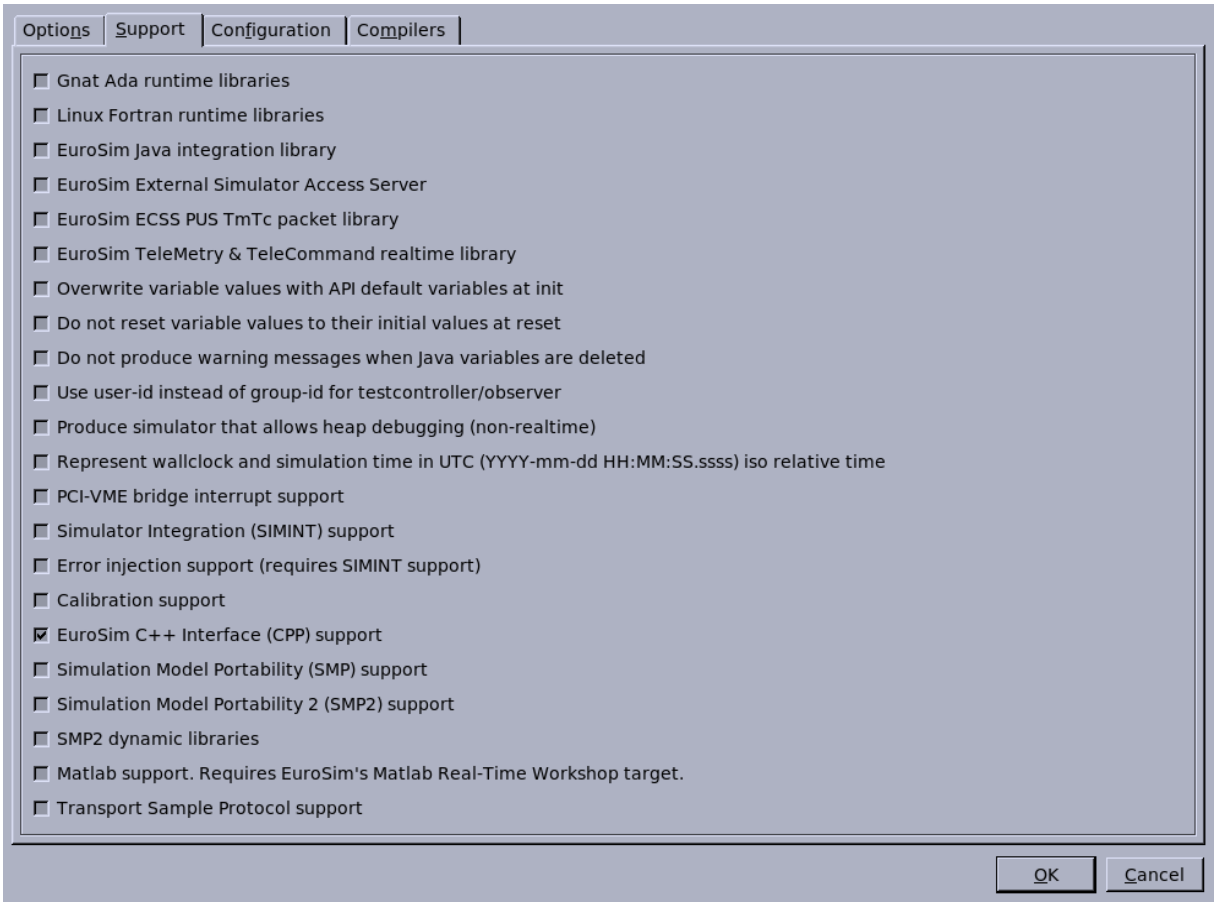


Figure 14.1: EuroSim build options

14.3 Publication interface

14.3.1 API Header

This section contains the lay-out of the API headers, as they are generated by EuroSim for C and Fortran model code. As EuroSim does not generate API headers for Ada-95 model code, the information in this appendix can be used to create API headers for Ada-95 model code by hand.

The API header is contained in a comment block at the top of the source code (i.e. between `/* */` in C, on lines starting with `C` in Fortran and on lines starting with `--` in Ada-95). In Ada-95 and Fortran, make sure that if the original source code started with a comment block, that there is an empty line between the API header and the source code comments.

Each API header consists of the following four keywords (see Section 2.4 for more information):

- `'Global_State_Variables`
- `'Global_Input_Variables`
- `'Global_Output_Variables`
- `'Entry_Point`

The first three keywords are used to describe the variables in the source code, and the last keyword is used to describe the entry points. The first keyword is used once per source file, the last three once per entry point.

Each keyword is preceded by a straight quote.

14.3.1.1 `'Global_State_Variables`

Global state variables are the variables which are used in the current source file only, and should not be seen by other source files.

The syntax of the keyword is:

`'Global_State_Variables` *VariableType VariableName* : *Attributes*

The *VariableType* and *VariableName* are as they are defined in the source file. The *Attributes* can be zero or more of the attributes described below. If more than one attribute is used, they should be separated by spaces or newlines. If more than one variable is defined with the keyword, each *VariableType VariableName* : *Attributes* set should be separated by commas.

- `UNIT="`*text*`"`

This defines *text* as the unit of the variable. The string *text* can be any string.

- `DESCRIPTION="`*text*`"`

This defines a string *text* which is used as description of the variable.

- `PARAMETER` or `RO`

No additional information. It defines a variable as 'parameter', meaning that EuroSim should not allow the value of the variable to be changed during a simulation (only during initialization).

- `INIT="`*value*`"`

This defines *value* as the initial value for the variable. *value* should be in the correct syntax for the associated variable.

- `MIN="`*value*`"`
- `MAX="`*value*`"`

These two define the minimum and maximum values of the variable. *value* should be in the correct syntax for the associated variable.

14.3.1.2 `'Global_Input_Variables`

This keyword is used to define the variables that are used by the current source file, and which are set to a value by another source file. The syntax of the keyword is the same as for global state variables.

14.3.1.3 `'Global_Output_Variables`

This keyword is used to define the variables that are used by other source files, and which are set to a value by the current source file. The syntax of the keyword is the same as for global state variables.

14.3.1.4 `'Entry_Point`

This keyword is used once per function/procedure that has to be available for the scheduler. See Section 14.5 for more information on restrictions on functions/procedures to be used as entry points.
The syntax of the keyword is:

`'Entry_Point` *FunctionName* `: DESCRIPTION="`*Description*`"`

14.3.2 Publication functions

It is also possible to 'publish' variables from the data dictionary. There are several functions that set the address where a variable or entry point in a certain data dictionary is stored, thus making it accessible from the outside. This is useful for people who want to make their own model interfaces.

The publish functions are divided in two categories, a function to get the runtime data dictionary and functions to publish data variables and entry points in a data dictionary.

14.3.2.1 Function to get the runtime data dictionary

When a EuroSim simulation application program needs access to the runtime data dictionary it must call `esimDict(void)`. This function returns a pointer to the runtime data dictionary (`DICT*`) and is defined in the header file `esimDict.h`.

14.3.2.2 Functions to publish data variables and entry points in a data dictionary

`dictPublish(DICT *dict, const char *name, const void *address)` sets the address of the variable specified by *name* in the data dictionary specified by *dict* to *address*. This function can be called from C or Ada.

`dictpublish_(DICT *dict, const char *name, const void *address, int namelen)` is the Fortran wrapper for `dictPublish`. It has an extra parameter with the length of the *name* parameter. This is required by the calling convention of Fortran functions.

`dictPubEntry(DICT *dict, const char *name, EntryPtr address)` sets the function address of the entry point specified by *name* in the runtime data dictionary to *address*. This function can be called from C or Ada.

`dictpubentry_(DICT *dict, const char *name, EntryPtr address, int namelen)` is the Fortran wrapper for `dictPubEntry`. It has an extra parameter with the length of the *name* parameter. This is required by the calling convention of Fortran. functions.

The prototypes for these functions can be found in `DictPublish.h`.

14.4 Service interface

This section describes all services and their interface description available for simulation models that want to use the EuroSim services. These services can be used both from C as well as Fortran programs. In the latter case the function calls are all in lower or upper case (depending on your programming style). Below a short description of the available functions is given. For more information, refer to the `esim(3C)` man page.

14.4.1 Usage in C

```
#include <esim.h>

cc ... -L$EFOROOT/lib32 -lesServer -les
```

14.4.1.1 Real-time (shared) memory allocation

```
void *esimMalloc(size_t size)
void esimFree(void *ptr)
void *esimRealloc(void *ptr, size_t size)
void *esimCalloc(size_t nelem, size_t elsize)
char *esimStrdup(const char *str)
```

14.4.1.2 Real-time timing functions

```
double esimGetSimtime(void)
struct timespec esimGetSimtimets(void)
void esimGetSimtimeYMDHMSs(int t[7])

double esimGetWallclocktime(void)
struct timespec esimGetWallclocktimets(void)
double esimGetHighResWallclocktime(void)

int esimSetSimtime(double simtime)
int esimSetSimtimets(struct timespec simtime)
int esimSetSimtimeYMDHMSs(int t[7])
```

14.4.1.3 Real-time simulation state functions

```
esimState esimGetState(void)
int esimSetState(esimState state)
int esimSetStateTimed(esimState state, const struct timespec *t,
                      int use_simtime)
struct timespec esimGetMainCycleTime(void)
struct timespec esimGetMainCycleBoundarySimtime(void)
struct timespec esimGetMainCycleBoundaryWallclocktime(void)
```

14.4.1.4 Real-time task related functions

```
const char *esimGetTaskname(void)
double esimGetTaskrate(void)
int esimEnableTask(const char *taskname)
int esimDisableTask(const char *taskname)
int esimEntrypointFrequency(esimState state, const char *entrypoint,
                            double freq)
int esimEntrypointSetEnabled(const char *entrypoint, bool enabled)
```



```
int esimGetRealtime(void)
int esimSetRealtime(int on)
```

14.4.1.5 Event functions

```
int esimEventRaise(const char *eventname, const void *data, int size)
int esimEventRaiseTimed(const char *eventname, const void *data,
             int size, const struct timespec *t, int use_simtime)
int esimEventCancelTimed(const char *eventname)
int esimEventData(void *data, int *size)
int esimEventTime(struct timespec *event_occurrence_time, struct_timespec *ev
int esimEventCount(const char *eventname)
typedef int (*esimEventHandlerDispatchFunc)(esimEH *context, const void* msg,
int esimEventHandlerHDispatch(esimEH *context, const char* name, const void *
int esimEventHandlerInstall(const char *name, esimEventHandlerDispatchFunc di
int esimEventHandlerUninstall(const char *name)
```

14.4.1.6 Real-time clock functions

```
double esimGetSpeed(void)
int esimSetSpeed(double speed)
```

14.4.1.7 Real-time recording functions

```
int esimGetRecordingState(void)
int esimSetRecordingState(int on)
```

14.4.1.8 Real-time reporting functions

```
void esimMessage(const char *format, ...)
void esimWarning(const char *format, ...)
void esimError(const char *format, ...)
void esimFatal(const char *format, ...)
void esimReport(int lvl, const char *fmt, ...)
int esimReportAddSeverity(const char *sev_name)
```

14.4.1.9 Real-time Heap functions

```
void esimGetHeapUsage(int *tot_size, int *max_used, int *current_use)
```

14.4.1.10 Real-time processor load functions

```
bool esimSetLoadMeasureInterval(int processor, double interval)
bool esimGetProcessorLoad(int processor, double *avg_load, double *max_load)
```

14.4.1.11 Non-real-time thread functions

```
esimThread* esimThreadCreate(const char *name,
                             void (*start_routine)(void*), void *arg)
int esimThreadKill(esimThread *thread, int signal)
void esimThreadExit(int exit_val)
```

14.4.1.12 Auxiliary functions

```
int esimGetProcessor(void)
const char *esimVersion(void)
void esimInstallErrorHandler(ErrorHandler userhandler)
void esimAbortNow(void)
bool esimIsResetting(void)
```

14.4.1.13 Tracing functions

```
void esimTracePause(void)
bool esimTraceResume(void)
void esimTraceMask(unsigned type_mask, unsigned proc_mask)
```

14.4.1.14 User-defined recording functions

```
#include <esimRec.h>

EsimRec* esimRecOpen(const char *path, int flags)
int esimRecWriteRaw(EsimRec *rec, const void *ptr, size_t size)
int esimRecWriteHeader(EsimRec *rec)
int esimRecWriteRecord(EsimRec *rec)
int esimRecClose(EsimRec *rec)

int esimRecInt8FieldAdd(EsimRec *rec, const char *name,
                        int8_t *address)
int esimRecUint8FieldAdd(EsimRec *rec, const char *name,
                         uint8_t *address)
int esimRecInt16FieldAdd(EsimRec *rec, const char *name,
                         int16_t *address)
int esimRecUint16FieldAdd(EsimRec *rec, const char *name,
                          uint16_t *address)
int esimRecInt32FieldAdd(EsimRec *rec, const char *name,
                         int32_t *address)
int esimRecUint32FieldAdd(EsimRec *rec, const char *name,
                          uint32_t *address)
int esimRecInt64FieldAdd(EsimRec *rec, const char *name,
                         int64_t *address)
int esimRecUint64FieldAdd(EsimRec *rec, const char *name,
                          uint64_t *address)
int esimRecFloatFieldAdd(EsimRec *rec, const char *name,
                         float *address)
int esimRecDoubleFieldAdd(EsimRec *rec, const char *name,
                          double *address)

int esimRecInt8ArrayFieldAdd(EsimRec *rec, const char *name,
                             size_t n_elem, int8_t *address)
int esimRecUint8ArrayFieldAdd(EsimRec *rec, const char *name,
                              size_t n_elem, uint8_t *address)
int esimRecInt16ArrayFieldAdd(EsimRec *rec, const char *name,
                              size_t n_elem, int16_t *address)
int esimRecUint16ArrayFieldAdd(EsimRec *rec, const char *name,
                               size_t n_elem, uint16_t *address)
int esimRecInt32ArrayFieldAdd(EsimRec *rec, const char *name,
```



```
                                size_t n_elem, int32_t *address)
int esimRecUint32ArrayFieldAdd(EsimRec *rec, const char *name,
                                 size_t n_elem, uint32_t *address)
int esimRecInt64ArrayFieldAdd(EsimRec *rec, const char *name,
                                size_t n_elem, int64_t *address)
int esimRecUint64ArrayFieldAdd(EsimRec *rec, const char *name,
                                 size_t n_elem, uint64_t *address)
int esimRecFloatArrayFieldAdd(EsimRec *rec, const char *name,
                                size_t n_elem, float *address)
int esimRecDoubleArrayFieldAdd(EsimRec *rec, const char *name,
                                 size_t n_elem, double *address)
```

14.4.2 Usage in Fortran

```
include 'esim.inc'

f77 ... -L$EFOROOT/lib32 -lesServer -les
```

The synopsis in this section uses the following variables:

```
double precision time, rate, frequency, speed
integer state, on, ok, level, counter, timespec(2), timeymd(7)
integer data(n), size, use_simtime, number
character*N eventname, taskname, message, version, entrypoint
```

14.4.2.1 Real-time timing functions

```
time = esimgetsimtime
time = esimgetwallclocktime
time = esimgethighreswallclocktime
call esimgetsimtimets(timespec)
call esimgetsimtimeymdhmss(timeymd)
call esimgetwallclocktimets(timespec)
ok = esimsetsimtime(time)
ok = esimsetsimtimets(timespec)
ok = esimsetsimtimeymdhmss(timeymd)
```

14.4.2.2 Real-time simulation state functions

```
state = esimgetstate
ok = esimsetstate(state)
ok = esimsetstatetimed(state, timespec, use_simtime)
call esimgetmaincycletime(timespec)
call esimgetmaincycleboundarysimtime(timespec)
call esimgetmaincycleboundarywallclocktime(timespec)
```

14.4.2.3 Real-time task related functions

```
call esimgettaskname(taskname)
rate = esimgettaskrate
ok = esimenabletask(taskname)
ok = esimdisabletask(taskname)
ok = esimentrypointfrequency(state, entrypoint, frequency)
```

14.4.2.4 Event functions

```
ok = esimeventraise(eventname, data, size)
ok = esimeventraisetimed(eventname, data, size, timespec,
                         use_simtime)
ok = esimeventdata(data, size)
ok = esimeventime(timespec, timespec)
counter = esimeventcount(eventname)
ok = esimeventhandlerinstall(name, dispatcher, user_data)
ok = esimeventhandleruninstall(name)
ok = esimeventhandlerdispatch(context,name, msg, size)
```

14.4.2.5 Real-time clock functions

```
on = esimgetrealtime
ok = esimsetrealtime(on)
speed = esimgetspeed
ok = esimsetspeed(speed)
```

14.4.2.6 Real-time recording functions

```
on = esimgetrecordingstate
ok = esimsetrecordingstate(on)
```

14.4.2.7 Real-time reporting functions

```
call esimmessage(message)
call esimwarning(message)
call esimerror(message)
call esimfatal(message)
call esimreport(level, message)
```

14.4.2.8 Auxiliary functions

```
number = esimgetprocessor()
call esimversion()
call esimabortnow()
```

14.4.2.9 Trace functions

```
call esimtracepause()
call esimtraceresume()
call esimtracemask()
```

14.4.3 Usage in Ada-95

```
use Esim; with Esim
```

Do not forget to check the 'Gnat Ada runtime libraries' option in the *Model:Options* window of the Model Editor (see Figure 7.6).

14.4.3.1 Real-time (shared) memory allocation

```
function EsimMalloc(Size : Size_T) return Void_Ptr
procedure EsimFree(Ptr : Void_Ptr)
function EsimRealloc(Ptr : Void_Ptr Size : Size_T) return Void_Ptr
```



```
function EsimCalloc(Nelem : Size_T Elsize : Size_T) return Void_Ptr
function EsimStrdup(Str : Chars_Ptr) return Chars_Ptr
function EsimStrdup(Str : String) return String
```

14.4.3.2 Real-time timing functions

```
function EsimGetSimtime return Long_Float
function EsimGetSimtimets return Time_Spec
procedure EsimGetSimtimeYMDHMSs(SimTime: out YMDHMSs)
function EsimSetSimtime(Simtime: Long_float) return Integer
function EsimSetSimtimets(Simtime: in Time_Spec) return Integer
function EsimSetSimtimeYMDHMSs(Simtime: in YMDHMSs) return Integer
function EsimGetWallclocktime return Long_Float
function EsimGetHighResWallclocktime return Long_Float
function EsimGetWallclocktimets return Time_Spec
```

14.4.3.3 Real-time simulation state functions

```
function EsimGetState return esimState
function EsimSetState(State : esimState) return Integer
function EsimSetState(State : esimState) return Boolean
function EsimSetStateTimed(State : EsimState;
                           T : in Time_Spec;
                           Use_Simtime : Integer) return Integer
function EsimSetStateTimed(State : EsimState;
                           T : in Time_Spec;
                           Use_Simtime : Boolean) return Boolean
function EsimGetMainCycleTime return Time_Spec
function EsimGetMainCycleBoundarySimtime return Time_Spec
function EsimGetMainCycleBoundaryWallclocktime return Time_Spec
```

14.4.3.4 Real-time task related functions

```
function EsimGetTaskname return Chars_Ptr
function EsimGetTaskname return String
function EsimGetTaskrate return Long_Float
function EsimEnableTask(Taskname : Chars_Ptr) return Integer
function EsimEnableTask(Taskname : String) return Boolean
function EsimDisableTask(Taskname : Chars_Ptr) return Integer
function EsimDisableTask(Taskname : String) return Boolean
```

14.4.3.5 Event functions

```
function EsimEventRaise(EventName : Chars_Ptr;
                        Data : Void_Ptr;
                        Size : Integer) return Integer
function EsimEventRaise(EventName: in String;
                        Data : in Void_Ptr;
                        Size : Integer) return Boolean
function EsimEventRaiseTimed(EventName : in Chars_Ptr;
                             Data : in Void_Ptr;
                             Size : Integer;
                             T : in Time_Spec;
                             Use_Simtime : Integer) return Integer
```

```
function EsimEventRaiseTimed(EventName : in String;
                             Data : in Void_Ptr;
                             Size : Integer;
                             T : in Time_Spec;
                             Use_Simtime : Boolean) return Boolean
type Integer_Ptr is access Integer;
function  EsimEventData(Data : in Void_Ptr;
                        Size : Integer_Ptr) return Integer
function EsimEventCount(EventName : String) return Integer
```

14.4.3.6 Real-time clock functions

```
function EsimGetSpeed return Long_Float
function EsimSetSpeed(Frequency : Long_Float) return Integer
function EsimSetSpeed(Frequency : Long_Float) return Boolean
function EsimGetRealtime return Integer
function EsimGetRealtime return Boolean
function EsimSetRealtime(On : Integer) return Integer
function EsimSetRealtime(On : Boolean) return Boolean
```

14.4.3.7 Real-time recording functions

```
function EsimGetRecordingState return Integer
function EsimGetRecordingState return Boolean
function EsimSetRecordingState(On : Integer) return Integer
function EsimSetRecordingState(On : Boolean) return Boolean
```

14.4.3.8 Real-time reporting functions

```
procedure EsimMessage(Warning : Chars_Ptr)
procedure EsimMessage(Warning : String)
procedure EsimWarning(Message : Chars_Ptr)
procedure EsimWarning(Message : String)
procedure EsimError(Error : Chars_Ptr)
procedure EsimError(Error : String)
procedure EsimFatal(Fatal : Chars_Ptr)
procedure EsimFatal(Fatal : String)
procedure EsimReport(S : esimSeverity Report : Chars_Ptr)
procedure EsimReport(S : esimSeverity Report : String)
```

14.4.3.9 Auxiliary functions

```
function EsimVersion return Chars_Ptr
function EsimVersion return String
procedure EsimAbortNow
```

14.4.3.10 Trace functions

```
procedure EsimTracePause
procedure EsimTraceResume
procedure EsimTraceMask(TyepMask : Integer ProcMask : Integer)
```


14.4.4 Description of functions

When you link in the `libesim.a` library a `main()` function is already included for your convenience. It makes sure all EuroSim processes are started up.

`esimMalloc`, `esimFree`, `esimRealloc`, `esimCalloc` and `esimStrdup` are common memory allocation functions. These are the same as their `malloc`(3) counterparts in the "C" library, with the exception that the EuroSim calls are optimized for parallel/real-time usage, and checks for memory exhaustion are built-in. For the semantics and arguments and return values see `malloc`(3) for details.

`esimGetSimtime()` returns the simulation time in seconds with the precision of the basic cycle with which the simulation runs (5 ms by default). In case the simulation is driven by the external interrupt the precision is equal to that period. If the simulator has real-time errors the simulation time will be slower than the wall clock. The simulation time is set to zero (0) on arriving in initializing state.

`esimGetWallclocktime()` returns the wallclock time in seconds. The basic resolution is equal to the resolution of the high-res time described next, but is truncated to milliseconds. The wallclock time is set to zero when the first model task is scheduled, and runs real-time which means that is independent from the simulation time.

`esimGetWallclocktimets()` returns the wallclock time in a timespec structure. It replaces the obsolescent `esimGetWallclocktimeUTC()`.

`esimGetHighResWallclocktime()` returns the "same" time as `esimGetWallclocktime()` but in milliseconds and with a higher resolution. This high resolution is 21 ns on high-end platforms such as a Challenge and Onyx. On low end platforms this resolution is as good as what can be achieved by the `gettimeofday(3)` call.

`esimGetSimtimets()` returns the simulation time in a timespec structure. It replaces the obsolescent `esimGetSimtimeUTC()`.

`esimGetSimtimeYMDHMSs()` returns the simulation time in an array of 7 integers containing: year, month, day, hour, minute, second and nanoseconds.

`esimSetSimtime()` sets the requested simulation time simtime in seconds. This can only be done in the standby state. If calling esimSetSimtime in any other state is attempted or simtime is less than zero, no simulation time is set and (-1) is returned. On success zero (0) is returned.

`esimSetSimtimets()` sets the simulation time using a timespec structure. It replaces the obsolescent `esimSetSimtimeUTC()`.

`esimSetSimtimeYMDHMSs()` sets the simulation time using an array of 7 integers containing: year, month, day, hour, minute, second and nanoseconds.

`esimGetState()` returns the current simulator state. The state can be any of the following values: `esimUnconfiguredState`, `esimInitialisingState`, `esimExecutingState`, `esimStandbyState` or `esimStoppingState`.

`esimSetState()` sets the simulator state to the indicated value *state*. *state* can be any of the following values: `esimUnconfiguredState`, `esimInitialisingState`, `esimExecutingState`, `esimStandbyState` or `esimStoppingState`. If *state* is not reachable from the current state 0 is returned; on a successful state transition 1. is returned.

`esimSetStateTimed()` sets the simulator state to the indicated value *state* at the specified time *t*. The possible values of *state* are listed in the previous paragraph. If the flag *use_simtime* is set to 1 (true), the specified time is interpreted as simulation time. If the flag is set to 0 (false), the specified time is interpreted as the wallclock time. The transition time uses a struct timespec where the number of seconds is relative to January 1, 1970. On success this function returns 0, otherwise -1.

`esimGetMainCycleTime()` returns the main cycle time of the schedule. The result can be used to compute valid state transition times for use in the function `esimSetStateTimed()`.

`esimGetMainCycleBoundarySimtime()` returns the simulation time of the last state transition. This boundary time can be used to compute valid state transition times for use in the function `esimSetStateTimed()` when the value of *use_simtime* is true.

`esimGetMainCycleBoundaryWallclocktime()` returns the wallclock time of the last state transition. This boundary time can be used to compute valid state transition times for use in the function `esimSetStateTimed()` when the value of *use_simtime* is false.

`esimGetTaskname()` returns the name of your current task.

`esimGetTaskrate()` returns the frequency (in Hz) of your current task.

`esimDisableTask()` disables the task 'taskname' defined with the Schedule Editor. It will be skipped (not executed) by the EuroSim runtime until a call is made to `esimEnableTask`.

`esimEnableTask()` enables the task 'taskname' defined with the Schedule Editor. It will be executed/scheduled according to the schedule made with the Schedule Editor.

`esimEntrypointFrequency()` stores the frequency (in Hz) of the entry point with the name 'entrypoint' in the argument 'freq' in the state 'state'. If the entry point appears multiple times in the schedule the function returns -1. If the entry point does not appear in the schedule in the given state, the frequency is 0.

`esimEventRaise()` raises the event *eventname* for triggering tasks defined with the Schedule Editor. User defined data can be passed in *data* and *size*. On success this function returns 0, otherwise -1.

`esimEventRaiseTimed()` raises the event *eventname* for triggering tasks defined with the schedule editor at the specified time *t*. User defined data can be passed in *data* and *size*. If the flag *use_simtime* is set to 1 (true), the specified time is interpreted as simulation time. If the flag is set to 0 (false), the specified time is interpreted as the wallclock time. The transition time uses a struct timespec where the number of seconds is relative to January 1, 1970. On success this function returns 0, otherwise -1.

`esimEventData()` gets the data passed with the event. This function can only be used in the task connected to the input connector. Beware that the size argument is both input and output. It specifies the size of the buffer pointed to by the data pointer, and is set by esimEventData to the actual number of bytes written in that buffer.

`esimEventTime()` gets the timestamps of detection of the occurrence of the external event (e.g. interrupt) and the timestamp of injection of the event into the scheduler as a EuroSim event. This function can only be used in the task connected to the input connector.

`esimEventCount()` returns the number of times that event *eventname* has been raised or -1 if no such event is defined.

`esimEventHandlerInstall` External Event Handlers are a means of handling asynchronous events such as device interrupts. Events are forwarded from its external source to an Input Connector. The External Event Handler are created with the Schedule Editor and can be automatic or user defined. Automatic event handlers forward the event to a single input connector that must have the same name as the eventhandler. This is the fastest route for an interrupt. However, the user can use the esimEventHandlerInstall function to install a callback that will be activated before the event is instert. This allows the user to inspect data and decide to which inputconnector the event should be forwarded. As a side effect, it also blocks the event handler from handling interrupts untill the esimEventHandlerInstall routine is called.

External event handlers interrupt the real-time scheduler, and thus influence the real-time performance of the system. To prevent jitter on the scheduler clock the external event handlers should be installed on other processors than the clock. Best performance can be obtained if the processor with the external event handler does not run any periodic tasks.

In a task connected directly to the input connector the event data can be retrieved with the esimEventData functions. The time at which EuroSim became aware of the external event and the time at which it injected the event into the scheduler can be retreived with the esimEventTime service function.

`esimEventHandlerDispatch` Is used from within the event handler callback function to the event with name *name* and message *msg* of *size* bytes to an inputconnector. This data can be retrieved withint a task with *esimEventData*. *context* should be the context parameter of the callback function. On success this function returns 0, otherwise -1.

`esimEventHandlerUninstall` uninstalls the previously installed callback functions.

`esimGetRealtime()` returns the current operational state of the EuroSim real-time Scheduler. If 1 is returned, hard real-time execution is in progress, whereas a return of 0 indicates that your model is not executing in real-time mode.

`esimSetRealtime()` sets the current operational state of the EuroSim real-time Scheduler. Hard real time execution can only be set if the scheduler was launched in hard real time mode. 1 is returned on success. 0 is returned on failure.

`esimGetSpeed()` returns the current speed of EuroSim Scheduler. e.g. 1.0 means (hard or soft) real time. 0.1 means slowdown by a factor 10. -1 means as fast as possible.

`esimSetSpeed()` sets the current speed of EuroSim Scheduler. e.g. 1.0 means (hard or soft) real time. 0.1 means slowdown by a factor 10. -1 means as fast as possible. The speed can only be changed if the scheduler is running non real-time. If speed is not a feasible speed 0 is returned; on a successful setting of the speed 1 is returned.

`esimGetRecordingState()` returns the current state of the EuroSim real-time data Recorder. If *true* is returned, data is logged to disk, whereas a return of *false* indicates that recording is switched off.

`esimSetRecordingState()` sets the state of the Recorder to *on*. If *on* is *true* data will subsequently be written to disk, if *on* is *false* data recording will be suspended. Return value is either *true* or *false*, depending on success or not.

The functions `esimReport`, `esimMessage`, `esimWarning`, `esimError` and `esimFatal` can be used to send messages from the EuroSim model code to the test-conductor interface. The `esimReport` function allows the caller to specify the severity of the message. The other functions have implicit severities. The possible *severity* levels are:

- esimSevMessage for comment or verbose information
- esimSevWarning for warnings
- esimSevError for errors
- esimSevFatal for non-recoverable errors

It is possible to define your own severity levels. The function `esimReportAddSeverity` creates a new severity with the name *sev_name*. The return value of the function is the new severity that can be used in calls to `esimReport()`.
In the C interface routines the message consists of a format string *format* and its optional arguments. (see `printf`(3)). In the Fortran interface routines the message consists of a single string argument *message*.

`esimRecOpen()` opens a user-defined recorder file. The file is opened for writing. If the *path* is relative, the file is created in the recorder directory. The *flags* parameter contains configuration and/or option flags. It shall be set to 0 if no options are selected. The recorder handle is returned. On error NULL is returned.

`esimRecWriteRaw()` writes the *size* bytes of data in *ptr* to the recorder file indicated by the recorder handle *rec*. On error -1 is returned, on success 0.

`esimRecWriteHeader()` writes the recorder file header to disk. The simulation time is automatically included as the first field of each recording. After calling this function no more fields can be added to the recorder. Only calls to `esimRecWriteRecord()` and `esimRecClose()` are allowed. *rec* is the recorder file handle. On error -1 is returned, on success 0.

`esimRecWriteRecord()` samples all the variables that are in the recording referenced by *rec* and writes it to disk. On error -1 is returned, on success 0.

`esimRec`*type*`FieldAdd()`, where *type* can be Int8, Uint8, Int16, Uint16, Int32, Uint32, Int64, Uint64, Float or Double, is used to add a data field to the recorder of the specified type. *rec* is the recorder file handle. *name* is the symbolic name of the field. *address* is the address pointing to the variable to be recorded. On error -1 is returned, on success 0.

`esimRec`*type*`ArrayFieldAdd()`, where *type* can be Int8, Uint8, Int16, Uint16, Int32, Uint32, Int64, Uint64, Float or Double, is used to add an array data field to the recorder of the specified type. *rec* is the recorder file handle. *name* is the symbolic name of the field. *n_elem* is the number of elements in the array. *address* is the address pointing to the variable to be recorded. On error -1 is returned, on success 0.

`esimRecClose()` closes the user-defined recorder file indicated by recorder handle *rec*. On error -1 is returned, on success 0.

`esimThreadCreate()` creates a new non-real-time thread in the address space of the simulator. The thread starts the routine *start_routine* with argument *arg*. The name of the thread is given in *name*. This function should only be called from a non real-time task. Usage from a real-time task will result in a warning message and no further action taken.

`esimThreadKill()` sends signal *signal* to thread *thread*.

`esimThreadExit()` ends the current thread with exit code *exit_val*.

`esimgetProcessor()` returns the number of the logical processor that executes the esimGetProcessor call. Only when running real-time, the logical number matches the physical processor number. In non real-time simulations the logical number would remain constant, whereas the actual execution may switch physical numbers to optimize load balancing. When the processor setting in the schedule is ANY processor, the returned number can fluctuate as the logical processor may change depending on which processor is first ready to execute the calling task.

`esimVersion()` returns a string indicating the current version of EuroSim that you are running.

`esimInstallErrorHandler()` installs a user-defined error handler callback of the form:

```
void userhandler(esimErrorScope scope,
                 const char *objectid)
```

This callback function is called when an error occurs that may need intervention in user code.
Passing a NULL pointer will de-install the user error handler. No stack of user error handlers is maintained. This means that the last call to `esimInstallErrorHandler` defines which handler will be called. The possible values for *scope* are:

- esimDeadlineError when the user defined error handler is called with this scope then the *objectid* is the name of a task in the simulator schedule that has exceeded its deadline by a factor of ten. This allows a model developer to take action (f.i. force a core dump) when part of a model is ill-behaved (never ending loops or simply a calculation that takes too long and causes real-time errors). If no error handler is installed, the default action is to disable the offending task and enter the stand-by state. Note that deadline checking is only performed when the simulator is running in real-time mode.

`esimAbortNow()` immediately starts termination and cleanup of the simulator. This is useful when an error condition is found (f.i. at initialisation time) and no more entry points should be scheduled for execution.

`esimTracePause()` can generate a detailed tracing of the scheduler execution. When enabled via the ScheduleEditors Timebar dialog, the tracing starts when the scheduler starts executing. The esimTracePause can be called to freeze the tracing unit.

`esimTraceResume()` can be called to resume the tracing of the scheduler execution. See also esimTracePause.

`esimTraceMask()` The EuroSim Scheduler tracing capability generates a stream of data at high rate. Especially when multiple processors are active this can either overflow the internal buffering, the file system or just make the visualisation in the TimeBarViewer very slow. Using the esimTraceMask function the user can filter out event types and/or processors. Setting bits in the processor mask to 1 enables the processor to be logged. The least significant bit (i.e. bit 0) identifies the Non RealTime processor, the subsequent bits identify the processor number as set in the Schedule Editor. Setting bits in the event type mask to 1 enables events to be logged,where

```
     bit 0= Timer item events, relating to the timers on the schedule canvas
     bit 1= Task item events, recording the execution time of tasks
     bit 2= Task Entry events, recording the execution time of entrypoints
     bit 3= Busy time, recording the time the scheduler is executing (not id
le)
     bit 4= Clock, recording the clock interrupt
     bit 5= Interrupt, recording the interrupt time
     bit 6= Event, recording the executing times of event handler execution
     bit 7= Input, recording the triggering of the input connector
     bit 8= Command, recording the triggering of the command connector
     bit 9= Execution, recording the preemption of tasks
```

`esimIsResetting()` returns `true` when the reset procedure is in progress and `false` when it is not. The reset procedure starts in standby state and progresses through exiting, unconfigured, initializing and back into standby state. This function allows you to distinguish between for example a user initiated state transitions to exiting state to stop the simulator and the state transitions performed in the reset procedure.

`esimGetHeapUsage()` returns the real-time heap size, the maximum heap size used since startup and the current use (all reported in bytes)

`esimSetLoadMeasureInterval()` sets the measurement interval (msec) over which the processor load percentages will be measured. The interval must be equal to or be a multiple of the basic cycle period. If not it will be truncated to the nearest multiple.

The start of a measurement interval is synchronized to a multiple of its period with respect to the start of the simulation (t=0). Synchronisation is delayed until the end of the running measurement interval. If no interval was set by a previous call to this function then synchronisation is started immediately.

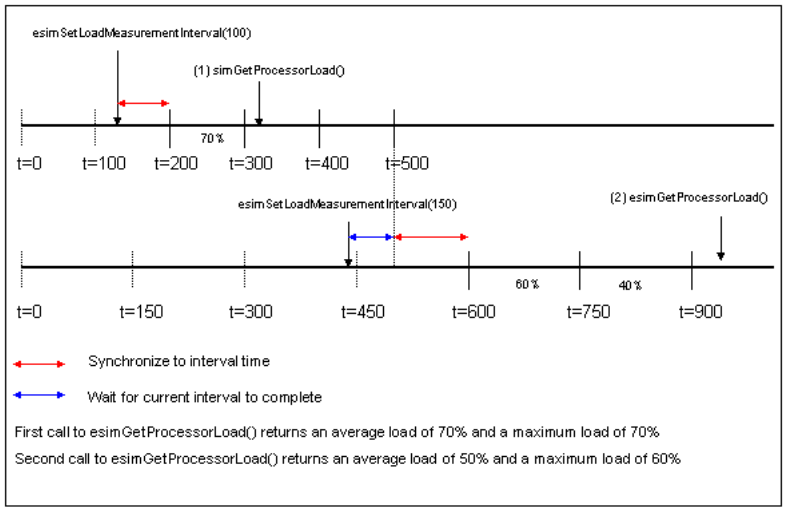


Figure 14.2: Example of using the processor load functions

Specifying a measurement interval equal to the major cycle time allows acurate load measurements of the major cycle to be made using the function `esimGetProcessorLoad()`

`esimGetProcessorLoad()` reads the maximum load and the average load of the specified processor (0-100%). The maximum is defined as the maximum percentage of time a processor was executing model tasks during a measurement interval (set by `esimSetLoadMeasurementInterval()`). The returned load values are only accurate when the simulator is running real time. Processing time of Eurosim itself and possible event handlers is not included. The maximum is reset each time the processor load is read (using this function). The average load is calculated over the number of measurement intervals that passed since the last call to this function. I.e. if the time interval is set to the main cycle period (by esimSetLoadMeasurementInterval) and this function is called every fourth main cycle, then the average load is calculated over the loads of the last four (completed) main cycle periods. Calling this function every main cycle will return the processor load over the last completed main cycle.

14.5 Limitations

14.5.1 Generial limitations

Model code should follow a set of rules when it is to be used in EuroSim. The rules are:

- Entry points should have no return value.
- Entry points should have no calling arguments/parameters (functions not used as entry points do not have this restriction). When calling arguments or parameters are needed they should be defined through one of two methods (of which the first one is recommended):

  1. Define global variables through an API as 'virtual' arguments/parameters.
  2. Encapsulate a function with arguments in a function which complies to the guidelines; this function can then call the function with arguments.

- If the entry point is used in the real-time domain it is not allowed to use any operating system call (`open`, `printf`, etc...). This is because operating system calls do not have deterministic execution times. Calls which are allowed are the services provided by EuroSim. See Section 14.4 for details on the EuroSim services.
- The entry point must not create a deadlock (i.e. waiting on a resource not available for some (undefined) time).
- No names should be used which conflict with one of the internal EuroSim functions. Refer to the file `$EFOROOT/etc/reserved-words.txt` for the complete list of reserved words.
- Only variables with a memory address that is fixed at load time can be used as API variables[1].

The operation must not make use of a locking mechanism (semaphores) to establish mutual exclusion of a common defined variable. This should be done using an asynchronous store (see Section 11.3).

During real-time simulation, the size of the system stack cannot change. Therefore, care should be taken with model code which allocates large data structures on the stack.

When combining programming languages in one model (e.g. C and Fortran), there are a number of rules to keep in consideration with respect to variable and function naming. Refer to the programming language documentation for more information. For an example, see Section 3.6.

[1] There is one exception: static variables declared within a C function have a load time fixed address but are not accessible by EuroSim. No implementation of such access is possible without violating the rule that EuroSim should not modify source code files.

14.5.2 C limitations

Unnamed structures, unions and bitfields cannot be used as API variables.

14.5.3 Fortran limitations

Because Fortran lacks the `extern` keyword as available in C, the 'owner' of a variable is not known to the Fortran compiler. Therefore, variables are declared in more than one Fortran source file. However, for EuroSim purposes, the API information for a variable should only be in *one* API header. The user should therefore make sure that a variable which is declared in more than one source file, should only be added to the API header of one of those files.

14.5.4 Ada-95 limitations

Although EuroSim does support the use of Ada-95 (except on the Windows platform) for the development of model code, the support is not at the same level as for C and Fortran. This is mostly due to the complexity of the Ada-95 language. The main difference with the use of C and Fortran code is that the API Editor does currently not support parsing of Ada-95 code. This means that any API headers have to be entered by hand to the source code. See Section 14.3.1 for details on the layout of the API headers, and Section 14.6.2 for an example of an Ada-95 header. Also, EuroSim currently only supports the use of the "GNAT" Ada-95 compiler. In this section, the limitations of the use of Ada-95 are described.

14.5.4.1 Ada-95 compilation

The GNAT compiler allows only one compilation unit per file. The `gnatchop` utility can be used to split the files. A body should be contained in a `.adb` file, and specifications should be in `.ads` files. If the package name `example` is given in a `with` clause, the compiler will look for `example.ads`. Filenames are mapped to lowercase, so the file `Example.ads` will not be found.

14.5.4.2 Ada-95 variables

Only variables which have a fixed address (as specified by the Ada-95 'Address' attribute) can be used as global variables within EuroSim. Variables that are to be used as globals must be made visible to the generated publish procedure. Therefore they must be put in a subprogram or package specification, so that they can be accessed by means of the `with` clause.

When two packages define a variable with the same name, the names should be fully qualified in the data dictionary (i.e. with the package name), otherwise the connection between variables and their compilation subunits would be lost.

If Ada-95 code is mixed with C and/or Fortran code, the model developer has to get the bindings of variable and entry names correct himself. An entity `name` that appears in a library package is accessible from C as `package__name` (two underscores). If the entity appears outside a package, its name will be prefixed with `_ada_`.

14.5.4.3 Ada-95 entry points

Ada-95 procedures without arguments can be used as entry points. In contrast with the global variables, they will not be referenced from generated Ada-95 publish code. However, they will be called from C code that is generated using information in the data dictionary, so the name in the data dictionary should correspond to the generated name in the object file.

Since entry points cannot have arguments, they cannot be overloaded.

14.5.4.4 Ada-95 Types

Generic packages cannot have API headers, because each instantiation would also have to instantiate a new API header. The API header has no support for generic types. If an instantiation of a generic package is made, the user has to perform the necessary parameter substitution himself.

User defined types are not supported by EuroSim.

14.5.4.5 Ada-95 Tasks

Since the EuroSim environment supplies its own task mechanism, the Ada-95 task and exception mechanism and associated commands (e.g. `select`, `delay`) should not be used.

14.5.4.6 Ada-95 Real time aspects

The timing of Ada-95 routines may be less predictable than the timing for C and Fortran, due to the dynamic allocation of variables.

14.6 Example API header

14.6.1 C Example

As an example, the API header from the Thruster.c file used in the case study is shown below (see Section 3.5 for the source code and the API information).

```
/*
'Entry_Point Thruster:
   DESCRIPTION="The thruster brings the satellite to"
   " the correct altitude."
   'Global_Input_Variables
      int lowerAltitudeLimit:
         UNIT="km"
         DESCRIPTION="Below this limit, the thruster must"
         " be turned on."
         INIT="210"
         MIN="0"
         MAX="1000",
      int sateliteAscentSpeed:
         UNIT="km/h"
         DESCRIPTION="The ascent speed of the satellite."
         INIT="10"
         MIN="1"
         MAX="200",
      int thrusterOnOff:
         UNIT="On/Off"
         DESCRIPTION="Indicates whether the thruster is"
         " on or off."
         INIT="1"
         MIN="0"
         MAX="1",
      int upperAltitudeLimit:
         UNIT="km"
         DESCRIPTION="The upper limit at which the thrust"
         "er is to be switched of."
         INIT="280"
         MIN="0"
         MAX="1000"
   'Global_Output_Variables
      int thrusterOnOff:
```

```
         UNIT="On/Off"
         DESCRIPTION="Indicates whether the thruster is"
         " on or off."
         INIT="1"
         MIN="0"
         MAX="1"
*/
```

Note that there is no restriction on line length for the API headers, but that the API Editor generates no lines longer than 80 characters. This is done to ensure good readability on most terminals.

Also note that variables which act both as input as well as output variables are defined twice in the API header.

14.6.2 Ada-95 Example

```
------------------------------------------------------
--
-- Name:   ball.adb
-- Type:   Ada-95 implementation.
--
-- Author: John Graat (NLR).
-- Date:   19961125
-- Changes: none
--
--
-- Purpose: Model for the Simulation of a Bouncing Ball.
--
--         The Bouncing Ball describes a ball that is thrown
--         straight-up from the ground with an initial velocity
--         or dropped from an initial height.
--         In the absence of friction, the ball should reach
--         exactly the same maximum height time and time again.
--         The ball is described as a mass point.
--
-- Parameters: GRAVITY Gravitation constant [m/s2]
--
-- State:  Height Height of the ball above the ground [m].
--         Velocity Velocity of the ball [m/s].
--
-- Additional: DeltaT Time Step for the Model.
--         LoadLoop Loop counter to increase computation time.
--         Duration Duration of the Ball Model.
--
-- Remark: The mass of the ball has mplicitly been set to 1 [kg].
--
-- API Header required for the correct Data Dictionary:
--
--     'Entry_Point ball.Ball:
--       DESCRIPTION="Computation of one time step of the ball"
--                "."
--        'Global_Input_Variables
--          Long_Float ball.deltat:
--                UNIT="s"
--                DESCRIPTION="Time step for the Ball Sub-Model."
--                MIN="0"
--                MAX="1",
--          Long_Float ball.height:
--                UNIT="m"
```

```
--                DESCRIPTION="Height of the ball."
--                MIN="0"
--                MAX="100",
--          Integer ball.loadloop:
--                UNIT="-"
--                DESCRIPTION="Loop counter to increase load."
--                MIN="0",
--          Long_Float ball.velocity:
--                UNIT="m/s"
--                DESCRIPTION="Velocity of the Ball."
--        'Global_Output_Variables
--          Long_Float ball.deltat,
--          Long_Float ball.height,
--          Long_Float ball.velocity,
--          Long_Float ball.duration:
--                DESCRIPTION="Duration of the Ball Model."
--
-----------------------------------------------------------------

with integr;
with esim;
use esim;

package body Ball is

  GRAVITY : constant Long_Float := 9.80664999;

  -- Global variables of the Bouncing Ball
  -- Actual declaration of these variables can be found in ball.ads
  -- Height, Velocity, DeltaT : Long_Float;
  -- Duration          : Long_Float;
  -- LoadLoop          : Integer;

  procedure Ball is
    -- Local Variables of the Bouncing Ball
    State, Dot   : Integr.Vector;
    Rate, Fine   : Long_Float;
    Loopcnt      : Integer;
    Start, Stop  : Long_Float;

    begin
      -- Get the Start time from the Wall Clock.
      Start := esimGetWallclocktime;

      -- Get DeltaT Time from the EuroSim Tool.
      Rate := EsimGetTaskrate;
      DeltaT := 1.000/Rate;
      Fine := DeltaT/Long_Float(100);

      for Counter in 1 .. 100 loop
        State(1) := Height;
        State(2) := Velocity;
        Dot(1) := Velocity;
        Dot(2) := -GRAVITY;

        -- Forward Euler Integration.
        Integr.intEulerADA( State, Dot, 2, Fine );

        -- Check on events, e.g. Ball touches the ground.
        if State(1) < 0.0 then
```

```
            State(2) := -State(2);
          end if;

          Height := State(1);
          Velocity := State(2);
        end loop;

        Loopcnt := 0;

        -- Loop to increase the computation time of the model.
        for Counter in 1..LoadLoop loop
          Loopcnt := Loopcnt + 1;
        end loop;

        -- Get Stop time from the Wall Clock and calculate Duration.
        Stop   := esimGetWallclocktime;
        Duration := Stop - Start;
    end Ball;
end Ball;
```


Chapter 15

C++ interface reference

15.1 Introduction

The C++ API is a complete application programmer interface for import and integration of models written in C++. In contrast with the classic EuroSim approach which uses parsers and GUIs to incorporate and integrate models, the C++ API provides an easy and intuitive programmers interface to accomplish this. This interface is designed such that it takes minimal effort for the user to develop, incorporate and integrate models in EuroSim. The interface also fits in very well with usage from modern tools such as Eclipse and UML design tools. An extension is available for the popular Enterprise Architect UML tool that automates design and includes tailored code generation for the C++ interface, thereby providing users with a unique jump start to their project. The performance and capabilities of the C++ interface are at least equivalent to the classic proven interface, including support for hard realtime execution. Provisions are made and guidelines are provided to keep the models portable, and even though the user must create an extension in his model, the paradigm of EuroSim that user model code must be left untouched is also maintained.

The C++ API consists of five sections:

- *Services:* the runtime platform service functions that models can use as for example reading the simulation time,
- *Publication:* the mechanism and associated functions that models can use to publish (member) variables and methods or functions in the EuroSim dictionary,
- *Type Library:* EuroSim C++ suitable implementations of Vector, List and Map that support the publication mechanism and can be used in hard realtime simulators,
- *Integration:* A C++ API solution to support dataflow based integration of models,
- *Error Injection:* An extension on the integration API part to support error injection.

Two examples are provided with the installation that show the usage of the C++ interface for different parts of the API. The Satellite++ example is intended for general usage and focusses on publication and type library usage, where as the SatelliteUML focusses on the application of EuroSim in test systems. The latter focusses on the C++ model Integration and Error Injection capabilities and includes the Enterprise Architect UML database with its EuroSim extensions for tranformation and generation. If you find the API complicated, then please jump to the UML section in this chapter and let the tool generate a complete simulator for you and study the generated code.

In this chapter we first show the setup of EuroSim for usage of the C++ interface in the section 15.2. In the following sections the different parts of the interface are explained in detail; Section 15.3 explains the publication interface, section 15.4 the available runtime interface functions, section 15.5 the data types that can be used in the C++ interface, section 15.6 the model integration concept and functions, section 15.7 the support for error injection and section 15.8 the UML support provided via Enterprise Architect. Finally tips and guidelines are provided in section 15.9.

15.2 Setup procedure

The EuroSim C++ API is provided as a build option. To enable support for this API, tick the check box in the Model Editor build options. See Figure 15.1.

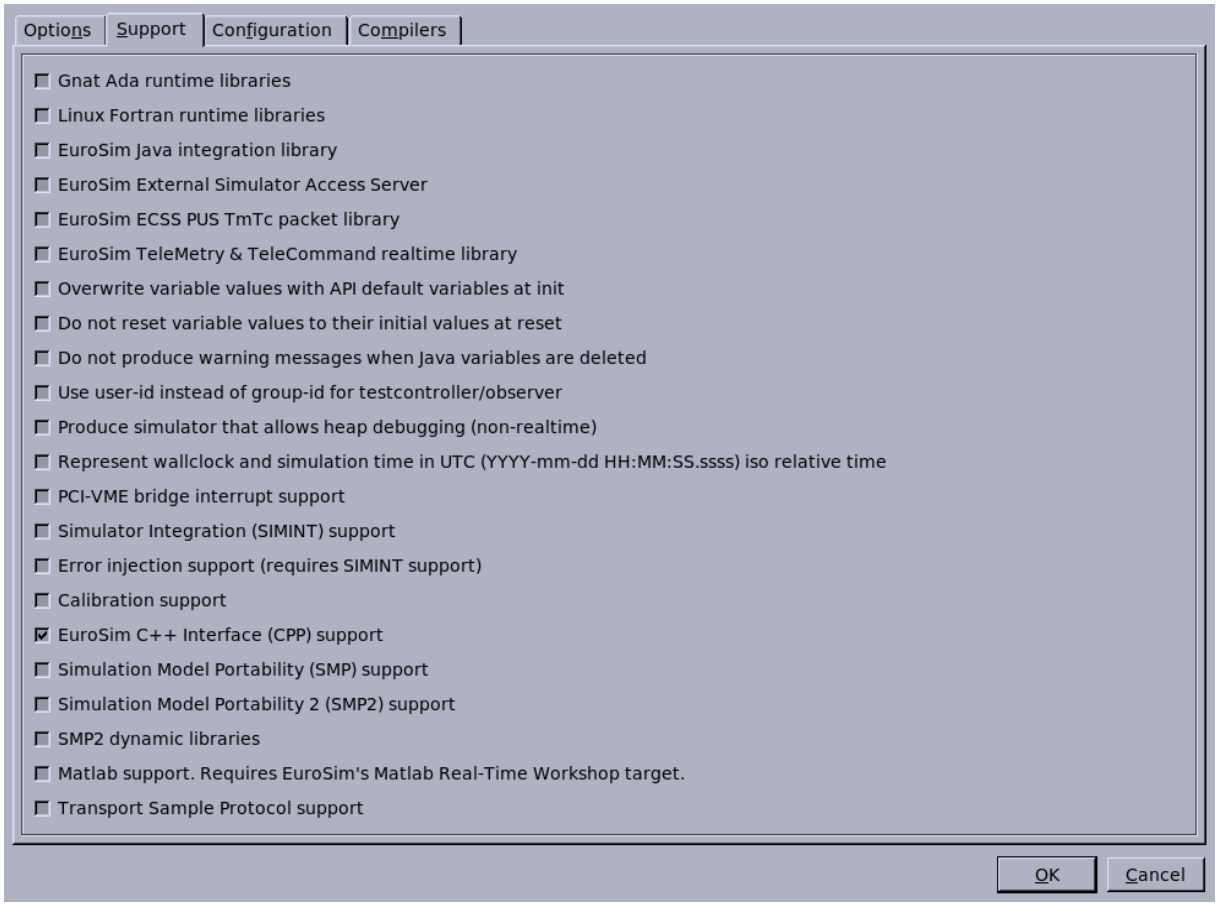


Figure 15.1: EuroSim C++ build option

When the EuroSim C++ support capability is switched on, the users model software is required to implement a bootstrap function called esimCppSetup in which scope the developer should create all objects and publish them into the EuroSim dictionary:

```
bool Esim::esimCppSetup()
```

Providing a return value of *false* will indicate to EuroSim that the publication process has failed and aborts the simulator before the scheduler starts. As with all functions of the C++ API, the esimCppSetup function prototype declaration is provided by including `esim++.h`.

Generally it is found that the C++ model code contains an OO factory pattern, which defines one object that creates all other objects and can be seen as the root of the object hierarchy. The esimCppSetup function scope is the appropriate time and location to create such factory object and initiate its functionality.

The allocation of memory for objects is automatically rerouted by EuroSim to its real-time memory allocator (esimMalloc), such that new and delete operators can be used safely without endangering the real-time performance.

When all objects are created, the models must be published in EuroSim's dictionary. The preferred approach is to use the recursive mechanism, in which case for every model that is to be published directly under the /CPP root node, the following function should be called:

```
bool Esim::publish( object,"dictionary name",<"description">)
```

The details on the recursive mechanism and function arguments are explained in Section 15.3. The result is a reflection of the object hierarchy in the dictionary. Figure 15.2 illustrates the CPP node.

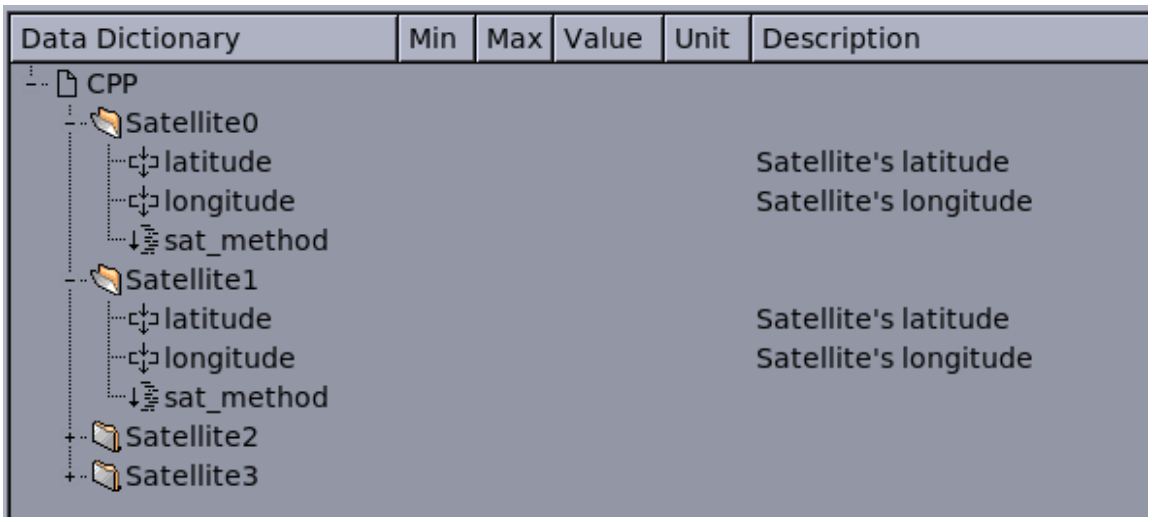


Figure 15.2: CPP Dictionary node

As shown in 15.2 the function call publishes the information on objects under the name `/CPP/.../objectname` in the dictionary with the `<optional description>` in the EuroSim dictionary. The publication API provides functions to further shape the dictionary and add more details. All other tools that use the dictionary, such as the ScheduleEditor and the SimulationController are unchanged and function with the C++ interface as they did with the classic EuroSim languages. Following listing shows the setup approach in a small example.

Listing 15.1: Example of source code organization using the C++ API

```
#include <esim++.h>

class Example
{
Private:
      Float aFloatAttribute;
      Int anIntAttributeArray[10];
      void someMethod();
Public:
      virtual esimPublish();
}

Bool esimPublish() {
      result=true; //to return the status of publication to higher levels,
         ultimately EuroSim itself

      result=result&&Esim::publish(aFloatAttribute,"aFloatAttribute',"
         Description of a float");
      result=result&&Esim::publish(anIntAttributeArray,"anIntAttArray","An
         integer array publish");
      result=result&&Esim::publish(&Example::someMethod,"someMethod","
         publishing a method");

      result=result&&Esim::setUnit("aFloatAttribute","kg");
      result=result&&Esim::setMin("aFloatAttribute",0.01);
      result=result&&Esim::setMax("aFloatAttribute",0.99);
      result=result&&Esim::setParameter("aFloatAttribute",0.99);
      result=result&&Esim::setInput("aFloatAttribute");

}

void esimCppSetup() {
      Example* expl=new Example();
      Esim::publish(*expl,"example","publishing my example directly under
         the /CPP root");
}
```

15.3 Publication interface

15.3.1 Standard publication interface

The goal of the C++ publication interface is to show all the variables and entrypoints in objects in a tree format that reflects the ownership relations (composition or aggregation) between instances in your application. If Object A is a composition of Objects B and C, then in the dictionary Objects B and C should be child nodes of Object A. These ownership relations are enclosed in objects through their member variables. The EuroSim C++ interface uses a simple but effective recursive mechanism that publishes objects and subsequently its member variables. The mechanism requires that every object that is to be published must provide an esimPublish() method:


```
bool esimPublish()
```

When performing `Esim::publish(x, "x")` on an object x, the publication mechanism adds object `"x"` to the dictionary and subsequently calls `x.esimPublish()`. The esimPublish method of the model should contain the publication code of each attribute and method that the model wishes to publish in the EuroSim dictionary.

```
bool Esim::publish(attribute,"attr_name", <"descr">)
bool Esim::publish(&class::method,"method name", <"descr">)
```

The publication always starts from the current scope, which is the object that contains the esimPublish call. There are three functions available to the user to change the scope:

- `bool Esim::getScope(char* scope)`
- `bool Esim::setScope(const char* new_scope)`
- `bool Esim::cmpScope(const char* my_scope)`

`Esim::getScope(buffer)` sets the provided argument buffer to the current scope (the caller thus has to provide the memory). `Esim::setScope("my new scope")` changes the current scope to the relative or absolute path argument. `Esim::cmpScope("my own scope")` matches the argument with the current scope. All three routines return true in case of success.
As shown in above listing, the actual publication of attributes and entrypoints is accomplished through the call Esim::publish:

```
bool Esim::publish( item, dictionary name, <"description">)
```

Where:

- `item` defines the object, attribute or method that is to be published.
- `"dictionary name"` defines the name that should be used in the dictionary to identify the published `item`, which in most cases will be the object, attribute or method name,
- `<"description">` defines an optional description that will be visible in the GUIs, e.g. in monitors in the *SimulationController* to aid the user in working with the simulation.

Through extensive overloading, the same method can be applied for every type that is to be published, being either an object, an attribute of an object or a method of an object, or a static method. For example:

```
Esim::publish(attribute, "attribute", "description of the attribute")
Esim::publish(&method, "method", "description of the method")
Esim::publish(object,"object","description of the object")
```

There are two exceptions where the Esim::publish needs additional information from the user to achieve the desired publication due to limitations in C++ overloading:

- The first case is for *enumerated types* . These types are not natively handled by EuroSim and are difficult for EuroSim to discern from integers. The user can cast the variable to either an integer type in the publish call, or let EuroSim handle that by calling:

  ```
  Esim::publish_enum(attribute,"attribute",<"description">)
  ```

  The advantage of the latter is that EuroSim will check what base type the compiler selected for this enumerated type. There is also an advanced solution, which is able to use label names in EuroSim instead of only values. The advanced solution will be elaborated in the section on Typed Publication.

- The second case is for *strings* of type `char*`. The `char*` type conflicts with `char[]` in the overloading and unfortunately you can not have both at the same time. The solution provided is that by default the `char[]` is supported, which automatically detects the size of the array and publishes the array variable correctly in the dictionary. If `char*` support is needed, for instance because it is the type of the key of an `Esim::Map` (see section 15.5), then this can be enabled by placing `#define ESIM_CPP_STRING` before <*esim++.h*> is included in the source file. After that point in that file, both `char*` and `char[]` publication assume the user intents to publish a zero terminated string and it determines the amount of characters to publish based on `strlen`.

The name with which a published item will appear in the EuroSim dictionary will in most cases be just the name of the object, variable or method that is published. However, this can be a relative or absolute path. A relative path is written as a command line directory navigation, e.g. "../../myobject/myitem" will publish the item "myitem" not as a child of the current object but as a child of the object myobject that exists two levels up in the hierarchy. An absolute path starts with /CPP, the root node in the dictionary for all models software that uses the C++ API. (See Section 15.3.1 for a description of the recursion mechanism).

The optional description `<"description">` in the method definition is only used to provide extra information to the user of the simulation in which the model is applied. If the optional description argument is left out, an empty string is applied. As shown in the example the description can also be set later on, after an item is published. A special case of that is setting the description of an object from within its own publication routine. When publishing a derived class by calling the publish routine of its base class, the desciption can then reflect information about the dervied class.

The publication of variables using overloading works on multi-dimensional arrays just as on scalars. The overloading will automatically detect the dimensions of the variable and assure a proper incorporation in the EuroSim dictionary such that it becomes available in EuroSim GUIs and scripting as multi-dimensional array. The maximum number of dimensions is currently limited to five, thus supporting arrays, matrices, cubes. and even 4- and 5 dimensional variables. We have not seen a demand for higher number of dimensions then three and thus expect up to 5 dimensions to be more then sufficient. Please contact the helpdesk if you have a case where more then 5 dimensions are required, workarounds are readily available and patch release can be provided. Note also that there is a fundamental difference in how multi-dimensional variables are stored for standard types and C-type structures versus objects that include methods. For objects, each object is seperately defined in the dictionary, which leads to large dictionaries and more processing time. If you have C-type structures we recommend publishing using the typed publication approach (Section 15.3.3).

A special case of Esim::publish overloading allows the creation of an empty object, or in other words a folder or tree node in the dictionary. When using

```
Esim::publish("itemname");
```

A folder is created in the dictionary with name itemname. The argument itemname may include an absolute or relative path specification to create a node anywhere in the dictionary. Use either the relative path mechanism to publish items in the created folder, or use Esim::setScope to set the publication scope to the newly created folder.

15.3.2 Adding publication details

When adding models to EuroSim via the classic C API approach, the EuroSim ModelEditor supports the user in adding minima, maxima and unit definitions to variables in the dictionary. In the approach it also supports definition of the access a simulation user has to attributes. With the C++ API, this information can be added from the model software. The Esim namespace contains the following methods to accomplish the same features for published C++ variables (attributes):

- `bool Esim::setUnit("dictionary name" ,"unit")`

- `bool Esim::setMin("dictionary name" ,minimum value)`
- `bool Esim::setMax("dictionary name" ,maximum value)`
- `bool Esim::setParameter("dictionary name" ,true (default) or false)`
- `bool Esim::setInput("dictionary name")`
- `bool Esim::setOutput("dictionary name")`
- `bool Esim::setDescription("dict name" , "description")`
- `bool Esim::setDescription("description")`

Where:

- `setUnit, setMin, setMax` have the same meaning as in the classic C API,
- `setInput` and `setOutput` can be used to manipulate the variable node icon to show the end user (e.g. in the Simulation Controller) that the variable is an input or output variable. This differs from the Access point of view taken in the classical API, where the parsers show whether entrypoints read or write in the variable. In the C++ API such information is not present and the input or output marking becomes a means by which the developer can visualize to the end user this this variable can be set during simulation (input, arrow pointing into the box) or is of interest for monitoring or recording (output, arrow pointing out of the box),
- `setParameter` marks the variable as one that only can be set at the start of the simulation, i.e. can only be set via an initial condition,
- `setDescription` is added to support setting the description of a dict variable separately from the publication. The special version with only a description as argument sets the description of the current object and is very usefull to show derived class information for objects in vectors, lists and maps.

15.3.3 Typed publication

The Typed Publication API is very similar to the standard publication API, but circumvents the overloading mechanism. Instead of the overloading mechanism that is build into the C++ publication API, the user can pass a string that identifies the type specification in the dictionary:

```
bool Esim::publish( "dictionary typename", object,
                    "dictionary name",<"description">)
```

This type specification is particularly usefull for publication of variables of a complex C style type such as structs, unions and enumerations. Because an API to define the types in the dictionary would be highly complex, the EuroSim C parser approach should be used. Declare a variable of the type in a C file and use the EuroSim parser to add the variable to the dictionary. The dictionary typename is the same name as the type of the variable in the C file and its specification in the dictionary includes all additional information added in the ModelEditor such as units, minumun, maximum and description. All types defined in the dictionary using the EuroSim C and Fortran parsers are known when puchinsing C++ interface based models.

Besides the benefit of an easy to use interface to define types in the dictionary, this also ensures that the type remains consistent with its definition in the header file because in every (re-)build the parsers will check the consistency, which outweighs the possible overhead of a global variable that may not be used. However in some cases this approach is unnecessary complex, in particular for enumerated types where the user mainly want to have the benefit of seeing labels in the Simulation Controller rather then integer numbers. Specifically for enumerated types a function is provided to allow the user to add a specification of the enumerated type with labels to the dictionary.

```
Esim::enumeration(const char *type, int nr_labels,
                  const char *label, int value, ...)
```

The Esim::enumeration function allows the user to define an enumerated type in the dictionary in order to see labels instead of values in the EuroSim Simulation Controller. The previously described approach of defining the type in the dictionary by creating a variable of it in a C file has benefits, but for merely associating labels to values, it may be overdone. In such case the user can also use the above enumberation function to add an enumeration type to the dictionary. The provided type string defines the name of the enumerated type in the dictionary, the `nr_labels` argument defines the number of fields of the enumerated type, and subsequent label-value pairs attach a label to an enumerated type value. Using typed publication the programmer can publish a variable for which EuroSim will assume that it is an enumerated type as defined in the dictionary for the specified type name.

15.3.4 Publication configuration and debugging

The C++ API provides a number of configuration functions to activate debug features and memory optimization features that are built into the C++API.

- `typedef enum Esim::OnOffMode_tag { OFF=0, ON=1 } OnOffMode`
- `void Esim::switchPublishVariable(OnOffMode onoff)`
- `void Esim::switchPublishEntrypoint(OnOffMode onoff)`
- `void Esim::switchPublishDescription(OnOffMode onoff)`
- `void Esim::switchPublishUnit(OnOffMode onoff)`
- `void Esim::switchPublishMinMax(OnOffMode onoff)`
- `void Esim::switchPurgeObject(OnOffMode onoff)`
- `void Esim::switchNullPointerWarning(OnOffMode onoff)`
- `void Esim::switchTrace(OnOffMode onoff)`
- `void Esim::switchCycleDetection(OnOffMode onoff)`

The functions switchNullPointerWarning, switchTraceEsim, switchCycleDetection support the debugging of the publication process. The C++ API generates a warning whenever it encounters a null pointer in the publication process, ignore this error and continue. The default is thus ON, but this can be surpressed, for instance when large amounts of nullpointers still occur because the code is not complete yet. The function switchTrace can be use to activate the tracing capability of the C++ API (default is off). The tracing feature will generate a message for every call to a publish routine, showing the dictionary path of what is to be published.

The switchCycleDetection function can be used to activate the cycle detection feature of the C++ API. Especially when generating the code from UML, associations lead to objects publishing eachother. The Cycle detection looks for repeating patterns in the path and generates an error message if one is found. In such cases one of the publish calls must be removed. The default value of the cycle detection feature is Esim::OFF.

The switchPublish functions and the switchPurgeObject function are related to memory consumption. These functions only need to be used in extreme cases of many objects and severe memory limitations. The default value is therefore OFF. The switchPublish routines switch the publication of a category of dictionary items on or off. The PurgeObject function removes an object that has no attributes in the dictionary directly after completion of publishing object. Objects without attributes are never visible in the EuroSim, and thus may as well me removed from the dictionary to reduce memory consumption. Be carefull though when using relative paths, as when removed you cannot add attributes in a later stage.

15.4 Service interface

The Services section of the C++ API is essentially a C++ style written version of the classic EuroSim C API. Thus where the EuroSim C API functions have `esim` as a name prefix, the C++ API functions have `Esim` as namespace. A function `esimMessage()` becomes `Esim::message()`, and an enumerated type `esimState` becomes the enumerated type `Esim::State`. The EuroSim C++ API is defined in the file esim++Services.h (which is automatically included by esim++.h).

Following is a complete listing of the EuroSim C++ API in relation to the C API functionality. The detail of each function can be found in in the manual page esim++services and is exactly the same as for the EuroSim runtime C API.

Listing 15.2: EuroSim's C++ API in relation with the C API

```
REALTIME MEMORY ALLOCATION:
void     *malloc(size_t size)
void      free(void *ptr)
void     *realloc(void *ptr, size_t size)
void     *calloc(size_t nelem, size_t elsize)
char     *strdup(const char *str)

REALTIME TMING FUNCTIONS:
double   getSimtime(void)
int      setSimtime(double simtime)
struct timespec getSimtimets(void)
void     getSimtimeYMDHMSs(int t[7])
double   getWallclocktime(void)
struct timespec getWallclocktimets(void)
double   getHighResWallclocktime(void)
int      setSimtime(double simtime)
int      setSimtimets(struct timespec simtime)
int      setSimtimeYMDHMSs(int t[7])

REALTIME STATE FUNCTIONS:
State    getState(void);
int      getState(State state);
int      setStateTimed(State state, const struct timespec *t,
                  int use_simtime)
struct timespec getMainCycleTime(void)
struct timespec getMainCycleBoundarySimtime(void)
struct timespec getMainCycleBoundaryWallclocktime(void)

REALTIME TASK RELATED FUNCTIONS:
const char *getTaskname(void)
double   getTaskrate(void)
int      enableTask(const char *taskname)
int      disableTask(const char *taskname)
int      entrypointFrequency(State state, const char *entrypoint,
                     double *freq)
Entrypoint *entrypointGet(const char *entrypoint_path)
int      entrypointEnable(Entrypoint *entrypoint, bool enabled)
int      entrypointExecute(Entrypoint *entrypoint)
int      entrypointFree(Entrypoint *entrypoint)
int      getRealtime(void)
int      setRealtime(int on)

EVENT FUNCTIONS:
int      eventRaise(const char *eventname, const void *data, int size)
int      eventRaiseTimed(const char *eventname, const void *data,
               int size, const struct timespec *t, int use_simtime)
```

```
int       eventCancelTimed(const char *eventname)
int       eventCount(const char *eventname)
int       eventData(void *data, int *size)
int       eventCount(const char *eventname)

REALTIME CLOCK FUNCTIONS:
double    getSpeed(void);
int       setSpeed(double speed)

REALTIME RECORDING FUNCTIONS:
int       getRecordingState(void)
int       setRecordingState(int on)

REALTIME REPORTING FUNCTIONS:
void      message(const char *fmt, ...)
void      warning(const char *fmt, ...)
void      error(const char *fmt, ...)
void      fatal(const char *fmt, ...)
void      report(int s, const char *fmt, ...)
int       reportAddSeverity(const char *sev_name)

NON-REALTIME THREAD FUNCTIONS
thread   *threadCreate(const char *name, void (*start_routine)(void*),
                  void *arg)
int       threadKill(Esim::thread *thread, int signal)
void      threadExit(int exit_val)
void      threadJoin(Esim::thread *thread)
void      threadDelete(Esim::thread *thread)

METRICS FUNCTIONS
bool      setLoadMeasureInterval(int processor, double interval)
bool      getProcessorLoad(int processor, double *avg_load,
                     double *max_load)
void      getHeapUsage(int *tot_size, int *max_used, int *current_use)

RACE FUNCTIONS
void      tracePause(void);
void      traceResume(void);
void      traceMask(unsigned type_mask, unsigned proc_mask);
```

The above C++ API functions thus wrap the EuroSim C API functions, and thus have the same arguments, effect and results as defined for the C API.

15.5 Supported data types

15.5.1 Basic types and arrays

The EuroSim C++ interface supports the C++ basic data types, and arrays thereof. The table below show how they are mapped to a type in EuroSim:

C++ type	EuroSim type Description
bool	8 bit unsigned integer type
byte	8 bit signed integer type
char	16 bit unsigned integer type
short	16 bit signed integer type
int	32 bit signed integer type
long	64 bit signed integer type
float	32 bit floating point type
double	64 bit floating point type

15.5.2 Container Types

In addition, the C++ API also provides a number of container types to provide a similar capability as the Standard Template Library. These containers support the recursive publication mechanism and allocate memory for their internal administration before publication; hence the maximum size must be provided at compilation time. Following container types and for each type a number of methods are provided.

`Esim::Vector<Element, Size>`

- `void clear()` Resets the administration of the Vector (contained objects are not destroyed by clear)
- `size_t size() const` Returns the number of elements added to the vector.
- `template <class Functor> void foreach( Functor&)` Iterates through all the elements in the vector and call for each element the user defined functor with the element as argument
- `bool push_back(const Element&,const char* name="",`
  `const char* description="" )`

  Adds element to the back of the vector. The optional name and description allow each element to appear in the vector with a user defined name
- `bool pop_back()` Remove the element at the back of the vector.
- `Type& front;` Provides a reference to the element at the front of the vector.
- `const Element& front()` Const version of front().
- `Element& back()` Provides a reference to the element at the back of the vector.
- `const Element& back()` Const version of back().
- `Element& operator[] (int index)` Provides a reference to the element at the specified index in the vector

`Esim::List<Element,Size>`

- `void clear()` Resets the administration of the Vector (contained objects are not destroyed by clear)
- `size_t size() const` Returns the number of elements in the list.
- `template <class Functor> void foreach( Functor&)` Iterates through all the elements in the vector and call for each element the user defined functor with the element as argument .

- `bool push_front(const Element&,const char* name="", const char* description="")`

  Adds element to the front of the list. The optional name and description allow each element to appear in the list with a user defined name

- `bool pop_front()` Removes element from the front of the list.

- `bool push_back(const Element&,const char* name="", const char* description="")`

  Adds element to the back of the list. The optional name and description allow each element to appear in the list with a user defined name

- `bool pop_back()` Removes element from the back of the list.

- `bool insert_after(const Element& after, const Element& e, const char* name="", const char* description="")`

  Inserts element e after element after. The optional name and description allow each element to appear in the list with a user defined name

- `bool insert_before(const Element& before, const Element& e, const char* name="", const char* description="")`

  Inserts element e before element before. The optional name and description allow each element to appear in the list with a user defined name

- `bool remove(const Element&)` Removes element from list.

- `Element& front` Provides a reference to the element at the front of the list.

- `const Element& front()` Const version of front().

- `Element& back()` Provides reference tothe element at the back of the list.

- `const Element& back()` Const version of back().

- `Element& operator[] (int rank)` Provides a reference to the element that is at the position rank in the ordered list.

`Esim::Map<Key, Element, Size>`

- `void clear()` Resets the administration of the Vector (contained objects are not destroyed by clear)

- `size_t size() const` Returns the number of elements in the map.

- `template <class Functor> void foreach( Functor&)` iterates through all the elements in the vector and call for each element the user defined functor with the element as argument .

- `Element* find( const Key& )` Return a pointer to the element that has the provided key, or NULL otherwise.

- `const Element* find( const Key& ) const` const version of find().

- `bool insert(const Key&, const Element&, const char* name="", const char* descri` Inserts the provided Key,Element pair in the map. The optional name and description allow each element to appear in the map with a user defined name

- `bool remove(const Key&)` Removes the element with the provided Key from the map.

- `Element& front` Provides a reference to the element at the front of the map.
- `const Element& front()` const version of front().
- `Element& back()` Provides a reference to the element at the back of the map.
- `const Element& back()` Const version of back().

In general the methods of the container types have the same meaning as their counterparts in the C++ standard template library, with the exception of the remove method and the foreach methods. The remove method only removes the element from the container, it does not deallocate memory. The foreach methods replaces the iterator mechanism of the standard template library. It iterates through all the elements in a container, with for each element executing the functor with a reference to an element as argument. This provides an easy interface without the need for inheritance. The functor is used by reference and can be used to collect data as it iterates through the elements. Following example shows the use of the foreach and functor feature:

```
Class ListFunctor {
   Private:
      MyAttr attr;
   Public:
   bool operator()(MyClass* p) {
            attr+=p->aMyClassmethod();
      }

}

Esim::List<MyClass*,10> myClassList;
ListFunctor f;
myClassList.foreach(f);
```

These container types are provided via the include file esim++tl.h, but users are advised to include esim++.h as it will include any other files needed and supports portability. Note that this current template library is designed to support hard realtime execution, as well as the recursive publication mechanism. It is mostly in line with the C++ standard template library but deviations do exist as for instance on the iterators and the EuroSim solution is considerably less efficient. EuroSim does not prevent the user from using the standard template library in his model code, however it's usage may affect the realtime execution and it is up to the user to assess if that conflicts with his requirements.

15.6 Simulator Integration interface

The Simulator Integration (simint) part of the C++ API allows the user to integrate object oriented models using a dataflow approach. This supports hard realtime simulator integration with typical test system features as configurability and error injection(see 15.7 for more details on injection). The SimInt interface is supported with an Enterprise Architect extension to allow the user to stereotype a class definition and generate code that matches the SimInt interface. The enterprise architect extension and resulting code can be found in the SatelliteUML example provided in the src directory of your EuroSim installation. This example illustrates the capabilities presented in this section and is a good source of additional information to get the user started.

The implementation of the proven realtime dataflow concept using the CPP API starts with the ability to add ports to model variables when programming models. Inports provide a model input gate to a variable and outports provide a model output gate from a model variable. A port is created by calling a port creation function after publication of a variable in the esimPublish function of a class. The resulting port object then becomes visible in de datadictionary. Following port creation functions are available

```
INPORT CREATION FUNCTIONS

bool Esim::addInPort<T>(T& var, const char* name,
                IErrorInjector* injector=0, bool active=true )

bool Esim::addInPort<T,size_t>( T (&var)[N], const char *name,
                IErrorInjector* injector=0, bool active=true )

bool Esim::addInPort(const char* var_path, const char* name,
                IErrorInjector* injector=0, bool active=true )

OUTPORT CREATION FUNCTIONS

bool Esim::addOutPort<T>(T& var, const char* name,
                IErrorInjector* injector=0, bool active=true )

bool Esim::addOutPort<T,size_t>( T (&var)[N], const char *name,
                IErrorInjector* injector=0, bool active=true )

bool Esim::addOutPort(const char* var_path, const char* name,
                IErrorInjector* injector=0, bool active=true )
```

The first variant creates an inport around the variable provided as first argument and appears in the dictionary under the name provided as second argument. The second variant provides the same feature for array variables, in which case a port is generated for each element of the array. These first two variants are the most common and reliable approach but can only be used when the variable is accessible, usually from within the esimPublish function of the class that the variable is a member of. The third variant supports creation of a port by refering to the variable via its dictionary path. In all cases the error injector parameter and port type parameter do not need to be provided if the most common ACTIVE port type is needed without an error injector (zero). For adding an error injection capability to a port, see section 15.7.

In line with the publication interface, the creation of ports also has a typed variant to support port creation on C-style types such as enum and struct. For typed port creation the name of the type of the variable must be added as string literal for the first argument to the addInPort or addOutPort call:

```
bool Esim::addInPort<T>(
                const char* typename, T& var, const char* name,
                IErrorInjector* injector=0, bool active=true )

bool Esim::addInPort<T,size_t>(
                const char* typename, T (&var)[N],  const char *name,
                IErrorInjector* injector=0, bool active=true )

bool Esim::addOutPort<T>(
                const char* typename, T& var, const char* name,
                IErrorInjector* injector=0, bool active=true )

bool Esim::addOutPort<T,size_t>(
                const char* typename, T (&var)[N], const char *name,
                IErrorInjector* injector=0, bool active=true )
```


Note that the variant with var_path is not yet supported for typed port creation.

Ports can be either active or passive. An active inport will automatically transfer its port contents to the associated model variable when a dataflow has filled it. An active outport will automatically copy the contents of the associated model variable into its port when a dataflow tries to transfer the outport contents. In most cases this is the desired effect, however sometimes the copy to and from the model variable can not be driven by the dataflow. In such occassions the port can be defined passive. An entrypoint named `set_input` or `set_output` is then automatically added to the port object. Scheduling of this entrypoint provides the user the control over the transfer of data from a port to the associated variabled or vice versa.

Instantiation of models in the datadictionary can be accomplished by creating an instance of the developers class and publishing it in the dicitonary. Rather then via the Esim::publish function, the SimInt interface provides the addModel function. Although this has the same effect as calling the publish function, the benefit it is that the object is shown with the EuroSim model icon rathern than a standard class icon. The model can be unfolded to show its ports and contained classes, variables and entrypoints.

```
MODEL ADDING FUNCTIONS

bool Esim::addModel<T>( T& object, const char *name, const char *descr="");

bool Esim::addModel<T,size_t>( T (& object)[N],const char *name, const char *
```

The integration of models is accomplished by creating interconnecting ports using the Channels provided by the SimInt interface.

```
CHANNEL ADDING FUNCTIONS

bool Esim::addChannel(const char* outport, const char* inport, const char* na
                      unsigned capacity=0, const char *description="");
```

The channel represents the ability to flow data from teh outport to the inport. The channel object contains a transfer entrypoint that can be scheduled to trigger such transfer. The ability to time the data transfer is required when using parallel and even concurrent scheduling techniques to ensure the proper execution of models.

Wen creating channels the user can specify a capacity, which relfects the internal buffering in the channel. When zero, as in most cases, the data is transfered directly from the outport to the inport. When the capacity is one, a double buffering takes place in the channel and the user is provided two instead of one transfer entrypoints contained in the channel. The double buffering allows the models on both sides of the channel to run in parallel without running into data corruption. Higher capacity numbers implement a ringbuffer mechanism that prevents the loss of data as can occur with double buffering which always provided the consumer part the latest data.

For convenience, the SimInt interface provides the ability to define sequences of entrypoints, such that a series of entrypoints can be controlled through a single name. The Sequence is typically used to bundle the execution of the channel trasnfer entrypoints. Quite often the presence of a model versus the presence of the equipment that the model simulates forces the scheduling of sets or sequences of transfer functions. Particularly in object oriented solutions the Sequence feature is usefule as OO solutions multiply the amount of transfers compared to the classic EuroSim C type solutions.

```
SEQUENCE CREATION FUNCTIONS

bool Esim::addSequence(const char *name, const char *description="");

bool Esim::addSequenceEntry(const char *source_entry_name, const char *sequence_ent

bool Esim::addEntryToTask(const char *taskname,const char *entrypath);
```

The C++ Simulator Integration API also provides a built in schedule feature that has no counterpart in other APIs and is specifically usefull in the context of Object Orientation where many more entrypoints will occur. Where in a C API solution the an entrypoint would work on an array of variables, the Object Oriented solution will have an array of objects each with a method working on one variable, requiring scheduling of an array of entrypoints. The addEntryTotask function therefore allows the model developer to add an entrypoint to a task in the schedule. This function is best called directly after the publication of a method, here assumed to be under the name ”entrypoint”. When a simulator starts, it reads in the provided schedule file. When the addEntryToTask method is encountered it then adds the entrypoint ”entrypoint” in the dictionary to the task ”taskname” in the schedule. In object oriented code multiple instances are created and thus multiple times the entrypoint ”entrypoint” is published (under a different parent object) in the dictionary. In the normal approach the entrypoint must be added the same amount of time as there are objects to a task using the ScheduleEditor. Using the addEntryToTask this is now done automatically from the code, avoiding discrepancies between code and schedule. The decisions on how the code is scheduled of the processors in time is still defined using the tasks and task properties in the schedule editor, but the schedule may contain only or mostly empty tasks.

Note that the timing statistics and timebar feature of EuroSim will still collect and contain the timing statistics of all entrypoints. The Simulation Controller however will not show entrypoints in the schedule tab, and no eurosim schedule breakpoint can be defined on entrypoints. (But the symbolic debugger can be used to set a breakpoint on any function). Further details can be found in the manual page esim++simint

15.7 Error Injection interface

The CPP Simulator Integration interface provides an error injection mechanism, that supports adding an error injector object to a port which affects the data as it flows from the port to the value (InPort) or vice versa (OutPort). An ErrorInjector object is an instantiation of a class that is either a default error injector class that is part of the CPP Error Injection interface, or it is an instance of the users own made specific Error Injector class. These Error Injection classes are created by derivation from the templated generic Error Injector class:

```
template <class T> class ErrorInjector : public IErrorInjector {
   public:
      virtual const T inject(const T& )=0;
      virtual void esimpublish(void)=0;
      void execute(void* a, void* b) {
         *(static_cast<T*>(b))=inject(*static_cast<const T*>(a));
      }
};
```

To create a new error injector class, the CPP interface user has to implement the inject method in his derived class in which he can add the error to the input argument and return that as output argument. A pointer to an object instance of this derived class must be provided with the addInPort or addOutPut method to associate the error injector instance with a port. The inject method is applied when the content of the inport is transfered to the associated model variable, or vice versa when the content of the model

variable is transfered to the output port. The esimPublish method must also be implemented in the derived class using the common CPP API publish functions. This allows the user to publish member variables in the dictionary that control the error injection function. These member variables will appear as children of the port object and can be read and manipulated via monitors and MDL scripts at runtime as any other published variable.

The default error injector classes implemented in the CPP Error Injection interface are made following the above approach and contain the features most commonly needed for error injection. It is important to select the correct type, but the capabilities and usage are always the same. Instances of the following classes can be made to create an error injector object:

- class ErrorInjectorDouble
- class ErrorInjectorUint

More default error injectors will be added in the next releases. To add a default error injector to a port, simply create the port with the addInPort call on a double variable as follows in the esimPublish method:

```
Esim::addInPort(my_var, "my_name", new ErrorInjectorDouble, Esim::ACTIVE);
```

The default error injectors then automatically adds control variables and descriptions to the port that are visible in the dictionary and allow the user to define the type of error injection as well as the control over the error injection variables. See Figure 15.3.

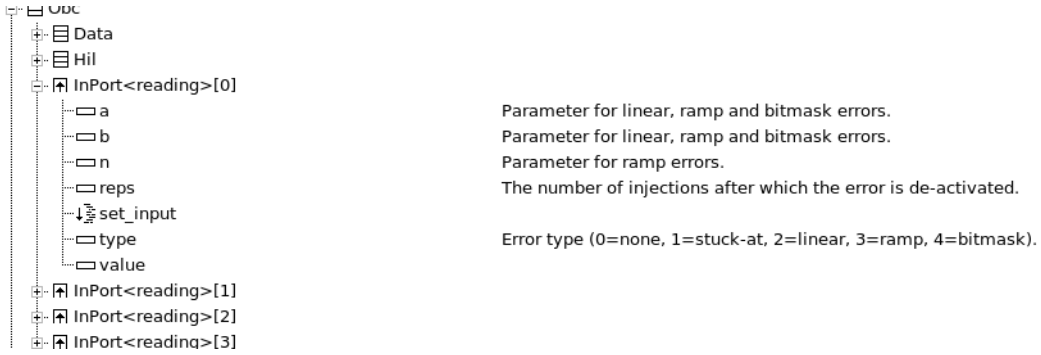


Figure 15.3: EuroSim C++ Default Error Injector control via dictionary variables

Note that in allmost all cases you want an independent (new) injector object associated with a port. It is however possible to associate one injector object with multiple ports, which will share the properties of the error injector between the ports that it is all associated with. The following error injection types and associated functionality are supported in the default error injectors:

- none
- lock (`stuck_at` last value for n samples)
- linear (e=ax+b for n samples)
- ramp (ramp from a to b in n steps followed by stuck at b)
- mask (mask based on `e = ( x & a ) ^ b` 32 bit operations)

15.8 UML support

15.8.1 Overview

Often Object Oriented design that leads to implementation in C++ is defined in UML. Enterprise Architect is a popular tool to support modeling in UML due to its affordability and abundance of features. An extension has been built in the form of Enterprise Architect transformation and code generation templates that you can use to jump start your EuroSim projects. The process from Architecture to Simulator consists of a sequence of steps, where after each step the user can tailor the results further towards specific needs if desired. An overview of this sequence is shown in Figure 15.4

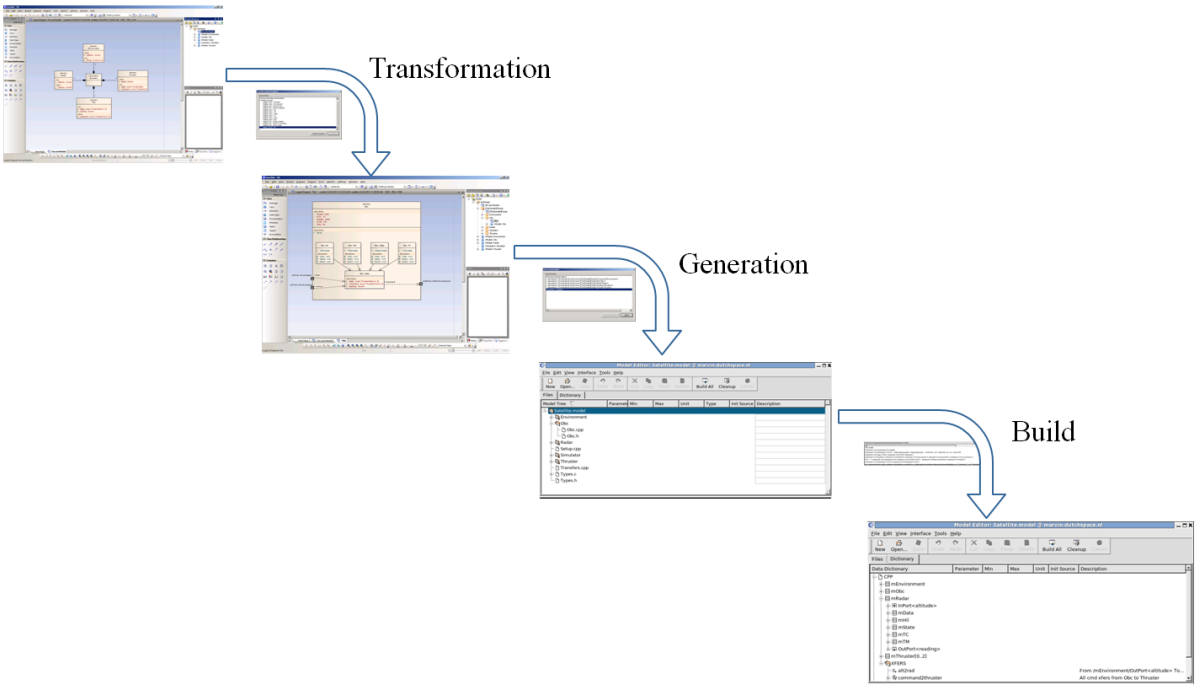


Figure 15.4: EuroSim UML transformation, generation and building process

In the top left of Figure 15.4 the class diagram defining the architecture is shown. Stereotypes are applied to identify models and their input-output variables, as well as their composition into a simulator. This simple diagram is input to the EuroSim transformation, which applies patterns to each model in the architecture, which results in a package per model with a detailed design and elements in UML. The user can enhance and elaborate the diagram as required, as long as EuroSim publishing related stereotyping is applied in order to allow the generation process to create code from these diagrams. The EuroSim tailored C++ code generation then results in source code files structured on the file system along the package structure in Enterprise Architect. These files can be included in the EuroSim ModelEditor for building. After a minor effort to add the EuroSim CPP setup routine, as well as coupling ports via dataflows, the EuroSim build can create the simulator with its objects, ports and transfers displayed in the EuroSim dictionary. From this point, schedules, scenarios and simulation definitions can be created to utilize the simulator in various simulations in the usual way.Of course at this point there is no functionality integrated in the code yet, it is an empty framework where algorithm developers and hardware interface developers can fill the entrypoints with C++ code. This is also a major benefit as the strcuture of code is provided, and that structure allows everyone to work in the same simulator software, yet only scheduling their own model and stimulating the ports with data for testing.

The following sections provide more detail om each of the three processes.

15.8.2 Architecture and Transformation

At the highest level a simulator as common in Electronic Ground Support Equipment (EGSE) or test systems in general is a composition of models that mimic the system under test. This can be described in a class diagram in UML as in Figure 15.5. The class diagram shows that the Simulator for the Satellite program is composed of an Obc, Thrusters(3), an Environment (dynamics) and a Radar altimiter. The stereotyping identifies classes as either Simulator or Model. The Simulator class must be named Simulator, for the Model stereotyped classes the name should indicate the function of the model. In each model you can define the input, output and input-output variables, by stereotyping the attributes as in, out or inout. Note that at this point we do not define the internals yet of models.

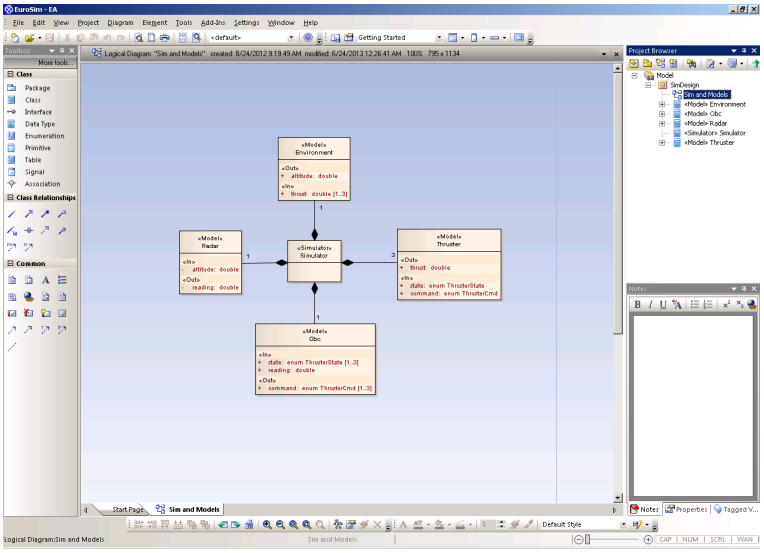


Figure 15.5: EuroSim UML transformation

The EuroSim transformation for test systems can be started by right clicking on the package symbol of the package that contains the drawing of Figure 15.5 in the browser window (on the right side in 15.5). The Transformation dialog in Figure 15.6 will appear.

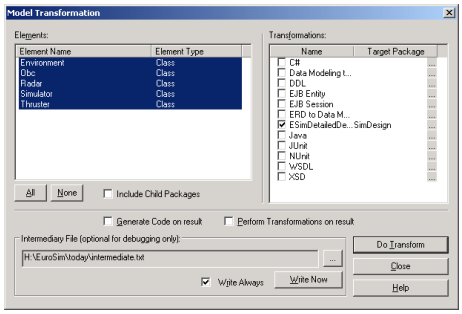


Figure 15.6: EuroSim UML transformation dialog

Please set all checkboxes as in Figure 15.6 to prepare for the transformation. This includes selecting Child Packages and the ESimDetailedDesign. When the dialog is set up as inFigure 15.7, you can start the transformation. During the transformation the drawing in Figure 15.5 is analyzed and for each class that is stereotyped Model a package is generated that wil contain a design drawing for that model. Figure 15.7 shows the progress dialog, which shows how every dialog is being expanded in multiple classes, ports etc.
After completion fo the transformation, you will see the list of packages in the browser on the right in Enterprise Architect under the package ESimDetailedDesign. If you change the Architecture diagram, a

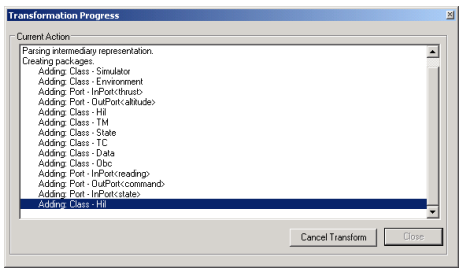


Figure 15.7: EuroSim UML transformation progress dialog

regeneration is needed to reflect the changes in the generated design diagrams. There is no incremental support at this point, you either delete the ESimDetailedDesign package and regenerate, meaning you loose all changes made in the design diagrams; or you make the change in the designs manually.

The templates that perform the transformation are included in the Enterprise Architect database, thus available as source code. By modifying these templates in your database it is possible to tailor the transformations to create project specific designs. More information on transformation and templates can be found in the Enterprise Architect documentation. This documentation is not extensive, hence two important tips: First the methodology of the transformation is that an intermediate text file is generated in the process according to the templates of the chosen transformation. The intermediate file is subsequently read back into the database to form the drawings. Second, to easily construct the template you want, draw the result in Enterprise Architect and use an emtpy transforamtion such as the `C#` transformation from Enterpise Architect. The intermdiate file that is specified in the transformation dialog then is close to what you need to write as template, except that you miss the references. For the latter you can study the EuroSim provided transforation templates.

The design diagrams that are the result of the transforation are further discussed in Section 15.8.3

15.8.3 Design and Generation

The Transformation process resulted in a series of packages, each containing a design of the model according to the EuroSim EGSE design pattern as shown in Figure 15.8. Note that the Enterprise Architect layouter is not able to drawn the diagram exactly as in Figure 15.8. To lay out the class diagram as shown, enlarge the class diagram on which the ports are located, move the ports to along the edges to the desired location and move the Data subclass to the bottom.
The design pattern used in the EuroSim transformation is rather Space domain and test system oriented, and follows the dataflow approach that fits with EuroSim's multicore scheduling capabilities. The design reflects that a model has low-cohesion with its environment, communicating via ports with other models. The ports will be interconnected at a later stage using dataflows. Internally, the model has high cohesion. It consists functional subclass that contains the funcionality of the model, a TC subclass for telecommand handling, a TM subclass for telemetry handling and a HIL subclass to support the Hardware In the Loop interface. All these classes communicate in a shared memory approach via the Data subclass. In the resulting implementation the Data class will thus contains the state variables of the model. These variables are access by the other subclasses via a pointer, and from the outside world via the ports.

The class diagram in Figure 15.8 has specific features that steer the EuroSim emhanced C++ code generation. The EuroSim stereotyping assures that members and entrypoints will be published via the EuroSim C++ API. Furthermore, the ports will assure that ports are created and published in EuroSim, which will be visisble in the EuroSim dictionary and may be enhance with error injectors when tailoring at the code level. Please follow the approach for ports exactly as generated. Because Enterpise Architect presently does not support code generation from Ports, the information needed by the C++ code generation had to be added in a slightly complex manner, specifically the dependency between the port and data class and the attributes along the dependency.

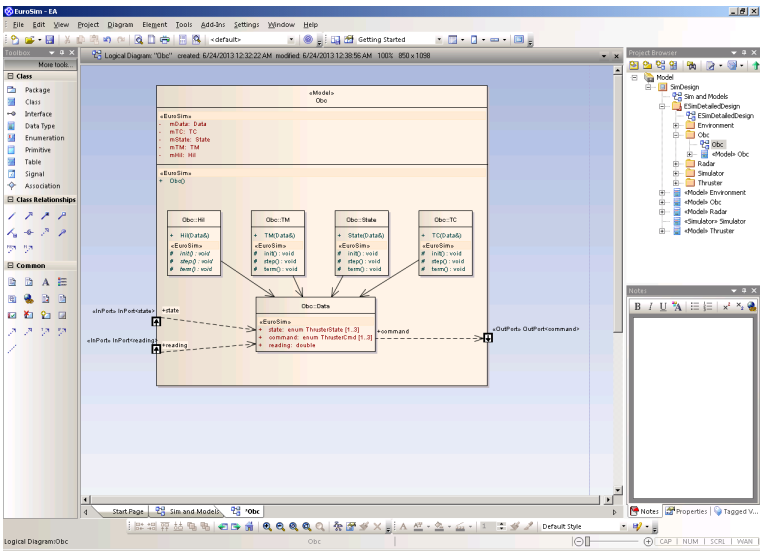


Figure 15.8: EuroSim UML generation

The user can further elaborate the class diagrams with additional design information, possibly to be taken into account in the code generation process. Alternatively it may be decided that elaboration is easier achieved at the code level. As a general advice, keeping the design clean and prevent clutter with to many details reduced maintenance. Also in the EuroSim team we found that elaboration is often quicker accomplished in the code using e.g. eclipse.

To start the code generation process, right click on the ESimDetailedDesign package and select code generation. The dialog show in Figure 15.9 should appear.

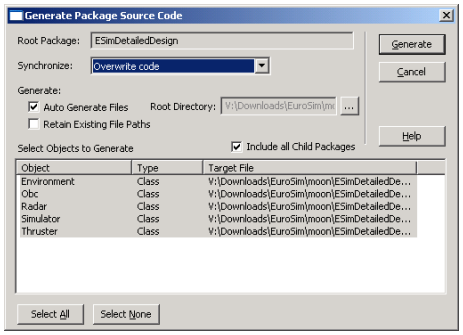


Figure 15.9: EuroSim UML generation dialog

Please make sure that you select all checkboxes as shown in Figure 15.9. Specifically be carefull with settings that merge generated code back in your design as the generated code contains more details then your design due to the EuroSim enhanced C++ code generator (hence select Overwrite). When you start the code generation process by pressing Generate, the code deneration progress dialog appears as shown in Figure 15.10.

You may need to move the resulting code to the proper location, especially when Enterpise Architect is used under Windows and the simulator is built under Linux, as will usually be the case for test system. Of course repositories can be of help, as well as shared directories. In any case, generally the source code ends up in a source code repository and is subsequently maintained at the source code level. The generation process does not support a roundtrip engineering. The best approach is that in subsequent regenerations the changes are merged with the baseline code. Tools as meld can easily support this as the source code files result from the same generation process and does have comparable layouts.

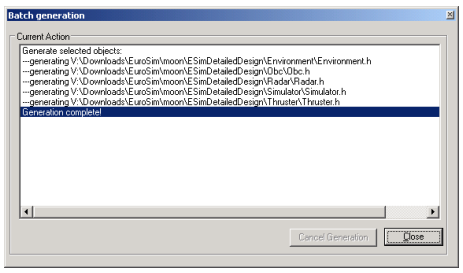


Figure 15.10: EuroSim UML generation progress dialog

The EuroSim enhanced C++ code generation templates are included in the database. Please check the Enterpise Architect documentation on Code Generation for detailed information. The most interesting change that users can make to the templates is the replacement of the file header such that generated code contains the Copyright statements for the project that is worked on. Note also that the generated code takes all comments and other information in the diagrams into the source code and that the generation process adds Doxygen make up to the files. If you run Doxygen over the code you therefore automatically extract the design from your software.

15.8.4 Simulator Building

The code generation process creates directories, source and header files along the tree of packages that code is generated from. This tree fits directly into the file browser part in the EuroSim ModelEditor as shown in Figure 15.11

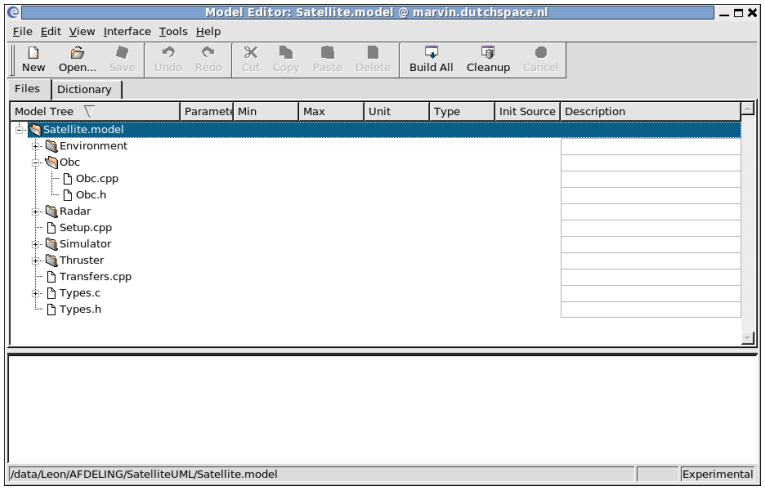


Figure 15.11: EuroSim UML source files in ModelEditor

The code will normally not need any extra work, unless specific header files and types are added, which is a standard C++ coding type effort. In addition, every class will have an extra esimPublish method that is added in the generation process. This class automatically contains all the code for publication of member variables, entrypoints and ports along the stereotyping that was applied in the design. The additional work that is needed in this stage is writing the CPP kick off routine where the objects must be created and published, and the creation of the dataflows from out-ports to in-ports to interconnect the models. Previous sections in this chapter contain the information, however the code in the SatelliteUML example can be used as a starting point, in general the code required in your project will be very similar. Note that all automatically generated ports are active and have no error injector. Where such features are needed the user can easily change this in the generated code by adding default error injectors and switching to passive ports for ultimate timing control.

Once the kick-off and transfers code is added, the user can built the simulator in the EuroSim ModelEditor with the BuiltAll button. As an advice on transfers it is recommended to group transfers in transfer-groups where possible as this prevents a lot of dragging and dropping of entrypoints in the ScheduleEditor, it even makes the scheduling independent of the number of instances of a class. The result of the built is a simulator and dictionary, the latter being visible in the Dictionary tab as show in Figure 15.12.

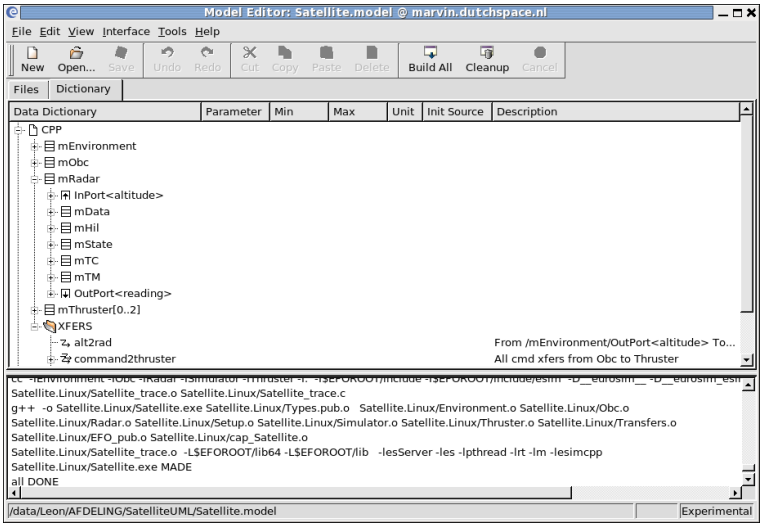


Figure 15.12: EuroSim UML build result in ModelEditor

From here on the process is as usual when applying the ScheduleEditor and SimulationController to define a simulation. Note that in the above approach the source code was integrated in the Simulator via the Files tab of the EuroSim ModelEditor. Many users, however, prefer to integrate the code in eclipse and possibly unit test in that environment. This is easily accomplished, the user can built a library in eclipse and link this library via the Built Options dialog to EuroSim. The result in the Dictionary tab is the same. For more details see Section 15.9.4.

15.8.5 Resources

With your EuroSim distribution an example SatelliteUML is included. This variant on the Satellite example contains the Enterprise Architect database (.eap) with the templates included as described in previous sections. The class diagram for the Satellite model is included as well. The easiest start of your project is to copy this entire directory to your project (mind the read only protections due to the location where EuroSim was installed) and modify and expand the Satellite example to your project, including the provided Enterprise Architect database. If you already started your own database, it is also possible to incorporate the templates via the MDG technology files included in the MDG subdirectory of the SatelliteUML example. Please refer to the Enterprise Architect documentation for the method to include MDG technology files.

Warning: Please note that the provided Enterprise Architect database has a modified C++ generation template set. The standard C++ code generation will not be availabel anymore and your C++ code generation will only be able to generate EuroSim tailored C++ code. The same holds for incorporation of EuroSim provided MDG files as these also permanently modify the C++ templates in your database. (The effect will be limited the database in use, hence making a copy before you incorporate MDG files is not a bad idea).

15.9 Tips, Tricks and Guidelines

15.9.1 Low level publication interface

Generally users will find that all functionality needed for object, variable and entrypoint publication is provided by the publication interface defined in section 15.3. However there is a low level interface that advanced users may find usefull to further shape the publication in the dictionary. This interface is defined in the header file esimcpp.h, but simply including esim++.h is sufficient to gain access to these functions.

The following low level functions support publication of pointers, objects and variables at the lowest level:

```
bool publishPointer( void *object_address,
                     const char *object_path,
                     const char *descr="")

bool publishObject( void *object_address,
                    unsigned int object_size,
                    const char *object_path,
                    CppObjectType object_type,
                    const char *descr="")

bool publishVar( void *var_address,
                 const  int length,
                 const char *var_path,
                 const char *var_type,
                 const char *descr)
```

The CppObjectType defines the icon that the object gets in the dictionary. The available object types are defined in esimcpp.h and set the icons for folders, C++ objects, input and output ports in the dictionary. The following low level interface support publication of methods and functions at the lowest level:

```
class IEntryPoint
{
   protected:
      IEntryPoint(){};
      virtual ~IEntryPoint(){};
   public:
      virtual void execute(void) const=0;
};


bool publishMethod(  IEntryPoint  *entrypoint,
                     const char*   name,
                     const char*   descr="")

bool publishFunction( void (*entrypoint)(void),
                     const char *name,
                     const char *descr="")
```

There has not been any specific usage by users of this low level interface to date.

Ports are of type IPort. When the address of the port is captured this type can be used to cast the type and use the virtual functions to manipulate the port.


```
class IPort
{
   public:
      virtual ~IPort(){};
      virtual void execute(void)=0;
      virtual bool isInput(void)=0;
      virtual bool isActive(void)=0;
      virtual bool esimPublish(void)=0;
      virtual void* getValueAddress(void)=0;
};
```

Some utility functions are available in the low level interface that could be useful to the advanced user to interact gather information from the dictionary, such as addresses of obejcts and variables by specifying the dictionary path:

```
Getting the address of elements by path:
void* getObjectAddress(const char* dictpath);
void* getVariableAddress(const char* dictpath);

Getting the name from a path:
const char* getObjectName(const char* dictpath);

Create an absolute path, resolving all relative elements:
bool resolvePath(char *destination, const char* source);

Create a path by connecting parent and child, hides path implemenation:
bool makePath(char *new_path, const char *parent, const char *child);
```

The getScope and setScope functions are better interfaces to change the scope of the publication. But if needed the following two low level utility functions are also available, their usage can be seen in the esim++publish header file.

```
//context management
const char* getContext(void);
bool setContext(const char*);
```

15.9.2 Portability

The C++ interface adds code to the model, but does not require changes in the model. This allows the models to be portable and used also outside EuroSim when some general precautions are taken. These precautions are in line with general praxis of writing portable code.

When you use the EuroSim C++ API there are two elements in it that make your code dependent on EuroSim and prevent it from being used without it: The C++ API publication alls in the esimPublish function and the C++ API runtime service calls in your code. With simple precautions you can eliminate this dependency, which fit in general good practice to shield your software from changes in its environment:

- To make your model software independent from runtime API calls, you should define your own runtime interface. Define this interface from the perspective of your needs and assure that it can be implemented using the platform APIs that you anticipate to use. You can use the EuroSim C++ services interface as an example and just use another name space, but beware that the EuroSim has a very rich interface and not all platforms may be able to provide the same runtime API capabilities. In any case, by defining your own interface your models will only depend on your interface definition and you can implement that interface for any platform of your choice.

- All content in the esimPublish function are calls to support publication into the EuroSim dictionary. none of your functionality should be in this function. Outside EuroSim the esimPublish will never be called. To further resolve any problems you can simply keep including the `esim++` header file. This esim+ header file has a built in stub for all the function calls in the esimPublish function. When `__eurosim__` is not defined (EuroSim passes this by default when it compiles files), the stubbing is active and since esimPublish will not be called you will not have any effects.
- The use of the EuroSim template library header file, which implements the vector, list and map, also make your code dependent on EuroSim. However, also for these container types there are solutions. When `__eurosim__` is not defined the EuroSim dependencies disappear and since all code is defined in the header file this container types can also be used without EuroSim. If this however is insufficient, then it is best to prevent using these types at all. To support this, the esim++.h header file checks whether `ESIM_CPP_EXCLUDE_TL` is defined. Simply pass `-DESIM_CPP_EXCLUDE_TL` = with your compilation flags to assure that the EuroSim container types are unknown to the compiler.
- Similar to the use of the EuroSim template library there may be a reason for not using the simulator integration library defined in esim++simint.h. Usage will not affect the portability directly as the calls for this API are only made from teh esimPublish function and a single function for transfer definition. However such API is not likely provided by other platforms and the user can integrate his software in other manners. If users should be prevented from using the simint interface the flag `-DESIM_CPP_EXCLUDE_SIMINT` can be added to the compiler flags to make the simint interface unknown.

15.9.3 Stubbing

If calls to the EuroSim runtime service routines have been used in the users model software, then linking errors will occur. A good example where this can occur is in unit testing outside EuroSim. Source files with stub code can be found in `$EFOROOT\etc` that provide a default implementation of all service calls. The user can tailor the source code to assure that the functions have the effect that is needed by their unit under test.

15.9.4 Usage of Eclipse

Eclipse is a modern open source integrated development environment that is popular with many software engineers. With the C++ API the usage of eclipse for EuroSim models has become easier, and has been sucesfully applied by the EuroSim consortium in projects. The combination with code generation from UML provides a powerfull source code development approach.

The model software can be written, compiled and linked into a library from eclipse, providing the engineer with the benefits of software development from within eclipse. The ModelEditor is only used to define the build options for EuroSim. In those build options you must specify the linking of your library. In addition it must contain one source file that defines the esimCppSetup function, which usually only contains the switch calls to configure the C++ API and a function call to the model software where the creation and publication of objects is further handled.

Write a Makefile which takes care of compiling your code and linking it into the library that you specified in the EuroSim Model Editor. Assure that you add `-D__eurosim__` to your compile flags to assure that esim++.h header file selects the EuroSim interface instead of the stub interface (see section 15.9.3. When in your make process your libraries have been linked, the following two lines must be executed to create an executable.

```
ModelMake modelname.model  modelname.make
make -f modelname.make all
```


This will have the same effect as pushing the Build All button in EuroSim. You can also clean up what EuroSim generated with `make -f modelname.make clean`. In eclipse you can now configure that when you active the build process it invokes your makefile.

With this approach the ModelEditor will not be needed anymore after defining build options and integrating the C++ setup code. The Schedule Editor will still be needed to define the schedule and the Simulation Controller to define and execute simulations.

Chapter 16

Simulation Model Portability 2 reference

Simulation Model Portability (SMP) is ESA's standard for simulation interfaces. The purpose of the standard is to promote portability of models among different simulation environments and operating systems, and to promote the re-use of simulation models. EuroSim has implemented an interface for this standard.
SMP2 is the successor of SMP. SMP2 is a totally new standard, adopting state-of-the-art techniques, and has a much wider scope than its predecessor. The way of working with this standard and its complexity demand tools for specification, development, integration, and storage of the SMP2 models. EuroSim incorporates a set of tools to accomplish many of these tasks.
Knowledge of the SMP2 standard is a prerequisite for successfully using the SMP2 tools to create SMP2 models. For an overview of the standard, refer to [SMP05c]. For a comprehensive, formal description of the standard, see [SMP05e] for the SMP2 Meta Model (or Simulation Model Definition Language, SMDL), [SMP05b] for the SMP2 Component Model, [SMP05a] for the SMP2 C++ Mapping and [SMP05d] for the SMP2 Model Development Kit (MDK).
Almost all of the SMP2 version 1.2 standard features are supported. Hard real-time execution is not a feature of SMP2 and is not supported for SMP2-aware EuroSim simulators.
EuroSim does not include an SMP2 artefact editor. If SMP2 artefacts must be created or edited, the user should use a specialized SMP2 modelling tool like MOSAIC or ultimately fall back to an XML editor for editing SMP2 artefacts.

16.1 SMP2 tools in the EuroSim Environment

Most of the workflow from importing catalogues to compilation and integration into a EuroSim simulator has been fully automated using the following tools:

- Model Editor

  This tool allows to import SMP2 artefacts, generated C++ code, and even compiled SMP2 libraries. It provides acces to the underlying SMP2 command line utilities described below and allows automatic building of an SMP2-aware EuroSim simulator. See Chapter 7 for more information on the Model Editor.

- Schedule Editor

  The Schedule Editor allows to import SMP2 schedules. These are converted by the underlying SMP2 command line utility **smp2sched** (see below). See Chapter 11 for more information on the Schedule Editor.

- SMP2 Validator **smp2val**

  This tool allows validation of SMP2 artefacts. The SMP2 validator is integrated in the Model Editor and accessible from the command line.

- SMP2 Code Generator and Integrator **smp2gen**

  This tool allows (re-)generation of SMP2-compliant C++ code from the implementations defined in an SMP2 package. Generated header files are compliant with the standard's C++ mapping. Generated implementation files supports the model developer to the maximum extent by automatically generating as much code as possible. The one thing that cannot be automatically generated from the model specifications is the model logic. The generated source code does contain marked areas that indicate that an implementation is expected there. Using these code markers, if code is regenerated from an updated package (or an updated catalogue to which the package refers) the existing model code made by the user can be preserved and integrated with the newly generated code automatically. The SMP2 code generator is integrated in the Model Editor and accessible from the command line.

- SMP2 Glue code generator **smp2glue**

  This tool generates code from one or more SMP2 assemblies that builds and initialises a hierarchy of model instances and data flows between them to form an SMP2 simulator. This tool is automatically invoked by the Model Editor when building an SMP2 aware EuroSim simulator and is accessible from the command line as well.

- SMP2 default package generator **smp2cat2pkg**

  This tool automates creation of a default package for implementation of the types of a catalogue. It is integrated in the Model Editor and accessible from the command line as well.

- SMP2 schedule converter **smp2sched**

  This tool automates conversion of one or more related SMP2 schedules to a EuroSim schedule. It is integrated in the Schedule Editor and accessible from the command line as well.

Apart from the tool and utilities described above, the EuroSim distribution comes with:

- `lib/SMP2COMPLIANCE.txt` describing details of SMP2 support for user reference.
- `Smp.cat`, the standard SMP2 catalogue defining some low-level details inside the Smp namespace. This file is included for reference by EuroSim when using SMP2 catalogues that refer to elements inside the Smp namespace (except the predefined types).
- Schemas of the SMP2 standard, at `lib/schemas/smp2`, for user reference.
- Compiled versions of the SmpCpp and SmpMdk libraries containing the MDK functionality, that are linked by EuroSim with an SMP2 simulator.
- A compiled version of the Component Model library that allows running of SMP2 models in the EuroSim run-time environment, linked by EuroSim with an SMP2 simulator.

For the command line tools described, on-line manual pages [MAN15] are available.

16.2 Using SMP2 in the EuroSim Environment

EuroSim is not a native SMP2 simulation environment. Instead, it offers an SMP2 import facility and maps all SMP2 concepts to native functionality. It offers user-friendly functionality to deal with SMP2 in the EuroSim simulation environment by automating as much as possible and providing access to SMP2 tools via its standard GUI-based editors.
EuroSim does not incorporate an SMP2 artefact editor, but it can be integrated with one via the Model Editor. Set the `SMP2EDITOR` environment variable to the path of an SMP2 artefact viewer/editor to allow direct acces from the Model Editor.
When using SMP2 in the EuroSim environment, always turn on SMP2 support in the *Build Options*. On Linux, you may choose between SMP2 support with dynamic linking of generated libraries and SMP2 support with static linking of generated libraries. On other platforms, only static linking of SMP2 libraries is available.

16.2.1 The Model Editor's SMP2 import facilities

The user will place SMP2 files to be imported in the EuroSim environment in the Model Editor's model tree except SMP2 schedules. Refer to Chapter 7 for more information about SMP2 functionality in the Model Editor. For SMP2 schedules, refer to Section 16.2.2.
Defining and implementing SMP2 models ultimately results in compiled models located in binary libraries. EuroSim allows the generation of both shared and static libraries on Linux and static libraries only on other platforms. We will call such a library an SMP2 library. In the model tree the user will organise all things SMP2 in one or more SMP2 lib nodes (see Section 7.3.3) which each represent an SMP2 library to be produced. Each SMP2 lib node can contain exactly one SMP2 package which defines the contents (implemented types) of the library. Each SMP2 lib node produces a static library and a dynamic one. Note that on platforms other than Linux, only the static library is used. The static library contains the compiled C++ code generated for the implementations defined in the package that is attached to the SMP2 lib node, and nothing else.
Packages may however depend on each other, i.e. if a type implemented in package `A` requires another type implementation defined in package `B`, `A` depends on `B`. The shared library that is built from package `A` contains the static library for `A`, containing all of `A`'s types, and the static library for `B`, containing all of `B`'s types. Therefore, such a shared library can be loaded stand alone, i.e. independent of other shared libraries. There are four (related) scenarios for importing SMP2 artefacts, source code, and binaries in the EuroSim environment using the Model Editor, which are detailed below.

16.2.1.1 Importing an SMP2 catalogue

The first way of using SMP2 in the EuroSim environment is by starting off with just one or more SMP2 catalogues, produced using some SMP2 modelling environment. This applies when no generated code and package are available, and when the user prefers to use the automatic package creation and C++ code generation and integration facilities of EuroSim.
If there are multiple catalogues these may be related, i.e. one catalogue may contain dependencies to another. These dependencies consist of references of a type specification in catalogue `A` to a type in a catalogue `B`. Take care to import all related artefacts, or else elements will be missing from the generated C++ code and the simulator cannot be built.
Do not import the `Smp.cat` catalogue, which defines the default SMP2 namespace. It is already installed as part of the EuroSim installation.
It is assumed that the user has an SMP2 modelling environment for producing an SMP2 assembly based on the packages to be generated.
The catalogue import scenario consists of the following steps:

Prepare import
: It is recommended to copy all SMP2 artefacts conveniently to the project directory. Note however, that the Uniform Resource Identifiers inside the SMP2 artefacts that refer to items located in the same or in another artefact may forbid this (e.g. if absolute paths are used). Check the artefacts using an SMP2 modelling environment or an XML viewer to find out.

Define library
: For each SMP2 library to be created, the user adds an SMP2 lib node to the model tree. In this scenario, it is required that each catalogue results in its own SMP2 library. For each catalogue to be imported, create an SMP2 lib node with the same name as the catalogue (see Section 7.3.3 for more information on SMP2 lib nodes). E.g. for a catalogue named `Mission.cat`, an SMP2 lib node named `Mission` must be created in the model tree using the *Add SMP2 Lib Node* menu option (see Section 7.5.2).

Import catalogue
: Attach the catalogue to the SMP2 lib node just created using the *Add SMP2 Catalogue* menu option (see Section 7.5.4). The catalogue file is expected to have the extension *.cat*. Optionally, run the validator on the catalogue using the *Validate SMP2 Artefact* menu option (see Section 7.5.7).

Note that the user may view and edit the catalogue from the Model Editor (using any SMP2 modelling environment) by double-clicking on the catalogue. See Section 7.3.4 for setting the SMP2 modelling environment of your choice.

Generate package

The contents of an SMP2 library is determined by the implementations defined in an SMP2 package. In this scenario, no package is available beforehand. For each SMP2 lib node, automatically generate a package from the catalogue that is attached to it using the *Generate Default Package* menu option (see Section 7.5.7). This generated package called the default package contains an implementation of all types in the catalogue from which it is generated (except the types that do not require an implementation in SMP2). Optionally, to be sure, run the validator on the generated package using the *Validate SMP2 Artefact* menu option (see Section 7.5.7).

Note that the user may view and edit the generated package (using any SMP2 modelling environment) by double-clicking on the package. See Section 7.3.4 for setting the SMP2 modelling environment of your choice.

Generate C++ code and Makefile

The next step is to generate code from the package attached to the SMP2 lib node using the *Generate C++ Code* menu option (see Section 7.5.7). A hierarchy of org nodes and file nodes will be attached to the SMP2 lib node. This tree has the same name as the SMP2 lib node and contains all code generated from the package attached to the SMP2 lib node. The code consists of a C++ header file (.h) for each type, a C++ implemention file (.cpp) for all types that need one, and for some types a C++ forward reference header file (_f.h). The C++ code is organised in a directory hierarchy which reflects the namespace hierarchy of the implemented types as defined in the attached catalogue. Apart from the type-related C++ code, three C++ files are generated for management of the types contained in the static and dynamic libraries that are built from the generated code. Finally, a Makefile is generated that manages the building of the libraries.

On the file system, the generated files are located in a directory named after the SMP2 lib node which is generated inside the project directory. The directory hierarchy inside this directory is identical to the org node attached to the SMP2 lib node.

Add model logic

The generated files can be inspected and edited by double clicking the file node (see Section 7.3.4). The user may add logic between the unique markers that indicate that a user implementation is expected at that location (where *$uuid$* and *id* are replaced by an actual univerally unique identifier (which is the type's implemention UUID as specified in the package) and an additional identifier, respectively):

```
// START USER CODE $uuid$-$id$
// END USER CODE $uuid$-$id$
```

It is strongly recommended not to remove these markers. Code placed between them will be integrated in a new version of the file if the code is re-generated. Other code added by the user is lost on code re-generation.

Install library

Build the SMP2 library using the menu option *Install SMP2 Library* (see Section 7.5.7). If compilation is successfull, the shared and static versions of the library are installed in the central installation directory of the project. If there are any compilation errors, fix them in the added code and retry.

Import assembly

Using an SMP2 modelling environment, create an assembly based on the implementations defined in the packages. Copy the assembly file conveniently to the project directory. Add an

assembly file node to the model tree using the *Add File Node* menu option (see Section 7.5.2, select *SMP2 Assemblies* as file type). The assembly is expected to have file extension *.ass*, *.asb*, or *.asm*. Any number of assemblies can be added. Note that if multiple interdependent assemblies exist, all of these must be added to the model tree, or building the simulator will fail.

Optionally, run the validator on the assembly using the *Validate SMP2 Artefact* menu option (see Section 7.5.7).

Turn on SMP2 support

Select the *Tools:Set Build Options* menu item. Go to the Support tab page and place a check mark on one of the SMP2 support items. On Linux, you may choose between SMP2 support with static linking of generated libraries and SMP2 support with dynamic linking of generated libraries. Choose the options which suits your needs best. Don't choose them both.

Build simulator

The final step is to build the SMP2-compliant EuroSim simulator using the *Build All* menu option.

Note that during this process, code is automatically generated from the assemblies. This code takes care of loading the shared libraries, creating instances, and interconnecting them as specified in the assemblies. (see Section 7.5.6).

16.2.1.2 Importing an SMP2 catalogue, package, and assembly

The second way of using SMP2 in the EuroSim environment is by starting off with one or more SMP2 catalogues, packages, and assemblies, produced using some SMP2 modelling environment. Either no generated code is available, or the user prefers to use the C++ code generation and integration facilities of EuroSim.
Note that the difference with the first scenario consists of the fact that a package is available (and an assembly can be created before the import as the package is available).
Take care to import all related artefacts, or else elements will be missing from the generated C++ code and the simulator cannot be compiled.
The catalogue, package and assembly import scenario consists of the following steps:

Prepare import

See Section 16.2.1.1, step *Prepare import*.

Define library

For each SMP2 library to be created, the user adds an SMP2 lib node to the model tree. In this scenario, it is required that each package results in its own library. For each package to be imported, create an SMP2 lib node with the same name as the package (see Section 7.3.3 for more information on SMP2 lib nodes). E.g. for a package named `Mission.pkg`, an SMP2 lib node named `Mission` must be created in the model tree using the *Add SMP2 Lib Node* menu option (see Section 7.5.2).

Import catalogue

Each package implements types specified in one or more catalogues. Attach these catalogues to the SMP2 lib node just created for the package using the *Add SMP2 Catalogue* menu option (see Section 7.5.4).

Note that any number of catalogues may be attached to an SMP2 lib node. If a package implements types from more than one catalogue, these can all be attached to the package's SMP2 lib node. See Section 16.2.1.1, step *Import catalogue* for more information.

Import package

Attach a package to each SMP2 lib node using the menu option *Add SMP2 Package* (see Section 7.5.2). The package is expected to have file extension *.pkg*. See Section 16.2.1.1, step *Generate package* for more information.

From this point on, the scenario is exactly as the one described in Section 16.2.1.1, step *Generate C++ code and Makefile* and further.

16.2.1.3 Importing an SMP2 catalogue, package, assembly, and generated code

The third way of using SMP2 in the EuroSim environment is by starting off with one or more SMP2 catalogues, packages, code generated from it (with model logic added), and assemblies, produced using some SMP2 modelling environment. The user wants to import an externally produced SMP2 library at the source level and an assembly.
Note that the difference with the second scenario consists of the fact that generated code is available and model logic is added to it.
There are limitations imposed on the generated code so that it can be (automatically) imported:

- The generated code must be located inside a directory with the same name as the package from which the code was generated. E.g. for a package named `Mission.pkg`, code must be inside a directory named `Mission`.
- A Makefile must be present in the location where it would be generated by EuroSim to allow import of source code, i.e. inside the top-level directory of the generated files. E.g. for a package named `Mission.pkg`, the Makefile should be located inside the `Mission` directory. The name of the Makefile must be `Makefile`.
- The Makefile must produce the same results when used as a Makefile generated by EuroSim.
- The generated code must not incorporate calls to unsupported ComponentModel interfaces. See the file `SMP2COMPLIANCE.txt` which is part of the EuroSim distribution.
- The generated code must be equivalent to code that would be generated by EuroSim for the provided artefacts.

Therefore, in practice this way of importing is limited to code generated by another instance of EuroSim and for code generated by an external tool that is specifically targeted at EuroSim.
Take care to import all related artefacts, or else elements will be missing from the generated C++ code and the simulator cannot be compiled.
This import scenario consists of the following steps:

Prepare import
: See Section 16.2.1.2, step *Prepare import*, on how to prepare import of catalogues, packages, and assemblies. Copy the generated code including the Makefile to the project directory.

Define library
: See Section 16.2.1.2, step *Define library*.

Import catalogue
: See Section 16.2.1.2, step *Import catalogue*.

Import package
: See Section 16.2.1.2, step *Import package*.

Import generated code and Makefile
: Using the menu option *Add Generated C++ Code* (see Section 7.5.2), attach the tree of generated code to the SMP2 lib node. You may have to edit the Makefile to make it compliant to EuroSim. Also, the name of the model file is used in the Makefile if the Makefile is originally generated by EuroSim. Change it to the actual name of the model file.

At this point, the scenario becomes identical to the first two from the step *Install library* onward. See Section 16.2.1.1.

16.2.1.4 Importing an SMP2 catalogue, package, assembly, and library

This final import scenario is comparable to the previous one, except that no source files are available, but only catalogues, packages, assemblies and shared libraries. This is the case e.g. when the originator of the executable model wishes to hide the model sources. The user wants to import an SMP2 library at the binary level.
This way of working in practice is limited to binaries generated by another instance of EuroSim, or by an external tool that is specifically targeted at EuroSim, on the same platform as the import platform.
This import scenario consists of the following steps:

Prepare import
: See Section 16.2.1.2, step *Prepare import*, on how to prepare import of catalogues, packages, and assemblies. Create a directory with the same name as the package inside the project directory. Inside it, copy the shared library.

Define library
: See Section 16.2.1.2, step *Define library*.

Import catalogue
: See Section 16.2.1.2, step *Import catalogue*.

Import package
: See Section 16.2.1.2, step *Import package*.

Generate Makefile template
: Using the menu option *Generate Makefile Template* (see Section 7.5.6), a Makefile is generated by EuroSim inside the folder containing the library.

Edit Makefile
: Double-click the Makefile and edit the install target to copy the SMP2 library to the model's central installation directory for the project, and edit the clean target to remove the installed library from the model's central installation directory. This allows EuroSim to use the Makefile as if it was generated natively as part of the *Build All* and *Build Clean* menu options. Note that the *Install SMP2 Library* and *Clean SMP2 Library* menu options are not available for this scenario.

At this point, the scenario becomes identical to the first two from the step *Import assembly* onward. See Section 16.2.1.1.

16.2.2 The SMP2 schedule import facilities

The SMP2 simulator can be scheduled using a native EuroSim schedule, like a normal EuroSim simulator. However, if an SMP2 schedule is available it can be imported into EuroSim for scheduling of the simulator.

16.2.2.1 Using the Schedule Editor for importing an SMP2 schedule

The Schedule Editor allows to import an SMP2 schedule artefact. Such a schedule is converted to an equivalent native EuroSim schedule by the command line tool **smp2sched**. From the *File* menu, use the *Open...* menu option and select *SMP2 Schedules* as file type. An SMP2 schedule is expected to have the file extension *.sed*. After conversion, the schedule can be inspected (and possibly edited) in the Schedule Editor. It is recommended not to change the converted schedule as any changes will be lost on when a future change in the original SMP2 schedule requires a new conversion to a EuroSim schedule.
Note that the result of the conversion is a simple, non real-time, single-processor EuroSim schedule. SMP2 schedules lack the semantics to express complex, hard real-time time scheduling. For details on the conversion, see the on-line manual page of the **smp2sched** tool. This manual page also describes some limitations that apply to the schedule conversion.

16.2.2.2 Importing multiple SMP2 schedules

An SMP2 simulator's schedule need not be limited to a single file. It is possible to specify a schedule using multiple SMP2 schedule files. EuroSim allows converting such a coherent set of SMP2 schedule files into a (single) EuroSim schedule. This can be achieved by using the **smp2sched** tool from the command line. See the manual page of **smp2sched** for details.

16.2.3 The Simulation Controller and SMP2

The Simulation Controller allows to run an SMP2-aware simulator exactly like a normal EuroSim simulator. The instances of SMP2 models are shown in a list under the *SMP2* top-level node.

Chapter 17

Java interface reference

17.1 Introduction

The purpose of the Java interface is to allow EuroSim users to program simulation models in Java. The setup required for the integration of Java models into EuroSim are described in the Section 17.2. Publication of Java model variables, entrypoints and annotations are described in Section 17.3. The Java data types supported by EuroSim are listed in Section 17.5.

The Java models are executed by the Java Virtual Machine from Sun. There are a couple of limitations that the user must be aware of.

1. The garbage collector may start at any time and may result in unpredictable execution times of Java models.
2. When a Java entry point is executed, the state of the variables as present in the data dictionary is copied to the Java model, then the Java method is called, followed by a copy of the data from the Java model to the data dictionary. The copying may be quite expensive in terms of execution time if the entry point is from an object that has many sub-objects. The entire tree will be traversed and copied twice.

In the EuroSim installation directory you can find a directory `Java` with a Java example project, in the `src` directory. This is a very simple test simulator which shows you a working example. In EuroSim just make a new project and add the model and use the Model Editor to open it.

17.2 Setup procedure

A EuroSim Java model is not quite the same as a normal Java application, there are some differences one should be aware of. Normally one would start a Java application with a main method in some class, in EuroSim however this is not the case. Instead there should be a class “main” that instantiates all the instances of the models:

Listing 17.1: Example of a Java main class

```
import nl.eurosim.model.*;

class main
{
   @eurosim(description="Model Instance 1")
   public model m1 = new model(1, 2, "one");

   @eurosim(description="Model Instance 2")
   public model m2 = new model(3, 4, "two");

   @eurosim(description="My New Red Car")
```

```
   public car c1 = new car("red");
}
```

In the example above, note the absence of the "main" method, the class itself assumes the task of the absent "main" method. Also note the `import nl.eurosim.model.*;` statement at the beginning of the example. This statement imports a number of classes associated with the EuroSim Java interface. These classes are necessary when using `eurosim` annotations or calling EuroSim run-time methods discussed next. It is not necessary to instantiate these classes, or any other class that does not contain an entry point method, in the main class. Access them in the normal way.

17.3 Publication interface

Because of the way Java is supported by EuroSim, it is not possible to see any member variables or entry point methods in the Model Editor. This makes it impossible to add descriptions or give units to these methods and variables like the way it is done with the other supported languages. Using the `eurosim` annotation, however, it is possible to do the same job in the model code. Information in the annotation is not shown in the Model Editor, but does show up in the EuroSim data dictionary. Member variables and entry point methods may be annotated with an `eurosim` annotation, for example: `@eurosim(description="Calculates distance",unit="[m]")`. A variable can have the following annotation fields:

- description: A description of the variable
- unit: The physical unit
- min: The minimum value
- max: The maximum value
- ignore: Boolean flag, if true, the variable or entry point is not published in the data dictionary.

An entry point method, however, can only have the `description` and `ignore` annotation. It also must not have any arguments, but must have the void return type.

Published data and entry points are placed under the `JAVA` org node in the EuroSim data dictionary.

Listing 17.2: Example of a Java model class

```
import nl.eurosim.model.*;

class model
{
   @eurosim(description="some variable", unit="m", min="0", max="10")
   public int var = 2;

   @eurosim(description="another variable")
   public double other = 3.1415;

   model(int x, int y, String name)
   {
   }

   @eurosim(description="this is an entry point")
   void compute()
   {
      double x = var * other;
   }
}
```


There are a number of EuroSim run-time methods you can use in your Java model. They are listed in EuroSim Manual pages and in Section 17.4. As all of these methods are static, it is not necessary to make an instance of the appropriate class. Just use the class name itself. For example: if you would like to get the simulator time, you would call the `esimGetSimtime()` method and use the class that gives this method, i.e., `EsimRuntime`. Your code would look like this:

Listing 17.3: Example of calling a run-time method

```
import nl.eurosim.model.*;

class example
{
   void someMethod()
   {
      // Get the simulator time
      double time = EsimRuntime.esimGetSimtime();
   }
}
```

The publication mechanism uses reflection to determine all the fields and methods of the classes. It stores the extra information given by the annotations in the data dictionary. The default initial value is automatically determined.

Java source files shall be stored in a hierarchical directory structure reflecting the package hierarchy in the same directory as where the model file referring to these files is stored.

When the model is ready to be build the user has to enable the Java capability support. This is done by selecting the "EuroSim Java integration library" option on the Support tab of the Build Options dialog in the Model Editor.

It is possible to add class-paths in the usual manner in the Build Options dialog box. Each element must be separated by a colon. You can specify directories with class files or jar files, however, when referring to a jar file the complete name of the jar file should be given, not just the directory the jar file is in.

After this the user just has to run the *Build All* command to compile the model source into a runnable simulator.

17.4 Service interface

```
import nl.eurosim.model.*;
```

Do not forget to check the 'EuroSim Java integration library' option in the *Model:Options* window of the Model Editor (see Figure 7.6).

The Java model interface currently does not cover the full range of run-time functions. This will be improved in future releases. The available functions are listed below. For an explanation of the function please check the C-Fortran-Ada reference.

17.4.0.1 Real-time timing functions

```
package nl.eurosim.model;

public class EsimRuntime {
    ...
    native public static double esimGetSimtime();
    native public static int esimSetSimtime(double simtime);
    native public static double esimGetWallclocktime();
    ...
}
```

17.4.0.2 Real-time simulation state functions

```
package nl.eurosim.model;

public class EsimRuntime {
    ...
    public enum esimState {
        esimUnconfiguredState(0),
            esimInitialisingState(1),
            esimExecutingState(2),
            esimStandbyState(3),
            esimStoppingState(4);
    }
    public static esimState esimGetState();
    public static boolean esimSetState(esimState state)
    ...
}
```

17.4.0.3 Real-time task related functions

```
package nl.eurosim.model;

public class EsimRuntime {
    ...
    native public static int esimDisableTask(String taskName);
    native public static int esimEnableTask(String taskName);
    native public static double esimGetTaskrate();
    native public static String esimGetTaskname();
    ...
}
```

17.4.0.4 Event functions

```
package nl.eurosim.model;

public class EsimRuntime {
    ...
    native public static int esimEventRaise(String eventName, byte[] data);
    native public static int esimEventData(byte[] data);
    ...
}
```

17.4.0.5 Real-time clock functions

```
package nl.eurosim.model;

public class EsimRuntime {
    ...
    native public static int esimSetSpeed(double speed);
    native public static double esimGetSpeed();
    native public static int esimGetRealtime();
    native public static int esimSetRealtime(int on);
    ...
}
```


17.4.0.6 Real-time recording functions

```
package nl.eurosim.model;

public class EsimRuntime {
    ...
    native public static int esimGetRecordingState();
    native public static int esimSetRecordingState(int on);
    ...
}
```

17.4.0.7 Real-time reporting functions

```
package nl.eurosim.model;

public class EsimRuntime {
    ...
    native public static void esimMessage(String msg);
    native public static void esimWarning(String msg);
    native public static void esimError(String msg);
    native public static void esimFatal(String msg);
    ...
}
```

17.4.0.8 Auxiliary functions

```
package nl.eurosim.model;

public class EsimRuntime {
    ...
    native public static void esimAbortNow();
    native public static String esimVersion();
    ...
}
```

17.4.0.9 Trace functions

```
package nl.eurosim.model;

public class EsimRuntime {
    ...
    native public static void esimTracePause();
    native public static void esimTraceResume();
    native public static void esimTraceResume(unsigned type_mask,unsigned pro
    ...
}
```

17.5 Supported data types

The EuroSim Java model library supports (arrays of) the following Java data types. The table below show how they are mapped to a type in EuroSim:

Java type	EuroSim type	Description
boolean	jboolean	8 bit unsigned integer type
byte	jbyte	8 bit signed integer type
char	jchar	16 bit unsigned integer type
short	jshort	16 bit signed integer type
int	jint	32 bit signed integer type
long	jlong	64 bit signed integer type
float	jfloat	32 bit floating point type
double	jdouble	64 bit floating point type
java.lang.Boolean	jboolean	8 bit unsigned integer type
java.lang.Byte	jbyte	8 bit signed integer type
java.lang.Character	jchar	16 bit unsigned integer type
java.lang.Short	jshort	16 bit signed integer type
java.lang.Integer	jint	32 bit signed integer type
java.lang.Long	jlong	64 bit signed integer type
java.lang.Float	jfloat	32 bit floating point type
java.lang.Double	jdouble	64 bit floating point type
java.lang.String	char[]	string class[1]
java.math.BigInteger	jlong	64 bit signed integer type
java.math.BigDecimal	jdouble	64 bit floating point type
java.util.Date	char[]	Date/time string in the format yyyy-MM-dd HH:mm:ss.SSS
java.util.Calendar	char[]	Date/time string in the format yyyy-MM-dd HH:mm:ss.SSS

Table 17.1: Supported Java data types

EuroSim also supports `List<>`'s of objects and arrays of object. Objects inside other objects are published as sub-objects in a hierarchical fashion.

Arrays and Lists are published as hierarchies with the individual elements as leaves. Each leaf element is published under the array node with the same name as the parent but with a post-fix in the form *_index*.

It is possible to rename array and list elements to a user defined name by implementing the `Renamable` interface.

The `Renamable` interface class defines one method: `public String getEsimId()`. The example below demonstrates the use:

Listing 17.4: Example of using the Renamable interface to rename an instance of an object

```
import nl.eurosim.model.*;

public class model_renamed implements Renamable {

   @eurosim(ignore=true)
   String name;
```

[1] java.lang.String may contain a Unicode string. EuroSim supports only ASCII (UTF-8) type strings.


```
   int value;

   public model_renamed(String nm, int v)
   {
      name = nm;
      value = v;
   }

   public String getEsimId()
   {
      return name;
   }
}
```


Chapter 18

Simulator Integration Support library reference

18.1 Introduction

The purpose of the Simulator Integration Support library is to support the integration of several independent models into one simulator without wanting to do the integration explicitly in (model) source code. In other words: the Simulator Integration Support library provides the "glue" between models.

18.2 Files

Two file types[1] have been introduced for this purpose:

- Model Description file
- Parameter Exchange file

Model Description files can be created and edited with the Model Description Editor, see Chapter 8. Parameter Exchange files can be created and edited with the Parameter Exchange Editor, see Chapter 9. The use of these files will be described in the following sub-sections by means of a use case example.

18.3 Use case example

18.3.1 Model files

Suppose we have two sub-models `modelA.c` and `modelB.c` as listed below.

Listing 18.1: The C source code for the `modelA` file node

```
#include <math.h>

static double x;
static double y;

void calc_sin(void)
{
  y = sin(x);
}
```

[1] The file extensions are provided in Appendix A.

Listing 18.2: The C source code for the `modelB` file node

```
static double counter;

void update_counter(void)
{
  counter = counter + 0.1;
}
```

The complete source code, including the other files discussed in this section, can be found in the `src` *subdirectory of the directory where EuroSim is installed.*

ModelA takes variable `x` as input to the `sin` function and stores the result in variable `y`. The entry point for the update of modelA is `calc_sin`.

ModelB takes variable `counter` as input, increments it and writes the result back to the same variable. The entry point for the update of modelB is `update_counter`.

When we want to use modelB to update the input variable of modelA, we would need to modify the source code of modelB to perform its update on variable `x` instead of using variable `counter`. We would also need to change modelA to remove the `static` keyword from variable `x` so that it can be accessed from modelB (global scope). When using the Simulator Integration Support library, we do not have to modify the source of the sub models as will be explained in the following sub-sections.

Figure 18.1 shows a screen shot of what the Model Editor looks like with the two sub-models *modelA* and *modelB*. The sub-models have been parsed and check marks are placed in front of the entry points and variables that have to be available in the data dictionary.

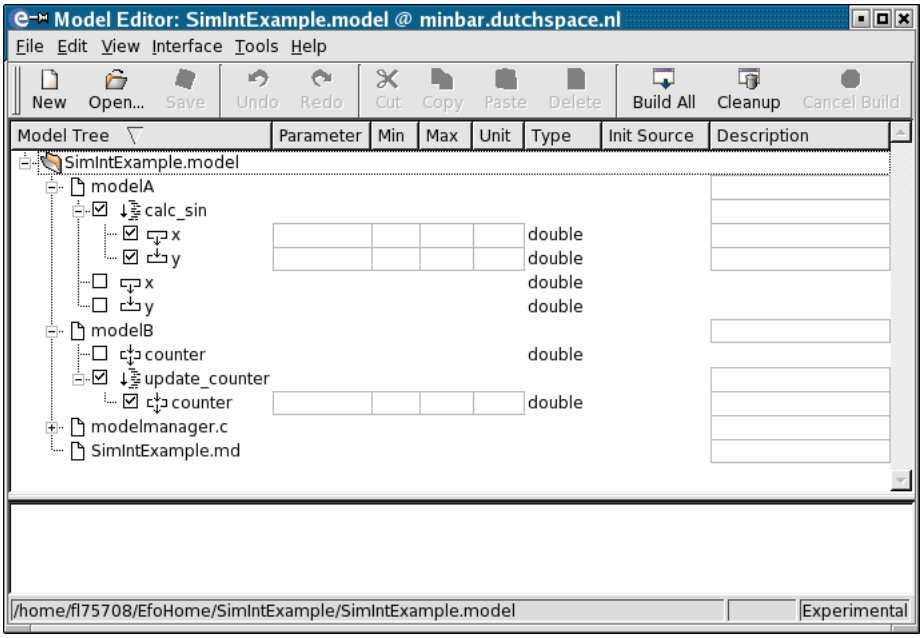


Figure 18.1: Model Editor

18.3.2 Model Description file

The philosophy behind the Model Description file is that each model has one or more input variables, one or more update functions (entry points) and one or more output variables. The Model Description Editor can be used to select the input and output variables and the entry points from the data dictionary and logically group them together, see for example the `calc_sin` node in Figure 18.2. This *describes* a model at a higher abstraction level even if the original model source code is rather unstructured or actually contains more than one sub-model. In the latter case, the Model Description file can be used to organize the model by defining multiple model nodes with entry points and variables that refer to a single

model source code file. Each model variable that is described as a variable in the Model Description file will be available for exchange with other variable(s).

It is possible to add one or more Model Description file nodes to a model using the EuroSim Model Editor, see Section 7.3.4.3. When you select the *Edit* command on a Model Description file node in the Model Editor, the Model Description Editor will be started.

After specifying which variables from the example models should be available for model to model exchanges, the Model Description Editor looks like Figure 18.2. We have created two model nodes `ModelA` and `ModelB` that contain references to the entry points in the respective models. Since this is a very simple example, the screen shot shows an almost one to one copy of the original model tree in the Model Editor. Notice that the `counter` variable in the Model Description file has been duplicated to serve as an input variable as well as an output variable for ModelB.

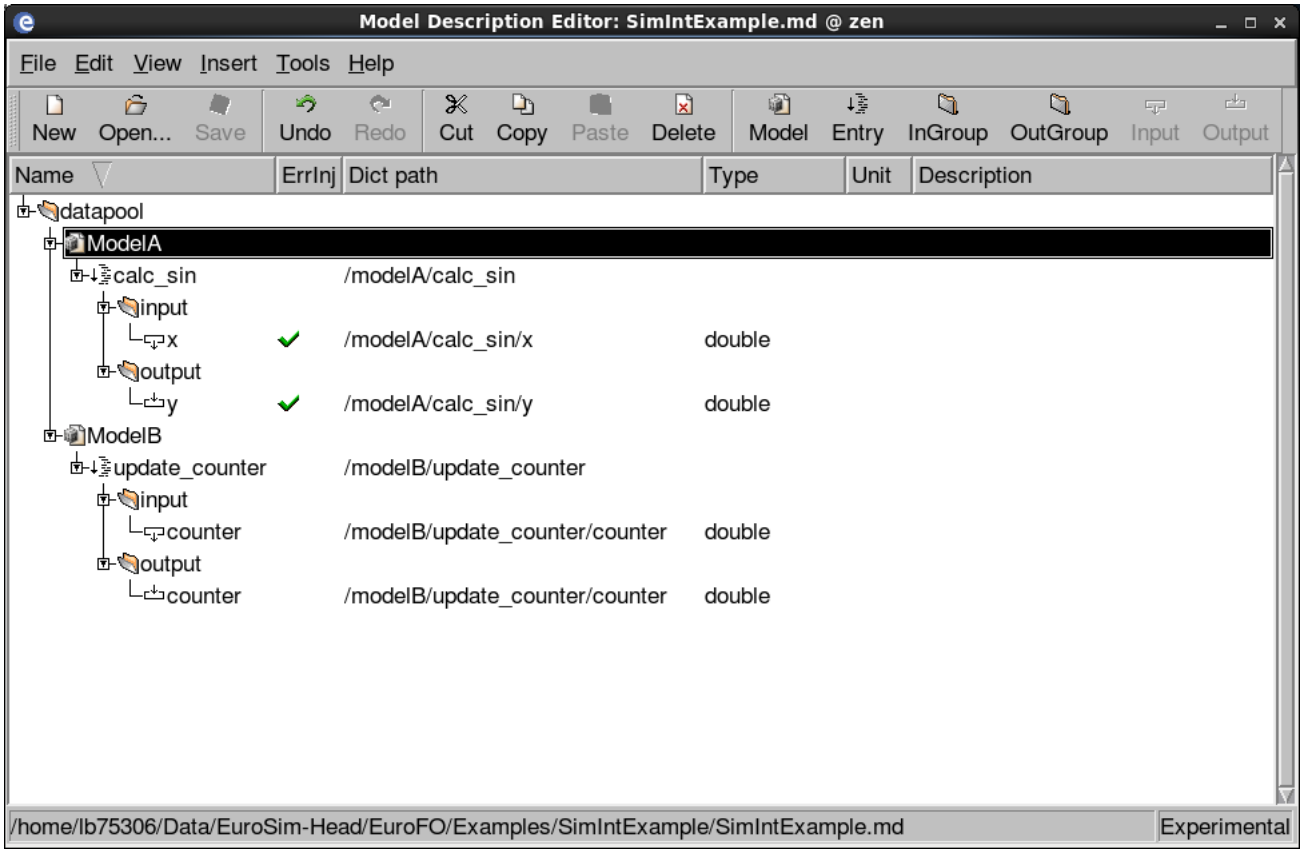


Figure 18.2: Model Description Editor

18.3.2.1 Datapool

Once you have finished editing a Model Description file, select the *Tools:Build All* menu command in the Model Editor, which generates the so called "datapool" (see also Section 8.1). The datapool contains the variables described in the Model Description file(s). It also contains automatically generated entry points to exchange the data between model variables and datapool variables. The variables in the datapool are always of the same type as the ones they refer to in the model files. During the build process, the variables and entry points in the datapool are merged into the data dictionary, see Section 18.5.

18.3.3 Parameter Exchange file

A Parameter Exchange file describes which output variables in the datapool should be copied to which input variables in the datapool. The input and output variables must be of the same type (and unit!). Parameter exchanges are grouped together in logical groups. For each parameter exchange group an

entry point will be generated. Scheduling the parameter exchanges is described in Section 18.3.4. Use the Parameter Exchange Editor to create or modify a Parameter Exchange file. There is no need to re-run the build process in the Model Editor after creating or modifying a Parameter Exchange file, as the entry points are generated "on the fly" when the simulator is started.

For our use case example a screen shot of the Parameter Exchange Editor looks like Figure 18.3. Each time the parameter exchange entry point is scheduled, the value of output variable `counter` of ModelB is copied to input variable `x` of ModelA and to the input variable `counter` of ModelB. The parameter exchange entry point receives the same name as name the exchange group node. Thus, in our example the entry point will be available as "Model_B_to_model_A".

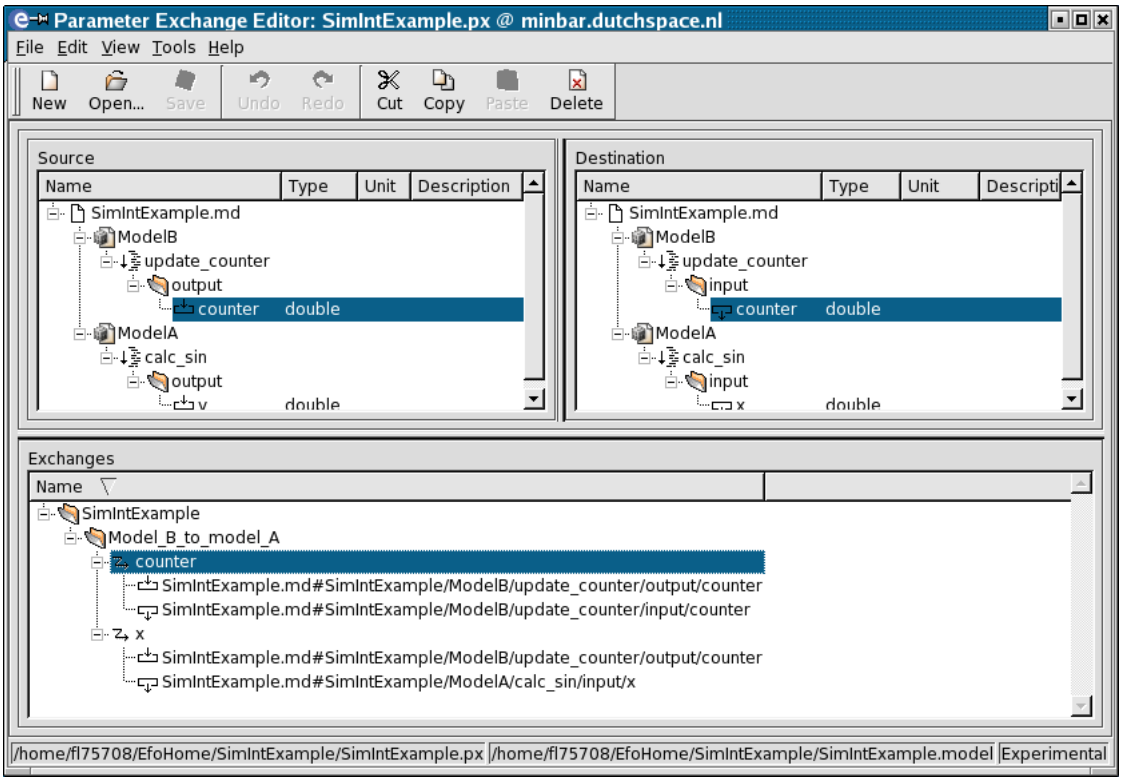


Figure 18.3: Parameter Exchange Editor

18.3.3.1 Why are Parameter Exchange files not part of the model?

This is done for flexibility. It allows the model developer to put together several sub-models into one simulator executable and describe the model variables by means of one or more Model Description files. The simulator developer could then create two Parameter Exchange files and reference these from two Schedule files. The first variant of the Parameter Exchange may for example update the input variables of one of the models with variables in the datapool that are updated by an external simulator (see Chapter 30). The second variant may update the input variables of one of the models with variables in the datapool that are updated by an internal model. In that way the test controller can easily switch between the two configurations, simply by selecting the appropriate Schedule file. The reason for having the Parameter Exchange file(s) referenced by the Schedule file is that the entry points are generated "on the fly" and you need the entry points when you edit the Schedule.

18.3.4 Specifying the schedule

As the last step when using Simulator Integration Support the schedule has to be specified. At this point we should have:

- A successfully built simulator executable,

- A successfully built data dictionary,
- One or more Model Description files (added to the model file as file nodes),
- One or more Parameter Exchange files (optionally added to the Project Manager).

We are now at a point were we can create the schedule file for the simulator. For our use case example a screen shot of the Schedule Editor looks like Figure 18.4.

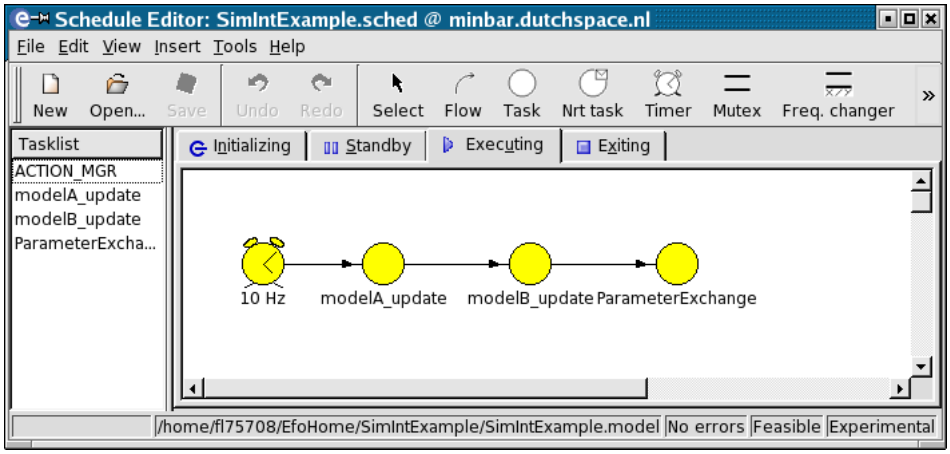


Figure 18.4: Schedule Editor

Task *ModelA_update* contains three entry points:

- /datapool/SimIntExample/ModelA/calc_sin/input/set_input_variables
- /modelA/calc_sin
- /datapool/SimIntExample/ModelA/calc_sin/output/set_output_variables

The first entry point is generated by the Model Editor build process when the Model Description file was read. It copies variable `x` from the datapool to variable `x` of model A (step 1 in Figure 18.5). The second entry point is the one from model A and uses variable `x` in model A to calculate the sine value and store the result in variable `y` (step 2). The last entry point is also generated and copies variable `y` from model A to variable `y` in the datapool (step 3).

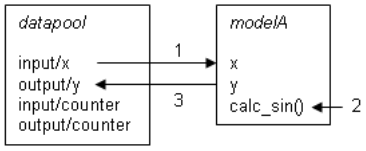


Figure 18.5: Datapool exchanges and update for model A

Task *ModelB_update* contains three entry points:

- /datapool/SimIntExample/ModelB/update_counter/input/set_input_variables
- /modelB/update_counter
- /datapool/SimIntExample/ModelB/update_counter/set_output_variables

The first entry point is generated by the Model Editor build process when the Model Description file was read. It copies variable `counter` from the datapool to variable `counter` of model B (step 4 in Figure 18.6). The second entry point is the one from model B and uses variable `counter` in model B to increment itself

(step 5). The last entry point is also generated and copies variable `counter` from model B to variable `counter` in the datapool (step 6).

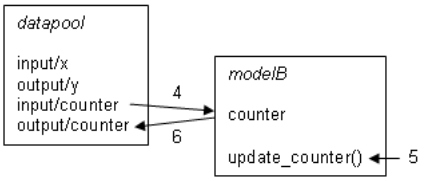


Figure 18.6: Datapool exchanges and update for model B

Task *ParameterExchange* contains one entry point:

- /paramexchg/Model_A_to_Model_B

This entry point copies the updated `counter` output variable in the datapool to the `counter` input variable and the `x` input variable (step 7 in Figure 18.7). After this parameter exchange the schedule starts again at step 1. This time model A uses the updated `x` variable to perform its model update.

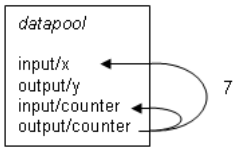


Figure 18.7: Parameter exchange

Notice that entry points that are generated for parameter exchanges are placed in a special node in the data dictionary called “paramexchg”. The name of the entry point is the same as the name of the parameter exchange group node in the Parameter Exchange file. The parameter exchange entry point copies the values of the specified variable(s) from the source to the destination.

The names of the generated entry points to update the datapool and model variables receive the names of the input and output group nodes as specified by the Model Description file:

Name of entry point `:= set_`*nodename*`_variables`

In order to generate the parameter exchange entry points, you must use the *File:Parameter Exchange files* command in the schedule editor to specify which parameter exchange file(s) should be used by the simulator. As soon as you add a parameter exchange file, the Schedule Editor will automatically add the appropriate entry points to the internal data dictionary (it will not change the data dictionary file on disk), so that the entry points are available in the task and non-rt task dialogs. At run-time, i.e. when the simulator reads the schedule file, the referenced parameter exchange files are read and the entry points are also generated, but this time they will point to internal data structures that describe which datapool variables to copy.

18.3.5 Concluding remarks

During the use case example in the previous sub-sections we have seen that we can integrate two models without having to write or modify a single line of source code. Of course, in practice model source code may have to be modified in order to match variable types (in the example we used doubles for all variables).

18.4 Initial values

The variables in the datapool will receive the same initial value as specified in the data dictionary for the related model variable. Use initial condition files if you wish to set the datapool variables to different

initial values.

18.5 Build process

Figure 18.8 shows the steps to build the simulator executable and data dictionary when using the Simulator Integration Support library. The build process (make) can be started from the Model Editor with the *Tools:Build All* menu command. First a data dictionary is generated from the model source code. This is the stage 1 data dictionary that is also used by the Model Description Editor. When the Model Description Editor is started from the Model Editor, the stage 1 data dictionary is always updated to ensure that all model variables are visible in the Model Description Editor. During the final build, i.e. when the Model Description file has been defined, the build process creates the datapool from the Model Description file(s) and merges its variables and entry points with the stage 1 data dictionary in order to create the final data dictionary. The final data dictionary will be used by the simulator and other EuroSim tools (such as the Schedule Editor).

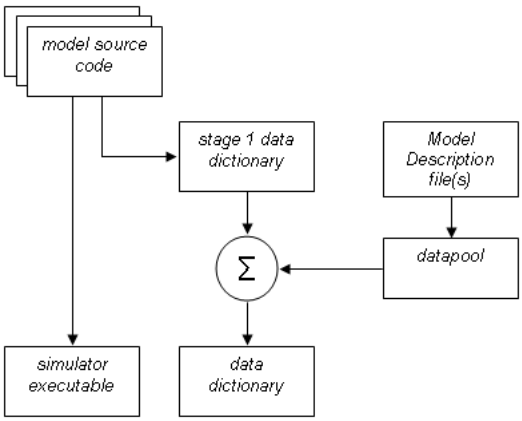


Figure 18.8: Build process steps

Chapter 19

Error Injection library reference

19.1 Introduction

The error injection library allows users to introduce errors in the transfer of data items from and to the datapool. It is therefore closely linked to the Simulator Integration Support library described in Chapter 18.
Error injection is enabled in the Model Editor in the support tab of the Build Options dialog box (see Figure 7.7).

19.2 Defining the error injection function

The error injection function is user defined. An example is shown in the listing below.

```
#include <stdlib.h>
#include <assert.h>
#include <esimErrInj.h>

static int enable_id;   /* boolean */
static int counter_id;  /* unsigned integer */
static int offset_id;   /* integer */
static int history_id;  /* double */


static esimErrInjDataValue_t error_injection_function(esimErrInj_t *error,
                                          esimErrInjDataValue_t input)
{
   bool *enable;
   unsigned int *counter;
   int *offset;
   double *history;
   esimErrInjDataValue_t output;
   double value;
   double prev_value;

   int res;

   res = esimErrInjGetBooleanValue(error, enable_id, &enable);
   assert(res == 0);    /* illegal id, type mismatch */
   res = esimErrInjGetUnsignedIntegerValue(error, counter_id, &counter);
   assert(res == 0);    /* illegal id, type mismatch */
   res = esimErrInjGetIntegerValue(error, offset_id, &offset);
   assert(res == 0);    /* illegal id, type mismatch */
   res = esimErrInjGetDoubleValue(error, history_id, &history);
   assert(res == 0);    /* illegal id, type mismatch */
```

```
   if (!*enable) {
      return input;
   }

   if (*counter == 0) {
      return input;
   }
   (*counter)--;

   switch (input.type) {
   case ESIM_ERROR_INJECTION_BOOLEAN:
      value = input.val_b;
      break;
   case ESIM_ERROR_INJECTION_INTEGER:
      value = input.val_i;
      break;
   case ESIM_ERROR_INJECTION_UNSIGNED_INTEGER:
      value = input.val_u;
      break;
   case ESIM_ERROR_INJECTION_DOUBLE:
      value = input.val_d;
      break;
   default:
      assert(0);
   }

   prev_value = *history;
   *history = value;

   value = prev_value + *offset;

   output.type = input.type;

   switch (input.type) {
   case ESIM_ERROR_INJECTION_BOOLEAN:
      output.val_b = value;
      break;
   case ESIM_ERROR_INJECTION_INTEGER:
      output.val_i = value;
      break;
   case ESIM_ERROR_INJECTION_UNSIGNED_INTEGER:
      output.val_u = value;
      break;
   case ESIM_ERROR_INJECTION_DOUBLE:
      output.val_d = value;
      break;
   }

   return output;
}

int userErrInjPublish(esimErrInjPublish_t *pub)
{
   esimErrInjDataValue_t value;

   value.type = ESIM_ERROR_INJECTION_BOOLEAN;
   value.val_b = false;
   enable_id = esimErrInjPublishParameter(pub,
                                "enable",
                                "enable error injection",
```



```
                                NULL,
                                value,
                                false);
    if (enable_id == -1) return -1;

    value.type = ESIM_ERROR_INJECTION_INTEGER;
    value.val_i = -10;
    offset_id = esimErrInjPublishParameter(pub,
                                "offset",
                                "offset to add to output value",
                                "m",
                                value,
                                false);
    if (offset_id == -1) return -1;

    value.type = ESIM_ERROR_INJECTION_UNSIGNED_INTEGER;
    value.val_u = 20;
    counter_id = esimErrInjPublishParameter(pub,
                                "counter",
                                "number of times to repeat error",
                                NULL,
                                value,
                                false);
    if (counter_id == -1) return -1;

    value.type = ESIM_ERROR_INJECTION_DOUBLE;
    value.val_d = 0.123e2;
    history_id = esimErrInjPublishParameter(pub,
                                "history",
                                "history of variable",
                                NULL,
                                value,
                                true);
    if (history_id == -1) return -1;

    esimErrInjPublishFunction(pub, error_injection_function);
    esimErrInjSetPostFix("_test_1_2_3_4");
    return 0;
}
```

The error injection function is called `error_injection_function`. The function first retrieves pointers to the error injection parameters. The pointers allow the user to modify the error injection parameter values. This example shows four parameters, one of each data type.

The input value of the error injection function is modified to perform the error injection. The result is returned. The type of the result variable must always be identical to the type of the input variable.

The error injection publication function must be called `userErrInjPublish`. The function is called at build time and at run time. At build time the publication is used in the process to generate the data dictionary. At run time it is used to pass the error injection function pointer and to retrieve the parameter id's. The parameter id's are needed to retrieve the pointers to the error injection parameters in the error injection function.

More information can be found in the esimErrInj(3) manual page.

19.3 Defining the variables affected by error injection

The user can enable error injection on individual variables or groups of variables in the model description editor (see Chapter 8) by toggling the error injection flag. It is possible to enable error injection on simple

variables and array variables. In the case of array variables, an error variable is created with the same dimensions as the array variable. The array elements of the error variable affect the corresponding elements of the original array variable.

19.4 Build process

The generation of error injection variables in the data dictionary is integrated in the datapool building process (see Section 18.5). It is possible to change the default postfix ("_error") of the error injection variable. The postfix may not be empty as it would then be the same as the variable on which the error injection operates.

Calls to the error injection function are automatically generated as part of the datapool code generation process.

Chapter 20

Calibration Library reference

20.1 Introduction

This chapter provides details on the Calibration Library. The Callibration library provides an API that allows the user to callibrate values based on a calibration curve that has been defined using the Calibration Editor (Chapter 10).

The calibration library API is typically used from the model code that interfaces with the external hardware such as electrical front-ends.

Through the API the user selects which calibration curve to use by refering to the calibration curve name. This name must refer to a calibration curve that is enclosed in a loaded calibration file, which can be enforced either by including the file in the ModelEditor or by adding it to the Input Files tab of the simulation controller (which means it is referenced from the .sim file). Using the calibration function, the user can then apply the selected curve to an input value in order to get the calibrated value in return.

20.2 Application Programmers Interface

The API of the library has the following synopsis:

```
#include <esimCalibration.h>

const EsimCalibration_t *esimCalibrationLookup(const char *name);

EsimCalStatus_t esimCalibrate(const EsimCalibration_t *cal, double in, double

const char *esimCalibrationErrorString(EsimCalStatus_t stat);
```

The esimCalibrationLookup function looks up the calibration curve with the given name in the list of loaded calibration files, as mentioned in the Simulation Controller. The returned value is a calibration curve handle that can then be used in esimCalibrate as parameter to perform the actual calibration. The input value in esimCalibrate is then calibrated into the output value out. The return code of the function esimCalibrate indicates success or failure of the calibration and can be converted to an error string with the function esimCalibrationErrorString. The following error status may occur:

- esimCalibrationErrorString always returns an error string. If you pass it an unknown status value, the string contains ”Unknown error occurred during calibration”.
- `ESIM_CAL_OK`: Calibration succeeded, no error.
- `ESIM_CAL_LOOKUP_FAILED`: Lookup calibration failed, lookup value was not in the lookup table.

- `ESIM_CAL_INPUT_TOO_SMALL`: Input value below allowed minimum.
- `ESIM_CAL_INPUT_TOO_LARGE`: Input value above allowed maximum.

Beware that esimCalibrationLookup will return NULL if the calibration curve with the given name does not exist, thus allways check this return value for a NULL before passing the handle to esimCalibrate.

Part IV

Scripting Reference Guide

Chapter 21

Mission Definition Language reference

The Mission Definition Language MDL is a simple yet versatile language for real-time simulation scripting. It allows users to write simulator control scripts in a "C-type", or—alternatively—in a limited "free-text" language. The language has all the facilities one can expect of a programming language, including if-statements, for-loops, global and local variables. Besides that, the user has full access to the variables in the EuroSim data dictionary. Direct simulation control commands can also be used in the language.

This appendix first starts with a primer in MDL, followed by a number of sections providing detailed information on the various language elements. A description of the built-in functions and a concise formal definition of the MDL language can be found in the last two sections of this appendix.

Note that the majority of MDL scripts in EuroSim will/can be made via the GUIs, for which the user doesn't need to know much about the MDL language. So this appendix is primarily intended for EuroSim users who want to do 'advanced' things, not supported via the predefined GUIs. Throughout this section, it is assumed that the reader has programming experience.

21.1 MDL primer

An MDL script (or "scenario") is normally created with EuroSim's Simulation Controller and interpreted during simulation by EuroSim's Action Manager (ACTION_MGR). An MDL script contains (amongst other things) a collection of *actions*. An MDL action consists of four parts:

1. Action name.
2. Action attributes (optional).
3. Action body.
4. Action condition (optional).

Each action in the MDL script is represented by an icon on the Simulation Controller's tree or icon view. The four parts of each action can be edited via the Simulation Controller (Section 12.10.3).

A simple example which prints a message 10 seconds into the simulation:

```
#
# action name and attributes
action "Primer" ["description",bitmap="script_stub",show+active+Executing
    , 50 50, 1]
#
# action body
{
  print "Hello at t=10"
```

```
}
#
# action condition
when (time() == 10)
```

The action attributes are used to:

- Give a description of the action.
- Manipulate the appearance of the action on the Simulation Controller tree or icon view.
- Set the *initial*[1] status of the action.

The action status can either be `active` or `nonactive`. Furthermore, one can specify in which of the four simulation states the action has to be evaluated when active: `Initializing`, `Executing`, `StandBy` or `Stopping`.

EuroSim maintains for each of these states a list of active actions. The action conditions of these actions are checked each time the `ACTION_MGR` is activated (in that state and normally at the end of each simulation step[2]). The action body is executed by EuroSim when the action condition evaluates true. When the action has no condition part, this never happens; these actions can only be activated manually (by double clicking the action icon on the Simulation Controller scenario tab page).

The MDL script is executed in the real-time part of EuroSim. In order to safeguard the real-time execution of a EuroSim simulator, error conditions within MDL actions are handled in the following way:

1. The execution of the action causing the error condition is suspended.
2. An error message of this event is reported to the Test Controller and the journal log.
3. The specific action is deactivated so the action will not be executed again.
4. The execution of remaining actions in the MDL script is resumed.

Run time error conditions include:

- MDL or data dictionary array bound overflows.
- Errors in MDL math functions or expressions (e.g. `sqrt(i)` with i<0).
- Errors in action condition frequency specification (e.g. frequency higher than the `ACTION_MGR` frequency).
- Trying to read stimuli from nonexisting or exhausted stimuli files.
- Observers (which have “read only” access) trying to change the data dictionary variables from actions, apply stimuli or raise events.
- MDL scripts accessing undefined (external) MDL variables or functions.
- MDL scripts trying to execute an undefined action.

An MDL action body consists of statements separated by newlines or by a semicolon. The latter may—however—only be used to separate multiple statements on a single line. MDL is case sensitive. Everything following a ‘#’ sign until end-of-line is considered comment.

MDL is a powerful languages, but remember that it is an interpreted language, running in the real-time part of the simulator. Hence keep your scripts as simple and small as possible. Don’t write large loops and keep computation to a minimum. If you have to do serious programming and/or computation, consider adding an extra sub-model and associated tasks to you model.

[1] Initial, as this can change during the simulation.
[2] See Section 11.3.5 for scheduling of the `ACTION_MGR`.

21.2 MDL constants, types, variables, operators and expressions

Variable names are made up of letters, underscores and digits. Upper and lower case letters are distinct. MDL has four basic variable types:

- `int` representing an integer value.
- `float` representing a floating point value[3].
- `string` representing a character string.
- `datetime` representing a time value.

Variables which are explicitly declared as one of the above are called 'static' variables. Static variables are, in the absence of an initializer, always initialize at zero or the empty string. Variables need not be declared in MDL. Undeclared variables are created automatically the first time they are used as a left hand value in an assignment. These variables are called 'automatic' variables.

The scope of variables is that of the enclosing action body (or function; see below). By prepending the action or function name, the static variables from other actions and functions can be accessed. Static variables retain their values in between different action or function invocations. Automatic variables are recreated each time their scope is entered and disappear when that scope is left.

Automatic type conversions are applied when needed between all the basic types.

Constants can be given either in decimal, octal or hexadecimal form, as in 'C'. Constants are of type int, except when the constant contains a decimal dot or is given in scientific notation (e.g. 3e-9), in which case they're of type float. A string constant consists of a number of characters between double quotes.

Some examples with MDL variables and constants:

```
action "action1"
{
 int a_variable      # a static variable of type int
 b_variable = "100"  # an automatic variable of type string
 a_variable = b_variable # type conversion from string to int
}

action "action 2"
{
  string a_variable = "hello" + " world" # an initialised static variable
}

action "two_externals"
{
 float f = action1:a_variable
 print f             # prints: "100.0000"
 print action1:a_variable # prints: "100"
 print "action 2":a_variable # prints: "hello world"
}

action "externals_from_another_file"
{
 print "common_actions.mdl":action1:b_variable
 print "common_actions.mdl":"action 2":c_variable
}

action "showtime"
{
```

[3] `int` and `float` are implemented as C doubles; check the documentation of your platform to see the valid range for that type.

```
  # NB: No UTC selected
  datetime t = 5.900
  print "time = ",t + 15.2 # prints: "time = 21.1000"
}

action "showtimeUTC"
{
  # NB: UTC selection in model options
  datetime t = 2001-02-24 16:10:05.900
  print "time = ",t + 15.2 # prints: "time = 2001-02-24 16:10:21.1000"
}
```

Arrays of basic types can be constructed using square brackets. Arrays must have fixed dimensions and type (no automatic arrays). Assignments are between basic types only.

```
action "sum"
{
  int a[10]
  for (i = 0; i < 10; i = i + 1) a[i] = i

  # compute sum of array
  i = 0; sum = 0
  while (i < 10) {
    sum = sum + a[i]; i = i + 1
  }
}
```

MDL has all the usual (C) operators, except for the address operator, which doesn't exist in MDL. Exponentiation is written as 3^4. In addition, the equivalent English words can be used as operators, e.g. `and`, `or`, `not`, `less_equal`, `greater_equal`, `equals`, `not_equals`, `less_than`, `greater_than`, `minus`, `plus`, `times`, `pow`.

21.3 Control Flow

MDL statements within an action body are executed in order from top to bottom, except as modified by control flow statements. MDL has the usual (C) keywords for control flow: `break`, `continue`, `do`, `else`, `for`, `if`, `while`, `return`. There's no switch-construct (yet), although the words 'switch' and 'case' are reserved words[4]. A conditional block (sequence of statements) may be delimited by either curly braces '{}' or by the keywords `begin` and `end`. The action body may be delimited by the keywords `action_begin` and `action_end`. These latter two keywords may thus not be nested, and help (when used) to find nesting problems, which are then confined to a single action in the MDL script. Below two examples are given, one in C-like syntax, and one in the alternative, free-style syntax.

```
action "looptest2"
{
  j = 0
  N = 100

  print ""
  print "# forloop test2, expect loopcount=", N

  for (i = 1; i < 10 * N; i = i + 1) {
    j = j + 1
    if (i == N) break;
  }
  print "loopcount=", j
}
```

[4] See Section 21.6 for a complete list of reserved, but unused words.

```
# free-style syntax
action "looptest5"
action_begin
  N = 3000
  k = 0

  print ""
  print "# forloop test5, expect loopcount=", N

  for i is 1 to N/10 loop begin
    for j is 1 to 10 loop begin
      k is k plus 1
    end
  end

  print "loopcount=", k
action_end
```

21.4 Functions

MDL has an extensive set of built-in functions for simulation support: see Section 21.6. It also supports user defined functions. Functions return simple values and can be used freely in MDL expressions.

User functions can be defined and used within the action body. Function arguments and return values must be basic types and behave like automatic variables. Within the function body the complete MDL syntax can be used (e.g. to define local variables or other functions).

The type of the function arguments and the type returned by the function may vary from invocation to invocation, as is shown in next example.

```
action "my_action"
{
  int i
  float x
  error = 0

  function sqr(n)
  {
    return n * n
  }

  for (i = 0; i < 5; i = i + 1) {
    # sqr with int
    if (sqr(i) != i * i) error = error + 1
  }

  for (x = 0.0; x < 5.0; x = x + 1.0) {
    # sqr with float
    if (sqr(x) != x * x) error = error + 1
  }

  if (!error) print "function test OK"
  else print "Error !!!"
}
```

The scope of the function name is that of the enclosing action. As with variables, one can use a function defined in another action, by prepending that action's name and a colon (':') to the function's name. It is also possible to refer to functions in actions in another MDL file by prepending the basename of the MDL file and a colon to the name of the action and the function.

```
# simple external function call
action "object"
{
  float velocity = 10.0 # static variable
  function speedup() { velocity = velocity * 2.0; }
  function slowdown() { velocity = velocity * 0.5; }
  function current() { return velocity; }
}

action "accel"
{
  object:speedup()
  print "speed=", object:current() # prints: "speed=20.0"
}
```

Warning: because all MDL variables have static storage, recursive function calls may have unexpected results.

21.5 Input/Output and Simulator Control

In MDL, input and output can be done in two ways, each having a particular purpose:

1. Via variables in the simulation model.
2. Via specific built-in commands.

An example of the latter is the `print` command, already shown in many of the previous examples. It prints the given expression on the Simulation Controller's message pane and in the simulation log.

MDL provides access to variables in the simulation model via the model's data dictionary. Array elements are selected using square (C) or round (Fortran) brackets. More dimensional array indexing follows the conventions of the sub-model language. Members of user defined type variables in C sub-models are selected using a dot:

```
action "position"
{
  # print three elements of an array in a Fortran style loop
  N = 3
  for i is 1 to N loop begin
    print "position(", i, "): ", :source.f:position(i)
  end
}

action "clear"
{
  # clear all elements of an 2-dim. array in a C style loop
  for (i = 0; i < 10; i = i + 1)
    for (j = 0; j < 10; j = j + 1)
      :source.c:matrix[i][j] = 0

  # clear a member of a C struct
  :source.c:vector.xcoord = 0.0
}
```

A combination of both mechanisms is used to stimulate and record certain data dictionary variables with the `stimulate` or `record` built-in commands.

```
action "register three"
{
  int n
  float x
```

```
  function f()
  {
    x += 1.0
    return x
  }

  n++;
  record "file1" n, f(), :A:B:C:source1.c:work1:local1
  record "file3" :A:E:C:source2.c:work4:localUdt
  record "file2" :A:E:C:source2.c:work4:localUdt[0].count
}
when (freq(100))
```

Note that also MDL variables can be recorded; this can be used e.g. for recording a derived variable (derived from one or more data dictionary variables).

From within MDL, the user has full control over the simulator by means of functions like `go`, `freeze`, `stop`, etc. (see Table 21.5) Also, from one action, one can activate other actions but also tasks and entry points within the model.

21.6 MDL Built-in functions and commands

MDL has built-in functions and commands for the following applications:

- Mathematical functions (see Table 21.2).
- Signal processing functions (see Table 21.3).
- Auxiliary functions (see Table 21.4).
- Input, output and control commands (see Table 21.5).

Functions return a value, whereas commands do not. Functions can be used in expressions. The MDL built-in functions all take numerical (or no) arguments. Required arguments are indicated as follows:

`func()`	This function takes no argument.
`func(x)`	This function takes one argument.
`func(x, ...)`	This function takes one or more arguments.

Arguments may be functions themselves. Non-numerical arguments are automatically converted to numerical.

Function	Description
atan(x)	Compute arc tangent of x and return it. Return value will be between $-\pi/2$ and $\pi/2$.
cos(x)	Compute cosine of x and return it. x is in radians.
exp(x)	Compute the x'th power of e and return it. e is the base of natural logarithms.
fabs(x)	Compute the absolute value of x and return it.
log(x)	Compute the natural logarithm of x and return it. If x is less than or equal to 0, a run time error results.
sin(x)	Compute the sine of x and return it. x is in radians.
sqrt(x)	Compute the square root of x and return it. If x is less than 0, a run time error results.
tan(x)	Compute the tangent of x and return it. x is in radians.

Table 21.2: Mathematical functions.

Function	Description
acos(x)	Compute the arc cosine of x and return it. Return value will be between 0 and π. If x is not between -1 and 1, a run time error results.
asin(x)	Compute the arc sine of x and return it. Return value will be between $-\pi/2$ and $\pi/2$. If x is not between -1 and 1, a run time error results.
ceil(x)	Rounds up x to the next highest integer and return it.
cosh(x)	Compute the hyperbolic cosine of x and return it.
floor(x)	Rounds down x to the next lowest integer and return it.
log10(x)	Compute the (base 10) logarithm of x and return it. If x is less or equal than 0, a run time error results.
sinh(x)	Compute the hyperbolic sine of x and return it.
tanh(x)	Compute the hyperbolic tangent of x and return it.

Table 21.2: Mathematical functions.

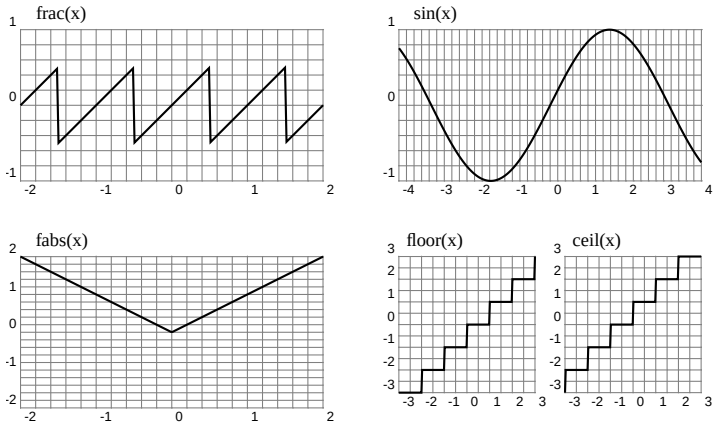


Figure 21.1: Some of MDL's mathematical functions.

Function	Description
doublet(x)	Compute the doublet of x and return it. If x is between 0 and 1 return 1, if x is between 0 and -1 return -1, else return 0.
ramp(x)	Compute the ramp of x and return it. If x is less than zero return zero, if x is greater than 1 return 1, else return x.
jigsaw(x)	Compute the jigsaw of x and return it. If x is less than 0 return 0, if x is greater than 1 return 0, else return x.
step(x)	Compute the step of x and return it. If x is less than 0 return 0, if x is greater than 0 return 1.
frac(x)	Compute the frac of x and return it. Frac is the remainder of x from its nearest integer value.

Table 21.3: Signal processing functions.

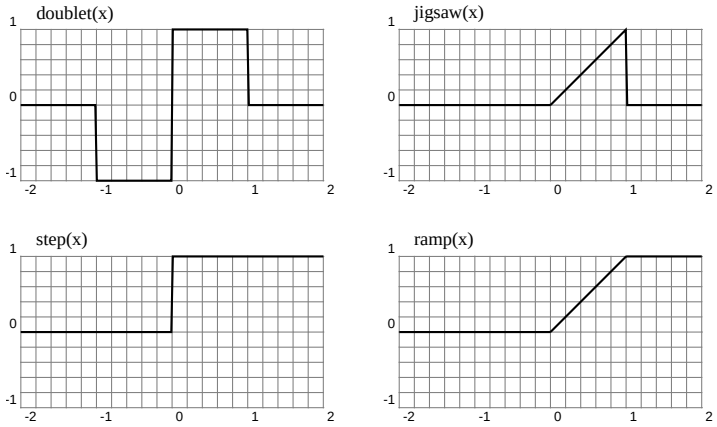


Figure 21.2: Some of MDL's signal processing functions.

By combining (or modulating) the various functions in expressions, many types of signals and *if-type* functions can be constructed. For example:

- `step(x+1)-step(x-1)` or `doublet(x)*doublet(x)` results in the box function which is only 1 in the range [-1, 1], and 0 everywhere else.
- `x*step(-x)+x*x*step(x)` results in a line for `x` less than zero and a parabola for `x` greater than zero.

Function	Description
catch`(x)`	Reserved for future use.
changed`(x)`	Return 1 if `x` has changed with respect to the previous invocation, else return 0. Typically used in the condition part of an action in combination with data dictionary variables: `freq(100) & changed(:model:var)`
duration`()`	Return the elapsed simulation time (in seconds) that the action has been continuously (i.e. at each activation of the `ACTION_MGR`) executed. Elapsed time is reset to zero when the action is not executed. This function can be used to have an action run for a certain period of time.
eventcount`(x)`	Return number of times event `x` has been raised in the schedule. Returns -1, if the event name is unknown.
format`(x,...)`	Return formatted string, using `printf` like format specification. E.g. `str = format("Hex value=%4x", :model:var)`
freq`(x, y)`	Use this function to have an action executed at a given frequency with a given offset. The offset argument is optional and defaults to 0 (i.e. no offset). It returns 1 if desired frequency `x` (in Hertz) is met by internal basic frequency and with the given offset `y` (in ms), else `freq` returns 0. The basic frequency is the frequency with which `ACTION_MGR` is scheduled. Depending on the scheduling table used, this frequency may differ from the scheduler basic frequency. If the basic frequency is not an exact multiple of the desired frequency `x` the desired frequency will be approximated in the long run. When parsing an action with a `freq` function, the `ACTION_MGR` will issue a warning if this is the case (provided `x` is a constant).

Table 21.4: Auxiliary functions.

Function	Description
getenv(x)	Return the string value of shell environment variable x.
main_cycle()	Return the main cycle time of the schedule in seconds.
realtime()	Return the current real-time mode of the simulator. Returns 1 if scheduler is in real-time mode, or 0 if it is in non-real-time mode.
simstate()	Return current simulator state as string value, e.g. `"standby"`. Can be used by actions which can execute in different simulator states in expressions like `if (simstate() = "executing") count = count + 1`
simtime_boundary()	Return simulation time of last state transition in seconds.
time()	Return the current simulation time in seconds.
wallclock()	Return the current wallclock time in seconds.
wallclock_boundary()	Return wallclock time of last state transition in seconds.
enable_entrypoint(x)	Enable entry point x.
disable_entrypoint(x)	Disable entry point x.

Table 21.4: Auxiliary functions.

The last table explains the MDL commands. The commands take numerical or string arguments. Contrary to functions, the command arguments are not to be given between parenthesis and commands do not return a value. Hence they cannot be used in expressions.

Command	Description
abort	request abort of the simulator

activate *action* | *task*	activate an action (i.e. make its state active) or enable a task. Actions from other MDL files may also be used. The action name must be prepended with the MDL file name (basename only). Actions and tasks must be specified as strings:
	`activate "Inject Error"`
	`activate "other.mdl:Enable Power"`
	`activate "task:Thruster"`

deactivate *action* | *task*	deactivate an action or disable a task. Actions from other MDL files may also be used. The action name must be prepended with the MDL file name (basename only). Actions and tasks must be specified as strings:
	`deactivate "Inject error"`
	`deactivate "other.mdl:Enable Power"`
	`deactivate "task:Thruster"`

Table 21.5: Input/Output and Control commands (do not return values)

Command	Description

exec *action* | *entrypoint* | *task*	execute action or model entry point or model task from within another action. Actions from other MDL files may also be used. The action name must be prepended with the MDL file name (basename only). Action, entry points and tasks must be specified as strings:
	`exec "Trigger action"`
	`exec "other.mdl:Inject error"`
	`exec "entry:do_step"`
	`exec "task:my_task"`

health	check internal diagnostics and report it to the journal file
mark [*expression*]	Produce a mark in the message pane and journal file. When expression is omitted, the mark looks like: `MARK-n`, with n being a sequence number. When expression is given, the mark looks like: `COMMENT-n comment`, with comment being the value of expression converted to string.
monitor [*options*] *dictlist*	Please note that this command is obsolescent. Pop-up a monitor on the "Script Monitors" tab pane. This command can be used to start monitoring of a (set of) variable(s) when a certain condition during simulation is met. Information on the variables is derived from the data dictionary. The *options* argument is a single string containing a comma separated list of options. Valid options are: type alfa|time|xy: type of monitor point cross|line|both: line style of monitor xsize *number*: xsize of monitor window ysize *number*: ysize of monitor window xmin *number*: minimum x value of monitor plot range xmax *number*: maximum x value of monitor plot range ymin *number*: minimum y value of monitor plot range ymax *number*: maximum y value of monitor plot range Example: `monitor "type=time, point=cross, xsize=1, ysize=2, xmin=3.0, xmax=4, ymin=5, ymax=6" :A:B:C:source1.c:work1:local1`
pause (or **freeze**)	request change simulator state from 'executing' to 'standby'.
print *expression_list*[5]	Evaluate the expressions in the *expression_list* and print them on the message pane and journal file.

Table 21.5: Input/Output and Control commands (do not return values)

[5] An *expression_list* is a comma-separated list of expressions.

Command	Description
raise *event*	raise an input event as defined in the EuroSim schedule, e.g.: `raise "HARDWARE_FAILURE"`
record [*per_switch*] [*filename*] *dictlist*[6] (or **registrate, datalog**)	Record one sample of a given set of variables to an optionally named file. The simulation time is recorded implicitly and need not be specified. The optional *per_switch* argument specifies the time (in seconds or hours) in case a recorder file should periodically switch. The *filename* argument is optional. It can be used for "named" recording. If *filename* is not specified, the action's name suffixed by `.rec` will be used as file name. In case of a periodic switch the *filename* becomes *filename-00n* (with switch counter *n*).
reinit ["soft" | "hard"] *filename* (or **initialise, init**)	Reload the data dictionary with the values from a snapshot file. If the "hard" option is given the simulation time will be set to the value defined in the snapshot file. The "soft" option is the default. When this option is used (or no option) the simulation time in the snapshot file is ignored. After the loading of the file has finished the scheduler event `SNAPSHOT_END` is raised so that a task can be triggered to use the values to reinitialize external hardware for instance.
run (or **go**)	Request change simulator state from 'standby' to 'executing'
schedspeed *expression*	Set the scheduler speed to result of expression. `schedspeed("AFAP")` sets the scheduler in 'as fast as possible' mode. This function only has effect if the scheduler is in non-realtime mode.
set_realtime *expression*	Change the real-time mode to result of expression.
set_time *expression*	Change the simulation time to result of expression.
snapshot [*filename*]	Make a snapshot of the current data dictionary and save it to a file. Default file name is snapshot-n.snap, n=0, 1, 2, ...
stimuli ["soft" | "hard" | "cyclic"] *filename dictlist*	Stimulate the specified set of data dictionary variables with the next record of values contained in *filename*. If the "hard" option is given, the next record in the stimuli file will be applied when the given timestamp (value in first column in the stimuli file) matches the simulation time. In the default case "soft" the timestamps are ignored. With the "cyclic" option the stimulation is applied periodically, ignoring the timestamps.
stop	request change simulator state to 'stopping'

Table 21.5: Input/Output and Control commands (do not return values)

21.7 MDL syntax

The syntax below is specified in a Backus-Naur Form.

[6] A *dictlist* is a comma-separated list of data dictionary variables.

':' indicates the start of the definition of the item listed before the colon. '|' indicates an alternative and ';' terminates the definition. So A: B|C|D; means that 'A' can be 'B', 'C' or 'D'.
Bold words are literal strings.

string is a placeholder for an actual string, i.e. a sequence of characters, delimited by double quotes.
Example: `"this is a string"`

identifier is a placeholder for an actual identifier of a variable or function. Identifiers consist of a sequence of letters, digits and the underscore and dollar character.
Examples: `var1`, `_var2` and `block$var3`

external-identifier is a placeholder for an actual identifier of a variable or function coming from another MDL action. It consists of the name of an action followed by an identifier of a variable or function separated by a colon. The name of an action may contain spaces and therefore it is possible to enclose the name of the action in double quotes. If there are no spaces in the name of the action the double quotes are not needed.

Examples: `action1:var1` and `"action two":var2`

dictpath is a placeholder for a data dictionary path name. A data dictionary path consists of a list of orgnodes followed by an identifier separated by colons.
Example: `:system-A:subsystem-B:source.c:variable_d`

{**Decimal**} is a decimal number.

{**Octadecimal**} is an octal number. It starts with a 0 and consists of one or more numbers in the range 0-7.

{**Hexadecimal**} is a hexadecimal number. It starts with 0x and consists of one or more numbers in the range 0-9 and letters in the range A-F or a-f.

{**FloatingPoint**} is a floating point number. It can have a decimal point and/or an exponent.

{**Time**} is a time specification. It has the following format: YYYY-MM-DD hh:mm:ss optionally followed with a decimal point followed by fractions of a second. YYYY is the year in four decimal digits. MM is the month of the year in the range of 1 to 12. DD is the day of the month in the range of 1 to 31. hh is the hour of the day in the range of 0 to 23. mm is the minute of the hour in the range of 0 to 59. ss are the seconds of the minute in the range of 0 to 59. You can specify sub-second precisions by adding a fraction to the seconds.
Example: `2003-06-05 10:11:12.131415`

```
#grammar:
MDL
         /* MDL action scripts */
         : MDLscript tEOF
         | MDLfuncs Cont MDLscript tEOF
         | tEOF
         ;

MDLscript
         : Action
         | MDLscript Action
         ;

MDLfuncs
         : FunctionDeclaration
         | MDLfuncs Term FunctionDeclaration
         ;

Action
         : action string
         /* CONTINUED */
         Attributes Cont
         /* CONTINUED */
         ActionBody
         Cont
         /* CONTINUED */
```

```
        ActionCondition
        ;

ActionBody
        : CompoundStatement
        | action_begin Cont StatementList Cont action_end
        | action_begin Cont action_end
        | { Cont }
        | begin Cont end
        | action_begin Cont StatementList tEOF
        | { Cont StatementList tEOF
        | begin Cont StatementList tEOF
        ;

Attributes
        : /* no attributes */
        | [ AttributeList ]
        ;

ActionCondition
        : /* no condition */
        | When ( Cont PossibleCondition ) Term
        ;

When
        : when
        ;

PossibleCondition
        : /* nothing */
        | Condition Cont
        ;

Condition
        : Expr
        ;

        /*
        * ActionAttribute are used to manipulate:
        * - appearance of Action in Action Sheet (GUI)
        * - initial status of action, when condition is specified
        *
        */
AttributeList
        : ActionAttribute
        | AttributeList , ActionAttribute
        ;

ActionAttribute
        : ActionStateAttribute          /* state attributes */
        | PixelCoord PixelCoord         /* x y position on action Sheet */
        | {Integer}                     /* icon # on action Sheet */
        | bitmap is string              /* bitmap */
        | bitmap = string               /* bitmap */
        | index is {Integer}            /* index */
        | index = {Integer}             /* index */
        | folder is string              /* folder */
        | folder = string               /* folder */
        | actionmgr is {Integer}
        | actionmgr = {Integer}
        /* action mgr nr */
        | type is string
        | type = string
        | string                        /* description field */
        ;

ActionStateAttribute
        : identifier
        | ActionStateAttribute || identifier
        | ActionStateAttribute or identifier
        | ActionStateAttribute + identifier
        | ActionStateAttribute plus identifier
        ;

CompoundStatement
        : { Cont StatementList Cont }
```



```
        | begin Cont StatementList Cont end
        ;

StatementList
        : Statement
        | StatementList Statement
        ;

Statement
        : DeclarationList
        | for ( Assignment ; Condition ; Assignment
        ) Cont Statement
        | for Assignment to Expr loop Cont Statement
        | while ( Condition ) Cont Statement
        | do Statement while ( Condition ) Term
        | do CompoundStatement while ( Condition ) Term
        | continue Term
        | break Term
        | return Term
        | return Expr Term
        | Assignment Term
        | BuiltInCommand Term
        | FunctionCall Term
        | ; Term
        | IfStatement
        | CompoundStatement Term
        ;

IfStatement
        : if ( Condition ) Cont ThenStatement ElseStatement
        | if ( Condition ) Cont ThenStatement
        ;

ThenStatement
        : Statement
        ;

ElseStatement
        : else Cont Statement
        ;

Assignment
        : Lvalue is Cont Expr
        | Lvalue = Cont Expr
        | set Lvalue to Expr
        | set Lvalue Expr
        | ComplexAssignment
        ;

ComplexAssignment
        : Lvalue += Expr
        | Lvalue -= Expr
        | Lvalue *= Expr
        | Lvalue /= Expr
        | Lvalue %= Expr
        ;

Lvalue
        : Variable
        ;

Expr
        : MdlExpr
        | Variable
        ;

Argument
        : MdlExpr
        | Variable
        ;

MdlExpr
        : Constant
        | FunctionCall
        | ( Expr )
        | Expr + Expr
```

```
          | Expr plus Expr
          | Expr - Expr
          | Expr minus Expr
          | Expr / Expr
          | Expr * Expr
          | Expr times Expr
          | Expr % Expr
          | - Expr
          | minus Expr
          | Expr ^ Expr
          | Expr pow Expr
          /* conditions */
          | Expr == Expr
          | Expr equals Expr
          | Expr != Expr
          | Expr not_equals Expr
          | Expr >= Expr
          | Expr greater_equal Expr
          | Expr <= Expr
          | Expr less_equal Expr
          | Expr > Expr
          | Expr greater_than Expr
          | Expr < Expr
          | Expr less_than Expr
          | Expr && Expr
          | Expr and Expr
          | Expr || Expr
          | Expr or Expr
          | Expr & Expr
          | Expr | Expr
          | Expr << Expr
          | Expr >> Expr
          | !  Expr
          | not Expr
          ;

FunctionCall
          : BuiltInFunction
          | UserFunction
          | ExternalFunction
          ;

UserFunction
          : identifier ( )
          | identifier ( ExprList )
          ;

ExternalFunction
          : external-identifier ( )
          | external-identifier ( ExprList )
          ;

BuiltInFunction
          : wallclock_boundary ( )
          | realtime ( )
          | time ( )
          | duration ( )
          | simstate ( )
          | wallclock ( )
          | main_cycle ( )
          | simtime_boundary ( )
          | disable_entrypoint ( Expr )
          | atan ( Expr )
          | cos ( Expr )
          | exp ( Expr )
          | fabs ( Expr )
          | log ( Expr )
          | sin ( Expr )
          | sqrt ( Expr )
          | tan ( Expr )
          | acos ( Expr )
          | asin ( Expr )
          | ceil ( Expr )
          | cosh ( Expr )
          | floor ( Expr )
          | log10 ( Expr )
```



```
        | sinh ( Expr )
        | tanh ( Expr )
        | doublet ( Expr )
        | ramp ( Expr )
        | jigsaw ( Expr )
        | step ( Expr )
        | frac ( Expr )
        | catch ( Expr )
        | eventcount ( Expr )
        | getenv ( Expr )
        | enable_entrypoint ( Expr )
        | format ( ExprList )
        | freq ( ExprList )
        | changed ( Expr )
        ;

BuiltInCommand
        : activate Expr
        | deactivate Expr
        | exec Expr
        | raise Expr
        | set_time Expr
        | set_realtime Expr
        | schedspeed Expr
        | print ExprList
        | monitor string ExprList        /* string contains options (obsolescent) */
        | monitor ExprList               /* no display options (obsolescent) */
        | stimuli string ArgumentList    /* first arg is file name */
        | stimulate string ArgumentList  /* first arg is file name */
        | stimuli string string ArgumentList
        | stimulate string string ArgumentList
        | record string string ArgumentList
        | datalog string string ArgumentList
        | registrate string string ArgumentList
        | record string ArgumentList
        | datalog string ArgumentList
        | registrate string ArgumentList
        | record ArgumentList
        | datalog ArgumentList
        | registrate ArgumentList
        | initialise Expr
        | reinit Expr
        | init Expr
        | initialise string Expr
        | reinit string Expr
        | init string Expr
        | AtomicAction
        ;

AtomicAction
        : run
        | go
        | pause
        | freeze
        | stop
        | abort
        | snapshot Expr
        | snapshot
        | mark Expr
        | mark
        | health
        ;

ExprList /* list of simple expressions */
        : Expr
        | ExprList , Cont Expr
        ;

ArgumentList
        /* list of generic (may contain complex types expressions */
        : Argument
        | ArgumentList , Cont Argument
        ;

IdentList
        : identifier
```

```
        | IdentList , identifier
        ;

Constant
        : string
        | {Integer}
        | {FloatingPoint}
        | {Time}
        | zero
        | off
        | on
        ;

PixelCoord
        : {Integer}
        | + {Integer}
        | plus {Integer}
        | - {Integer}
        | minus {Integer}
        ;

Variable
        : identifier
        | identifier ArraySelector
        | ExternalVar
        | DictVar
        ;

ExternalVar
        : external-identifier
        | external-identifier ArraySelector
        ;

DictVar
        : DictPath
        | DictPath DictSelectorList      /* ctype selectors */
        | DictPath ( ArgumentList )      /* fortran array */
        ;

DictPath
        : dictpath
        ;

DictSelectorList
        : DictSelector
        | DictSelectorList DictSelector
        ;

DictSelector
        : RecSelector
        | ArraySelector
        ;

RecSelector
        : .identifier
        | RecSelector .identifier
        ;

DeclarationList
        : Type identifier Term
        | Type identifier is Expr Term
        | Type identifier = Expr Term
        | Type identifier ArraySelector Term
        | FunctionDeclaration Term
        ;

FunctionDeclaration
        : function identifier ( IdentList ) Cont
        CompoundStatement
        | function identifier ( ) Cont
        CompoundStatement
        ;

ArraySelector
        : [ Expr ]
        | ArraySelector [ Expr ]
```



```
        ;

Type
        : int
        | float
        | string
        | datetime
        ;

Cont
        :                                   /* nothing */
        | tNEWLINE
        ;

Term
        : tNEWLINE
        | ;
        ;

#tokens:
tAND_ASSIGN: &=                             (reserved)
tCASE: case                                 (reserved)
tDEC_OP: --                                 (reserved)
tDEFAULT: default                           (reserved)
tEOF: end-of-file
tINC_OP: ++                                 (reserved)
tNEWLINE: newline character
tOR_ASSIGN: |=                              (reserved)
tSWITCH: switch                             (reserved)
tUSED_OP: used | ?                          (reserved)
tXOR_ASSIGN: ^=                             (reserved)
```


Chapter 22

Perl batch reference

22.1 Introduction

This chapter provides details on the batch utility for the perl scripting language[1]. Various perl modules have been created that provide an interface to existing EuroSim libraries. This means that a batch script is no more than an ordinary perl script using EuroSim modules.

The main reason to choose perl as the batch utility engine is that it is the ultimate glue language. The EuroSim modules can be combined with the built-in features of perl itself or with one of the many perl modules which are freely available on the internet. A complete overview of all available perl modules can be found on the Comprehensive Perl Archive Network (CPAN).

There is an interactive shell which can be used to type commands directly on the command line to start and manipulate simulators. This tool has been implemented in perl using the EuroSim modules and a few other helper modules for the command line interaction.

Section 22.2 describes the conversion utility for people using the event-probe tool. Section 22.3 shows you how to use the interactive batch shell. Section 22.4 explains all EuroSim modules. Section 22.5 shows you how to extend the batch utility to integrate it in a larger system. Section 22.6 contains a simple example script, Section 22.7 contains commandline utilities to monitor and control smiulator processes.

22.2 Conversion utility for event-probe users

Event-probe is an unsupported batch utility program which was meant to be used for internal testing only. In order to facilitate the users of this tool to convert to the new batch facilities a conversion tool has been supplied. This tool is called `probe2esh`. To convert an existing event-probe script use the following command:

```
probe2esh < probe_script > perl_script
```

For more information read the manual page *probe2esh(1)*.

22.3 Starting the interactive batch shell

The EuroSim command line shell is started by running the `esimsh` command. The `esim>` prompt appears and you can start typing commands. The shell has various forms of completion. Typing TAB once will show you a complete list of available commands. Each command is in fact a perl function provided by the EuroSim modules. Read the manual pages for detailed information on arguments and return values.

[1] Not supported on the Windows platform.

You can save the commands by using the built-in logging function. This function is started by calling `log_open` "*perl-script*". All commands entered after this are written to the file called *perl-script*. This file can then be used as a starting point for further non-interactive runs. To stop logging commands you call `log_close`.

When you start a simulation in interactive mode (the default when starting esimsh) an xterm window is started to show the journal messages.

22.4 Batch utility modules

The batch utility consists of one module for each object. This follows the perl object-oriented design features. It means that given an object you can call methods in the following manner:

```
$object->method($arg1, $arg2);
```

There is one module which forms an exception to this rule for convenience reasons when using the interactive shell: `EuroSim::Session`. All functions (methods) can be called directly without the object reference. This is done to reduce typing in the interactive shell. Each function uses the current session. This works fine as long as you only have one session. If you want to manage multiple sessions in parallel within one script you must use the full notation.

22.4.1 EuroSim::Session module

This is the central module used to run simulations. It supports the complete client/server protocol with the running simulator executable. For each command you can send to the simulator there is a function. For each message sent from the simulator to the application you can install a callback. You can also wait synchronously for any message. The messages and responses are documented in detail in Chapter 28. The idea behind this module is that it is a replacement for the simulation controller. It can fully automate anything you can do with the simulation controller.
To start a simulator all you need to do is:

```
use EuroSim::Session ':all';

$s = new EuroSim::Session("some.sim");
$s->realtime(1);
$s->init;
```

This command will use the information defined in the simulation definition file to start the simulator. The `realtime` flag results in a real-time run of the simulator.

As you can see you pass similar information to the function call as needed by the simulation controller. In the simulation controller you open a simulation definition file and then you select whether or not you want to run real-time. Then you hit the init button, which launches the simulator. The simulation controller automatically connects to the simulator, just like the `init` function does. This function also sets up a number of callback functions for incoming events. The information carried by each event is stored in the session structure. The user can at any moment print the contents of this structure by calling `print_session_parameters`.

To install a new handler for an event you call the function `event_addhandler` with the name of the event you want to handle and the callback to call for that event. You can install more than one handler for each event. Handlers are called in the order they were installed. The name of the event is the same as the name of the enumeration identifier, e.g. `rtExecuting`. To remove the handler, call `event_removehandler` with the same parameters.

Each callback receives the following parameters:

1. Session object, reference to the session hash (see Section 22.4.1.1)
2. Name of the event (name of the enumeration identifier)

3. Simulation time (sec)
4. Simulation time (nsec)
5. Wallclock time (sec)
6. Wallclock time (nsec)
7. Parameters (event specific)

Example:

```
sub cb_standby
{
 my ($session, $event_name, $simtime_sec, $simtime_nsec,
    $wallclock_sec, $wallclock_nsec) = @_;
 print "going to standby at $wallclock_sec\n";
}
$session->event_addhandler("rtStandby", \&cb_standby);

# or a bit more compact
$session->event_addhandler("rtExecuting",
                     sub { print "going to executing at $_[4]\n"; });
```

It is possible to synchronously wait for an event you expect. In this case you call `wait_event` with the name of the event (same name as used to install a handler) and an optional time-out.

To synchronously wait for some time to pass, you can call `wait_time`. This function takes the number of seconds you want to wait as an argument.

A complete overview of all functions provided by this module can be found in the manual page *EuroSim::Session(3)*.

22.4.1.1 Session data structure reference

The Session object is a hash table with the following fields:

MDL Hash table of loaded MDL files. Each hash key is the name of a loaded MDL file. The hash value is a `EuroSim::MDL` object. MDL files are loaded at start-up when a .sim file is loaded or during run-time when extra MDL files are loaded. Extra files can be loaded by the built-in event handler for event `maNewMission` or by manually adding MDL files with `new_scenario`.

clientname
The name under which this session is known to the simulator. The value is set with the function `clientname`.

conn `EuroSim::Conn` object. Low level connection object.

cwd Current working directory of the simulator. The value is set by the built-in event handler for event `maCurrentWorkingDir`.

dict Data dictionary file name. The value is set by the built-in event handler for event `maCurrentDict`.

eventlist
List of events present in the schedule. The value is set by the built-in event handler for the following events: `scEventListStart`, `scEventInfo`, `scEventListEnd`. The `eventlist` is an array of hash tables. Each table consists of three elements:

name The name of the event.

state The scheduler state for which it is defined.

is_standard
: Flag indicating that it is a standard event, i.e. predefined by EuroSim.

handler Event handler table.

sim_hostname
: Simulation host name. The value is set with the function `sim_hostname`.

startup_timeout
: Simulation startup timeout. The default value is 5 seconds and it can be change with the function `startup_timeout`.

initconds
: Initial condition files. The value is set by the built-in event handler for event `maCurrentInitconds`.

calibrations
: Calibration files. The value is set by the event handler for event `maCurrentCalibrations`.

logwindow
: `EuroSim::Window` object. Used to display simulation messages in interactive mode.

monitored_vars
: Table of monitored variables.

outputdir
: Result directory used in current simulation run. The value is set by the built-in event handler for event `maCurrentResultDir`.

prefcon Connection number.

realtime
: Realtime mode. `1` is real-time, `0` is non-realtime. The value is set by the built-in event handler for event `scGoRT`.

recording
: Flag indicating that recording is enabled or not. `1` means enabled. `0` means disabled. The value is set by the built-in event handler for event `maRecording`.

recording_bandwidth
: Recorder bandwidth in bytes/second. The value is set by the built-in event handler for event `maRecordingBandwidth`.

schedule
: Schedule file name. The value is defined in the simulation definition file.

simdef Simulation definition handle to a `EuroSim::SimDef` object.

sim_time
: The simulation time (as seen by the running simulator). The value is set by the built-in event handler for event `dtHeartBeat`.

speed The clock acceleration factor achieved by the simulator. Values larger than `1` indicate faster than real-time. Values smaller than `1` indicate slower than real-time. The value is set by the built-in event handler for event `scSpeed`.

state Simulator state. Can be: unconfigured, initialising, standby, executing, exiting. The value is set by the built-in event handler for the following events: `rtUnconfigured`, `rtInitialising`, `rtStandby`, `rtExecuting` and `rtExiting`.

stimulator_bandwidth
: Stimulator bandwidth in bytes/second. The value is set by the built-in event handler for event `maStimulatorBandwidth`.

tasklist List of tasks present in the schedule. The value is set by the built-in event handlers for the events `scTaskListStart`, `scTaskStart`, `scTaskEntry`, `scTaskEnd` and `scTaskListend`. The field tasklist is a hash table. Each key in the hash table is the name of a task (e.g. `$session->tasklist->taskna`
Each task consists of a number of entry points and a flag called disable. The disable flag is set by the built-in event handler of `scTaskDisable`. The entry points are stored in an array. Each array element is a hash table consisting of three fields:

name The name of the entry point.

breakpoint
Flag indicating that a breakpoint has been set on this entry point. The value is set by the built-in event handler for event `scSetBrk`.

trace Flag indicating that this entry point is being traced. The value is set by the built-in event handler for event `scSetTrc`.

time_mode
The time mode can be relative or absolute (UTC). Relative is `0` and absolute is `1`. The value is set by the built-in event handler for event `maCurrentTimeMode`.

alias Alias file used in current simulation run. The value is set by the built-in event handler of event `maCurrentAliasFile`.

tsp_map
TSP map file used in current simulation run. The value is set by the built-in event handler of event `maCurrentTSPMapFile`.

user_defined_outputdir
User defined output directory path. This directory path overrides the default output directory path. The value is set with the function `outputdir`.

wallclock_time
The wallclock time (as seen by the running simulator). The value is set by the built-in event handler for event `dtHeartBeat`.

wallclock_boundary
The wallclock boundary time to be used for timed state transitions. If you add an integer number of times the main_cycle time to this value it will produce a valid state transition boundary time.

simtime_boundary
The simulation time boundary to be used for timed state transitions. If you add an integer number of times the main_cycle time to this value it will produce a valid state transition boundary time.

main_cycle
The main cycle time of the current schedule. It can be used to calculate valid boundary times for timed state transitions.

watcher
`Event::io` object. Used to process incoming events.

where Current breakpoint. The value is set by the built-in event handlers for the following events: `scWhereListStart`, `scWhereEntry`, `scWhereListEnd`. It is cleared by the following events: `scStepTsk` and `scContinue`. The value is an array of value pairs stored in an array. The first value in the array is the task name and the second is the entry number. For example:

```
print "task: $s->{where}->[0][0]\n";
print "entry_nr: $s->{where}->[0][1]\n";
```

write_access
Flag to indicate whether this client is allowed to change variable values in the simulator. The value is set by the built-in event handler for event `maDenyWriteAccess`.

22.4.1.2 Monitoring variables

In order to monitor variables you must call the function `monitor_add` with the variable you want to monitor. The variable parameter is in the form of a valid EuroSim data dictionary path. This function will add the variable to the list of variables monitored in EuroSim. The value of each variable will be updated with a frequency of 2 Hz if they change. If there is no change, no update is sent.

The values of the variables are stored in the `monitored_vars` hash array of the session hash array. To access the value of a variable use the following expression: `$s->{monitored_vars}->{var_path}`.

To stop monitoring a variable you must call the function `monitor_delete` with the variable you want to stop monitoring.

If you only want to get the value of a variable once, it is better to call the function `monitor_get`. This function retrieves the value of the variable immediately from the simulator, but only once. The value of the variable is in the return value.

22.4.1.3 Modifying variables

If you want to change the value of a variable in the simulator you can simply call `monitor_set` with the name and value of the variable. The value will be set as soon as possible in the simulator.

22.4.2 EuroSim::SimDef module

This is the low-level module use to set and get values in the session definition RPC structure used to launch simulators. It is accessed through the EuroSim::Session module by end users.

22.4.3 EuroSim::MDL module

This is a wrapper module for the EuroSim Script functions. These functions manipulate MDL files and actions.

The following (sets of) functions are available:

- read MDL file
- write MDL file
- add actions to the MDL file
- delete actions from the MDL file
- utility functions to ease the creation of new actions

There are four functions to generate action text:

script_action
: create a generic action script

monitor_action
: create a monitor action script

recorder_action
: create a recorder action script

stimulus_action
: create a stimulus action script

A complete overview of all functions provided by this module can be found in the manual page *EuroSim::MDL(3)*.

22.4.4 EuroSim::Dict module

This is a wrapper module for the EuroSim data dictionary functions. You can open and close EuroSim data dictionary files. You can get and set individual values of variables. This is used in conjunction with the initial condition module.

This module is also used for command line completion in interactive mode to complete the path of data dictionary variables.

A complete overview of all functions provided by this module can be found in the manual page *EuroSim::Dict(3)*.

22.4.5 EuroSim::InitCond module

This module offers reading and writing of initial condition files. You can also use it to combine multiple initial condition files into one file. In conjunction with the `EuroSim::Dict` module it is possible to set variables to specific values, and then save them in an initial condition file.

The following steps must be taken to change values in an initial condition file:

1. Load a data dictionary file.
2. Load one or more initial condition files into that data dictionary
3. Set one or more values of variables to their initial values.
4. Save the initial condition file with the new values.

This initial condition file can be used in a new simulation run, or it can be loaded into an already running simulator. In order to load it into a running simulator, the simulator must be in standby state, or it can be used for reinitialization.

A complete overview of all functions provided by this module can be found in the manual page *EuroSim::InitCond(3)*.
Example:

```
# load a data dictionary
$dict = EuroSim::Dict::open("test.dict");

# load initial values into that dictionary
$initcond = EuroSim::InitCond::read("test.init", $dict);

# get an initial condition value
$value = $dict->var_value_get("/test/var1");

# set an initial condition value
$dict->var_value_set("/test/var2", 3.1415);

# save the new initial condition file in ASCII format
$initcond->write("test2.init", 0);
```

22.4.6 EuroSim::Link module

This module wraps the EuroSimTM/TC Link library (see Chapter 29). You can create a TM/TC link and connect to a running simulator with `link_open` and `link_connect`. Then you can read and write to the link from perl using the functions `link_read` and `link_write`. When you are finished you can call `link_close`.

A complete overview of all functions provided by this module can be found in the manual page *EuroSim::Link(3)*.

22.4.7 EuroSim::Conn module

This is the low-level module used to send and receive events (messages) from/to a running simulator. All of these functions are used internally by the `EuroSim::Session` module.

To print a list of all events use `print_event_list`. This function prints a list of all events, their internal event number and their arguments.

A complete overview of all functions provided by this module can be found in the manual page *EuroSim::Conn(3)*.

22.5 Extending the batch utility

The batch utility is based on the Event module. This perl module provides a framework where you can integrate various systems with each other. The client-server connection with the simulator sends packets to its clients (such as the batch utility). These packets are handled by a callback (watcher in Event module terminology). The Event module is used to perform the mapping between incoming data on a socket to the central event dispatching function of the `EuroSim::Session` module. Also the wait functions are implemented by using the timer watcher.

The interactive EuroSim shell is implemented using this module. The input is processed by the package `Term::ReadLine::Gnu`. This package reads commands from stdin. The readline input function is hooked into the Event framework using an io watcher. The EuroSim connection is handled by another `Event::io` watcher. This enables the interactive shell to stay interactive. It reads simultaneously from the standard input and from the EuroSim socket. This mechanism can be extended to your needs. For a complete reference check out the *Event(3)* manual page.

22.6 Example

The following example is a complete script which performs one simulation run. Some event handlers are installed as well as some monitors.

Batch script example

```
#!/usr/bin/perl
# This is an example perl script using the EuroSim bindings
# to automate a simulation run.
# Import all modules.
use EuroSim ':all';
use EuroSim::InitCond ':all';
use EuroSim::Session ':all';
use EuroSim::Link ':all';
use EuroSim::Conn ':all';
use EuroSim::MDL ':all';

# Load the simulation definition file.
$s = new EuroSim::Session("some.sim");

# Set to real-time.
$s->realtime(1);

# Define a callback to be called when standby state is reached.
sub cb_standby
{
   my ($session, $event_name, $simtime_sec, $simtime_nsec,
      $wallclock_sec, $wallclock_nsec) = @_;
   print "going to standby at $wallclock_sec\n";
}
```



```
# Install the callback.
$s->event_addhandler("rtStandby", \&cb_standby);

# The same thing but then a bit more compact.
# Isn't perl wonderful :-)
$s->event_addhandler("rtExecuting",
                sub { print "going to executing at $_[4]\n"; });

# Start the simulation run.
$s->init;

# Wait for standby state.
$s->wait_event("rtStandby");

# Add a monitor for variable "/test/var1".
# Note that the $ sign in fortran variables must be escaped.
$var = "/test/var1";
$s->monitor_add($var);

# Wait one second. This should be more than enough for the 2Hz
# update to take place.
$s->wait_time(1);

# Print the value of the monitored variable.
print "The value of $var is $s->{monitored_vars}->{$var}\n";

# Trigger an event "my_event".
$s->raise_event("my_event");

# Trigger another event at some time in the future. In this
# case at simulation time 5.025 s.
$s->raise_event_at_simtime("another_event", 5, 25000000);

# Trigger an action in an MDL script.
$s->action_execute("some_loaded.mdl", "inject a failure");

# Go to executing state.
$s->go;

# Wait for the state transition to executing state.
$s->wait_event("rtExecuting");

# Schedule a state transition to standby state at simulation
# time 1000.0 s.
$s->freeze_at_simtime(1000, 0);

# Wait for the state transition to standby state.
$s->wait_event("rtStandby");

# Stop the simulation.
$s->stop;

# Wait until the connection with the simulator is shut down.
$s->wait_event("evShutdown");

# Quit the script.
$s->finish;
```

22.7 Useful command line utilities

There are two EuroSim command line utilities that can be very useful in combination with the batch utility. They are briefly described in the following subsections.

22.7.1 efoList

The `efoList` command line utility shows a list of currently running simulators. See the ICD document or the manual page *efoList(1)* for information on the command line options that can be passed to `efoList`.

22.7.2 efoKill

The `efoKill` command line utility lets you terminate a running simulator. See the ICD document or the manual page *efoKill(1)* for information on the command line options that can be passed to `efoKill`.

Chapter 23

Java batch reference

23.1 Introduction

This chapter provides details on the batch utility for the java programming language. Various java classes have been created that provide an interface to existing EuroSim libraries. This means that a batch application is no more than an ordinary java application using EuroSim classes.

The java glue code is generated using SWIG. It is possible to generated wrapper code for multiple scripting languages using the same interface definition. The python and TCL interfaces are generated in the same manner.

The batch utility for java consists of various classes. Each class (or group of classes) is described in a separate chapter. The most important classes are the Session and EventHandler classes.

Due to the fact that the classes are in fact wrapper classes around existing C++ code you have to load the native code library explicitly. In order to use the EuroSim batch classes you have to add the following code:

```
import nl.eurosim.batch.*;

public class example {
   static {
      try {
         System.loadLibrary("eurosim");
      } catch (UnsatisfiedLinkError e) {
         System.err.println("Native code library failed to load. " + e);
         System.exit(1);
      }
   }

   // your code
}
```

23.2 Session class

This is the central class used to run simulations. It supports the complete network protocol required to control the running simulator executable. For each command you can send to the simulator there is a function. In order to handle messages sent from the simulator to the application you can install an instance of an EventHandler class (see Section 23.3). You can also wait synchronously for any message. The messages and responses are documented in detail in Chapter 28. The idea behind this class is that it is a replacement for the simulation controller. It can fully automate anything you can do with the simulation controller.

To start a simulator all you need to do is:

```
Session s = new Session("some.sim"); // load simulation definition
s.init();                            // start simulator
```

The constructor of the Session class uses the information in the simulation definition file to start the simulator.

As you can see you pass similar information to these calls as needed by the simulation controller. In the simulation controller you open a simulation definition file and then you can click on the Init button which launches the simulator. The simulation controller automatically connects to the simulator, just like the `init` method does. This function also sets up a number of standard event handlers for incoming events (messages) from the simulator. The information is stored in the session class. The user can at any moment print the contents of this structure by calling the `print_session_parameters` method.

To install a new event handler you have to create a derived class from the EventHandler class. The constructor of the class also installs the event handler so that it the event handler methods are automatically called on each incoming event. To remove the event handlers call the `remove` method of the event handler class. See Section 23.3 for detailed information on each event handler class method.

It is also possible to synchronously wait for an event you expect. In this case you call the `wait_event` method with the name of the event (same name as the method in the event handler class) and a time-out (in milliseconds).

To synchronously wait for some time to pass, you can call `wait_event` with an empty string as the event name.

23.2.1 Monitoring variables

In order to monitor variables you must call the method `monitor_add` with the variable you want to monitor. The variable parameter is in the form of a valid EuroSim data dictionary path. This method will add the variable to the list of variables monitored in EuroSim. The value of each variable will be updated with a frequency of 2 Hz if they change. If there is no change, no update is sent.

The values of the variables are stored in the Session class. To get the value of a variable use the following expression: `s.monitor_value(var_path)`. The value is always returned as a string.

To stop monitoring a variable you must call the function `monitor_remove` with the variable you want to stop monitoring.

If you only want to get the value of a variable once, it is better to call the function `get_value`. This function retrieves the value of the variable immediately from the simulator, but only once. The value of the variable is returned as a string.

23.2.2 Modifying variables

If you want to change the value of a variable in the simulator you can simply call `set_value` with the name and value (as a string) of the variable. The value will be set as soon as possible in the simulator. Calling `set_value` also works on an array variables.

23.2.3 Method reference

23.2.3.1 Constructors

```
public Session()
public Session(String sim)
public Session(String sim, String hostname)
```


Description

Creates a EuroSim simulation session by loading the given simulation definition file *sim*. The simulation run will be started on the host with the given hostname or on the current host if not specified.

Parameters

sim the simulation definition file name

hostname the name of the host on which to run the simulator

23.2.3.2 Methods

`public String` **`cwd`**`()`

Description

Returns the path name of the current working directory of the simulator. The value is set by the event handler for event `maCurrentWorkingDir`.

Return value

Path name of the current working directory

`public String` **`dict`**`()`

Description

Returns the path name of the EuroSim data dictionary of the simulator. The value is set by the event handler for event `maCurrentDict`.

Return value

Path name of the EuroSim data dictionary

`public String` **`outputdir`**`()`

Description

Returns the path name of the directory where the output files of the simulator are stored (journal file, recorder files, etc.) The value is set by the event handler for event `maCurrentResultDir`.

Return value

Path name of the output directory

`public String` **`state`**`()`

Description

Returns the simulator state. Can be: unconfigured, initialising, stand-by, executing, exiting. The value is set by the event handler for the following events: `rtUnconfigured`, `rtInitialising`, `rtStandby`, `rtExecuting` and `rtExiting`.

Return value

Simulator state

`public void` **`set_remote_path`**`()`

Description

If client and server have different paths (e.g. A Windows client launching a simulator on a linux server) `set_remote_path` can be used to set the root path of the simulator in the remote EuroSim server.

Return value

None

`public String` **`journal`**`()`

Description

Returns the path name of the journal file.

Return value

Path name of the journal file

`public String` **`schedule`**`()`

Description

Returns the path name of the schedule file.

Return value

Path name of the schedule file

`public String` **`exports`**`()`

Description

Returns the path name of the exports file.

Return value

Path name of the exports file

`public String` **`alias`**`(String alias)`

`public String` **`alias`**`()`

Description

Set or get the alias file name.

Parameters

alias Override the alias file specified in the SIM file. If *alias* was not specified, then the alias file remains unchanged.

Return value

Path name of the alias file. If the simulation is running, then the value is set by the event handler for event `maCurrentAliasFile`.

`public String` **`tsp_map`**`(String tsp_map)`

`public String` **`tsp_map`**`()`

Description

Set or get the TSP map file name.

Parameters

tsp_map Override the TSP map file specified in the SIM file. If *tsp_map* was not specified, then the TSP map file remains unchanged.

Return value

Path name of the TSP map file. If the simulation is running, then the value is set by the event handler for event `maCurrentTSPMapFile`.

`public String` **`model`**`()`

Description

Returns the path name of the model file.

Return value

Path name of the model file

`public double` **`recording_bandwidth`**`()`

Description

Returns the recorder bandwidth in bytes/second. The value is set by the event handler for event `maRecordingBandwidth`.

Return value

Recorder bandwidth in bytes/second

`public double` **`stimulator_bandwidth`**`()`

Description

Returns the stimulator bandwidth in bytes/second. The value is set by the event handler for event `maStimulatorBandwidth`.

Return value

Stimulator bandwidth in bytes/second

`public double` **`speed`**`()`

Description

Returns the clock acceleration factor achieved by the simulator. Values larger than 1 indicate faster than real-time. Values smaller than 1 indicate slower than real-time. The value is set by the event handler for event `scSpeed`.

Return value

Acceleration factor

`public double` **`sim_time`**`()`

Description

Returns the simulation time (as seen by the running simulator). The value is set by the event handler for event `dtHeartBeat`.

Return value

Simulation time in seconds

`public double` **`wallclock_time`**`()`

Description

Returns the wallclock time (as seen by the running simulator). The value is set by the event handler for event `dtHeartBeat`.

Return value

Wallclock time in seconds

`public double` **`wallclock_boundary`**`()`

Description

Returns the wallclock boundary time to be used for timed state transitions. If you add an integer number of times the main cycle time to this value it will produce a valid state transition boundary time.

Return value

Wallclock time boundary in seconds

`public double` **`simtime_boundary`**`()`

Description

Returns the simulation time boundary to be used for timed state transitions. If you add an integer number of times the main cycle time to this value it will produce a valid state transition boundary time.

Return value

Simulation time boundary in seconds

`public double` **`main_cycle`**`()`

Description

Returns the main cycle time of the current schedule. It can be used to calculate valid boundary times for timed state transitions.

Return value

Main cycle in seconds.

`public boolean` **`recording`**`()`

Description

Returns the flag indicating that recording is enabled or not. True means enabled, false means disabled. The value is set by the event handler for event `maRecording`.

Return value

Recording is enabled

`public boolean` **`write_access`**`()`

Description

Returns the flag to indicate whether this client is allowed to change variable values in the simulator. The value is set by the event handler for event `maDenyWriteAccess`.

Return value

Client is allowed to change variables

`public int` **`time_mode`**`()`

Description

Returns the time mode. It can be relative or absolute (UTC). Relative is 0 and absolute is 1. The value is set by the event handler for event `maCurrentTimeMode`.

Return value

Time mode

`public boolean` **`realtime`**`(boolean realtime)`

`public boolean` **`realtime`**`()`

Description

Set or get the realtime mode.

Parameters

realtime If the realtime mode is not specified, then the realtime mode is not set. If *realtime* is 0, then realtime mode is disabled, otherwise it is enabled. The new setting will not effect an already running simulation.

Return value

The realtime mode, true for realtime, false for non-realtime. If a simulation is running, then the value as was set by the event handler for event `scGoRT` is reported. Non-realtime is the default.

```
public boolean auto_init(boolean auto_init)
```

```
public boolean auto_init()
```

Description

Set or get the auto initialization flag.

Parameters

auto_init If the auto initialization flag is not specified, then the auto initialization flag is not set. If *auto_init* is 0, then the simulator will not go automatically to initializing state on startup, otherwise it will go automatically to initializing (this is the default). The new setting will not effect an already running simulation.

Return value

The auto_init flag, true if the state transition to initializing state is performed automatically, false if it isn't.

Automatic state transition to initializing is the default.

```
public int prefcon(int prefcon)
```

```
public int prefcon()
```

Description

Set or get the preferred connection.

Parameters

prefcon The preferred connection. This can be used in a situation where you need to reconnect to an already running simulator. To start new simulation runs, this number is not used. If *prefcon* was not specified, then the preferred connection is not set.

Return value

Return the connection number of the current simulation session.

```
public int startup_timeout(int timeout)
```

```
public int startup_timeout()
```

Description

Set or get the startup timeout.

The startup timeout default is 5 seconds. If starting up a simulator takes longer than this you must change that default to a higher value.

If *timeout* was not specified, then the startup timeout is not set.

Parameters

timeout The startup timeout.

Return value

Return the startup timeout in seconds of the current simulation session.

```
public String clientname(String clientname)
```

```
public String clientname()
```

Description

Set or get the name under which this session is known to the simulator.

Parameters

clientname The client name of the current simulation session. The default is "esimbatch". If *clientname* was not specified, then the client name is not changed.

Return value

Return the client name of the current simulation session.

```
public vector_string initconds(vector_string initconds)
```

```
public String initconds()
```

Description

Set or get the initial condition files.

Parameters

initconds Override the initial condition files specified in the SIM file. If *initconds* was not specified, then the initial condition files remain unchanged.

Return value

Initial condition files. If the simulation is running, then the value is set by the event handler for event `maCurrentInitconds`.

```
public vector_string calibrations(vector_string calibrations)
```

```
public String calibrations()
```

Description

Set or get the calibration files.

Parameters

calibrations Override the calibration files specified in the SIM file. If *calibrations* was not specified, then the calibration files remain unchanged.

Return value

Calibration files. If the simulation is running, then the value is set by the event handler for event `maCurrentCalibrations`.

```
public String workdir(String workdir)
```

```
public String workdir()
```

Description

Set or get the work directory.

Parameters

workdir Use this directory as the work or project directory instead of the current directory.

Return value

The work directory.

```
public String user_defined_outputdir(String outputdir)
```

```
public String user_defined_outputdir()
```

Description

Set or get the user defined output directory.

Parameters

outputdir Use this output directory instead of the default *date/time* directory. If not set, then the user defined output directory is not changed.

Return value

The user defined output directory.

```
public String hostname(String hostname)
```

```
public String hostname()
```

Description

Set or get the EuroSim server hostname.

Parameters

hostname Use this EuroSim server. If not set, then the hostname is not changed.

Return value

The EuroSim server hostname.

```
public String sim(String sim, String hostname)
```

```
public String sim(String sim)
```

```
public String sim()
```

Description

Set or get the simulation definition file.

This simulation definition file is used to start the simulator. Information derived from the simulation definition file is used to provide sensible defaults for all parameters.

Parameters

sim The simulation definition file. If not set, then the simulation definition is not changed.

hostname The EuroSim server hostname. If not set, then the local host is used instead.

Return value

The filename of the simulation definition file.

```
public int init()
```

Description

Start a new simulation run.

Return value

1 on success, 0 on failure.

```
public int join_channel(String channel)
```

Description

Join a channel of a simulation session. By default each session connects to all channels. The following channels are available: mdlAndActions, data-monitor, rt-control, sched-control. To join all channels use channel “all”.

Parameters

channel The channel to join.

Return value

1 on success, 0 on failure.

`public int` **`leave_channel`**`(String channel)`

Description

Leave a channel of a simulation channel.

Parameters

channel The channel that you want to leave.

Return value

1 on success, 0 on failure.

`public boolean` **`wait_event`**`(String event, int timeout_ms)`

Description

Wait for an incoming event

This function is used to wait synchronously for the given *event*. The timeout is used to limit the amount of time to wait for this event.

Parameters

event The name of the event to wait for. If the event name is empty this function can be used to read all pending events while waiting for the given amount of time.

timeout_ms The timeout in milliseconds. A value of -1 means that this this function will wait until the event arrives for an unlimited amount of time. A value of 0 means that the function will return immediately even if the event has not arrived yet.

Return value

true if the event had arrived, false if it has not.

`public int` **`monitor_add`**`(String var)`

Description

Monitor a variable.

The value of the variable is updated with 2 Hz.

Parameters

var The variable from the data dictionary that you want to monitor.

Return value

1 on success, 0 on failure.

`public String` **`monitor_value`**`(String var)`

Description

Retrieve the value of a monitored variable

Parameters

var The name of the monitored variable.

Return value

the value of the variable

`public int` **`monitor_remove`**`(String var)`

Description

Remove the monitor of a variable.

Parameters

var The variable from the data dictionary that should be removed from the monitor list.

Return value

1 on success, 0 on failure.

`public long` **`create_session_list`**`(String hostname)`

`public long` **`create_session_list`**`()`

Description

Create a list of all sessions and return the size of that list.

Parameters

hostname If set, then report the sessions running on that host. Otherwise report all sessions running on the subnet.

Return value

the number of sessions.

`public SessionInfo` **`session_list`**`(long idx)`

Description

Return the session info for the session with the given index.

Parameters

idx The index in the session list.

Return value

The session info.

`public int` **`esim_connect`**`()`

Description

Connect to a running simulation; a new journal file is opened.

Return value

1 on success, 0 on failure.

`public void` **`esim_disconnect`**`()`

Description

Disconnect from the simulation session. The simulator will continue to run in the background.

`public void` **`print_monitored_vars`**`()`

Description

Print a list of currently monitored variables and their current values. All variables in active monitors send values to the batch tool. A table with all variables is kept with their current values.

`public void` **`print_session_parameters`**`()`

Description

Print a complete overview of all available parameters.

`public void` **`print_event_list`**`()`

Description

Print a list of all events (messages) and parameters used in the communication between the test controller and the simulator.

`public String` **`script_action`**`(String name, String script, String condition)`

`public String` **`script_action`**`(String name, String script)`

Description

Create an MDL script text.

Parameters

name The action name.

script The action script.

condition The optional condition.

Return value

The fully composed action script.

`public String` **`recorder_action`**`(String name, double freq, vector_string vars)`

Description

Create a recorder script.

Parameters

name The action name.

freq The recorder frequency.

vars A list of all variables to be recorded.

Return value

The fully composed recorder script.

`public String` **`stimulus_action`**`(String name, String option, String filename, double freq, vector_string vars)`

Description

Create a stimulus script.

Parameters

name The action name.

freq The stimulus frequency.

option An option string (“soft”, “hard” or “cyclic”).

filename The stimulus filename.

vars A list of all variables to serve as stimulus.

Return value

The fully composed stimulus script.

`public long` **`event_list_size`**`()`

Description

Return the size of the list of events present in the schedule. The value is set by the event handler for the following events: `scEventListStart`, `scEventInfo`, `scEventListEnd`.

Return value

The size of the list of events.

`public EventInfo` **`event_list`**`(long idx)`

Description

Return the event info of the event with the given index.

The value is set by the event handler for the following events: `scEventListStart`, `scEventInfo`, `scEventListEnd`.

Parameters

idx The index in the event list (the first element has index 0).

Return value

Event info.

`public long` **`where_list_size`**`()`

Description

Return the size of the current breakpoint list.

The value is set by the event handlers for the following events: `scWhereListStart`, `scWhereEntry`, `scWhereListEnd`. It is cleared by the following events: `scStepTsk` and `scContinue`.

Return value

The size of the list.

`public WhereInfo` **`where_list`**`(long idx)`

Description

Return the current breakpoint with the given index.

The value is set by the event handlers for the following events: `scWhereListStart`, `scWhereEntry`, `scWhereListEnd`. It is cleared by the following events: `scStepTsk` and `scContinue`.

Parameters

idx The index in the current breakpoint list.

Return value

The breakpoint location.

`public long` **`task_list_size`**`()`

Description

Return the size of the task list.

The value is set by the event handler for events `scTaskListStart`, `scTaskStart`, `scTaskEntry`, `scTaskEnd` and `scTaskListend`. Each task consists of a number of entry points and a flag called disable. The disable flag is set by the event handler of `scTaskDisable`.

Return value

The size of the task list.

`public TaskInfo` **`task_list`**`(long idx)`

Description

Return the task info for the task with the given index.

The value is set by the event handler for events `scTaskListStart`, `scTaskStart`, `scTaskEntry`, `scTaskEnd` and `scTaskListend`. Each task consists of a number of entry points and a flag called disable. The disable flag is set by the event handler of `scTaskDisable`.

Parameters

idx The index in the task list.

Return value
The task info

`public long` **`find_task_index`**`(String taskname)`

Description
Convert task name to index number.

Parameters
taskname The name of the task.

Return value
The index in the task list.

`public vector_string` **`mdl_list`**`()`

Description
Return a list of all loaded MDL files.

MDL files are loaded at start-up when a .sim file is loaded or during run-time when extra MDL files are loaded. Extra files can be loaded by the event handler for event `maNewMission` or by manually adding MDL files with new_scenario.

Return value
The list of MDL files.

`public vector_string` **`action_list`**`(String mdl)`

Description
Return a list with the names of all the actions.

Parameters
mdl The name of the MDL file.

Return value
The list of action names.

`public vector_string` **`monitored_vars`**`()`

Description
Return a list of all monitored variables.

Return value
The list of variables.

`public long` **`event_type_list_size`**`()`

Description
Return the size of the event messages table.

Return value
The number of event messages.

`public EventTypeInfo` **`event_type_list`**`(long idx)`

Description
Return the event type info of event message *idx*.

Parameters
idx The index in the event messages table.

Return value

The event type info.

```
public String sev_to_string(int sev)
```

Description

Return a string respresentation of a message severity

Parameters

sev Message severity

Return value

String representation of severity

```
public int go(int sec, int nsec)
public int go(int sec)
public int go()
```

Description

Change the simulator state from stand-by to executing. Equivalent to the Go button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is specified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

```
public int stop(int sec, int nsec)
public int stop(int sec)
public int stop()
```

Description

Stop the simulation run. Equivalent to the Stop button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

```
public int pause(int sec, int nsec)
public int pause(int sec)
public int pause()
```

Description

Change the simulator state from executing to stand-by. Equivalent to the Pause button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

```
public int freeze(int sec, int nsec)
```

```
public int freeze(int sec)
```

```
public int freeze()
```

Description

Change the simulator state from executing to stand-by. Equivalent to the Pause button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

```
public int freeze_at_simtime(int sec, int nsec)
```

```
public int freeze_at_simtime(int sec)
```

Description

Change the simulator state from executing to stand-by on the specified simulation time. The simulation time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Simulation time (seconds)

nsec Simulation time (nanoseconds)

Return value

1 on success, 0 on failure.

```
public int step()
```

Description

Perform one main scheduler cycle. Equivalent to the Step button of the test controller.

Return value

1 on success, 0 on failure.

```
public int abort()
```

Description

Abort the current simulation run. Equivalent to the Abort button of the test controller.

Return value

1 on success, 0 on failure.

```
public int health()
```


Description

Request a health check of the running simulator. Prints health information to the test controller.

Return value

1 on success, 0 on failure.

`public int` **`reset_sim`**`()`

Description

Restart the current simulation with the current settings. Equivalent to the Reset button of the test controller.

Return value

1 on success, 0 on failure.

`public int` **`new_scenario`**`(String scen)`

Description

Create a new scenario in the simulator. This new scenario is only a container for new actions. It is not a file on disk. It is a pure in core representation.

Parameters

scen The scenario name.

Return value

1 on success, 0 on failure.

`public int` **`open_scenario`**`(String scen)`

Description

Open a new scenario file in the simulator with file name *scen*. The file must be on disk and readable.

Parameters

scen Scenario file name.

Return value

1 on success, 0 on failure.

`public int` **`close_scenario`**`(String scen)`

Description

Close a currently opened scenario with name *scen* in the simulator.

Parameters

scen Scenario file name.

Return value

1 on success, 0 on failure.

`public int` **`new_action`**`(String scen, String action_text)`

Description

Add a new action in the scenario file with name *scen*. *action_text* is the complete action text. There are a few utility functions to generate those actions.

Parameters

scen The scenario file name.

action_text The action text.

Return value

1 on success, 0 on failure.

`public int` **`delete_action`**`(String scen, String action)`

Description

Delete an action from scenario *scen* with name *action*.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

`public int` **`action_execute`**`(String scen, String action)`

Description

Trigger the execution of the action with name *action* in scenario with name *scen*. This is equivalent to triggering an action manually on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

`public int` **`action_activate`**`(String scen, String action)`

Description

Make action with name *action* in scenario with name *scen* active in the running simulator. The action must already be defined in the scenario. This is equivalent to activating an action on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

`public int` **`action_deactivate`**`(String scen, String action)`

Description

Deactivate action with name *action* in scenario with name *scen* in the running simulator. This is equivalent to deactivating an action on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

`public int` **`snapshot`**`(String filename, String comment)`

`public int` **`snapshot`**`(String filename)`

`public int` **`snapshot`**`()`

Description

Make a snapshot of the current state of the variables in the data dictionary. The *comment* string is optional. If you omit the filename, a filename is chosen of the form snapshot *simtime*.snap. The snapshot is saved in the output directory, unless the filename is absolute. This is equivalent to the "Take Snaphot..." menu option in the "Control" menu of the test controller.

Parameters

filename Path name of the snapshot file.

comment Comment string

Return value

1 on success, 0 on failure.

`public int` **`mark`**`(String comment)`

`public int` **`mark`**`()`

Description

Make a mark in the journal file. The *comment* string is optional. This is equivalent to the "Mark Journal" and "Comment Journal Mark" menu options in the "Insert" menu of the Simulation Controller.

Parameters

comment Comment string

Return value

1 on success, 0 on failure.

`public int` **`sim_message`**`(String msg)`

Description

Send a message to the simulator for distribution to all clients. This is useful if your client application is not the only client of the simulator. The message is broadcasted to all clients.

Parameters

msg Message string

Return value

1 on success, 0 on failure.

`public int` **`suspend_recording`**`()`

Description

Suspend recording in the simulator. This is equivalent to unchecking the "Enable Recordings" menu item of the "Control" menu of the Simulation Controller.

Return value

1 on success, 0 on failure.

`public int` **`resume_recording`**`()`

Description

Resume recording in the simulator. This is equivalent to checking the "Enable Recordings" menu item of the "Control" menu of the Simulation Controller.

Return value

1 on success, 0 on failure.

`public int` **`recording_switch`**`()`

Description

Switch all recording files of a simulation run. All currently open recorder files are closed and new recorder files are created. Recording will continue in the new recorder files.

Return value

1 on success, 0 on failure.

```
public int reload(String snapfile, String hard)
```

```
public int reload(String snapfile)
```

Description

Load initial condition file or snapshot file with file name *snapfile* into the running simulator. Parameter *hard* is by default "off". This means that the simulation time stored in the snapshot file is ignored. If *hard* is set to "on", the simulation time is set to the value specified in the snapshot file.

Parameters

snapfile Path name of snapshot file.

hard "on" or "off".

Return value

1 on success, 0 on failure.

```
public int set_value(String var, String value)
```

Description

Set the value of a variable.

Parameters

var The data dictionary path name of variable you want to change.

value The new value as string. To set an array variable write the value as a comma seperated list between curly brackets. For example:

```
::s set_value "/Thrusters/force" "{1,2, 2, 3, 4, 5, 6, -2, 2}"
```

Return value

1 on success, 0 on failure.

```
public String get_value(String var)
```

Description

Get the value of a variable.

Parameters

var The data dictionary path name of the variable

Return value

The value, empty on failure

```
public int cpuload_set_peak(int cpu, int peak_time)
```

Description

Configure the CPU load monitor peak time in msecs.

Parameters

cpu CPU number

peak_time Peak time in seconds.

Return value

1 on success, 0 on failure.

`public int` **`set_breakpoint`**`(String taskname, int entrynr, boolean enable)`

Description

Set a breakpoint on entry nr *entrynr* in task *taskname* in the scheduler. If parameter *enable* is set to true the breakpoint is enabled. To disable it again set the parameter to false.

Parameters

taskname Name of the task.

entrynr Entry point number

enable true to enable, false to disable

Return value

1 on success, 0 on failure.

`public int` **`set_trace`**`(String taskname, int entrynr, boolean enable)`

Description

Enable/disable tracing of entry points. Entry points are defined by specifying the number of the entry point *entrynr* (numbering starts at 0) and the name of the task *taskname*. To enable a trace set *enable* to true, to disable it set it to false. Tracing an entry point means that messages are printed to the journal window.

Parameters

taskname Name of the task.

entrynr Entry point number

enable true to enable, false to disable

Return value

1 on success, 0 on failure.

`public int` **`where`**`()`

Description

Request the current position when the scheduler has stopped on a break point. The reply to the message is automatically stored and can be retrieved by using *where_list*. Normally the position is sent to the client whenever the scheduler hits a breakpoint. So there is rarely any need to request the position manually if you store the position on the client side (as is done in this tool.)

Return value

1 on success, 0 on failure.

`public int` **`step_task`**`()`

Description

Perform one step (=one entry point) in the scheduler debugger.

Return value

1 on success, 0 on failure.

`public int` **`cont`**`()`

Description

Continue executing upto the next breakpoint in the scheduler debugger.

Return value

1 on success, 0 on failure.

`public int` **`task_disable`**`(String taskname)`

Description

Disable task with name *taskname* in the current schedule of the simulator.

Parameters

taskname Name of the task.

Return value

1 on success, 0 on failure.

`public int` **`task_enable`**`(String taskname)`

Description

Enable task with name *taskname* in the current schedule of the simulator.

Parameters

taskname Name of the task.

Return value

1 on success, 0 on failure.

`public int` **`clear_breaks`**`()`

Description

Remove all breakpoints in the current schedule of the simulator.

Return value

1 on success, 0 on failure.

`public int` **`clear_traces`**`()`

Description

Remove all traces in the current schedule of the simulator.

Return value

1 on success, 0 on failure.

`public int` **`set_simtime`**`(int sec, int nsec)`

`public int` **`set_simtime`**`(int sec)`

Description

Set the simulation time to *sec* seconds and *nsec* nanoseconds. This can only be done in stand-by state.

Parameters

sec Simulation time in seconds.

nsec Simulation time in nanoseconds.

Return value

1 on success, 0 on failure.

`public int` **`enable_realtime`**`()`

Description

Switch to real-time mode. This can only be done when the simulator has started off in real-time mode, and has switched to non-real-time mode.

Return value

1 on success, 0 on failure.

`public int` **`disable_realtime`**`()`

Description

Switch to non-real-time mode.

Return value

1 on success, 0 on failure.

`public int` **`list_tasks`**`()`

Description

Request a list of all tasks in the current schedule of the simulator. The list is also sent automatically upon joining the "sched-control" channel.

Return value

1 on success, 0 on failure.

`public int` **`list_events`**`()`

Description

Request a list of all events in the schedule of the simulator in all states. The list is automatically sent to the client when subscribing to the "sched-control" channel at start-up.

Return value

1 on success, 0 on failure.

`public int` **`raise_event`**`(String eventname, SWIGTYPE_p_void data, int size)`

`public int` **`raise_event`**`(String eventname)`

Description

Raise event with name *eventname* in the scheduler. An event is defined by the input connector on the scheduler canvas. The event is handled as fast as possible. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

`public int` **`raise_event_at`**`(String eventname, int sec, int nsec, SWIGTYPE_p_void data, int size)`

`public int` **`raise_event_at`**`(String eventname, int sec, int nsec)`

`public int` **`raise_event_at`**`(String eventname, int sec)`

Description

Raise event with name *eventname* in the schedler at a specified wallclock time. The wallclock time is specified as *sec* seconds and *nsec* nanoseconds. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

sec Wallclock time in seconds.

nsec Wallclock time in nanoseconds.

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

```
public int raise_event_at_simtime(String eventname, int sec, int nsec, SWIGTYPE_p_voi
data, int size)
```

```
public int raise_event_at_simtime(String eventname, int sec, int nsec)
```

```
public int raise_event_at_simtime(String eventname, int sec)
```

Description

Raise event with name *eventname* in the schedler at a specified simulation time. The simulation time is specified as *sec* seconds and *nsec* nanoseconds. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

sec Simulation time (seconds)

nsec Simulation time (nanoseconds)

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

```
public int set_speed(double speed)
```

Description

Set the acceleration/deceleration of the scheduler of the simulator. Values smaller than 1 will cause a proportional deceleration of the scheduler clock. Values larger than 1 will cause a proportional acceleration of the scheduler clock. Magical value -1 means that the scheduler will run in an optimized as-fast-as-possible mode.

Parameters

speed acceleration factor

Return value

1 on success, 0 on failure.

```
public int add_MDL(String mdlname)
```

Description

Load (another) new MDL file in the session.

Parameters

mdlname Path name of the MDL file.

Return value

1 on success, 0 on failure.

`public int` **`sync_send`**`(int token)`

Description

Send sync token to simulator

Parameters

token synchronization token id

Return value

1 on success, 0 on failure

`public int` **`sync_recv`**`(int token)`

Description

Wait for sync token from simulator

Parameters

token synchronization token id

Return value

1 on success, 0 on failure

`public int` **`kill`**`(int signal)`

`public int` **`kill`**`()`

Description

Kill the simulator with signal *signal*. By default the simulator is killed with SIGTERM.

Parameters

signal Signal to send to the simulator

Return value

1 on success, 0 on failure

23.3 EventHandler class

The EventHandler class is used to handle events coming from the simulator. The user must derive from this class and implement the methods for the events that must be handled.
When a messsage from the simulator is received, first the built-in message handling is performed followed by the user defined message handlers. The message handlers are installed by instantiating the handler. The message handler is removed by calling the `remove` method.
To define a user defined message handler all you need to do is:

```
class ExampleEventHandler extends EventHandler {

   // constructor
   public ExampleEventHandler(Session s)
   {
      super(s);
   }

   // handler for maMessage events
```

```
    public void maMessage(int simtime_sec, int simtime_nsec,
                          int runtime_sec, int runtime_nsec,
                          int sev, String procname, String msg)
    {
        System.out.println(procname + " " + msg);
    }
}

ExampleEventHandler eh;

// instantiate event handler (implicitly installs it)
void example_handler_init(Session s)
{
    eh = new ExampleEventHandler(s);
}

// remove event handler
void example_handler_remove(Session s)
{
    eh.remove();
}
```

23.3.1 Method reference

23.3.1.1 Constructors

`public` **`EventHandler`**`(Session s)`

Description

Construct a new EventHandler and install the handler.

Parameters

s The simulator session

23.3.1.2 Methods

`public Session` **`session`**`()`

Description

Return the session for this event handler.

Return value

The simulator session.

23.3.1.3 Event Handler Methods

In order to create a user defined event handler, one or more methods must be implemented.

`public void` **`maNewMission`**`(String mission)`

Description

A new mission (MDL) is created.

Parameters

mission The name of the mission.

`public void` **`maOpenMission`**`(String mission)`

Description

A mission (MDL) file is opened.

Parameters

mission The filename of the mission file.

`public void` **`maCloseMission`**`(String mission)`

Description

A mission (MDL) file is closed.

Parameters

mission The filename of the mission file.

`public void` **`maSimDef`**`(String simdef)`

Description

Inform that client which simulation definition file is currently loaded.

Parameters

simdef The filename of the simulation definition file.

Return value

`public void` **`maCurrentDict`**`(String dict)`

Description

Inform the client which data dictionary file is currently loaded.

Parameters

dict The filename of the data dictionary file.

Return value

`public void` **`maCurrentWorkingDir`**`(String cwd)`

Description

Inform the client what the current working directory of the simulator is.

Parameters

cwd The path name of the current working directory.

`public void` **`maCurrentResultDir`**`(String result_dir)`

Description

Inform the client what the result directory is. The result directory contains all the journal files, recorder files, snapshots and timings file.

Parameters

result_dir The path name of the result directory.

`public void` **`maCurrentAliasFile`**`(String filename)`

Description

Inform the client what the alias file is. The alias file contains the data dictionary aliases.

Parameters

filename The path name of the alias file.

`public void` **`maCurrentTSPMapFile`**`(String filename)`

Description

Inform the client what the TSP map file is. The TSP map file contains the TSP data dictionary path name map.

Parameters

filename The path name of the TSP map file.

`public void` **`maNewAction`**`(String mission, String actiontext)`

Description

Inform the client that a new action has been created.

Parameters

mission The name of the mission.

actiontext The new action.

`public void` **`maDeleteAction`**`(String mission, String actionname)`

Description

Inform the client that an action has been deleted.

Parameters

mission The name of the mission.

actionname The name of the action.

`public void` **`maActionExecute`**`(String mission, String actionname)`

Description

Inform the client that an action is being executed.

Parameters

mission The name of the mission.

actionname The name of the action.

`public void` **`maActionExecuteStop`**`(String mission, String actionname)`

Description

Inform the client that an action is no longer being executed.

Parameters

mission The name of the mission.

actionname The name of the action.

`public void` **`maActionExecuting`**`(String mission, String actionname)`

Description

Inform a newly connected client that the action is currently executing.

Parameters

mission The name of the mission.

actionname The name of the action.

`public void` **`maActionActivate`**`(String mission, String actionname)`

Description

Inform the client that an action has been activated. I.e. is allowed to execute.

Parameters

mission The name of the mission.

actionname The name of the action.

`public void` **`maActionDeActivate`**`(String mission, String actionname)`

Description

Inform the client that an action has been deactivated. I.e. is no longer allowed to execute.

Parameters

mission The name of the mission.

actionname The name of the action.

`public void` **`maExecuteCommand`**`(String name, String command, int action_mgr_nr)`

Description

Inform the client that a one shot action has been executed.

Parameters

name The name of the action.

command The commands of the action.

action_mgr_nr The number of the action manager that has executed the action.

`public void` **`maSnapshot`**`(String snapshot, String comment)`

Description

Handle maSnapshot event. This event is sent after a snapshot of the current simulator state has been made.

Parameters

snapshot Path name of the snapshot file.

comment Comment describing the snapshot.

`public void` **`maMark`**`(String message, int marknumber)`

Description

Inform the client that a mark has been made in the journal file.

Parameters

message The descriptive message of the mark.

marknumber The number of the mark.

`public void` **`maMessage`**`(int simtime_sec, int simtime_nsec, int runtime_sec, int runtime_nsec, int sev, String process, String msg)`

Description

Inform the client that a message has been generated in the simulator. This message is also automatically logged in the journal file by the simulator.

Parameters

simtime_sec Simulation time stamp (seconds part)

simtime_nsec Simulation time stamp (nanoseconds part)

runtime_sec Wallclock time stamp (seconds part)

runtime_nsec Wallclock time stamp (nanoseconds part)

sev Severity of the message. The name of the severity can be retrieved by using the `sev_to_string()` method of the Session class.

process Name of the simulator thread from where the message was generated.

msg The message text.

`public void` **`maRecording`**`(String on_off)`

Description

Inform the client that recording has been globally enabled/disabled.

Parameters

on_off If the string is equal to "on", recording is enabled. If it is "off" it is disabled.

`public void` **`maRecordingBandwidth`**`(double bandwidth)`

Description

Report the bandwidth used to record data to disk.

Parameters

bandwidth Number of bytes per seconds written to disk.

`public void` **`maStimulatorBandwidth`**`(double bandwidth)`

Description

Report the bandwidth used to read data from disk for stimulation.

Parameters

bandwidth Number of bytes per second read from disk.

`public void` **`maRecorderFileClosed`**`(String filename)`

Description

Inform the client that a recorder file has been closed and can be used for further processing.

Parameters

filename The file name of the recorder file.

`public void` **`maDenyWriteAccess`**`(boolean denied)`

Description

Inform the client that the write access to variables is denied. This is the case if the client has the role of observer.

Parameters

denied Flag to indicate denial of write access to the simulator variables.

`public void` **`maCurrentInitconds`**`(String simdef, String initconds)`

Description

Inform the client of the current list of initial conditions as used for the initialization of the simulator.

Parameters

simdef The name of the simulation definition file.

initconds The list of initial condition files (space separated).

`public void` **`maCurrentCalibrations`**`(String simdef, String calibrations)`

Description

Inform the client of the current list of calibration definition files as used by the simulator.

Parameters

simdef The name of the simulation definition file.

calibrations The list of calibration files (space separated).

`public void` **`maCurrentTimeMode`**`(int time_mode)`

Description

Inform the client of the current time mode. The time mode can be relative time or absolute time (UTC mode).

Parameters

time_mode The time mode, 0 is relative time mode, 1 is absolute time mode (UTC mode).

`public void` **`maNewSeverity`**`(int sev, String sev_name)`

Description

Inform the client about a new user-defined message severity. This message is automatically handled. The severity identifier can be mapped to its symbolic name using the `sev_to_string()` method of the Session class.

Parameters

sev The severity numerical identifier.

sev_name The symbolic name of the severity.

`public void` **`rtUnconfigured`**`()`

Description

Inform the client that the state of the simulator is `unconfigured`. This state means that the simulator is either still starting up, or is in its final clean up phase. This is a transient state. When starting up, the next state will be `Initialising`. When cleaning up the last event will be `evShutdown`.

`public void` **`rtInitialising`**`()`

Description

Inform the client that the state of the simulator is `initialising`. Depending on the schedule definition, this state will automatically be followed by the `standby` state. Otherwise you have to manually change the state to `standby` using the `eventStandby()` method of the Session() class.

`public void` **`rtStandby`**`()`

Description

Inform the client that the state of the simulator is `standby`.

`public void` **`rtExecuting`**`()`

Description

Inform the client that the state of the simulator is `executing`.

`public void` **`rtExiting`**`()`

Description

Inform the client that the state of the simulator is `exiting`. This is a transient state. The next state will be the `unconfigured` state.

`public void` **`rtTimeToNextState`**`(int sec, int nsec)`

Description

Report the time to the next state transition. This is useful when the major cycle is quite long (more than a couple of seconds). This can be the case if the schedule definition contains a clock with a very low frequency or when the lowest common denominator of the clocks results in a long major cycle.

Parameters

sec Time to next state (seconds part)

nsec Time to next state (nanoseconds part)

`public void` **`rtMainCycle`**`(int sec, int nsec)`

Description

Report the length of the main cycle of the schedule.

Parameters

sec Main cycle (seconds part)

nsec Main cycle (nanoseconds part)

`public void` **`scSetBrk`**`(String taskname, int entrynr, int enable)`

Description

Inform the client about the enabling/disabling of a break point on a specific entry point in a task in the schedule.

Parameters

taskname The name of the task.

entrynr The number of the entry point (counting starts at 0).

enable Whether the break point is enabled (1) or disabled (0).

`public void` **`scStepTsk`**`()`

Description

Inform the client that a step to the next task has been performed in debugging mode.

`public void` **`scContinue`**`()`

Description

Inform the client that the execution is now continued after being stopped on a break point in debugging mode.

`public void` **`scGoRT`**`(bool enable)`

Description

Inform the client that the real-time mode has changed.

Parameters

enable Real-time mode is enabled (true) or disabled (false).

`public void` **`scTaskDisable`**`(String taskname, bool disable)`

Description

Inform the client that a task has been disabled. This means that the task is no longer executed.

Parameters

taskname The name of the task.

disable The task is disabled (true), or enabled again (false).

`public void` **`scSetTrc`**`(String taskname, int entrynr, bool enable)`

Description

Inform the client that a trace has been set on an entry point in a task.

Parameters

taskname The name of the task.

entrynr The number of the entry point in the task (counting starts at 0).

enable The trace is enabled (true), or disabled (false).

`public void` **`scSpeed`**`(double speed)`

Description

Report the speed of the scheduler clock. This is only relevant in non-real-time mode when going slower or faster than real time.

Parameters

speed Speed factor. 1 means real-time, less than 1 means slower than real-time, more than 1 means faster than real-time. E.g. 2 means two times faster than real-time.

`public void` **`scTaskListStart`**`()`

Description

Start the description of the list of tasks.

`public void` **`scTaskStart`**`(String taskname, bool enabled)`

Description

Start the description of a task. This is followed by a number of scTaskEntry events, one for each entry in the order of execution in the task.

Parameters

taskname The name of the task

enabled The task is enabled (true), or disabled (false).

`public void` **`scTaskEntry`**`(String entryname, bool breakpoint, bool trace)`

Description

Report information of an entry point in a task.

Parameters

entryname The name of the entry point.

breakpoint The entry point has a break point set (true) or not set (false).

trace The entry point is traced (true) or not (false).

`public void` **`scTaskEnd`**`()`

Description

Report the end of the task information.

`public void` **`scTaskListEnd`**`()`

Description

Report the end of the list of tasks.

`public void` **`scEventListStart`**`()`

Description

Report the start of the list of schedule events.

`public void` **`scEventInfo`**`(String eventname, int state, bool is_standard)`

Description

Report all information about a specific schedule event.

Parameters

eventname The name of the event.

state The state in which it is present.

is_standard Whether or not it is a built-in (standard) event (true), or a user defined event (false).

`public void` **`scEventListEnd`**`()`

Description

Report the end of the list of events.

`public void` **`scWhereListStart`**`()`

Description

Report the start of the list of places where the scheduler has stopped execution when reaching a break point. As there are possibly more than 1 executers executing tasks, there can be multiple places where the execution has stopped.

`public void` **`scWhereEntry`**`(String taskname, int entrynr)`

Description

Report a location where the execution has stopped.

Parameters

taskname The name of the task.

entrynr The number of the entry point (counting starts at 0).

`public void` **`scWhereListEnd`**`()`

Description

End of the list of locations where the execution has stopped.

`public void` **`scEntrypointSetEnabled`**`(String entrypointname, bool enabled)`

Description

Report the enabling or disabling of the execution of an entry point. The execution of the entry point is disabled for all tasks and also when executing the entry point from MDL scripts.

Parameters

entrypointname The name of the entry point.

enabled Whether the entry point is enabled for execution (true), or disabled (false).

`public void` **`dtLogValueUpdate`**`(String var, String value)`

Description

Report an updated value for a logged variable.

Parameters

var The name of the variable.

value The value of the variable.

`public void` **`dtHeartBeat`**`()`

Description

This event is sent at 2 Hz by default and indicates that the simulator is still alive. It is also the last event sent after a series of dtLogValueUpdate events.

`public void` **`dtCpuLoad`**`(int cpu, double average, double peak)`

Description

Report the load of a CPU.

Parameters

cpu CPU number

average Average load over a main cycle.

peak Peak load over a minor cycle.

`public void` **`evLinkData`**`(String link_id)`

Description

Event that is used internally to transmit (TM/TC) packets. The actual data of the packet is not passed to this callback function. It is stored internally and can be retrieved using the `read()` method of the TmTcLink class.

Parameters

link_id The symbolic name of the link.

`public void` **`evExtSetData`**`(String view_id)`

Description

Event that is used internally to update External Simulator Access views. The actual data of the event is not passed to this callback function. It is decoded and stored in the view variables and can be retrieved with the `get()` method of the ExtSimVar* classes.

Parameters

view_id The symbolic name of the view.

`public void` **`evShutdown`**`(int error_code, String error_string)`

Description

Event that is received when the connection with the simulator is lost.

Parameters

error_code The value of errno at the time the connection was terminated. This value is zero when the connection was terminated in a normal way.

error_string The description of the error code.

`public void` **`evEventDisconnect`**`()`

Description

Event that is received when the connection with the simulator is closed. This is normally done using the method `esim_disconnect()`.

23.4 eurosim class

This class contains a couple of utility methods that are not linked to a session.

23.4.1 Method reference

`public static` **`vector_string host_list`**`()`

Description

Return the list of EuroSim hosts.

Return value

The list of hosts.

`public static int` **`session_kill_by_name`**`(String simname, int signal, String hostname)`

`public static int` **`session_kill_by_name`**`(String simname, int signal)`

`public static int` **`session_kill_by_name`**`(String simname)`

Description

Kill a simulation session by name.

Parameters

simname The name of the session. This is normally the basename of the executable.

signal The signal to send to the session (default = SIGTERM)

hostname The name of the host where the session runs (default = localhost)

Return value

-1 if creating the connection with the EuroSim daemon on the host failed, 0 on success, otherwise the result is the value of errno of the failed kill system call or EPERM if you do not have the right permissions to kill the simulator or ESRCH if the simulator with the specified name could not be found.

`public static int` **`session_kill_by_pid`**`(int pid, int signal, String hostname)`

`public static int` **`session_kill_by_pid`**`(int pid, int signal)`

`public static int` **`session_kill_by_pid`**`(int pid)`

Description

Kill a simulation session by pid.

Parameters

pid The process id of the session.

signal The signal to send to the session (default = SIGTERM)

hostname The name of the host where the session runs (default = localhost)

Return value

-1 if creating the connection with the EuroSim daemon on the host failed, 0 on success, otherwise the result is the value of errno of the failed kill system call or EPERM if you do not have the right permissions to kill the simulator or ESRCH if the simulator with the specified pid could not be found.

`public int` **`open_log`**`()`

Description

Allows the client to log to a file. After opening the log file everything that is sent to stdout and to stderr is also logged to the spedified file.

Return value

0 if succeeded.

`public int` **`close_log`**`()`

Description

Closes the log file created by `open_log`.

Return value

0 if succeeded.

23.5 EventInfo class

The EventInfo data is return by the `event_list` method of the Session class. The methods allow you to retrieve the individual attributes of a scheduler event.

23.5.1 Method reference

`public String` **`name`**`()`

Description

Get the name of the event.

Return value

The name of the event

`public int` **`state`**`()`

Description

Get the number of the state where this event is defined.

Return value

The number of the state.

`public String` **`state_name`**`()`

Description
Get the name of the state where this event is defined.

Return value
The name of the state.

`public boolean` **`is_standard`**`()`

Description
Whether the event is a standard event or a user defined event.

Return value
true if it is a standard event, false if it is a user defined event.

23.6 WhereInfo class

The WhereInfo data is return by the `where_list` method of the Session class. The methods allow you to retrieve the individual attributes of a scheduler break point location.

23.6.1 Method reference

`public String` **`name`**`()`

Description
Get the name of the task where the scheduler is currently stopped.

Return value
The task name.

`public int` **`entrynr`**`()`

Description
Get the entry point number of the current break point within the task.

Return value
The entry point number. Counting starts at 0.

23.7 EntryInfo class

The EntryInfo data is return by the `entry_list` method of the TaskInfo class. The methods allow you to retrieve the individual attributes of an entry point in a task.

23.7.1 Method reference

`public String` **`name`**`()`

Description
Get the name of the entry point.

Return value
The name of the entry point.

`public boolean` **`breakpoint`**`()`

Description
Get the break point status of the entry point.

Return value
True if a break point is set, false if not.

`public boolean` **`trace`**`()`

Description
Get the trace status of the entry point.

Return value
True if a trace is set, false if not.

23.8 TaskInfo class

The TaskInfo data is return by the `task_list` method of the Session class. The methods allow you to retrieve the individual attributes of a task.

23.8.1 Method reference

`public String` **`name`**`()`

Description
Get the name of the task.

Return value
The name of the task.

`public boolean` **`disabled`**`()`

Description
Get the disabled state of the task.

Return value
True if the task is disabled, false if it is enabled.

`public long` **`entry_list_size`**`()`

Description
Get the number of entry points of the task.

Return value
The number of entry points.

`public EntryInfo` **`entry_list`**`(long idx)`

Description
Get the entry point information of the entry point with the given index.

Parameters
idx The entry point index (counting starts at 0).

Return value
The entry point information.

23.9 EventTypeInfo class

The EventTypeInfo data is return by the `event_type_list` method of the Session class. The methods allow you to retrieve the individual attributes of a client/server message (called event internally).

23.9.1 Method reference

`public String` **`name`**`()`

Description
Get the name of the message.

Return value
The name of the message.

`public String` **`args`**`()`

Description
Get the argument types of the message. This is a character coded string with one character for each argument type.

Return value
The argument types.

`public String` **`argdescr`**`()`

Description
Get a description of the arguments of the message.

Return value
The description of the arguments.

`public int` **`id`**`()`

Description
Get the numerical identifier of the message.

Return value
The numerical identifier.

23.10 SessionInfo class

The SessionInfo data is return by the `session_list` method of the Session class. The methods allow you to retrieve the individual attributes of a simulation session.

23.10.1 Method reference

`public String` **`sim_hostname`**`()`

Description
Get the host name running the simulation session.

Return value
The host name.

`public String` **`sim`**`()`

Description
Get the simulation definition file.

Return value
The file name of the simulation definition file.

`public String` **`workdir`**`()`

Description

Get the working directory.

Return value

The path name of the working directory.

`public String` **`simulator`**`()`

Description

Get the simulator executable.

Return value

The path name of the executable.

`public String` **`schedule`**`()`

Description

Get the simulator schedule.

Return value

The path name of the schedule file.

`public vector_string` **`scenarios`**`()`

Description

Get the list of scenario (MDL) files.

Return value

The list with path names of the MDL files.

`public String` **`dict`**`()`

Description

Get the data dictionary file.

Return value

The path name of the data dictionary file.

`public String` **`model`**`()`

Description

Get the model file.

Return value

The path name of the model file.

`public String` **`recorderdir`**`()`

Description

Get the recorder directory.

Return value

The path name of the recorder directory.

`public vector_string` **`initconds`**`()`

Description
Get the list of initial condition files.

Return value
The list of path names of the initial condition files.

`public vector_string` **`calibrations`**`()`

Description
Get the list of calibration files.

Return value
The list of path names of the calibration files.

`public String` **`exports`**`()`

Description
Get the exports file.

Return value
The path name of the exports file.

`public String` **`alias`**`()`

Description
Get the alias file.

Return value
The path name of the alias file.

`public String` **`tsp_map`**`()`

Description
Get the TSP map file.

Return value
The path name of the TSP map file.

`public String` **`timestamp`**`()`

Description
Get the time stamp.

Return value
The time stamp.

`public int` **`prefcon`**`()`

Description
Get the connection number. Each session has a connection number that can be used to connect a client to that session.

Return value
The connection number.

`public int` **`uid`**`()`

Description

Get the UNIX user id of the user who started the simulator.

Return value

The user id.

```
public int gid()
```

Description

Get the UNIX group id of the user who started the simulator.

Return value

The group id.

```
public int pid()
```

Description

Get the UNIX process id of the simulation session.

Return value

The process id.

```
public boolean realtime()
```

Description

Get the real-time state of the simulation session.

Return value

True if the simulator was started in real-time mode, false if it was started in non-real-time mode.

23.11 TmTcLink class

The TmTcLink class is used to create a packet link with a model in the simulator. The packet link can be used to send arbitrary packets (binary or not) to a simulator model and receive packets from a simulator model. Multiple packet links can be created. See Chapter 29 for detailed information on how to use the link.

23.11.1 Constructors

```
public TmTcLink(String id, String mode)
```

Description

Open one end of a TmTc link.

Parameters

id The symbolic name of the TmTc link.

mode Mode is “r”, “w” or “rw”, similar to the modes of the fopen() function in the standard C library.

23.11.2 Method reference

```
public int connect(Session s)
```

Description

Connect the link to the other end in a running simulator.

Parameters

s The session of the running simulator.

Return value

-1 on failure, 0 on success.

```
public int write(String data)
```

Description

Write a packet to the link.

Parameters

data The data (binary string).

Return value

The number of bytes sent or -1 on failure.

```
public String read()
```

Description

Read data from the link.

Return value

The data read as a binary string.

23.12 InitCond class

This class is used for the manipulation of initial condition files. This allows the user to create a new initial condition file or modify an existing file. Individual values can be set or modified. It is also possible to merge two initial condition files.

23.12.1 Constructors

```
public InitCond(String filename, String dictfile)
```

Description

Create a new set of initial conditions from an existing file.

Parameters

filename The initial condition file.

dictfile The path of the data dictionary file.

23.12.2 Method reference

```
public boolean add(String filename)
```

Description

Merge an existing initial condition file with the current initial condition data.

Parameters

filename The path of the to-be-merged initial condition file.

Return value
true on success, false on failure.

`public boolean` **`write`**`(String filename, boolean binary)`

Description
Write the initial condition data to a file.

Parameters
filename The path of the new initial condition file.

binary If true, write a binary file, otherwise write the data in human readable (ASCII) format.

Return value
true on success, false on failure.

`public double` **`simtime`**`()`

Description
Return the simulation time of the initial condition file.

Return value
The simulation time.

`public String` **`comment`**`()`

Description
Get the comment of in the initial condition file.

Return value
The comment string.

`public vector_string` **`get_varlist_failed`**`()`

Description
Get the list of variables in the initial condition file which were successfully loaded into the data dictionary.

Return value
The list of variables.

`public vector_string` **`get_varlist_set`**`()`

Description
Get the list of variables in the initial condition file which were successfully loaded into the data dictionary.

Return value
The list of variables.

`public double` **`var_value_get`**`(String path)`

Description
Get the numerical value of a variable.

Parameters
path The data dictionary path.

Return value
The numerical value of the variable.

`public String` **`var_string_get`**`(String path)`

Description

Get the string value of a variable.

Parameters

path The data dictionary path.

Return value

The string value of the variable.

`public boolean` **`var_value_set`**`(String path, double value)`

Description

Set the numerical value of a variable.

Parameters

path The data dictionary path name.

value The new value.

Return value

true on success, false on failure.

`public boolean` **`var_string_set`**`(String path, String value)`

Description

Set the string value of a variable.

Parameters

path The data dictionary path name.

value The new value.

Return value

true on success, false on failure.

`public vector_string` **`list`**`(String path)`

`public vector_string` **`list`**`()`

Description

Get a list of child node names beneath a parent node.

Parameters

path The path of the parent node (default the root "/").

Return value

The list of child node names.

23.13 ExtSimView class

This class wraps the External Simulator Access interface. Detailed information on the use of this interface can be found in Chapter 30.

23.13.1 Constructors

```
public ExtSimView(Session session, String id)
```

Description

Create a new External Simulator Access view.

Parameters

session The simulation session.

id The symbolic identifier of the view.

23.13.2 Method reference

```
public int add(ExtSimVar var)
```

Description

Add a variable to this view.

Parameters

var The variable to add to the view.

Return value

0 on success, -1 on failure.

```
public int connect(int rw_flags, double frequency, int compression)
```

Description

Create a new view with the variables previously added to the view.

Parameters

rw_flags Read/write flags, 1 is read, 2 is write.

frequency Update frequency in Hz.

compression Compression type to be used for the data transmission. 0 is no compression, 1 means that unchanched values in the view are not transmitted. Please note that in case the whole view is not changed, no update is sent in any case.

Return value

0 is success, -1 is failure.

```
public int change_freq(double frequency)
```

Description

Parameters

Change the update frequency of the view.

frequency The update frequency in Hz.

Return value

0 is success, -1 is failure.

```
public int send()
```

Description

Send the view with the updated values to the simulator.

Return value

0 is success, -1 is failure.

23.14 ExtSimVar class

This is the base class of the ExtSimVar* classes. It is not to be used directly.

23.14.1 Method reference

`public ExtSimVar.extvar_t` **`type`**`()`

Description

Get the variable type.

Return value

The variable type.

`public boolean` **`is_array`**`()`

Description

Find out if the variable is an array variable.

Return value

true if it is an array.

`public boolean` **`is_fortran`**`()`

Description

Find out if the variable is a Fortran variable. Only relevant for arrays, as the Fortran column/row order is different from C/Ada.

Return value

true if it is a Fortran variable.

`public int` **`nof_dims`**`()`

Description

Get the number of dimensions of the array variable.

Return value

The number of array dimensions.

`public SWIGTYPE_p_int` **`dims`**`()`

Description

Get the dimensions of the array variable.

Return value

The array dimensions.

`public String` **`path`**`()`

Description

Get the data dictionary path of the variable.

Return value

The data dictionary path.

`public long` **`size`**`()`

Description

Get the size in bytes of the variable.

Return value

The size in bytes.

23.15 ExtSimVar* classes

Below are the derived classes of ExtSimVar described. All similar methods are grouped to reduce the amount of documentation that only repeats the same information again and again. Therefore only two different cases are documented. One for the single element case and one for the array case.

For both cases the following variants are possible: Char, Double, Float, Int, Long, Short, UnsChar, UnsInt, UnsLong and UnsShort.

The java types corresponding to the above types are: char, double, float, int, int, short, short, long, long and int.

For arrays there are two variants: ExtSimVar*Array and ExtSimVar*FortranArray.

To summarize for one type you can have the following classes: ExtSimVarChar, ExtSimVarCharArray and ExtSimVarCharFortranArray.

23.15.1 Constructors

```
public ExtSimVar*(String path)
public ExtSimVar*Array(String path, int dim0)
public ExtSimVar*Array(String path, int dim0, int dim1)
public ExtSimVar*Array(String path, int dim0, int dim1, int dim2)
public ExtSimVar*FortranArray(String path, int dim0)
public ExtSimVar*FortranArray(String path, int dim0, int dim1)
public ExtSimVar*FortranArray(String path, int dim0, int dim1, int dim2)
```

Description

Create a new variable to be used in an ExtSimView.

Parameters

path The data dictionary path

dim0 The size of the first dimension.

dim1 The size of the second dimension.

dim2 The size of the third dimension.

23.15.2 Method reference

```
public * get()
public * get(int idx0)
public * get(int idx0, int idx1)
public * get(int idx0, int idx1, int idx2)
```

Description

Get the value of a single variable or single array element. The variant without the idx* parameters is for a single variable, the others are for 1, 2 and 3 dimensional arrays.

Parameters

idx0 Index in first dimension.

idx1 Index in second dimension.

idx2 Index in third dimension.

Return value

The value of the variable. The type of the return value depends on the type of the function. The type mapping is listed above in the introduction.

```
public void set(* val)
public void set(* val, int idx0)
public void set(* val, int idx0, int idx1)
public void set(* val, int idx0, int idx1, int idx2)
```

Description

Set the value of a single variable or single array element. The variant without the idx* parameters is for a single variable, the others are for 1, 2 and 3 dimensional arrays.

Parameters

val The new value. The type of the value depends on the type of the function. The type mapping is listed above in the introduction.

idx0 Index in first dimension.

idx1 Index in second dimension.

idx2 Index in third dimension.

Chapter 24

Python batch reference

24.1 Introduction

This chapter provides details on the batch utility for the python scripting language. Various python classes have been created that provide an interface to existing EuroSim libraries. This means that a batch application is no more than an ordinary python script using EuroSim classes.

The python glue code is generated using SWIG. It is possible to generated wrapper code for multiple scripting languages using the same interface definition. The Java and TCL interfaces are generated in the same manner.

The batch utility for python consists of various classes. Each class (or group of classes) is described in a separate chapter. The most important classes are the Session and EventHandler classes.

24.2 Session class

This is the central class used to run simulations. It supports the complete network protocol required to control the running simulator executable. For each command you can send to the simulator there is a function. In order to handle messages sent from the simulator to the application you can install an instance of an EventHandler class (see Section 24.3). You can also wait synchronously for any message. The messages and responses are documented in detail in Chapter 28. The idea behind this class is that it is a replacement for the simulation controller. It can fully automate anything you can do with the simulation controller.
To start a simulator all you need to do is:

```
s = eurosim.Session("some.sim") # load simulation definition
s.init()                        # start simulator
```

The constructor of the Session class uses the information in the simulation definition file to start the simulator.
As you can see you pass similar information to these calls as needed by the simulation controller. In the simulation controller you open a simulation definition file and then you can click on the Init button which launches the simulator. The simulation controller automatically connects to the simulator, just like the `init` method does. This function also sets up a number of standard event handlers for incoming events (messages) from the simulator. The information is stored in the session class. The user can at any moment print the contents of this structure by calling the `print_session_parameters` method.

To install a new event handler you have to create a derived class from the EventHandler class. The constructor of the class also installs the event handler so that it the event handler methods are automatically called on each incoming event. To remove an event handler, just delete the created event handler object. See Section 24.3 for detailed information on each event handler class method.

It is also possible to synchronously wait for an event you expect. In this case you call the `wait_event` method with the name of the event (same name as the method in the event handler class) and a time-out (in milliseconds).

To synchronously wait for some time to pass, you can call `wait_event` with an empty string as the event name.

24.2.1 Monitoring variables

In order to monitor variables you must call the method `monitor_add` with the variable you want to monitor. The variable parameter is in the form of a valid EuroSim data dictionary path. This method will add the variable to the list of variables monitored in EuroSim. The value of each variable will be updated with a frequency of 2 Hz if they change. If there is no change, no update is sent.

The values of the variables are stored in the Session class. To get the value of a variable use the following expression: `s.monitor_value(var_path)`. The value is always returned as a string.

To stop monitoring a variable you must call the function `monitor_remove` with the variable you want to stop monitoring.

If you only want to get the value of a variable once, it is better to call the function `get_value`. This function retrieves the value of the variable immediately from the simulator, but only once. The value of the variable is returned as a string.

24.2.2 Modifying variables

If you want to change the value of a variable in the simulator you can simply call `set_value` with the name and value (as a string) of the variable. The value will be set as soon as possible in the simulator. Calling `set_value` also works on an array variables.

24.2.3 Method reference

24.2.3.1 Constructors

`Session``(`*`[sim[, hostname]]`*`)`

Description

Creates a EuroSim simulation session by loading the given simulation definition file *sim*. The simulation run will be started on the host with the given hostname or on the current host if not specified.

Parameters

sim the simulation definition file name

hostname the name of the host on which to run the simulator

24.2.3.2 Methods

`cwd``()`

Description

Returns the path name of the current working directory of the simulator. The value is set by the event handler for event `maCurrentWorkingDir`.

Return value

Path name of the current working directory

`dict``()`

Description

Returns the path name of the EuroSim data dictionary of the simulator. The value is set by the event handler for event `maCurrentDict`.

Return value

Path name of the EuroSim data dictionary

---

outputdir()

Description

Returns the path name of the directory where the output files of the simulator are stored (journal file, recorder files, etc.) The value is set by the event handler for event `maCurrentResultDir`.

Return value

Path name of the output directory

---

state()

Description

Returns the simulator state. Can be: unconfigured, initialising, stand-by, executing, exiting. The value is set by the event handler for the following events: `rtUnconfigured`, `rtInitialising`, `rtStandby`, `rtExecuting` and `rtExiting`.

Return value

Simulator state

---

set_remote_path()

Description

If client and server have different paths (e.g. A Windows client launching a simulator on a linux server) `set_remote_path` can be used to set the root path of the simulator in the remote EuroSim server.

Return value

New paths for the simulator.

---

journal()

Description

Returns the path name of the journal file.

Return value

Path name of the journal file

---

schedule()

Description

Returns the path name of the schedule file.

Return value

Path name of the schedule file

---

exports()

Description

Returns the path name of the exports file.

Return value

Path name of the exports file

---

alias(*[alias]*)

Description

Set or get the alias file name.

Parameters

alias Override the alias file specified in the SIM file. If *alias* was not specified, then the alias file remains unchanged.

Return value

Path name of the alias file. If the simulation is running, then the value is set by the event handler for event `maCurrentAliasFile`.

---

tsp_map(*[tsp_map]*)

Description

Set or get the TSP map file name.

Parameters

tsp_map Override the TSP map file specified in the SIM file. If *tsp_map* was not specified, then the TSP map file remains unchanged.

Return value

Path name of the TSP map file. If the simulation is running, then the value is set by the event handler for event `maCurrentTSPMapFile`.

---

model()

Description

Returns the path name of the model file.

Return value

Path name of the model file

---

recording_bandwidth()

Description

Returns the recorder bandwidth in bytes/second. The value is set by the event handler for event `maRecordingBandwidth`.

Return value

Recorder bandwidth in bytes/second

---

stimulator_bandwidth()

Description

Returns the stimulator bandwidth in bytes/second. The value is set by the event handler for event `maStimulatorBandwidth`.

Return value

Stimulator bandwidth in bytes/second

---

speed()

Description

Returns the clock acceleration factor achieved by the simulator. Values larger than 1 indicate faster than real-time. Values smaller than 1 indicate slower than real-time. The value is set by the event handler for event `scSpeed`.

Return value

Acceleration factor

---

sim_time()

Description

Returns the simulation time (as seen by the running simulator). The value is set by the event handler for event `dtHeartBeat`.

Return value

Simulation time in seconds

---

wallclock_time()

Description

Returns the wallclock time (as seen by the running simulator). The value is set by the event handler for event `dtHeartBeat`.

Return value

Wallclock time in seconds

---

wallclock_boundary()

Description

Returns the wallclock boundary time to be used for timed state transitions. If you add an integer number of times the main cycle time to this value it will produce a valid state transition boundary time.

Return value

Wallclock time boundary in seconds

---

simtime_boundary()

Description

Returns the simulation time boundary to be used for timed state transitions. If you add an integer number of times the main cycle time to this value it will produce a valid state transition boundary time.

Return value

Simulation time boundary in seconds

---

main_cycle()

Description

Returns the main cycle time of the current schedule. It can be used to calculate valid boundary times for timed state transitions.

Return value

Main cycle in seconds.

---

recording()

Description

Returns the flag indicating that recording is enabled or not. True means enabled, false means disabled. The value is set by the event handler for event `maRecording`.

Return value

Recording is enabled

---

write_access()

Description

Returns the flag to indicate whether this client is allowed to change variable values in the simulator. The value is set by the event handler for event `maDenyWriteAccess`.

Return value

Client is allowed to change variables

`time_mode``()`

Description

Returns the time mode. It can be relative or absolute (UTC). Relative is 0 and absolute is 1. The value is set by the event handler for event `maCurrentTimeMode`.

Return value

Time mode

`realtime``(`*`[realtime]`*`)`

Description

Set or get the realtime mode.

Parameters

realtime If the realtime mode is not specified, then the realtime mode is not set. If *realtime* is 0, then realtime mode is disabled, otherwise it is enabled. The new setting will not effect an already running simulation.

Return value

The realtime mode, true for realtime, false for non-realtime. If a simulation is running, then the value as was set by the event handler for event `scGoRT` is reported. Non-realtime is the default.

`auto_init``(`*`[auto_init]`*`)`

Description

Set or get the auto initialization flag.

Parameters

auto_init If the auto initialization flag is not specified, then the auto initialization flag is not set. If *auto_init* is 0, then the simulator will not go automatically to initializing state on startup, otherwise it will go automatically to initializing (this is the default). The new setting will not effect an already running simulation.

Return value

The auto_init flag, true if the state transition to initializing state is performed automatically, false if it isn't.

Automatic state transition to initializing is the default.

`prefcon``(`*`[prefcon]`*`)`

Description

Set or get the preferred connection.

Parameters

prefcon The preferred connection. This can be used in a situation where you need to reconnect to an already running simulator. To start new simulation runs, this number is not used. If *prefcon* was not specified, then the preferred connection is not set.

Return value

Return the connection number of the current simulation session.

---

startup_timeout(*[timeout]*)

Description

Set or get the startup timeout.

The startup timeout default is 5 seconds. If starting up a simulator takes longer than this you must change that default to a higher value.

If *timeout* was not specified, then the startup timeout is not set.

Parameters

timeout The startup timeout.

Return value

Return the startup timeout in seconds of the current simulation session.

---

clientname(*[clientname]*)

Description

Set or get the name under which this session is known to the simulator.

Parameters

clientname The client name of the current simulation session. The default is "esimbatch". If *clientname* was not specified, then the client name is not changed.

Return value

Return the client name of the current simulation session.

---

initconds(*[initconds]*)

Description

Set or get the initial condition files.

Parameters

initconds Override the initial condition files specified in the SIM file. If *initconds* was not specified, then the initial condition files remain unchanged.

Return value

Initial condition files. If the simulation is running, then the value is set by the event handler for event `maCurrentInitconds`.

---

calibrations(*[calibrations]*)

Description

Set or get the calibration files.

Parameters

calibrations Override the calibration files specified in the SIM file. If *calibrations* was not specified, then the calibration files remain unchanged.

Return value

Calibration files. If the simulation is running, then the value is set by the event handler for event `maCurrentCalibrations`.

---

workdir(*[workdir]*)

Description

Set or get the work directory.

Parameters

workdir Use this directory as the work or project directory instead of the current directory.

Return value

The work directory.

---

user_defined_outputdir(*[outputdir]*)

Description

Set or get the user defined output directory.

Parameters

outputdir Use this output directory instead of the default *date/time* directory. If not set, then the user defined output directory is not changed.

Return value

The user defined output directory.

---

hostname(*[hostname]*)

Description

Set or get the EuroSim server hostname.

Parameters

hostname Use this EuroSim server. If not set, then the hostname is not changed.

Return value

The EuroSim server hostname.

---

sim(*[sim[, hostname]]*)

Description

Set or get the simulation definition file.

This simulation definition file is used to start the simulator. Information derived from the simulation definition file is used to provide sensible defaults for all parameters.

Parameters

sim The simulation definition file. If not set, then the simulation definition is not changed.

hostname The EuroSim server hostname. If not set, then the local host is used instead.

Return value

The filename of the simulation definition file.

---

init()

Description

Start a new simulation run.

Return value

1 on success, 0 on failure.

---

join_channel(*channel*)

Description

Join a channel of a simulation session. By default each session connects to all channels. The following channels are available: mdlAndActions, data-monitor, rt-control, sched-control. To join all channels use channel “all”.

Parameters

channel The channel to join.

Return value

1 on success, 0 on failure.

---

leave_channel(*channel*)

Description

Leave a channel of a simulation channel.

Parameters

channel The channel that you want to leave.

Return value

1 on success, 0 on failure.

---

wait_event(*event, timeout_ms*)

Description

Wait for an incoming event

This function is used to wait synchronously for the given *event*. The timeout is used to limit the amount of time to wait for this event.

Parameters

event The name of the event to wait for. If the event name is empty this function can be used to read all pending events while waiting for the given amount of time.

timeout_ms The timeout in milliseconds. A value of -1 means that this this function will wait until the event arrives for an unlimited amount of time. A value of 0 means that the function will return immediately even if the event has not arrived yet.

Return value

true if the event had arrived, false if it has not.

---

monitor_add(*var*)

Description

Monitor a variable.

The value of the variable is updated with 2 Hz.

Parameters

var The variable from the data dictionary that you want to monitor.

Return value

1 on success, 0 on failure.

---

monitor_value(*var*)

Description

Retrieve the value of a monitored variable

Parameters

var The name of the monitored variable.

Return value

the value of the variable

---

monitor_remove(*var*)

Description

Remove the monitor of a variable.

Parameters

var The variable from the data dictionary that should be removed from the monitor list.

Return value

1 on success, 0 on failure.

`create_session_list``([hostname])`

Description

Create a list of all sessions and return the size of that list.

Parameters

hostname If set, then report the sessions running on that host. Otherwise report all sessions running on the subnet.

Return value

the number of sessions.

`session_list``(idx)`

Description

Return the session info for the session with the given index.

Parameters

idx The index in the session list.

Return value

A `SessionInfo` object.

`esim_connect``()`

Description

Connect to a running simulation; a new journal file is opened.

Return value

1 on success, 0 on failure.

`esim_disconnect``()`

Description

Disconnect from the simulation session. The simulator will continue to run in the background.

`print_monitored_vars``()`

Description

Print a list of currently monitored variables and their current values. All variables in active monitors send values to the batch tool. A table with all variables is kept with their current values.

`print_session_paramters``()`

Description

Print a complete overview of all available parameters.

`print_event_list``()`

Description

Print a list of all events (messages) and parameters used in the communication between the test controller and the simulator.

---

script_action(*name, script[, condition]*)

Description

Create an MDL script text.

Parameters

name The action name.

script The action script.

condition The optional condition.

Return value

The fully composed action script.

---

recorder_action(*name, freq, vars*)

Description

Create a recorder script.

Parameters

name The action name.

freq The recorder frequency.

vars A list of all variables to be recorded.

Return value

The fully composed recorder script.

---

stimulus_action(*name, option, filename, freq, vars*)

Description

Create a stimulus script.

Parameters

name The action name.

freq The stimulus frequency.

option An option string (“soft”, “hard” or “cyclic”).

filename The stimulus filename.

vars A list of all variables to serve as stimulus.

Return value

The fully composed stimulus script.

---

event_list_size()

Description

Return the size of the list of events present in the schedule. The value is set by the event handler for the following events: `scEventListStart`, `scEventInfo`, `scEventListEnd`.

Return value

The size of the list of events.

---

event_list(*idx*)

Description

Return the event info of the event with the given index.

The value is set by the event handler for the following events: `scEventListStart`, `scEventInfo`, `scEventListEnd`.

Parameters

idx The index in the event list (the first element has index 0).

Return value

An `EventInfo` object.

`where_list_size``()`

Description

Return the size of the current breakpoint list.

The value is set by the event handlers for the following events: `scWhereListStart`, `scWhereEntry`, `scWhereListEnd`. It is cleared by the following events: `scStepTsk` and `scContinue`.

Return value

The size of the list.

`where_list``(`*idx*`)`

Description

Return the current breakpoint with the given index.

The value is set by the event handlers for the following events: `scWhereListStart`, `scWhereEntry`, `scWhereListEnd`. It is cleared by the following events: `scStepTsk` and `scContinue`.

Parameters

idx The index in the current breakpoint list.

Return value

A `WhereInfo` object describing the break point location.

`task_list_size``()`

Description

Return the size of the task list.

The value is set by the event handler for events `scTaskListStart`, `scTaskStart`, `scTaskEntry`, `scTaskEnd` and `scTaskListend`. Each task consists of a number of entry points and a flag called disable. The disable flag is set by the event handler of `scTaskDisable`.

Return value

The size of the task list.

`task_list``(`*idx*`)`

Description

Return the task info for the task with the given index.

The value is set by the event handler for events `scTaskListStart`, `scTaskStart`, `scTaskEntry`, `scTaskEnd` and `scTaskListend`. Each task consists of a number of entry points and a flag called disable. The disable flag is set by the event handler of `scTaskDisable`.

Parameters

idx The index in the task list.

Return value

A `TaskInfo` object.

`find_task_index`(*`taskname`*)

Description

Convert task name to index number.

Parameters

taskname The name of the task.

Return value

The index in the task list.

`mdl_list`()

Description

Return a list of all loaded MDL files.

MDL files are loaded at start-up when a .sim file is loaded or during run-time when extra MDL files are loaded. Extra files can be loaded by the event handler for event `maNewMission` or by manually adding MDL files with new_scenario.

Return value

The list of MDL files.

`action_list`(*`mdl`*)

Description

Return a list with the names of all the actions.

Parameters

mdl The name of the MDL file.

Return value

The list of action names.

`monitored_vars`()

Description

Return a list of all monitored variables.

Return value

The list of variables.

`event_type_list_size`()

Description

Return the size of the event messages table.

Return value

The number of event messages.

`event_type_list`(*`idx`*)

Description

Return the event type info of event message *idx*.

Parameters

idx The index in the event messages table.

Return value

An `EventTypeInfo` object.

---

sev_to_string(*sev*)

Description

Return a string respresentation of a message severity

Parameters

sev Message severity

Return value

String representation of severity

---

go(*[sec[, nsec]]*)

Description

Change the simulator state from stand-by to executing. Equivalent to the Go button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is specified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

---

stop(*[sec[, nsec]]*)

Description

Stop the simulation run. Equivalent to the Stop button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

---

pause(*[sec[, nsec]]*)

Description

Change the simulator state from executing to stand-by. Equivalent to the Pause button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

---

freeze(*[sec[, nsec]]*)

Description

Change the simulator state from executing to stand-by. Equivalent to the Pause button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

---

freeze_at_simtime(*sec[, nsec]*)

Description

Change the simulator state from executing to stand-by on the specified simulation time. The simulation time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Simulation time (seconds)

nsec Simulation time (nanoseconds)

Return value

1 on success, 0 on failure.

---

step()

Description

Perform one main scheduler cycle. Equivalent to the Step button of the test controller.

Return value

1 on success, 0 on failure.

---

abort()

Description

Abort the current simulation run. Equivalent to the Abort button of the test controller.

Return value

1 on success, 0 on failure.

---

health()

Description

Request a health check of the running simulator. Prints health information to the test controller.

Return value

1 on success, 0 on failure.

---

reset_sim()

Description

Restart the current simulation with the current settings. Equivalent to the Reset button of the test controller.

Return value

1 on success, 0 on failure.

---

new_scenario()

Description

Create a new scenario in the simulator. This new scenario is only a container for new actions. It is not a file on disk. It is a pure in core representation.

Parameters

scen The scenario name.

Return value

1 on success, 0 on failure.

---

open_scenario(*scen*)

Description

Open a new scenario file in the simulator with file name *scen*. The file must be on disk and readable.

Parameters

scen Scenario file name.

Return value

1 on success, 0 on failure.

---

close_scenario(*scen*)

Description

Close a currently opened scenario with name *scen* in the simulator.

Parameters

scen Scenario file name.

Return value

1 on success, 0 on failure.

---

new_action(*scen, action_text*)

Description

Add a new action in the scenario file with name *scen*. *action_text* is the complete action text. There are a few utility functions to generate those actions.

Parameters

scen The scenario file name.

action_text The action text.

Return value

1 on success, 0 on failure.

---

delete_action(*scen, action*)

Description

Delete an action from scenario *scen* with name *action*.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

---

action_execute(*scen, action*)

Description

Trigger the execution of the action with name *action* in scenario with name *scen*. This is equivalent to triggering an action manually on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

---

action_activate(*scen, action*)

Description

Make action with name *action* in scenario with name *scen* active in the running simulator. The action must already be defined in the scenario. This is equivalent to activating an action on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

---

action_deactivate(*scen, action*)

Description

Deactivate action with name *action* in scenario with name *scen* in the running simulator. This is equivalent to deactivating an action on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

---

snapshot(*[filename[, comment]]*)

Description

Make a snapshot of the current state of the variables in the data dictionary. The *comment* string is optional. If you omit the filename, a filename is chosen of the form snapshot *simtime*.snap. The snapshot is saved in the output directory, unless the filename is absolute. This is equivalent to the "Take Snaphot..." menu option in the "Control" menu of the test controller.

Parameters

filename Path name of the snapshot file.

comment Comment string

Return value

1 on success, 0 on failure.

---

mark(*[comment]*)

Description

Make a mark in the journal file. The *comment* string is optional. This is equivalent to the "Mark Journal" and "Comment Journal Mark" menu options in the "Insert" menu of the Simulation Controller.

Parameters

comment Comment string

Return value

1 on success, 0 on failure.

---

sim_message(*msg*)

Description

Send a message to the simulator for distribution to all clients. This is useful if your client application is not the only client of the simulator. The message is broadcasted to all clients.

Parameters

msg Message string

Return value

1 on success, 0 on failure.

---

suspend_recording()

Description

Suspend recording in the simulator. This is equivalent to unchecking the "Enable Recordings" menu item of the "Control" menu of the Simulation Controller.

Return value

1 on success, 0 on failure.

---

resume_recording()

Description

Resume recording in the simulator. This is equivalent to checking the "Enable Recordings" menu item of the "Control" menu of the Simulation Controller.

Return value

1 on success, 0 on failure.

---

recording_switch()

Description

Switch all recording files of a simulation run. All currently open recorder files are closed and new recorder files are created. Recording will continue in the new recorder files.

Return value

1 on success, 0 on failure.

---

reload(*snapfile[, hard]*)

Description

Load initial condition file or snapshot file with file name *snapfile* into the running simulator. Parameter *hard* is by default "off". This means that the simulation time stored in the snapshot file is ignored. If *hard* is set to "on", the simulation time is set to the value specified in the snapshot file.

Parameters

snapfile Path name of snapshot file.

hard "on" or "off".

Return value

1 on success, 0 on failure.

---

set_value(*var, value*)

Description

Set the value of a variable.

Parameters

var The data dictionary path name of variable you want to change.

value The new value as string. To set an array variable write the value as a comma seperated list between curly brackets. For example:

```
::s set_value "/Thrusters/force" "{1,2, 2, 3, 4, 5, 6, -2, 2}"
```

Return value

1 on success, 0 on failure.

---

get_value(*var*)

Description

Get the value of a variable.

Parameters

var The data dictionary path name of the variable

Return value

The value, empty on failure

---

cpu_load_set_peak(*cpu, peak_time*)

Description

Configure the CPU load monitor peak time in msecs.

Parameters

cpu CPU number

peak_time Peak time in seconds.

Return value

1 on success, 0 on failure.

---

set_breakpoint(*taskname, entrynr, enable*)

Description

Set a breakpoint on entry nr *entrynr* in task *taskname* in the scheduler. If parameter *enable* is set to true the breakpoint is enabled. To disable it again set the parameter to false.

Parameters

taskname Name of the task.

entrynr Entry point number

enable true to enable, false to disable

Return value

1 on success, 0 on failure.

---

set_trace(*taskname, entrynr, enable*)

Description

Enable/disable tracing of entry points. Entry points are defined by specifying the number of the entry point *entrynr* (numbering starts at 0) and the name of the task *taskname*. To enable a trace set *enable* to true, to disable it set it to false. Tracing an entry point means that messages are printed to the journal window.

Parameters

taskname Name of the task.

entrynr Entry point number

enable true to enable, false to disable

Return value

1 on success, 0 on failure.

---

where()

Description

Request the current position when the scheduler has stopped on a break point. The reply to the message is automatically stored and can be retrieved by using *where_list*. Normally the position is sent to the client whenever the scheduler hits a breakpoint. So there is rarely any need to request the position manually if you store the position on the client side (as is done in this tool.)

Return value

1 on success, 0 on failure.

---

step_task()

Description

Perform one step (=one entry point) in the scheduler debugger.

Return value

1 on success, 0 on failure.

---

cont()

Description

Continue executing upto the next breakpoint in the scheduler debugger.

Return value

1 on success, 0 on failure.

---

task_disable(*taskname*)

Description

Disable task with name *taskname* in the current schedule of the simulator.

Parameters

taskname Name of the task.

Return value

1 on success, 0 on failure.

---

task_enable(*taskname*)

Description

Enable task with name *taskname* in the current schedule of the simulator.

Parameters

taskname Name of the task.

Return value

1 on success, 0 on failure.

---

clear_breaks()

Description

Remove all breakpoints in the current schedule of the simulator.

Return value

1 on success, 0 on failure.

---

clear_traces()

Description

Remove all traces in the current schedule of the simulator.

Return value

1 on success, 0 on failure.

---

set_simtime(*sec[, nsec]*)

Description

Set the simulation time to *sec* seconds and *nsec* nanoseconds. This can only be done in stand-by state.

Parameters

sec Simulation time in seconds.

nsec Simulation time in nanoseconds.

Return value

1 on success, 0 on failure.

---

enable_realtime()

Description

Switch to real-time mode. This can only be done when the simulator has started off in real-time mode, and has switched to non-real-time mode.

Return value

1 on success, 0 on failure.

---

disable_realtime()

Description

Switch to non-real-time mode.

Return value

1 on success, 0 on failure.

---

list_tasks()

Description

Request a list of all tasks in the current schedule of the simulator. The list is also sent automatically upon joining the "sched-control" channel.

Return value

1 on success, 0 on failure.

---

list_events()

Description

Request a list of all events in the schedule of the simulator in all states. The list is automatically sent to the client when subscribing to the "sched-control" channel at start-up.

Return value

1 on success, 0 on failure.

---

raise_event(*eventname[, data, size]*)

Description

Raise event with name *eventname* in the scheduler. An event is defined by the input connector on the scheduler canvas. The event is handled as fast as possible. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

---

raise_event_at(*eventname, sec[, nsec[, data, size]]*)

Description

Raise event with name *eventname* in the schedler at a specified wallclock time. The wallclock time is specified as *sec* seconds and *nsec* nanoseconds. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

sec Wallclock time in seconds.

nsec Wallclock time in nanoseconds.

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

---

raise_event_at_simtime(*eventname, sec[, nsec[, data, size]*)

Description

Raise event with name *eventname* in the schedler at a specified simulation time. The simulation time is specified as *sec* seconds and *nsec* nanoseconds. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

sec Simulation time (seconds)

nsec Simulation time (nanoseconds)

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

---

set_speed(*speed*)

Description

Set the acceleration/deceleration of the scheduler of the simulator. Values smaller than 1 will cause a proportional deceleration of the scheduler clock. Values larger than 1 will cause a proportional acceleration of the scheduler clock. Magical value -1 means that the scheduler will run in an optimized as-fast-as-possible mode.

Parameters

speed acceleration factor

Return value

1 on success, 0 on failure.

---

add_MDL(*mdlname*)

Description

Load (another) new MDL file in the session.

Parameters

mdlname Path name of the MDL file.

Return value

1 on success, 0 on failure.

---

sync_send(*token*)

Description

Send sync token to simulator

Parameters

token synchronization token id

Return value

1 on success, 0 on failure

---

sync_recv(*token*)

Description

Wait for sync token from simulator

Parameters

token synchronization token id

Return value

1 on success, 0 on failure

---

kill(*[signal]*)

Description

Kill the simulator with signal *signal*. By default the simulator is killed with SIGTERM.

Parameters

signal Signal to send to the simulator

Return value

1 on success, 0 on failure

24.3 EventHandler class

The EventHandler class is used to handle events coming from the simulator. The user must derive from this class and implement the methods for the events that must be handled.

When a messsage from the simulator is received, first the built-in message handling is performed followed by the user defined message handlers. The message handlers are installed by instantiating the handler. The message handler is removed by deleting the created event handler instance.

To define a user defined message handler all you need to do is:

```
class ExampleEventHandler(eurosim.EventHandler):

   # constructor
   def __init__(self, session):
         eurosim.EventHandler.__init__(self, session)

   # handler for maMessage events
   def maMessage(self, simtime_sec, simtime_nsec, runtime_sec,
       runtime_nsec, sev, procname, msg):
         print procname, msg

# instantiate event handler (implicitly installs it)
eh = ExampleEventHandler(s)
```

24.3.1 Method reference

24.3.1.1 Constructors

EventHandler(*s*)

Description

Construct a new EventHandler and install the handler.

Parameters

s The simulator session

24.3.1.2 Methods

session()

Description

Return the session for this event handler.

Return value

The `Session` object of the simulator session.

24.3.1.3 Event Handler Methods

In order to create a user defined event handler, one or more methods must be implemented.

maNewMission(*mission*)

Description

A new mission (MDL) is created.

Parameters

mission The name of the mission.

---

maOpenMission(*mission*)

Description
A mission (MDL) file is opened.

Parameters
mission The filename of the mission file.

---

maCloseMission(*mission*)

Description
A mission (MDL) file is closed.

Parameters
mission The filename of the mission file.

---

maSimDef(*simdef*)

Description
Inform that client which simulation definition file is currently loaded.

Parameters
simdef The filename of the simulation definition file.

Return value

---

maCurrentDict(*dict*)

Description
Inform the client which data dictionary file is currently loaded.

Parameters
dict The filename of the data dictionary file.

Return value

---

maCurrentWorkingDir(*cwd*)

Description
Inform the client what the current working directory of the simulator is.

Parameters
cwd The path name of the current working directory.

---

maCurrentResultDir(*result_dir*)

Description
Inform the client what the result directory is. The result directory contains all the journal files, recorder files, snapshots and timings file.

Parameters
result_dir The path name of the result directory.

---

maCurrentAliasFile(*filename*)

Description
Inform the client what the alias file is. The alias file contains the data dictionary aliases.

Parameters

filename The path name of the alias file.

---

maCurrentTSPMapFile(*filename*)

Description

Inform the client what the TSP map file is. The TSP map file contains the TSP data dictionary path name map.

Parameters

filename The path name of the TSP map file.

---

maNewAction(*mission, actiontext*)

Description

Inform the client that a new action has been created.

Parameters

mission The name of the mission.

actiontext The new action.

---

maDeleteAction(*mission, actionname*)

Description

Inform the client that an action has been deleted.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionExecute(*mission, actionname*)

Description

Inform the client that an action is being executed.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionExecuteStop(*mission, actionname*)

Description

Inform the client that an action is no longer being executed.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionExecuting(*mission, actionname*)

Description

Inform a newly connected client that the action is currently executing.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionActivate(*mission, actionname*)

Description

Inform the client that an action has been activated. I.e. is allowed to execute.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionDeActivate(*mission, actionname*)

Description

Inform the client that an action has been deactivated. I.e. is no longer allowed to execute.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maExecuteCommand(*name, command, action_mgr_nr*)

Description

Inform the client that a one shot action has been executed.

Parameters

name The name of the action.

command The commands of the action.

action_mgr_nr The number of the action manager that has executed the action.

---

maSnapshot(*snapshot, comment*)

Description

Handle maSnapshot event. This event is sent after a snapshot of the current simulator state has been made.

Parameters

snapshot Path name of the snapshot file.

comment Comment describing the snapshot.

---

maMark(*message, marknumber*)

Description

Inform the client that a mark has been made in the journal file.

Parameters

message The descriptive message of the mark.

marknumber The number of the mark.

---

maMessage(*simtime_sec, simtime_nsec, runtime_sec, runtime_nsec, sev, process, msg*)

Description

Inform the client that a message has been generated in the simulator. This message is also automatically logged in the journal file by the simulator.

Parameters

simtime_sec Simulation time stamp (seconds part)

simtime_nsec Simulation time stamp (nanoseconds part)

runtime_sec Wallclock time stamp (seconds part)

runtime_nsec Wallclock time stamp (nanoseconds part)

sev Severity of the message. The name of the severity can be retrieved by using the `sev_to_string()` method of the Session class.

process Name of the simulator thread from where the message was generated.

msg The message text.

---

maRecording(*on_off*)

Description

Inform the client that recording has been globally enabled/disabled.

Parameters

on_off If the string is equal to "on", recording is enabled. If it is "off" it is disabled.

---

maRecordingBandwidth(*bandwidth*)

Description

Report the bandwidth used to record data to disk.

Parameters

bandwidth Number of bytes per seconds written to disk.

---

maStimulatorBandwidth(*bandwidth*)

Description

Report the bandwidth used to read data from disk for stimulation.

Parameters

bandwidth Number of bytes per second read from disk.

---

maRecorderFileClosed(*filename*)

Description

Inform the client that a recorder file has been closed and can be used for further processing.

Parameters

filename The file name of the recorder file.

---

maDenyWriteAccess(*denied*)

Description

Inform the client that the write access to variables is denied. This is the case if the client has the role of observer.

Parameters

denied Flag to indicate denial of write access to the simulator variables.

---

maCurrentInitconds(*simdef, initconds*)

Description

Inform the client of the current list of initial conditions as used for the initialization of the simulator.

Parameters

simdef The name of the simulation definition file.

initconds The list of initial condition files (space separated).

---

maCurrentCalibrations(*simdef, calibrations*)

Description

Inform the client of the current list of calibration definition files as used by the simulator.

Parameters

simdef The name of the simulation definition file.

calibrations The list of calibration files (space separated).

---

maCurrentTimeMode(*time_mode*)

Description

Inform the client of the current time mode. The time mode can be relative time or absolute time (UTC mode).

Parameters

time_mode The time mode, 0 is relative time mode, 1 is absolute time mode (UTC mode).

---

maNewSeverity(*sev, sev_name*)

Description

Inform the client about a new user-defined message severity. This message is automatically handled. The severity identifier can be mapped to its symbolic name using the `sev_to_string()` method of the Session class.

Parameters

sev The severity numerical identifier.

sev_name The symbolic name of the severity.

---

rtUnconfigured()

Description

Inform the client that the state of the simulator is `unconfigured`. This state means that the simulator is either still starting up, or is in its final clean up phase. This is a transient state. When starting up, the next state will be `Initialising`. When cleaning up the last event will be `evShutdown`.

---

rtInitialising()

Description

Inform the client that the state of the simulator is `initialising`. Depending on the schedule definition, this state will automatically be followed by the `standby` state. Otherwise you have to manually change the state to `standby` using the `eventStandby()` method of the Session() class.

---

rtStandby()

Description

Inform the client that the state of the simulator is `standby`.

---

rtExecuting()

Description

Inform the client that the state of the simulator is `executing`.

`rtExiting``()`

Description

Inform the client that the state of the simulator is `exiting`. This is a transient state. The next state will be the `unconfigured` state.

`rtTimeToNextState``(`*`sec, nsec`*`)`

Description

Report the time to the next state transition. This is useful when the major cycle is quite long (more than a couple of seconds). This can be the case if the schedule definition contains a clock with a very low frequency or when the lowest common denominator of the clocks results in a long major cycle.

Parameters

sec Time to next state (seconds part)

nsec Time to next state (nanoseconds part)

`rtMainCycle``(`*`sec, nsec`*`)`

Description

Report the length of the main cycle of the schedule.

Parameters

sec Main cycle (seconds part)

nsec Main cycle (nanoseconds part)

`scSetBrk``(`*`taskname, entrynr, enable`*`)`

Description

Inform the client about the enabling/disabling of a break point on a specific entry point in a task in the schedule.

Parameters

taskname The name of the task.

entrynr The number of the entry point (counting starts at 0).

enable Whether the break point is enabled (1) or disabled (0).

`scStepTsk``()`

Description

Inform the client that a step to the next task has been performed in debugging mode.

`scContinue``()`

Description

Inform the client that the execution is now continued after being stopped on a break point in debugging mode.

`scGoRT``(`*`enable`*`)`

Description

Inform the client that the real-time mode has changed.

Parameters

enable Real-time mode is enabled (true) or disabled (false).

---

scTaskDisable(*taskname, disable*)

Description

Inform the client that a task has been disabled. This means that the task is no longer executed.

Parameters

taskname The name of the task.

disable The task is disabled (true), or enabled again (false).

---

scSetTrc(*taskname, entrynr, enable*)

Description

Inform the client that a trace has been set on an entry point in a task.

Parameters

taskname The name of the task.

entrynr The number of the entry point in the task (counting starts at 0).

enable The trace is enabled (true), or disabled (false).

---

scSpeed(*speed*)

Description

Report the speed of the scheduler clock. This is only relevant in non-real-time mode when going slower or faster than real time.

Parameters

speed Speed factor. 1 means real-time, less than 1 means slower than real-time, more than 1 means faster than real-time. E.g. 2 means two times faster than real-time.

---

scTaskListStart()

Description

Start the description of the list of tasks.

---

scTaskStart(*taskname, enabled*)

Description

Start the description of a task. This is followed by a number of scTaskEntry events, one for each entry in the order of execution in the task.

Parameters

taskname The name of the task

enabled The task is enabled (true), or disabled (false).

---

scTaskEntry(*entryname, breakpoint, trace*)

Description

Report information of an entry point in a task.

Parameters

entryname The name of the entry point.

breakpoint The entry point has a break point set (true) or not set (false).

trace The entry point is traced (true) or not (false).

---

scTaskEnd()

Description

Report the end of the task information.

---

scTaskListEnd()

Description

Report the end of the list of tasks.

---

scEventListStart()

Description

Report the start of the list of schedule events.

---

scEventInfo(*eventname, state, is_standard*)

Description

Report all information about a specific schedule event.

Parameters

eventname The name of the event.

state The state in which it is present.

is_standard Whether or not it is a built-in (standard) event (true), or a user defined event (false).

---

scEventListEnd()

Description

Report the end of the list of events.

---

scWhereListStart()

Description

Report the start of the list of places where the scheduler has stopped execution when reaching a break point. As there are possibly more than 1 executers executing tasks, there can be multiple places where the execution has stopped.

---

scWhereEntry(*taskname, entrynr*)

Description

Report a location where the execution has stopped.

Parameters

taskname The name of the task.

entrynr The number of the entry point (counting starts at 0).

---

scWhereListEnd()

Description

End of the list of locations where the execution has stopped.

---

scEntrypointSetEnabled(*entrypointname, enabled*)

Description

Report the enabling or disabling of the execution of an entry point. The execution of the entry point is disabled for all tasks and also when executing the entry point from MDL scripts.

Parameters

entrypointname The name of the entry point.

enabled Whether the entry point is enabled for execution (true), or disabled (false).

---

dtLogValueUpdate(*var, value*)

Description

Report an updated value for a logged variable.

Parameters

var The name of the variable.

value The value of the variable.

---

dtHeartBeat()

Description

This event is sent at 2 Hz by default and indicates that the simulator is still alive. It is also the last event sent after a series of dtLogValueUpdate events.

---

dtCpuLoad(*cpu, average, peak*)

Description

Report the load of a CPU.

Parameters

cpu CPU number

average Average load over a main cycle.

peak Peak load over a minor cycle.

---

evLinkData(*link_id*)

Description

Event that is used internally to transmit (TM/TC) packets. The actual data of the packet is not passed to this callback function. It is stored internally and can be retrieved using the `read()` method of the TmTcLink class.

Parameters

link_id The symbolic name of the link.

---

evExtSetData(*view_id*)

Description

Event that is used internally to update External Simulator Access views. The actual data of the event is not passed to this callback function. It is decoded and stored in the view variables and can be retrieved with the `get()` method of the ExtSimVar* classes.

Parameters

view_id The symbolic name of the view.

---

evShutdown(*error_code, error_string*)

Description

Event that is received when the connection with the simulator is lost.

Parameters

error_code The value of errno at the time the connection was terminated. This value is zero when the connection was terminated in a normal way.

error_string The description of the error code.

---

evEventDisconnect()

Description

Event that is received when the connection with the simulator is closed. This is normally done using the method `esim_disconnect()`.

24.4 eurosim class

This class contains a couple of utility methods that are not linked to a session.

24.4.1 Method reference

host_list()

Description

Return the list of EuroSim hosts.

Return value

The list of hosts.

---

session_kill_by_name(*simname[, signal[, hostname]]*)

Description

Kill a simulation session by name.

Parameters

simname The name of the session. This is normally the basename of the executable.

signal The signal to send to the session (default = SIGTERM)

hostname The name of the host where the session runs (default = localhost)

Return value

-1 if creating the connection with the EuroSim daemon on the host failed, 0 on success, otherwise the result is the value of errno of the failed kill system call or EPERM if you do not have the right permissions to kill the simulator or ESRCH if the simulator with the specified name could not be found.

---

session_kill_by_pid(*pid[, signal[, hostname]]*)

Description

Kill a simulation session by pid.

Parameters

pid The process id of the session.

signal The signal to send to the session (default = SIGTERM)

hostname The name of the host where the session runs (default = localhost)

Return value

-1 if creating the connection with the EuroSim daemon on the host failed, 0 on success, otherwise the result is the value of errno of the failed kill system call or EPERM if you do not have the right permissions to kill the simulator or ESRCH if the simulator with the specified pid could not be found.

`open_log``()`

Description

Allows the client to log to a file. After opening the log file everything that is sent to stdout and to stderr is also logged to the spedified file.

Return value

0 if succeeded.

`close_log``()`

Description

Closes the log file created by `open_log`.

Return value

0 if succeeded.

24.5 EventInfo class

The EventInfo data is return by the `event_list` method of the Session class. The methods allow you to retrieve the individual attributes of a scheduler event.

24.5.1 Method reference

`name``()`

Description

Get the name of the event.

Return value

The name of the event

`state``()`

Description

Get the number of the state where this event is defined.

Return value

The number of the state.

`state_name``()`

Description

Get the name of the state where this event is defined.

Return value

The name of the state.

`is_standard``()`

Description

Whether the event is a standard event or a user defined event.

Return value

true if it is a standard event, false if it is a user defined event.

24.6 WhereInfo class

The WhereInfo data is return by the `where_list` method of the Session class. The methods allow you to retrieve the individual attributes of a scheduler break point location.

24.6.1 Method reference

`name``()`

Description

Get the name of the task where the scheduler is currently stopped.

Return value

The task name.

`entrynr``()`

Description

Get the entry point number of the current break point within the task.

Return value

The entry point number. Counting starts at 0.

24.7 EntryInfo class

The EntryInfo data is return by the `entry_list` method of the TaskInfo class. The methods allow you to retrieve the individual attributes of an entry point in a task.

24.7.1 Method reference

`name``()`

Description

Get the name of the entry point.

Return value

The name of the entry point.

`breakpoint``()`

Description

Get the break point status of the entry point.

Return value

True if a break point is set, false if not.

`trace``()`

Description

Get the trace status of the entry point.

Return value

True if a trace is set, false if not.

24.8 TaskInfo class

The TaskInfo data is return by the `task_list` method of the Session class. The methods allow you to retrieve the individual attributes of a task.

24.8.1 Method reference

name()

Description
Get the name of the task.

Return value
The name of the task.

---

disabled()

Description
Get the disabled state of the task.

Return value
True if the task is disabled, false if it is enabled.

---

entry_list_size()

Description
Get the number of entry points of the task.

Return value
The number of entry points.

---

entry_list(*idx*)

Description
Get the entry point information of the entry point with the given index.

Parameters
idx The entry point index (counting starts at 0).

Return value
An `EntryInfo` object describing the entry point information.

24.9 EventTypeInfo class

The EventTypeInfo data is return by the `event_type_list` method of the Session class. The methods allow you to retrieve the individual attributes of a client/server message (called event internally).

24.9.1 Method reference

name()

Description
Get the name of the message.

Return value
The name of the message.

---

args()

Description
Get the argument types of the message. This is a character coded string with one character for each argument type.

Return value
The argument types.

---

argdescr()

Description
Get a description of the arguments of the message.

Return value
The description of the arguments.

---

id()

Description
Get the numerical identifier of the message.

Return value
The numerical identifier.

24.10 SessionInfo class

The SessionInfo data is return by the `session_list` method of the Session class. The methods allow you to retrieve the individual attributes of a simulation session.

24.10.1 Method reference

sim_hostname()

Description
Get the host name running the simulation session.

Return value
The host name.

---

sim()

Description
Get the simulation definition file.

Return value
The file name of the simulation definition file.

---

workdir()

Description
Get the working directory.

Return value
The path name of the working directory.

---

simulator()

Description
Get the simulator executable.

Return value
The path name of the executable.

`schedule``()`

Description

Get the simulator schedule.

Return value

The path name of the schedule file.

`scenarios``()`

Description

Get the list of scenario (MDL) files.

Return value

The list with path names of the MDL files.

`dict``()`

Description

Get the data dictionary file.

Return value

The path name of the data dictionary file.

`model``()`

Description

Get the model file.

Return value

The path name of the model file.

`recorderdir``()`

Description

Get the recorder directory.

Return value

The path name of the recorder directory.

`initconds``()`

Description

Get the list of initial condition files.

Return value

The list of path names of the initial condition files.

`calibrations``()`

Description

Get the list of calibration files.

Return value

The list of path names of the calibration files.

`exports``()`

Description
Get the exports file.

Return value
The path name of the exports file.

---

alias()

Description
Get the alias file.

Return value
The path name of the alias file.

---

tsp_map()

Description
Get the TSP map file.

Return value
The path name of the TSP map file.

---

timestamp()

Description
Get the time stamp.

Return value
The time stamp.

---

prefcon()

Description
Get the connection number. Each session has a connection number that can be used to connect a client to that session.

Return value
The connection number.

---

uid()

Description
Get the UNIX user id of the user who started the simulator.

Return value
The user id.

---

gid()

Description
Get the UNIX group id of the user who started the simulator.

Return value
The group id.

---

pid()

Description

Get the UNIX process id of the simulation session.

Return value

The process id.

`realtime``()`

Description

Get the real-time state of the simulation session.

Return value

True if the simulator was started in real-time mode, false if it was started in non-real-time mode.

24.11 TmTcLink class

The TmTcLink class is used to create a packet link with a model in the simulator. The packet link can be used to send arbitrary packets (binary or not) to a simulator model and receive packets from a simulator model. Multiple packet links can be created. See Chapter 29 for detailed information on how to use the link.

24.11.1 Constructors

`TmTcLink``(`*`id, mode`*`)`

Description

Open one end of a TmTc link.

Parameters

id The symbolic name of the TmTc link.

mode Mode is “r”, “w” or “rw”, similar to the modes of the fopen() function in the standard C library.

24.11.2 Method reference

`connect``(`*`s`*`)`

Description

Connect the link to the other end in a running simulator.

Parameters

s The `Session` object of the running simulator.

Return value

-1 on failure, 0 on success.

`write``(`*`data`*`)`

Description

Write a packet to the link.

Parameters

data The data (binary string).

Return value

The number of bytes sent or -1 on failure.

`read``()`

Description

Read data from the link.

Return value

The data read as a binary string.

24.12 InitCond class

This class is used for the manipulation of initial condition files. This allows the user to create a new initial condition file or modify an existing file. Individual values can be set or modified. It is also possible to merge two initial condition files.

24.12.1 Constructors

InitCond(*filename, dictfile*)

Description

Create a new set of initial conditions from an existing file.

Parameters

filename The initial condition file.

dictfile The path of the data dictionary file.

24.12.2 Method reference

add(*filename*)

Description

Merge an existing initial condition file with the current initial condition data.

Parameters

filename The path of the to-be-merged initial condition file.

Return value

true on success, false on failure.

---

write(*filename, binary*)

Description

Write the initial condition data to a file.

Parameters

filename The path of the new initial condition file.

binary If true, write a binary file, otherwise write the data in human readable (ASCII) format.

Return value

true on success, false on failure.

---

simtime()

Description

Return the simulation time of the initial condition file.

Return value

The simulation time.

---

comment()

Description

Get the comment of in the initial condition file.

Return value

The comment string.

---

get_varlist_failed()

Description

Get the list of variables in the initial condition file which were successfully loaded into the data dictionary.

Return value

The list of variables.

---

get_varlist_set()

Description

Get the list of variables in the initial condition file which were successfully loaded into the data dictionary.

Return value

The list of variables.

---

var_value_get(*path*)

Description

Get the numerical value of a variable.

Parameters

path The data dictionary path.

Return value

The numerical value of the variable.

---

var_string_get(*path*)

Description

Get the string value of a variable.

Parameters

path The data dictionary path.

Return value

The string value of the variable.

---

var_value_set(*path, value*)

Description

Set the numerical value of a variable.

Parameters

path The data dictionary path name.

value The new value.

Return value

true on success, false on failure.

---

var_string_set(*path, value*)

Description

Set the string value of a variable.

Parameters

path The data dictionary path name.

value The new value.

Return value

true on success, false on failure.

`list``(`*`[path]`*`)`

Description

Get a list of child node names beneath a parent node.

Parameters

path The path of the parent node (default the root "/").

Return value

The list of child node names.

24.13 ExtSimView class

This class wraps the External Simulator Access interface. Detailed information on the use of this interface can be found in Chapter 30.

24.13.1 Constructors

`ExtSimView``(`*`session, id`*`)`

Description

Create a new External Simulator Access view.

Parameters

session The `Session` object of the simulation session.

id The symbolic identifier of the view.

24.13.2 Method reference

`add``(`*`var`*`)`

Description

Add a variable to this view.

Parameters

var An `ExtSimVar` object of the variable to add to the view.

Return value

0 on success, -1 on failure.

`connect``(`*`rw_flags, frequency, compression`*`)`

Description

Create a new view with the variables previously added to the view.

Parameters

rw_flags Read/write flags, 1 is read, 2 is write.

frequency Update frequency in Hz.

compression Compression type to be used for the data transmission. 0 is no compression, 1 means that unchanched values in the view are not transmitted. Please note that in case the whole view is not changed, no update is sent in any case.

Return value
0 is success, -1 is failure.

---

change_freq(*frequency*)

Description

Parameters
Change the update frequency of the view.

frequency The update frequency in Hz.

Return value
0 is success, -1 is failure.

---

send()

Description
Send the view with the updated values to the simulator.

Return value
0 is success, -1 is failure.

24.14 ExtSimVar class

This is the base class of the ExtSimVar* classes. It is not to be used directly.

24.14.1 Method reference

type()

Description
Get the variable type.

Return value
The variable type.

---

is_array()

Description
Find out if the variable is an array variable.

Return value
true if it is an array.

---

is_fortran()

Description
Find out if the variable is a Fortran variable. Only relevant for arrays, as the Fortran column/row order is different from C/Ada.

Return value
true if it is a Fortran variable.

---

nof_dims()

Description
Get the number of dimensions of the array variable.

Return value
The number of array dimensions.

---

dims()

Description
Get the dimensions of the array variable.

Return value
The array dimensions.

---

path()

Description
Get the data dictionary path of the variable.

Return value
The data dictionary path.

---

size()

Description
Get the size in bytes of the variable.

Return value
The size in bytes.

24.15 ExtSimVar* classes

Below are the derived classes of ExtSimVar described. All similar methods are grouped to reduce the amount of documentation that only repeats the same information again and again. Therefore only two different cases are documented. One for the single element case and one for the array case.
For both cases the following variants are possible: Char, Double, Float, Int, Long, Short, UnsChar, UnsInt, UnsLong and UnsShort.
For arrays there are two variants: ExtSimVar*Array and ExtSimVar*FortranArray.
To summarize for one type you can have the following classes: ExtSimVarChar, ExtSimVarCharArray and ExtSimVarCharFortranArray.

24.15.1 Constructors

ExtSimVar*(*path*)

ExtSimVar*Array(*path, dim0[, dim1[, dim2]]*)

ExtSimVar*FortranArray(*path, dim0[, dim1[, dim2]]*)

Description
Create a new variable to be used in an ExtSimView.

Parameters
path The data dictionary path

dim0 The size of the first dimension.

dim1 The size of the second dimension.

dim2 The size of the third dimension.

24.15.2 Method reference

get(*[idx0[, idx1[, idx2]]]*)

Description

Get the value of a single variable or single array element. The variant without the idx* parameters is for a single variable, the others are for 1, 2 and 3 dimensional arrays.

Parameters

idx0 Index in first dimension.

idx1 Index in second dimension.

idx2 Index in third dimension.

Return value

The value of the variable. The type of the return value depends on the type of the function. The type mapping is listed above in the introduction.

---

set(*val[, idx0[, idx1[, idx2]]]*)

Description

Set the value of a single variable or single array element. The variant without the idx* parameters is for a single variable, the others are for 1, 2 and 3 dimensional arrays.

Parameters

val The new value. The type of the value depends on the type of the function. The type mapping is listed above in the introduction.

idx0 Index in first dimension.

idx1 Index in second dimension.

idx2 Index in third dimension.

Chapter 25

Tcl batch reference

25.1 Introduction

This chapter provides details on the batch utility for the TCL scripting language. Various TCL objects have been created that provide an interface to existing EuroSim libraries. This means that a batch application is no more than an ordinary TCL script using EuroSim objects.

The TCL glue code is generated using SWIG. It is possible to generated wrapper code for multiple scripting languages using the same interface definition. The Java and Python interfaces are generated in the same manner.

The batch utility for TCL consists of various objects. Each object (or group of objects) is described in a separate chapter. The most important object is the Session class.

25.2 Session class

This is the central class used to run simulations. It supports the complete network protocol required to control the running simulator executable. For each command you can send to the simulator there is a function. In order to handle messages sent from the simulator to the application you can install event handlers. You can also wait synchronously for any message. The messages and responses are documented in detail in Chapter 28. The idea behind this class is that it is a replacement for the simulation controller. It can fully automate anything you can do with the simulation controller.
To start a simulator all you need to do is:

```
# load simulation definition
eurosim::Session s "some.sim"
# start simulator
s init
```

The constructor of the Session class uses the information in the simulation definition file to start the simulator.

As you can see you pass similar information to these calls as needed by the simulation controller. In the simulation controller you open a simulation definition file and then you can click on the Init button which launches the simulator. The simulation controller automatically connects to the simulator, just like the `init` method does. This function also sets up a number of standard event handlers for incoming events (messages) from the simulator. The information is stored in the session class. The user can at any moment print the contents of this structure by calling the `print_session_parameters` method.

To install a new event handler you have to add an event handler callback procedure. See Section 25.3.

It is also possible to synchronously wait for an event you expect. In this case you call the `wait_event` method with the name of the event (same name as the method in the event handler class) and a time-out (in milliseconds).

To synchronously wait for some time to pass, you can call `wait_event` with an empty string as the event name.

25.2.1 Monitoring variables

In order to monitor variables you must call the method `monitor_add` with the variable you want to monitor. The variable parameter is in the form of a valid EuroSim data dictionary path. This method will add the variable to the list of variables monitored in EuroSim. The value of each variable will be updated with a frequency of 2 Hz if they change. If there is no change, no update is sent.

The values of the variables are stored in the Session class. To get the value of a variable use the following expression: `s.monitor_value(var_path)`. The value is always returned as a string.

To stop monitoring a variable you must call the function `monitor_remove` with the variable you want to stop monitoring.

If you only want to get the value of a variable once, it is better to call the function `get_value`. This function retrieves the value of the variable immediately from the simulator, but only once. The value of the variable is returned as a string.

25.2.2 Modifying variables

If you want to change the value of a variable in the simulator you can simply call `set_value` with the name and value (as a string) of the variable. The value will be set as soon as possible in the simulator. Calling `set_value` also works on an array variables.

25.2.3 Method reference

25.2.3.1 Constructors

`eurosim::Session` *`session ?sim hostname?`*

Description

Creates a EuroSim simulation session by loading the given simulation definition file *sim*. The simulation run will be started on the host with the given hostname or on the current host if not specified.

Parameters

session The name of the new `Session` object

sim the simulation definition file name

hostname the name of the host on which to run the simulator

25.2.3.2 Methods

`cwd`

Description

Returns the path name of the current working directory of the simulator. The value is set by the event handler for event `maCurrentWorkingDir`.

Return value

Path name of the current working directory

`dict`

Description

Returns the path name of the EuroSim data dictionary of the simulator. The value is set by the event handler for event `maCurrentDict`.

Return value

Path name of the EuroSim data dictionary

`outputdir`

Description

Returns the path name of the directory where the output files of the simulator are stored (journal file, recorder files, etc.) The value is set by the event handler for event `maCurrentResultDir`.

Return value

Path name of the output directory

`state`

Description

Returns the simulator state. Can be: unconfigured, initialising, stand-by, executing, exiting. The value is set by the event handler for the following events: `rtUnconfigured`, `rtInitialising`, `rtStandby`, `rtExecuting` and `rtExiting`.

Return value

Simulator state

`set_remote_path`

Description

If client and server have different paths (e.g. A Windows client launching a simulator on a linux server) `set_remote_path` can be used to set the root path of the simulator in the remote EuroSim server. Note: When setting the remote path the recordings files and the EuroSim journal are stored in the /tmp directory on the server machine.

Return value

New paths for the simulator.

`journal`

Description

Returns the path name of the journal file.

Return value

Path name of the journal file

`schedule`

Description

Returns the path name of the schedule file.

Return value

Path name of the schedule file

`exports`

Description

Returns the path name of the exports file.

Return value

Path name of the exports file

---

alias *?alias?*

Description

Set or get the alias file name.

Parameters

alias Override the alias file specified in the SIM file. If *alias* was not specified, then the alias file remains unchanged.

Return value

Path name of the alias file. If the simulation is running, then the value is set by the event handler for event `maCurrentAliasFile`.

---

tsp_map *?tsp_map?*

Description

Set or get the TSP map file name.

Parameters

tsp_map Override the TSP map file specified in the SIM file. If *tsp_map* was not specified, then the TSP map file remains unchanged.

Return value

Path name of the TSP map file. If the simulation is running, then the value is set by the event handler for event `maCurrentTSPmapFile`.

---

model

Description

Returns the path name of the model file.

Return value

Path name of the model file

---

recording_bandwidth

Description

Returns the recorder bandwidth in bytes/second. The value is set by the event handler for event `maRecordingBandwidth`.

Return value

Recorder bandwidth in bytes/second

---

stimulator_bandwidth

Description

Returns the stimulator bandwidth in bytes/second. The value is set by the event handler for event `maStimulatorBandwidth`.

Return value

Stimulator bandwidth in bytes/second

---

speed

Description

Returns the clock acceleration factor achieved by the simulator. Values larger than 1 indicate faster than real-time. Values smaller than 1 indicate slower than real-time. The value is set by the event handler for event `scSpeed`.

Return value

Acceleration factor

`sim_time`

Description

Returns the simulation time (as seen by the running simulator). The value is set by the event handler for event `dtHeartBeat`.

Return value

Simulation time in seconds

`wallclock_time`

Description

Returns the wallclock time (as seen by the running simulator). The value is set by the event handler for event `dtHeartBeat`.

Return value

Wallclock time in seconds

`wallclock_boundary`

Description

Returns the wallclock boundary time to be used for timed state transitions. If you add an integer number of times the main cycle time to this value it will produce a valid state transition boundary time.

Return value

Wallclock time boundary in seconds

`simtime_boundary`

Description

Returns the simulation time boundary to be used for timed state transitions. If you add an integer number of times the main cycle time to this value it will produce a valid state transition boundary time.

Return value

Simulation time boundary in seconds

`main_cycle`

Description

Returns the main cycle time of the current schedule. It can be used to calculate valid boundary times for timed state transitions.

Return value

Main cycle in seconds.

`recording`

Description

Returns the flag indicating that recording is enabled or not. True means enabled, false means disabled. The value is set by the event handler for event `maRecording`.

Return value

Recording is enabled

---

write_access

Description

Returns the flag to indicate whether this client is allowed to change variable values in the simulator. The value is set by the event handler for event `maDenyWriteAccess`.

Return value

Client is allowed to change variables

---

time_mode

Description

Returns the time mode. It can be relative or absolute (UTC). Relative is 0 and absolute is 1. The value is set by the event handler for event `maCurrentTimeMode`.

Return value

Time mode

---

realtime

Description

Set or get the realtime mode.

Parameters

realtime If the realtime mode is not specified, then the realtime mode is not set. If *realtime* is 0, then realtime mode is disabled, otherwise it is enabled. The new setting will not effect an already running simulation.

Return value

The realtime mode, true for realtime, false for non-realtime. If a simulation is running, then the value as was set by the event handler for event `scGoRT` is reported. Non-realtime is the default.

---

auto_init *?auto_init?*

Description

Set or get the auto initialization flag.

Parameters

auto_init If the auto initialization flag is not specified, then the auto initialization flag is not set. If *auto_init* is 0, then the simulator will not go automatically to initializing state on startup, otherwise it will go automatically to initializing (this is the default). The new setting will not effect an already running simulation.

Return value

The auto_init flag, true if the state transition to initializing state is performed automatically, false if it isn't.

Automatic state transition to initializing is the default.

---

prefcon *?prefcon?*

Description

Set or get the preferred connection.

Parameters

prefcon The preferred connection. This can be used in a situation where you need to reconnect to an already running simulator. To start new simulation runs, this number is not used. If *prefcon* was not specified, then the preferred connection is not set.

Return value

Return the connection number of the current simulation session.

---

startup_timeout *?timeout?*

Description

Set or get the startup timeout.

The startup timeout default is 5 seconds. If starting up a simulator takes longer than this you must change that default to a higher value.

If *timeout* was not specified, then the startup timeout is not set.

Parameters

timeout The startup timeout.

Return value

Return the startup timeout in seconds of the current simulation session.

---

clientname *?clientname?*

Description

Set or get the name under which this session is known to the simulator.

Parameters

clientname The client name of the current simulation session. The default is "esimbatch". If *clientname* was not specified, then the client name is not changed.

Return value

Return the client name of the current simulation session.

---

initconds *?initconds?*

Description

Set or get the initial condition files.

Parameters

initconds Override the initial condition files specified in the SIM file. If *initconds* was not specified, then the initial condition files remain unchanged.

Return value

Initial condition files. If the simulation is running, then the value is set by the event handler for event `maCurrentInitconds`.

---

calibrations *?calibrations?*

Description

Set or get the calibration files.

Parameters

calibrations Override the calibration files specified in the SIM file. If *calibrations* was not specified, then the calibration files remain unchanged.

Return value

Calibration files. If the simulation is running, then the value is set by the event handler for event `maCurrentCalibrations`.

---

workdir *?workdir?*

Description

Set or get the work directory.

Parameters

workdir Use this directory as the work or project directory instead of the current directory.

Return value

The work directory.

---

user_defined_outputdir *?outputdir?*

Description

Set or get the user defined output directory.

Parameters

outputdir Use this output directory instead of the default *date/time* directory. If not set, then the user defined output directory is not changed.

Return value

The user defined output directory.

---

hostname *?hostname?*

Description

Set or get the EuroSim server hostname.

Parameters

hostname Use this EuroSim server. If not set, then the hostname is not changed.

Return value

The EuroSim server hostname.

---

sim *?sim hostname?*

Description

Set or get the simulation definition file.

This simulation definition file is used to start the simulator. Information derived from the simulation definition file is used to provide sensible defaults for all parameters.

Parameters

sim The simulation definition file. If not set, then the simulation definition is not changed.

hostname The EuroSim server hostname. If not set, then the local host is used instead.

Return value

The filename of the simulation definition file.

---

init

Description

Start a new simulation run.

Return value

1 on success, 0 on failure.

---

join_channel *channel*

Description

Join a channel of a simulation session. By default each session connects to all channels. The following channels are available: mdlAndActions, data-monitor, rt-control, sched-control. To join all channels use channel “all”.

Parameters

channel The channel to join.

Return value

1 on success, 0 on failure.

---

leave_channel *channel*

Description

Leave a channel of a simulation channel.

Parameters

channel The channel that you want to leave.

Return value

1 on success, 0 on failure.

---

event_addhandler *name cb*

Description

Add TCL event handler. The event handler is added to the end of the list if there are already event handlers installed for this event.

Parameters

name The name of the event.

cb The name of the callback function.

Return value

1 on success, 0 on failure.

---

event_removehandler *name cb*

Description

Remove callback function.

Parameters

name The name of the event.

cb The name of the callback function.

Return value

1 on success, 0 on failure.

---

wait_event *event timeout_ms*

Description

Wait for an incoming event

This function is used to wait synchronously for the given *event*. The timeout is used to limit the amount of time to wait for this event.

Parameters

event The name of the event to wait for. If the event name is empty this function can be used to read all pending events while waiting for the given amount of time.

timeout_ms The timeout in milliseconds. A value of -1 means that this this function will wait until the event arrives for an unlimited amount of time. A value of 0 means that the function will return immediately even if the event has not arrived yet.

Return value

true if the event had arrived, false if it has not.

---

monitor_add *path var*

Description

Monitor a variable.

The value of the variable is updated with 2 Hz.

Parameters

path The pathname of the variable from the data dictionary that you want to monitor.

var The name of the variable to use to store the monitored value in.

Return value

1 on success, 0 on failure.

---

monitor_value *var*

Description

Retrieve the value of a monitored variable

Parameters

var The name of the monitored variable.

Return value

the value of the variable

---

monitor_remove *var*

Description

Remove the monitor of a variable.

Parameters

var The variable from the data dictionary that should be removed from the monitor list.

Return value

1 on success, 0 on failure.

---

create_session_list *?hostname?*

Description

Create a list of all sessions and return the size of that list.

Parameters

hostname If set, then report the sessions running on that host. Otherwise report all sessions running on the subnet.

Return value

the number of sessions.

---

session_list *idx*

Description

Return the session info for the session with the given index.

Parameters

idx The index in the session list.

Return value

A `SessionInfo` object.

---

esim_connect

Description

Connect to a running simulation; a new journal file is opened.

Return value

1 on success, 0 on failure.

---

esim_disconnect

Description

Disconnect from the simulation session. The simulator will continue to run in the background.

---

print_monitored_vars

Description

Print a list of currently monitored variables and their current values. All variables in active monitors send values to the batch tool. A table with all variables is kept with their current values.

---

print_session_paramters

Description

Print a complete overview of all available parameters.

---

print_event_list

Description

Print a list of all events (messages) and parameters used in the communication between the test controller and the simulator.

---

script_action *name script ?condition?*

Description

Create an MDL script text.

Parameters

name The action name.

script The action script.

condition The optional condition.

Return value

The fully composed action script.

---

recorder_action *name freq vars*

Description

Create a recorder script.

Parameters

name The action name.

freq The recorder frequency.

vars A list of all variables to be recorded.

Return value

The fully composed recorder script.

---

stimulus_action *name option filename freq vars*

Description

Create a stimulus script.

Parameters

name The action name.

freq The stimulus frequency.

option An option string (“soft”, “hard” or “cyclic”).

filename The stimulus filename.

vars A list of all variables to serve as stimulus.

Return value

The fully composed stimulus script.

---

event_list_size

Description

Return the size of the list of events present in the schedule. The value is set by the event handler for the following events: `scEventListStart`, `scEventInfo`, `scEventListEnd`.

Return value

The size of the list of events.

---

event_list *idx*

Description

Return the event info of the event with the given index.

The value is set by the event handler for the following events: `scEventListStart`, `scEventInfo`, `scEventListEnd`.

Parameters

idx The index in the event list (the first element has index 0).

Return value

An `EventInfo` object.

---

where_list_size

Description

Return the size of the current breakpoint list.

The value is set by the event handlers for the following events: `scWhereListStart`, `scWhereEntry`, `scWhereListEnd`. It is cleared by the following events: `scStepTsk` and `scContinue`.

Return value

The size of the list.

---

where_list *idx*

Description

Return the current breakpoint with the given index.

The value is set by the event handlers for the following events: `scWhereListStart`, `scWhereEntry`, `scWhereListEnd`. It is cleared by the following events: `scStepTsk` and `scContinue`.

Parameters

idx The index in the current breakpoint list.

Return value

A `WhereInfo` object describing the break point location.

`task_list_size`

Description

Return the size of the task list.

The value is set by the event handler for events `scTaskListStart`, `scTaskStart`, `scTaskEntry`, `scTaskEnd` and `scTaskListend`. Each task consists of a number of entry points and a flag called disable. The disable flag is set by the event handler of `scTaskDisable`.

Return value

The size of the task list.

`task_list` *idx*

Description

Return the task info for the task with the given index.

The value is set by the event handler for events `scTaskListStart`, `scTaskStart`, `scTaskEntry`, `scTaskEnd` and `scTaskListend`. Each task consists of a number of entry points and a flag called disable. The disable flag is set by the event handler of `scTaskDisable`.

Parameters

idx The index in the task list.

Return value

A `TaskInfo` object.

`find_task_index` *taskname*

Description

Convert task name to index number.

Parameters

taskname The name of the task.

Return value

The index in the task list.

`mdl_list`

Description

Return a list of all loaded MDL files.

MDL files are loaded at start-up when a .sim file is loaded or during run-time when extra MDL files are loaded. Extra files can be loaded by the event handler for event `maNewMission` or by manually adding MDL files with new_scenario.

Return value

The list of MDL files.

`action_list` *mdl*

Description

Return a list with the names of all the actions.

Parameters

mdl The name of the MDL file.

Return value
The list of action names.

---

monitored_vars

Description
Return a list of all monitored variables.

Return value
The list of variables.

---

event_type_list_size

Description
Return the size of the event messages table.

Return value
The number of event messages.

---

event_type_list *idx*

Description
Return the event type info of event message *idx*.

Parameters
idx The index in the event messages table.

Return value
An `EventTypeInfo` object.

---

sev_to_string *sev*

Description
Return a string respresentation of a message severity

Parameters
sev Message severity

Return value
String representation of severity

---

go *?sec nsec?*

Description
Change the simulator state from stand-by to executing. Equivalent to the Go button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is specified as *sec* seconds and *nsec* nanoseconds.

Parameters
sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value
1 on success, 0 on failure.

---

stop *?sec nsec?*

Description

Stop the simulation run. Equivalent to the Stop button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

---

pause *?sec nsec?*

Description

Change the simulator state from executing to stand-by. Equivalent to the Pause button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

---

freeze *?sec nsec?*

Description

Change the simulator state from executing to stand-by. Equivalent to the Pause button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

---

freeze_at_simtime *sec ?nsec?*

Description

Change the simulator state from executing to stand-by on the specified simulation time. The simulation time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Simulation time (seconds)

nsec Simulation time (nanoseconds)

Return value

1 on success, 0 on failure.

---

step

Description

Perform one main scheduler cycle. Equivalent to the Step button of the test controller.

Return value

1 on success, 0 on failure.

---

abort

Description

Abort the current simulation run. Equivalent to the Abort button of the test controller.

Return value

1 on success, 0 on failure.

---

health

Description

Request a health check of the running simulator. Prints health information to the test controller.

Return value

1 on success, 0 on failure.

---

reset_sim

Description

Restart the current simulation with the current settings. Equivalent to the Reset button of the test controller.

Return value

1 on success, 0 on failure.

---

new_scenario *scen*

Description

Create a new scenario in the simulator. This new scenario is only a container for new actions. It is not a file on disk. It is a pure in core representation.

Parameters

scen The scenario name.

Return value

1 on success, 0 on failure.

---

open_scenario *scen*

Description

Open a new scenario file in the simulator with file name *scen*. The file must be on disk and readable.

Parameters

scen Scenario file name.

Return value

1 on success, 0 on failure.

---

close_scenario *scen*

Description

Close a currently opened scenario with name *scen* in the simulator.

Parameters

scen Scenario file name.

Return value

1 on success, 0 on failure.

---

new_action *scen action_text*

Description

Add a new action in the scenario file with name *scen*. *action_text* is the complete action text. There are a few utility functions to generate those actions.

Parameters

scen The scenario file name.

action_text The action text.

Return value

1 on success, 0 on failure.

---

delete_action *scen action*

Description

Delete an action from scenario *scen* with name *action*.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

---

action_execute *scen action*

Description

Trigger the execution of the action with name *action* in scenario with name *scen*. This is equivalent to triggering an action manually on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

---

action_activate *scen action*

Description

Make action with name *action* in scenario with name *scen* active in the running simulator. The action must already be defined in the scenario. This is equivalent to activating an action on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

---

action_deactivate *scen action*

Description

Deactivate action with name *action* in scenario with name *scen* in the running simulator. This is equivalent to deactivating an action on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

---

snapshot *?filename comment?*

Description

Make a snapshot of the current state of the variables in the data dictionary. The *comment* string is optional. If you omit the filename, a filename is chosen of the form snapshot *simtime*.snap. The snapshot is saved in the output directory, unless the filename is absolute. This is equivalent to the "Take Snaphot..." menu option in the "Control" menu of the test controller.

Parameters

filename Path name of the snapshot file.

comment Comment string

Return value

1 on success, 0 on failure.

---

mark *?comment?*

Description

Make a mark in the journal file. The *comment* string is optional. This is equivalent to the "Mark Journal" and "Comment Journal Mark" menu options in the "Insert" menu of the Simulation Controller.

Parameters

comment Comment string

Return value

1 on success, 0 on failure.

---

sim_message *msg*

Description

Send a message to the simulator for distribution to all clients. This is useful if your client application is not the only client of the simulator. The message is broadcasted to all clients.

Parameters

msg Message string

Return value

1 on success, 0 on failure.

---

suspend_recording

Description

Suspend recording in the simulator. This is equivalent to unchecking the "Enable Recordings" menu item of the "Control" menu of the Simulation Controller.

Return value

1 on success, 0 on failure.

---

resume_recording

Description

Resume recording in the simulator. This is equivalent to checking the "Enable Recordings" menu item of the "Control" menu of the Simulation Controller.

Return value

1 on success, 0 on failure.

---

recording_switch

Description

Switch all recording files of a simulation run. All currently open recorder files are closed and new recorder files are created. Recording will continue in the new recorder files.

Return value

1 on success, 0 on failure.

---

reload *snapfile ?hard?*

Description

Load initial condition file or snapshot file with file name *snapfile* into the running simulator. Parameter *hard* is by default "off". This means that the simulation time stored in the snapshot file is ignored. If *hard* is set to "on", the simulation time is set to the value specified in the snapshot file.

Parameters

snapfile Path name of snapshot file.

hard "on" or "off".

Return value

1 on success, 0 on failure.

---

set_value *var value*

Description

Set the value of a variable.

Parameters

var The data dictionary path name of variable you want to change.

value The new value as string. To set an array variable write the value as a comma seperated list between curly brackets. For example:

```
::s set_value "/Thrusters/force" "{1,2, 2, 3, 4, 5, 6, -2, 2}"
```

Return value

1 on success, 0 on failure.

---

get_value *var*

Description

Get the value of a variable.

Parameters

var The data dictionary path name of the variable

Return value

The value, empty on failure

---

cpu_load_set_peak *cpu peak_time*

Description

Configure the CPU load monitor peak time in msecs.

Parameters

cpu CPU number

peak_time Peak time in seconds.

Return value

1 on success, 0 on failure.

---

set_breakpoint *taskname entrynr enable*

Description

Set a breakpoint on entry nr *entrynr* in task *taskname* in the scheduler. If parameter *enable* is set to true the breakpoint is enabled. To disable it again set the parameter to false.

Parameters

taskname Name of the task.

entrynr Entry point number

enable true to enable, false to disable

Return value

1 on success, 0 on failure.

---

set_trace *taskname entrynr enable*

Description

Enable/disable tracing of entry points. Entry points are defined by specifying the number of the entry point *entrynr* (numbering starts at 0) and the name of the task *taskname*. To enable a trace set *enable* to true, to disable it set it to false. Tracing an entry point means that messages are printed to the journal window.

Parameters

taskname Name of the task.

entrynr Entry point number

enable true to enable, false to disable

Return value

1 on success, 0 on failure.

---

where

Description

Request the current position when the scheduler has stopped on a break point. The reply to the message is automatically stored and can be retrieved by using *where_list*. Normally the position is sent to the client whenever the scheduler hits a breakpoint. So there is rarely any need to request the position manually if you store the position on the client side (as is done in this tool.)

Return value

1 on success, 0 on failure.

---

step_task

Description
Perform one step (=one entry point) in the scheduler debugger.

Return value
1 on success, 0 on failure.

---

cont

Description
Continue executing upto the next breakpoint in the scheduler debugger.

Return value
1 on success, 0 on failure.

---

task_disable *taskname*

Description
Disable task with name *taskname* in the current schedule of the simulator.

Parameters
taskname Name of the task.

Return value
1 on success, 0 on failure.

---

task_enable *taskname*

Description
Enable task with name *taskname* in the current schedule of the simulator.

Parameters
taskname Name of the task.

Return value
1 on success, 0 on failure.

---

clear_breaks

Description
Remove all breakpoints in the current schedule of the simulator.

Return value
1 on success, 0 on failure.

---

clear_traces

Description
Remove all traces in the current schedule of the simulator.

Return value
1 on success, 0 on failure.

---

set_simtime *sec ?nsec?*

Description
Set the simulation time to *sec* seconds and *nsec* nanoseconds. This can only be done in stand-by state.

Parameters
sec Simulation time in seconds.

nsec Simulation time in nanoseconds.

Return value

1 on success, 0 on failure.

`enable_realtime`

Description

Switch to real-time mode. This can only be done when the simulator has started off in real-time mode, and has switched to non-real-time mode.

Return value

1 on success, 0 on failure.

`disable_realtime`

Description

Switch to non-real-time mode.

Return value

1 on success, 0 on failure.

`list_tasks`

Description

Request a list of all tasks in the current schedule of the simulator. The list is also sent automatically upon joining the "sched-control" channel.

Return value

1 on success, 0 on failure.

`list_events`

Description

Request a list of all events in the schedule of the simulator in all states. The list is automatically sent to the client when subscribing to the "sched-control" channel at start-up.

Return value

1 on success, 0 on failure.

`raise_event` *`eventname ?data size?`*

Description

Raise event with name *eventname* in the scheduler. An event is defined by the input connector on the scheduler canvas. The event is handled as fast as possible. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

`raise_event_at` *`eventname sec ?nsec data size?`*

Description

Raise event with name *eventname* in the schedler at a specified wallclock time. The wallclock time is specified as *sec* seconds and *nsec* nanoseconds. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

sec Wallclock time in seconds.

nsec Wallclock time in nanoseconds.

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

---

raise_event_at_simtime *eventname sec ?nsec data size?*

Description

Raise event with name *eventname* in the schedler at a specified simulation time. The simulation time is specified as *sec* seconds and *nsec* nanoseconds. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

sec Simulation time (seconds)

nsec Simulation time (nanoseconds)

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

---

set_speed *speed*

Description

Set the acceleration/deceleration of the scheduler of the simulator. Values smaller than 1 will cause a proportional deceleration of the scheduler clock. Values larger than 1 will cause a proportional acceleration of the scheduler clock. Magical value -1 means that the scheduler will run in an optimized as-fast-as-possible mode.

Parameters

speed acceleration factor

Return value

1 on success, 0 on failure.

---

add_MDL *mdlname*

Description

Load (another) new MDL file in the session.

Parameters

mdlname Path name of the MDL file.

Return value

1 on success, 0 on failure.

---

sync_send *token*

Description

Send sync token to simulator

Parameters

token synchronization token id

Return value

1 on success, 0 on failure

---

sync_recv *token*

Description

Wait for sync token from simulator

Parameters

token synchronization token id

Return value

1 on success, 0 on failure

---

kill *?signal?*

Description

Kill the simulator with signal *signal*. By default the simulator is killed with SIGTERM.

Parameters

signal Signal to send to the simulator

Return value

1 on success, 0 on failure

25.3 Event handler callbacks

Event handler callbacks can be installed to handle events coming from the simulator.

When a messsage from the simulator is received, first the built-in message handling is performed followed by the user defined message handlers. The message handlers are installed by calling the `event_addhandler` method of the `Session` object. The message handler is removed by calling the `event_removehandler` method.

To define a user defined message handler all you need to do is:

```
# handler for maMessage events
proc cb_message {s t1 t2 t3 t4 varargs} {
  puts "[lindex $varargs 1] [lindex $varargs 2]"
}

# install event handler
s event_addhandler maMessage cb_message
```

Each message type has a specific set of arguments apart from an initial set of standard arguments. The specific arguments are described in the next section. The initial set of standard arguments are:

session The `Session` object.

simtime_sec The simulation time (seconds part)

simtime_nsec The simulation time (nanoseconds part)

runtime_sec The wallclock time (seconds part)

runtime_nsec The wallclock time (nanoseconds part)

varargs The remaining message specific arguments.

25.3.1 Message reference

maNewMission *mission*

Description

A new mission (MDL) is created.

Parameters

mission The name of the mission.

---

maOpenMission *mission*

Description

A mission (MDL) file is opened.

Parameters

mission The filename of the mission file.

---

maCloseMission *mission*

Description

A mission (MDL) file is closed.

Parameters

mission The filename of the mission file.

---

maSimDef *simdef*

Description

Inform that client which simulation definition file is currently loaded.

Parameters

simdef The filename of the simulation definition file.

Return value

---

maCurrentDict *dict*

Description

Inform the client which data dictionary file is currently loaded.

Parameters

dict The filename of the data dictionary file.

Return value

---

maCurrentWorkingDir *cwd*

Description

Inform the client what the current working directory of the simulator is.

Parameters

cwd The path name of the current working directory.

---

maCurrentResultDir *result_dir*

Description

Inform the client what the result directory is. The result directory contains all the journal files, recorder files, snapshots and timings file.

Parameters

result_dir The path name of the result directory.

---

maCurrentAliasFile *filename*

Description

Inform the client what the alias file is. The alias file contains the data dictionary aliases.

Parameters

filename The path name of the alias file.

---

maCurrentTSPMapFile *filename*

Description

Inform the client what the TSP map file is. The TSP map file contains the TSP data dictionary path name map.

Parameters

filename The path name of the TSP map file.

---

maNewAction *mission actiontext*

Description

Inform the client that a new action has been created.

Parameters

mission The name of the mission.

actiontext The new action.

---

maDeleteAction *mission actionname*

Description

Inform the client that an action has been deleted.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionExecute *mission actionname*

Description

Inform the client that an action is being executed.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionExecuteStop *mission actionname*

Description

Inform the client that an action is no longer being executed.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionExecuting *mission actionname*

Description

Inform a newly connected client that the action is currently executing.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionActivate *mission actionname*

Description

Inform the client that an action has been activated. I.e. is allowed to execute.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maActionDeActivate *mission actionname*

Description

Inform the client that an action has been deactivated. I.e. is no longer allowed to execute.

Parameters

mission The name of the mission.

actionname The name of the action.

---

maExecuteCommand *name command action_mgr_nr*

Description

Inform the client that a one shot action has been executed.

Parameters

name The name of the action.

command The commands of the action.

action_mgr_nr The number of the action manager that has executed the action.

---

maSnapshot *snapshot comment*

Description

Handle maSnapshot event. This event is sent after a snapshot of the current simulator state has been made.

Parameters

snapshot Path name of the snapshot file.

comment Comment describing the snapshot.

---

maMark *message marknumber*

Description

Inform the client that a mark has been made in the journal file.

Parameters

message The descriptive message of the mark.

marknumber The number of the mark.

---

maMessage *sev msg*

Description

Inform the client that a message has been generated in the simulator. This message is also automatically logged in the journal file by the simulator.

Parameters

sev Severity of the message. The name of the severity can be retrieved by using the `sev_to_string()` method of the Session class.

process Name of the simulator thread from where the message was generated.

msg The message text.

---

maRecording *on_off*

Description

Inform the client that recording has been globally enabled/disabled.

Parameters

on_off If the string is equal to "on", recording is enabled. If it is "off" it is disabled.

---

maRecordingBandwidth *bandwidth*

Description

Report the bandwidth used to record data to disk.

Parameters

bandwidth Number of bytes per seconds written to disk.

---

maStimulatorBandwidth *bandwidth*

Description

Report the bandwidth used to read data from disk for stimulation.

Parameters

bandwidth Number of bytes per second read from disk.

---

maRecorderFileClosed *filename*

Description

Inform the client that a recorder file has been closed and can be used for further processing.

Parameters

filename The file name of the recorder file.

---

maDenyWriteAccess *denied*

Description

Inform the client that the write access to variables is denied. This is the case if the client has the role of observer.

Parameters

denied Flag to indicate denial of write access to the simulator variables.

---

maCurrentInitconds *simdef initconds*

Description

Inform the client of the current list of initial conditions as used for the initialization of the simulator.

Parameters

simdef The name of the simulation definition file.

initconds The list of initial condition files (space separated).

---

maCurrentCalibrations *simdef calibrations*

Description

Inform the client of the current list of calibration definition files as used by the simulator.

Parameters

simdef The name of the simulation definition file.

calibrations The list of calibration files (space separated).

---

maCurrentTimeMode *time_mode*

Description

Inform the client of the current time mode. The time mode can be relative time or absolute time (UTC mode).

Parameters

time_mode The time mode, 0 is relative time mode, 1 is absolute time mode (UTC mode).

---

maNewSeverity *sev sev_name*

Description

Inform the client about a new user-defined message severity. This message is automatically handled. The severity identifier can be mapped to its symbolic name using the `sev_to_string()` method of the Session class.

Parameters

sev The severity numerical identifier.

sev_name The symbolic name of the severity.

---

rtUnconfigured

Description

Inform the client that the state of the simulator is `unconfigured`. This state means that the simulator is either still starting up, or is in its final clean up phase. This is a transient state. When starting up, the next state will be `Initialising`. When cleaning up the last event will be `evShutdown`.

---

rtInitialising

Description

Inform the client that the state of the simulator is `initialising`. Depending on the schedule definition, this state will automatically be followed by the `standby` state. Otherwise you have to manually change the state to `standby` using the `eventStandby()` method of the Session() class.

`rtStandby`

Description

Inform the client that the state of the simulator is `standby`.

`rtExecuting`

Description

Inform the client that the state of the simulator is `executing`.

`rtExiting`

Description

Inform the client that the state of the simulator is `exiting`. This is a transient state. The next state will be the `unconfigured` state.

`rtTimeToNextState` *`sec nsec`*

Description

Report the time to the next state transition. This is useful when the major cycle is quite long (more than a couple of seconds). This can be the case if the schedule definition contains a clock with a very low frequency or when the lowest common denominator of the clocks results in a long major cycle.

Parameters

sec Time to next state (seconds part)

nsec Time to next state (nanoseconds part)

`rtMainCycle` *`sec nsec`*

Description

Report the length of the main cycle of the schedule.

Parameters

sec Main cycle (seconds part)

nsec Main cycle (nanoseconds part)

`scSetBrk` *`taskname entrynr enable`*

Description

Inform the client about the enabling/disabling of a break point on a specific entry point in a task in the schedule.

Parameters

taskname The name of the task.

entrynr The number of the entry point (counting starts at 0).

enable Whether the break point is enabled (1) or disabled (0).

`scStepTsk`

Description

Inform the client that a step to the next task has been performed in debugging mode.

`scContinue`

Description

Inform the client that the execution is now continued after being stopped on a break point in debugging mode.

---

scGoRT *enable*

Description

Inform the client that the real-time mode has changed.

Parameters

enable Real-time mode is enabled (true) or disabled (false).

---

scTaskDisable *taskname disable*

Description

Inform the client that a task has been disabled. This means that the task is no longer executed.

Parameters

taskname The name of the task.

disable The task is disabled (true), or enabled again (false).

---

scSetTrc *taskname entrynr enable*

Description

Inform the client that a trace has been set on an entry point in a task.

Parameters

taskname The name of the task.

entrynr The number of the entry point in the task (counting starts at 0).

enable The trace is enabled (true), or disabled (false).

---

scSpeed *speed*

Description

Report the speed of the scheduler clock. This is only relevant in non-real-time mode when going slower or faster than real time.

Parameters

speed Speed factor. 1 means real-time, less than 1 means slower than real-time, more than 1 means faster than real-time. E.g. 2 means two times faster than real-time.

---

scTaskListStart

Description

Start the description of the list of tasks.

---

scTaskStart *taskname enabled*

Description

Start the description of a task. This is followed by a number of scTaskEntry events, one for each entry in the order of execution in the task.

Parameters

taskname The name of the task

enabled The task is enabled (true), or disabled (false).

---

scTaskEntry *entryname breakpoint trace*

Description

Report information of an entry point in a task.

Parameters

entryname The name of the entry point.

breakpoint The entry point has a break point set (true) or not set (false).

trace The entry point is traced (true) or not (false).

---

scTaskEnd

Description

Report the end of the task information.

---

scTaskListEnd

Description

Report the end of the list of tasks.

---

scEventListStart

Description

Report the start of the list of schedule events.

---

scEventInfo *eventname state is_standard*

Description

Report all information about a specific schedule event.

Parameters

eventname The name of the event.

state The state in which it is present.

is_standard Whether or not it is a built-in (standard) event (true), or a user defined event (false).

---

scEventListEnd

Description

Report the end of the list of events.

---

scWhereListStart

Description

Report the start of the list of places where the scheduler has stopped execution when reaching a break point. As there are possibly more than 1 executers executing tasks, there can be multiple places where the execution has stopped.

---

scWhereEntry *taskname entrynr*

Description

Report a location where the execution has stopped.

Parameters

taskname The name of the task.

entrynr The number of the entry point (counting starts at 0).

---

scWhereListEnd

Description

End of the list of locations where the execution has stopped.

---

scEntrypointSetEnabled *entrypointname enabled*

Description

Report the enabling or disabling of the execution of an entry point. The execution of the entry point is disabled for all tasks and also when executing the entry point from MDL scripts.

Parameters

entrypointname The name of the entry point.

enabled Whether the entry point is enabled for execution (true), or disabled (false).

---

dtLogValueUpdate *var value*

Description

Report an updated value for a logged variable.

Parameters

var The name of the variable.

value The value of the variable.

---

dtHeartBeat

Description

This event is sent at 2 Hz by default and indicates that the simulator is still alive. It is also the last event sent after a series of dtLogValueUpdate events.

---

dtCpuLoad *cpu average peak*

Description

Report the load of a CPU.

Parameters

cpu CPU number

average Average load over a main cycle.

peak Peak load over a minor cycle.

---

evLinkData *link_id*

Description

Event that is used internally to transmit (TM/TC) packets. The actual data of the packet is not passed to this callback function. It is stored internally and can be retrieved using the `read()` method of the TmTcLink class.

Parameters

link_id The symbolic name of the link.

---

evExtSetData *view_id*

Description

Event that is used internally to update External Simulator Access views. The actual data of the event is not passed to this callback function. It is decoded and stored in the view variables and can be retrieved with the `get()` method of the ExtSimVar* classes.

Parameters

view_id The symbolic name of the view.

---

evShutdown *error_code error_string*

Description

Event that is received when the connection with the simulator is lost.

Parameters

error_code The value of errno at the time the connection was terminated. This value is zero when the connection was terminated in a normal way.

error_string The description of the error code.

---

evEventDisconnect

Description

Event that is received when the connection with the simulator is closed. This is normally done using the method `esim_disconnect()`.

25.4 eurosim class

This class contains a couple of utility methods that are not linked to a session.

25.4.1 Method reference

host_list

Description

Return the list of EuroSim hosts.

Return value

The list of hosts.

---

session_kill_by_name *simname ?signal hostname?*

Description

Kill a simulation session by name.

Parameters

simname The name of the session. This is normally the basename of the executable.

signal The signal to send to the session (default = SIGTERM)

hostname The name of the host where the session runs (default = localhost)

Return value

-1 if creating the connection with the EuroSim daemon on the host failed, 0 on success, otherwise the result is the value of errno of the failed kill system call or EPERM if you do not have the right permissions to kill the simulator or ESRCH if the simulator with the specified name could not be found.

---

session_kill_by_pid *pid ?signal hostname?*

Description

Kill a simulation session by pid.

Parameters

pid The process id of the session.

signal The signal to send to the session (default = SIGTERM)

hostname The name of the host where the session runs (default = localhost)

Return value

-1 if creating the connection with the EuroSim daemon on the host failed, 0 on success, otherwise the result is the value of errno of the failed kill system call or EPERM if you do not have the right permissions to kill the simulator or ESRCH if the simulator with the specified pid could not be found.

`open_log`

Description

Allows the client to log to a file. After opening the log file everything that is sent to stdout and to stderr is also logged to the spedified file.

Return value

0 if succeeded.

`close_log`

Description

Closes the log file created by `open_log`.

Return value

0 if succeeded.

25.5 EventInfo class

The EventInfo data is return by the `event_list` method of the Session class. The methods allow you to retrieve the individual attributes of a scheduler event.

25.5.1 Method reference

`name`

Description

Get the name of the event.

Return value

The name of the event

`state`

Description

Get the number of the state where this event is defined.

Return value

The number of the state.

`state_name`

Description

Get the name of the state where this event is defined.

Return value
The name of the state.

---

is_standard
Description
Whether the event is a standard event or a user defined event.
Return value
true if it is a standard event, false if it is a user defined event.

25.6 WhereInfo class

The WhereInfo data is return by the `where_list` method of the Session class. The methods allow you to retrieve the individual attributes of a scheduler break point location.

25.6.1 Method reference

name
Description
Get the name of the task where the scheduler is currently stopped.
Return value
The task name.

---

entrynr
Description
Get the entry point number of the current break point within the task.
Return value
The entry point number. Counting starts at 0.

25.7 EntryInfo class

The EntryInfo data is return by the `entry_list` method of the TaskInfo class. The methods allow you to retrieve the individual attributes of an entry point in a task.

25.7.1 Method reference

name
Description
Get the name of the entry point.
Return value
The name of the entry point.

---

breakpoint
Description
Get the break point status of the entry point.
Return value
True if a break point is set, false if not.

---

trace
Description
Get the trace status of the entry point.
Return value
True if a trace is set, false if not.

25.8 TaskInfo class

The TaskInfo data is return by the `task_list` method of the Session class. The methods allow you to retrieve the individual attributes of a task.

25.8.1 Method reference

`name`

Description

Get the name of the task.

Return value

The name of the task.

`disabled`

Description

Get the disabled state of the task.

Return value

True if the task is disabled, false if it is enabled.

`entry_list_size`

Description

Get the number of entry points of the task.

Return value

The number of entry points.

`entry_list` *`idx`*

Description

Get the entry point information of the entry point with the given index.

Parameters

idx The entry point index (counting starts at 0).

Return value

An `EntryInfo` object describing the entry point information.

25.9 EventTypeInfo class

The EventTypeInfo data is return by the `event_type_list` method of the Session class. The methods allow you to retrieve the individual attributes of a client/server message (called event internally).

25.9.1 Method reference

`name`

Description

Get the name of the message.

Return value

The name of the message.

`args`

Description
Get the argument types of the message. This is a character coded string with one character for each argument type.

Return value
The argument types.

`argdescr`

Description
Get a description of the arguments of the message.

Return value
The description of the arguments.

`id`

Description
Get the numerical identifier of the message.

Return value
The numerical identifier.

25.10 SessionInfo class

The SessionInfo data is return by the `session_list` method of the Session class. The methods allow you to retrieve the individual attributes of a simulation session.

25.10.1 Method reference

`sim_hostname`

Description
Get the host name running the simulation session.

Return value
The host name.

`sim`

Description
Get the simulation definition file.

Return value
The file name of the simulation definition file.

`workdir`

Description
Get the working directory.

Return value
The path name of the working directory.

`simulator`

Description
Get the simulator executable.

Return value
The path name of the executable.

`schedule`

Description
Get the simulator schedule.

Return value
The path name of the schedule file.

`scenarios`

Description
Get the list of scenario (MDL) files.

Return value
The list with path names of the MDL files.

`dict`

Description
Get the data dictionary file.

Return value
The path name of the data dictionary file.

`model`

Description
Get the model file.

Return value
The path name of the model file.

`recorderdir`

Description
Get the recorder directory.

Return value
The path name of the recorder directory.

`initconds`

Description
Get the list of initial condition files.

Return value
The list of path names of the initial condition files.

`calibrations`

Description
Get the list of calibration files.

Return value
The list of path names of the calibration files.

---

exports

Description

Get the exports file.

Return value

The path name of the exports file.

---

alias

Description

Get the alias file.

Return value

The path name of the alias file.

---

tsp_map

Description

Get the TSP map file.

Return value

The path name of the TSP map file.

---

timestamp

Description

Get the time stamp.

Return value

The time stamp.

---

prefcon

Description

Get the connection number. Each session has a connection number that can be used to connect a client to that session.

Return value

The connection number.

---

uid

Description

Get the UNIX user id of the user who started the simulator.

Return value

The user id.

---

gid

Description

Get the UNIX group id of the user who started the simulator.

Return value

The group id.

---

pid

Description

Get the UNIX process id of the simulation session.

Return value

The process id.

`realtime`

Description

Get the real-time state of the simulation session.

Return value

True if the simulator was started in real-time mode, false if it was started in non-real-time mode.

25.11 TmTcLink class

The TmTcLink class is used to create a packet link with a model in the simulator. The packet link can be used to send arbitrary packets (binary or not) to a simulator model and receive packets from a simulator model. Multiple packet links can be created. See Chapter 29 for detailed information on how to use the link.

25.11.1 Constructors

`eurosim::TmTcLink` *`link id mode`*

Description

Open one end of a TmTc link.

Parameters

link The name of the new `TmTcLink` object.

id The symbolic name of the TmTc link.

mode Mode is “r”, “w” or “rw”, similar to the modes of the fopen() function in the standard C library.

25.11.2 Method reference

`connect` *`s`*

Description

Connect the link to the other end in a running simulator.

Parameters

s The `Session` object of the running simulator.

Return value

-1 on failure, 0 on success.

`write` *`data`*

Description

Write a packet to the link.

Parameters

data The data (binary string).

Return value

The number of bytes sent or -1 on failure.

`read`

Description

Read data from the link.

Return value

The data read as a binary string.

25.12 InitCond class

This class is used for the manipulation of initial condition files. This allows the user to create a new initial condition file or modify an existing file. Individual values can be set or modified. It is also possible to merge two initial condition files.

25.12.1 Constructors

`eurosim::InitCond` *`ic filename dictfile`*

Description

Create a new set of initial conditions from an existing file.

Parameters

ic The name of the new `InitCond` object.

filename The initial condition file.

dictfile The path of the data dictionary file.

25.12.2 Method reference

`add` *`filename`*

Description

Merge an existing initial condition file with the current initial condition data.

Parameters

filename The path of the to-be-merged initial condition file.

Return value

true on success, false on failure.

`write` *`filename binary`*

Description

Write the initial condition data to a file.

Parameters

filename The path of the new initial condition file.

binary If true, write a binary file, otherwise write the data in human readable (ASCII) format.

Return value

true on success, false on failure.

`simtime`

Description

Return the simulation time of the initial condition file.

Return value

The simulation time.

---

comment

Description

Get the comment of in the initial condition file.

Return value

The comment string.

---

get_varlist_failed

Description

Get the list of variables in the initial condition file which were successfully loaded into the data dictionary.

Return value

The list of variables.

---

get_varlist_set

Description

Get the list of variables in the initial condition file which were successfully loaded into the data dictionary.

Return value

The list of variables.

---

var_value_get *path*

Description

Get the numerical value of a variable.

Parameters

path The data dictionary path.

Return value

The numerical value of the variable.

---

var_string_get *path*

Description

Get the string value of a variable.

Parameters

path The data dictionary path.

Return value

The string value of the variable.

---

var_value_set *path value*

Description

Set the numerical value of a variable.

Parameters

path The data dictionary path name.

value The new value.

Return value

true on success, false on failure.

---

var_string_set *path value*

Description

Set the string value of a variable.

Parameters

path The data dictionary path name.

value The new value.

Return value

true on success, false on failure.

---

list *?path?*

Description

Get a list of child node names beneath a parent node.

Parameters

path The path of the parent node (default the root "/").

Return value

The list of child node names.

25.13 ExtSimView class

This class wraps the External Simulator Access interface. Detailed information on the use of this interface can be found in Chapter 30.

25.13.1 Constructors

eurosim::ExtSimView *view session id*

Description

Create a new External Simulator Access view.

Parameters

view The name of the new `ExtSimView` object.

session The `Session` object of the simulation session.

id The symbolic identifier of the view.

25.13.2 Method reference

add *var*

Description

Add a variable to this view.

Parameters

var An `ExtSimVar` object of the variable to add to the view.

Return value

0 on success, -1 on failure.

---

connect *rw_flags frequency compression*

Description

Create a new view with the variables previously added to the view.

Parameters

rw_flags Read/write flags, 1 is read, 2 is write.

frequency Update frequency in Hz.

compression Compression type to be used for the data transmission. 0 is no compression, 1 means that unchanched values in the view are not transmitted. Please note that in case the whole view is not changed, no update is sent in any case.

Return value

0 is success, -1 is failure.

---

change_freq *frequency*

Description

Parameters

Change the update frequency of the view.

frequency The update frequency in Hz.

Return value

0 is success, -1 is failure.

---

send

Description

Send the view with the updated values to the simulator.

Return value

0 is success, -1 is failure.

25.14 ExtSimVar class

This is the base class of the ExtSimVar* classes. It is not to be used directly.

25.14.1 Method reference

type

Description

Get the variable type.

Return value

The variable type.

---

is_array

Description

Find out if the variable is an array variable.

Return value

true if it is an array.

---

is_fortran

Description

Find out if the variable is a Fortran variable. Only relevant for arrays, as the Fortran column/row order is different from C/Ada.

Return value
true if it is a Fortran variable.

---

nof_dims
Description
Get the number of dimensions of the array variable.
Return value
The number of array dimensions.

---

dims
Description
Get the dimensions of the array variable.
Return value
The array dimensions.

---

path
Description
Get the data dictionary path of the variable.
Return value
The data dictionary path.

---

size
Description
Get the size in bytes of the variable.
Return value
The size in bytes.

25.15 ExtSimVar* classes

Below are the derived classes of ExtSimVar described. All similar methods are grouped to reduce the amount of documentation that only repeats the same information again and again. Therefore only two different cases are documented. One for the single element case and one for the array case.
For both cases the following variants are possible: Char, Double, Float, Int, Long, Short, UnsChar, UnsInt, UnsLong and UnsShort.
For arrays there are two variants: ExtSimVar*Array and ExtSimVar*FortranArray.
To summarize for one type you can have the following classes: ExtSimVarChar, ExtSimVarCharArray and ExtSimVarCharFortranArray.

25.15.1 Constructors

eurosim::ExtSimVar* *var path*

eurosim::ExtSimVar*Array *var path dim0 ?dim1 dim2?*

eurosim::ExtSimVar*FortranArray *var path dim0 ?dim1 dim2?*
Description
Create a new variable to be used in an ExtSimView.
Parameters
var The name of the new `ExtSimVar*` object.
path The data dictionary path
dim0 The size of the first dimension.
dim1 The size of the second dimension.
dim2 The size of the third dimension.

25.15.2 Method reference

get *?idx0 idx1 idx2?*

Description

Get the value of a single variable or single array element. The variant without the idx* parameters is for a single variable, the others are for 1, 2 and 3 dimensional arrays.

Parameters

idx0 Index in first dimension.

idx1 Index in second dimension.

idx2 Index in third dimension.

Return value

The value of the variable. The type of the return value depends on the type of the function. The type mapping is listed above in the introduction.

---

set *val ?idx0 idx1 idx2?*

Description

Set the value of a single variable or single array element. The variant without the idx* parameters is for a single variable, the others are for 1, 2 and 3 dimensional arrays.

Parameters

val The new value. The type of the value depends on the type of the function. The type mapping is listed above in the introduction.

idx0 Index in first dimension.

idx1 Index in second dimension.

idx2 Index in third dimension.

Part V

Interface Reference Guide

Chapter 26

Hardware Interface reference

26.1 Introduction

EuroSim is often used in applications that require hardware interfaces. A typical example is a simulation setup where a control computer is executing in a simulated environment, or where a control computer with real sensors and actuators operate in a simulated environment to support verification or training. Models running in EuroSim then simulate or stimulate the equipment in such a manner that the control computer operates in an environment that equals its operational environment. To simulate or stimulate the equipment in such case, generally requires interfacing with realtime busses and synchronization with external clocks. Essential in such case is the response time of the simulation as jitter and latencies must be limted and guarded. It must be assured that the product under test is verified in an environment that matches the end situation, otherwise the measurements and thus the verification is not representative for the later operational use. Essential in such case is the timely exchange of data because the product under test in its intended environment operates in the real world. Often it is stated that modern computers are fast enough to assure that such response is in time, but only a hard real-time system as EuroSim can provide the assurance that that is actually the case, and will provide feedback if it isn't.

EuroSim Mk5.3 provides three different hardware interfaces [1]:

- External Clock Interface
- External Event Handler
- External Interface libraries

External Clock support allows EuroSim to be driven by an external clock source and use synchronized time sources. Details are described in Section 26.2. *External Event Handling* is essential for real-time (avionics) and allows a variety of events from external sources, such as interrupts, to trigger events in the schedule, including passing of messages. A detailed description of this interface can be found in Section 26.3. Finally, *External Interface libraries* , also called Userland libraries, provide additional code to make access to hardware easier. Further information can be found in Section 26.4.

Note that in the past, EuroSim integrated solutions for specific hardware into the EuroSim product. In the era of main frames and specialised computers such as the SGI systems the commonality of the hardware that was used was large and hence only a minimal set needed to be maintained. However, such approach no longer meets customer demand. In practice we find that customers prefer to be able to select and integrate their specific hardware. Since EuroSim Mk 5.3 the new strategy is therefore to open up the EuroSim hardware interface in a plugin approach and support the community by providing available plugins in source code format as example. Several plugins are made available by the consortium such as for the Aim Mil1553 APX-1 board, others are contributed by customers who prefer to see their plugin as part of the EuroSim distribution.

[1] Not supported on the Windows platform.

26.2 External Clock Interface

26.2.1 Introduction

External clock support provides the user with the capability to install an external clock as the EuroSim master clock. This involves two aspects

- Providing the heartbeat to the EuroSim scheduler via interrupts from the external device,
- Reading the time from the external clock instead of the internal computer clock.

Note that it is also possible to have an external driven heartbeat while reading the internal clock, for instance if time is synchronized over NTP.

Following sections describe the selection of an external clock (Section 26.2.2), the implementation of an external clock interface (Section 26.2.3), and alternative approach using NTP synchonization (Section 26.2.4) and the deprecated IRIG-B built-in support option (Section 26.2.5).

26.2.2 External Clock Selection

At startup of the Scheduler, EuroSim will install and initialise the clock that is configured in the ScheduleEditor. The available clocks in the ScheduleEditor depend on the operating system. The largest selection is provided on the Concurrent Redhawk platform as shown in figure 26.1.

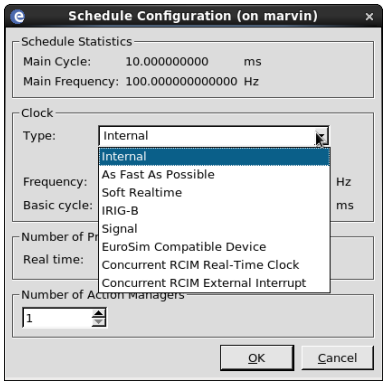


Figure 26.1: Available clocks on a Concurrent Redhawk operating system

:
The options offered are:

- *Internal clock:* This is the clock maintained on the motherboard.
- *Plugin clock:* This allows the user to select a plugin library for a clock
- *IRIG-B clock:* This utilizes an Irig-B card via the builtin support of the ModelEditor (see section Section 26.2.5).
- *RCIM clock:* Selecting this clock will read the time from the RCIM card, allowing GPS and RCIM chain synchronized clocks.
- *POSIX Signal:* Signals in the range RTMIN to RTMAX can be routed to the EuroSim master clock to drive the scheduler.
- *RCIM interrupt:* Ticking the EuroSim clock on the basis of the external interrupt input on the RCIM card

- *EuroSim Compatible Device (type 1):* Ticking the EuroSim clock on the basis of a EuroSim Compatible driver. These devices provide specific ioctl functions which EuroSim uses to wait for interrupts.See section Section 26.3.4.1 on how to make a driver EuroSim compatible.The plugin is preferred, this option is however still available.

In case of Windows, there is currently only the Internal clock. In case of Red Hat Linux there are several options, including the internal clock and a full external clock plugin solution, as well as a signal based and EuroSim compatible device externally triggered solution.

Note that the default basic frequency of the scheduler is 100 Hz, which means that one interrupt stands for 10 ms in real-time. The scheduler assumes that with every heartbeat the configured time interval has passed. For the internal clock and the two synchronizable external clocks, the user defined frequency configures the clock. For the interrupt clocks,however, the frequency defines only the assumed interval and the simulation time is incremented accordingly. If for the latter the interval between interrupts does not match the actual interval, the EuroSim simulation time will be faster of slower then realtime but your wallclock is not affected.

26.2.3 External Clock Plugin

The Plugin solution for clocks requires the user to build a shared library that implements the functions declared in the file esimClock.h which is provided in the include directory of the EuroSim installation. The user specifies the path to the shared library in the ScheduleEditor Connfiguration dialog that is part of the Tools menu:

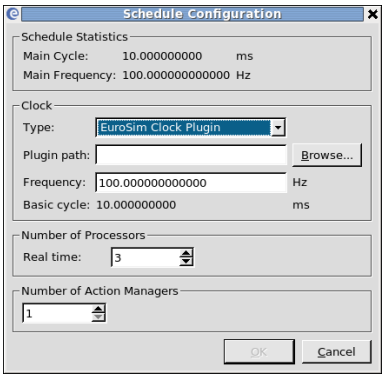


Figure 26.2: Specifying the location of the Clock Plugin in the ScheduleEditor

:
The functions to be implemented by the user in the plugin and declared in the esimClock.g header file are:

```
int esimClockOpen(void)
void esimClockClose(void)
int esimClockGetres(struct timespec *res)
int esimClockGettime(struct timespec *tp)
int esimClockTimerSettime(int id, const struct itimerspec *value)
int esimClockTimerWait(int id)
int esimClockTimerDelete(int id)
```

These functions are thus to be implemented by the developer of the plugin. The esimClock interface resembles the functions of the Posix clock and timer interface. The Open and Close calls allow opening a device and closing it, the unix conventions are followed thus on success zero is returned. The clock resolution is normally not required but can be implemented by setting the resulolution in the struct timespec that is passed as argument. The gettime function returns the current wallclock time to EuroSim

by setting the time read from a device in the passed timespec argument. The subsequent three time functions are passed an id, which has one of the following values as defined in esimClock.h:

```
#define ESIM_CLOCK_TIMER_ONESHOT  1  //!< timer id for oneshot timer
#define ESIM_CLOCK_TIMER_PERIODIC 2  //!< timer id for periodic timer
#define ESIM_CLOCK_TIMER_1PPS     3  //!< timer id for 1PPS timer
```

These values identify if the clock is periodic or single shot, and whether the device should wait to sync to 1PPS. It follows from the generic interface in EuroSim that all of these must be defined, but the user will initially see the 1PPS and subsequently the periodic id. When delaying the return when the 1PPS is passed in order to sync on 1PPS, EuroSim may give a timer error on startup, this however only occurs once on startup. You may ignore the calls with ID 1PPS if you do not require EuroSim to be started on a 1 second signal.

The esimClockTimerSettime then is used to set a timer on which TimerWait then waits for its expiration. Make sure the TimerSettime is setup for periodic alarms for a normal simulation. EuroSim will call esimClockTimerDelete to clean up a timer at the end of the simulation run.

As an example of a plugin implementation the examples provided with EuroSim contain an implementation of a Posix based plugin implementation. This example thus implements what is internally implemented in EuroSim for the Internal clock using a Plugin solution and hence does not need any special hardware.

26.2.4 NTP Synchronized clock

The External clock interfaces in the previous section illustrate how EuroSim can directly utilize specialized timing devices for either time or heartbeat or the combination thereof. There is however another approach that is utilized; slaving the internal clock to an external clock: NTP synchronization. This method is applied in test equipment by Airbus Defence and Space using a Meinberg Irig-B interface board that comes wiht the capability of using NTP to synchonize the onboard computer with the clock on the Meinberg card. The approach has proven to provide excellent result and only requires the configuration of the NTP solution in Linux systems.

Note that in this case EuroSim's wallclock is the hosts wallclock. This may be a problem when the time is switch to the future as the Eurosim license will check the host date and will state an expiration. If this is the case the plugin is the best solution or contact the EuroSim helpdesk to find an optimal approach for you specific case.

26.2.5 Irig-B (deprecated)

Any IRIG-B card can be used with EuroSim as long as the user provides a shared library that implements the interface specified in the include file `$EFOROOT/include/esim_irigb.h`. To use your own IRIG-B card, take these steps:

1. Write the glue layer between the userland library of your IRIG-B card and EuroSim by implementing the functions in `$EFOROOT/include/esim_irigb.h`. Compile this into a shared library with position independent code (-fPIC).
2. Edit `$EFOROOT/etc/EuroSim.capabilities`. Update the libs entry of the IRIG-B capability so that it mentions the name of your 'glue library'. The default setting is tfp, which will load libtfp.so for the Datum IRIG-B card.
3. Enable the capability 'IRIG-B support' in the build options of the ModelEditor.
4. If necessary, add the directory where you keep your 'glue library' to build options / loader options in the ModelEditor.
5. Select IRIG-B as time source in the ScheduleEditor.

26.3 External Event Handler

26.3.1 Introduction

The External Event Handler solution is essential when integrating a realtime device such as an avionics bus like Mil1553. The key to realtime systems is a seperation of control and data. In a non realtime streaming solution, the data is handled when convenient after arrival. On a realtime bus however, the data may only be available for a short time, and when they contain commands for a device, the response must be written to bus at a certain moment in time. In practice, interface devices that support such realtime busses are capable of sending an interrupt to signal to the simulation that it needs to take action, including paramters that define the current situation. Looking from the perspective of the EuroSim scheduler these interrupts are external events, which can need to be caught using an InputConnector on the schedule canvas which will trigger an association task. The standard InputConnectors however are associated with the scheduler heartbeat and thus pass on events in synchronization with the heartbeat of the scheduler, meaning at the start of a minor scheduler cycle. This delay may be far to slow for the realtime bus interface and therefore the user is able to create Event Handlers. An EventHandler owns a very high priority thread on a realtime processor in parallel to the executer threads that execute tasks. The EventHandler thread is blocked on an interrupt source and when awoken will take control of the processor core and raise an InputConnector that is associated with the EventHandler. The InputConnector will immediately activate all dependent tasks. The tasks follow the normal scheduling parameters that can be defined in the ScheduleEditor. Normally you want a high priority and other tasks shold not be non-preemptive to benefit from the very fast asynchonous event handling that Event Handler offer. There should not be more than one Eventhandler per core in the system.

Figure 26.3 illustrates the above explained event handler mechanism, showing the route from an interrupt from a device to a running task in the scheduler.

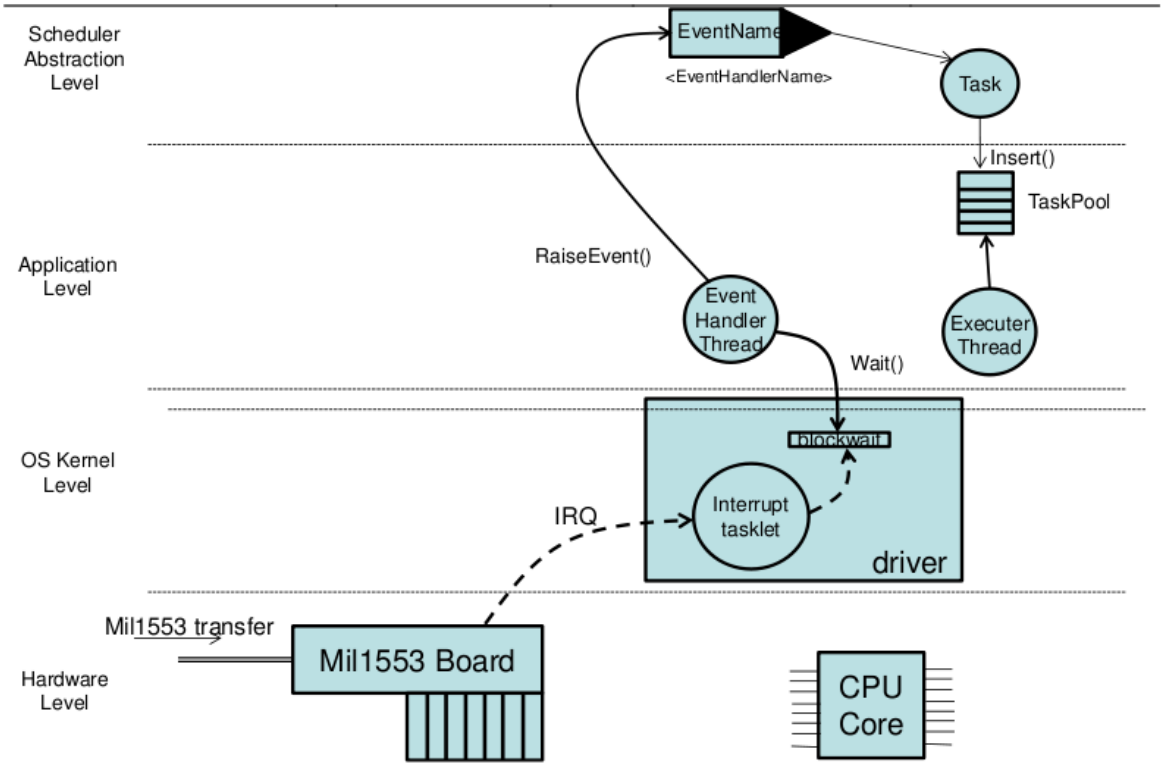


Figure 26.3: Architecture of the Event Handler mechanism

In some cases the OEM provides a device driver which creates a thread to handle interrupts from the

device. This approach will not be realtime as EuroSim isolates the processors and will push the thread to the remaining cores where it must compete with the rest of the system and is susceptible to for instance network hickups. The event handler solution is actually creating the thread in a manner that is guaranteeing fast response. In such case the EuroSim plugin solution may be used by copying the code that normally runs in the thread of the manufacturer into the event handler thread. In many cases the host computer will be fast enough, but it may fail without informing the user and hence test results are by definition unreliable.

Following sections explain how event handlers are defined and used in the Schedule Editor (Section 26.3.2, how they are programmed for the various options (Section 26.3.3 and (Section 26.3.4) and an elaborate example of implementation for a Mil1553 bus (Section 26.3.4.4).

26.3.2 ScheduleEditor Event Handler usage

The event handlers are defined in the scheduler editor with a specialized Event Handler Configuration dialog which can be found in the Tools menu.Here the user can choose what the source of the external event is. External events can be generated by:

- *EuroSim Compatible Device (type 1):* EuroSim compatible devices have device drivers adapted for EuroSim. These devices provide specific ioctl functions which EuroSim uses to wait for interrupts. The Type 1 device is the classic EuroSim compatible device which can not pass data to EuroSim in association to an interrupt
- *EuroSim Compatible Device (type 2):* This second generation of compatible devices has a different set of ioctls and do allow passing data with interrupt from the device ioctl to the EuroSim event handler.
- *EuroSim Compatible Plugins:* these are shared libraries (plugins) that are loaded by EuroSim from the path specified in the Event Handler Configuration dialog and must implement the functions defined in the include file esimEH.h. The plugin approach is the latest development and provides the same capabilities as the type 2 device, however allowing the user to implement how it accesses the available interface provided by the manufacturer instead of needing to modify the manfacturer's source code to add the EuroSim required interface.
- *Signals:* available are the signal numbers between `SIGRTMIN` and `SIGRTMAX` that are not used by EuroSim internally (use numbers above 39)
- POSIX *named semaphores:* see the manual page of sem_open. The semaphores can posted by any application on the same machine.

In the past the usage was mostly via the Compatible Device Type 1. This is expected to be replaced mostly by the plugin solution which gives much more flexibility to users. The Type 2 device is also suitable for those users that do not mind modifying drivers. The actual implementation required is not difficult, but programming at the kernel level easily leads to hangups of the system and is not for the faint at heart. The signals interface is sometimes usefull for debugging as it allows easy triggering of the event handler via the kill command on unix command line. The posix named spemaphores can be used for synchonization with other applications at the unix level, but are rarely used.

When configuring the Event Handlers the user can select either an Automatic or User Defined Event Handler. When configured automatic, there can only be one input connector which must have the same name as the Event Handler. These are intended for situations where the interrupt source is not further decoded in the Event Handler, but directly linked to an input connect. When configured as User Defined, the user can install a call-back which will be activated by the Event Handler when it wakes up. From this call-back the user can make a selection of which input connectors to raise defined on the ScheduleEditor canvas as long as they are associated with the Event Handler. Such selection can be made on the basis of data that is passed by the device with the interrupt or by accessing globally available memory in the driver to identify the cause of the interrupt. Quite often however users select Automatic as it is easier to

use and still data that is provided with the interrupt is passed on to the InputConnector, thus the user can fetch the data and decode it in a EuroSim entrypoint. Following is a listing of a EuroSim user defined event handler callback routing that decodes the data that is passed with the interrupt, as well as how this callback is installed:

26.3.3 Programming User Defined Event Handlers

User defined event handlers require the installation of a callback in the event handler through which the user can arrange which event in the schedule is to be raised and which data is to be passed to the InputConnector. The following interface is available for installing the event handler callback:

```
typedef int (*esimEventHandlerDispatchFunc)(esimEH *context,
                    const void* msg, int size,void* user_data);

int esimEventHandlerInstall(const char *name,
                    esimEventHandlerDispatchFunc dispatcher, void *user_data);

int esimEventHandlerDispatch(esimEH *context,
                    const char* name, const void *msg, int size);

int esimEventHandlerUninstall(const char *name);
```

The esimEventHandlerInstall function is used to install the callback function programmed by the user in the Event Handler with the provided name. That name must thus match an event handler defined via the Schedule Editor. The user_data argument is a pointer that is passed to the callback, on every activation. The callback is activated directly after the wait in the event handler unblocks. The arguments msg and size contain size number of bytes of information passed with the interrupt. The user should inspect this data in his code if the size is larger than zero and subsequently call the esimEventHandlerDispatch function to activate an InputConnector on the schedule canvas. The context parameter is a handle that refers to the EventHandler in which this user defined handler callback is activated. This must be passed to the call esimEventHandlerDispatch in addition to the name of the event, the size of the message to pass and a size argument to indicate how many bytes are passed to the input event. The task that is activated as a result of the InputConnector activation can use the esimEventGetData call to retrieve the message that was passed on from the event handler.

Example of external event handler user code:

```
#include <inttypes.h>
#include <string.h>
#include "esim.h"
#include "esimEH.h"

#define START_ID "Start"
#define STOP_ID "STOP"
#define SHUTDOWN_ID 2
#define ERROR_ID 3

#define START 0x04
#define STOP 0x05
#define PANIC 0x10

#define STREQ(a,b) (!strcmp(a,b))

enum hw_status {
  DO_RESET,
  INTERRUPT
};
```

```
extern enum hw_status hw_status_get(void);
extern void hw_reset(void);
extern int hw_data_get(void);
extern void hw_shutdown(void);

static int dispatcher(esimEH *context,
                const void* msg,
                int size,
                void *user_data)
{
  enum hw_status status = *(enum hw_status*)msg;
  int data;

  (void) user_data;      /* not used */
  (void) size;           /* not used */

  data = hw_data_get();
  switch (status) {
  case START:
    esimEventHandlerDispatch(context, "START" , &data, sizeof(data));
    break;
  case STOP:
    esimEventHandlerDispatch(context, "STOP", &data, sizeof(data));
    break;
  case PANIC:
    hw_shutdown();
    esimEventHandlerDispatch(context, "SHUTDOWN", &data, sizeof(data));
    esimEventHandlerDispatch(context, "HW_ERROR", &data, sizeof(data));
    break;
  default:
    break;
  }
  return 0;
}

/* function for event handler installation */
int event_handler_install(void)
{
  return esimEventHandlerInstall("HW_INT", dispatcher, NULL);
}

/* function for event handler uninstallation */
int event_handler_uninstall(void)
{
  return esimEventHandlerUninstall("HW_INT");
}

/* entry point raised by "START" */
void started(void)
{
  int hw_data;
  struct timespec occurrence,raise;

  int size = sizeof(hw_data);
  esimEventData(&hw_data, &size);
  esimEventTime(&occurrence,&raise);
  esimMessage("HW started: data = %d occurrence={%jd:%ld} raise={%jd:%ld}",
           hw_data,
           (intmax_t)occurrence.tv_sec, occurrence.tv_nsec,
           (intmax_t)raise.tv_sec, raise.tv_nsec);
```



```
}
```

An extensive example of the user defined event handler usage can be found in the AimMil1553 example passed with the EuroSim distribution. This example acutally receives the loglist from the driver that contains details on what caused the interrupt. For instance an end of scenario message is not necessarily passed to the EuroSim scheduler. However, if it is a reception of data at a subaddress and the user had defined in the MIL1553.cfg file that an interrupt is to be raised, then the labelname of the message is used to find the input connector to activate.

26.3.4 Programming Event Handler Plugins and Devices

External events such as interrupts are caught and transformed to EuroSim events by EuroSim Event-Handlers. The configuration of these event handlers can be performed via the Schedule Editor's Event Handler dialog. The Compatible devices and Event Handler Plugins are to be programmed by the user. For devices this usually requires the implementation of a small extension in the driver provided by the manufacturer, which is described in sections Section 26.3.4.1 and Section 26.3.4.2. For plugins it involves the implementation of a set of predefined functions and linking that code into a shared library, which is elaborated in section Section 26.3.4.3. For the plugin approach this is not required, but often usefull as the plugin may directly call the ioctls in the driver.

26.3.4.1 EuroSim compatible devices Type 1

The EuroSim compatibel device Type 1 is the classic EuroSim compatible device solution, availabel since EuroSim mk3. This solution requires the extension of a driver with three IOCTLs that are directly accessed from EuroSim to be able to handle the interrupt. For the EuroSim compatible devices approach it is required to have the source code from the manufacturer when extending a driver provided with an interface board. The user should verify that the driver source is provided as part of the board support package, preferably including tooling to build and install the driver. To make the driver into a EuroSim compatibel device the driver must be enhanced with three ioctl() commands: `OS_IOCTL_WAITINT` (95), `OS_IOCTL_BREAKWAITINT` (96) and `OS_IOCTL_GETIRQ` (97). These commands are defined in `osIntr.h`. The `OS_IOCTL_GETIRQ` command is optional.

- The call to `ioctl(OS_IOCTL_WAITINT)` must wait for an interrupt or an event to arrive. It must block forever if needed. It can only return on two occasions: an incoming interrupt (or event) or after an ioctl call with parameter `OS_IOCTL_BREAKWAITINT`. Whenever the call returns EuroSim expects that an interrupt (or event) has arrived.
- The call to ioctl with command `OS_IOCTL_BREAKWAITINT` is issued when the application exits or when the user calls `esimEHUninstall()`. This ensures that the thread blocking on the `ioctl(OS_IOCTL_WAITINT)` can terminate properly.
- The call to ioctl with command `OS_IOCTL_GETIRQ` is issued when the event handler is installed. If implemented, then this ioctl is to return the IRQ number used for interrupts sent by this driver. This IRQ number is used by EuroSim to ensure that the interrupts go only to the CPU where the event handler is running.

Note that if the device supports interrupts then the manufacturer usually already provides some IOCTLs related to interrupt handling. What the user needs to do is to relate the prescribed IOCTL numbers in the driver to this implementation as it is quite rare that the manufacturer chosen numbers and interface would exactly match that of EuroSim.

The existing type 1 enhanced drivers available with earlier versions of EuroSim are outdated. Of course the EuroSim consortium can develop drivers, but it very well possible to enhance a driver yourself into your own EuroSim compatible device type 1 driver. If desired the driver can be passed to the consortium for inclusion as example code in the distribution. The consortium can not maintain the driver, but the driver will be in a standard location and part of the distribution.

An example if a device type 1 driver can be found in the examples when the user has access to the Aim 1553 APX board support package. The patch file in the package will add the three IOCTLs to the driver. Below is an extract which shows the added IOCTLs in this driver. As can be seen the code added is minor and hooks into existing wait queues in the driver

26.3.4.2 EuroSim compatible devices Type 2

The EuroSim compatible device type 2 is more capable then the device type 1 as it can pass data with the interrupt. For instance the Aim Mil1553 driver from the manufacturer supports passing a loglist on return of an ioctl that contains all the reasons for interrupts. This is event data that is to be passed to EuroSim such that the event handler can decide which event to raise (e.g. transfer completion, data arrival, mode code braodcast received etc). The alternative would be that on receiving an interrupt the user code that is activated retreives the loglist and inspects registers. This however due to even a minor delay is not the situation encountered when the driver was processing the interrupt.

Similar to the Type 1 solution, the type 2 requires the driver to be enhanced with three ioctl() commands: `OS_IOCTL_WAITINTDATA` (98), `OS_IOCTL_BREAKWAITINTDATA` (99) and `OS_IOCTL_GETIRQ` (97). The command `OS_IOCTL_GETIRQ` is shared with the Type 1 solution and optional, but if not implemented EuroSim is not able to optimize the interrupt routing to the appropriate processor (core) thus all processors (cores) will receive the interrupt. As for type 1 compatible drivers, for the EuroSim compatible devices approach it is required to have the source code from the manufacturer when extending a driver provided with an interface board. The user should verify that the driver source is provided as part of the board support package, preferably including tooling to build and install the driver.

Being more capable, the Type 2 device also requires additional parameters with the ioctl calls. In particular the WAITINTDATA command is provided a block of memory that the ioctl can fill and on return will be forwarded as message to the event handler. This datablock is structured as:

```
struct {
int  size;            //input: bytes available, output: bytes filled
int  returnreason;    //1=data available 2=timeout (no user dispatch)
char returndata[512]; //free space for return data
} esimdata_t;
```

- The call to ioctl `OS_IOCTL_BREAKWAITINTDATA` is issued when the application exits or when the user calls `esimEHUninstall()`. This ensures that the thread blocking on the ioctl `(OS_IOCTL_WAITINTDATA)` can terminate properly. In case the `BREAKWAITINTDATA` has a timeout mechanism this IOCTL does not have to force a release of the `BREAKWAITINTDATA` ioctl, but it can provide a usefull service by passing a timeout value back to the Event Handler which states how long it is expected to take before the `WAITINT` will terminate. As for `WAITINTDATA` the memory space for the timeout value is provided as an unsigned pointer passed as argument to the ioctl call. Setting this value in the driver prevents EuroSim from terminating to quickly and generating errors on termination because the Event Handler thread has not terminated. This is an optimization however, it is not required and the user should typically first ignore this argument and see if an error arises.

- The call to ioctl `OS_IOCTL_WAITINTDATA` must wait for an interrupt or an event to arrive. It may have a timeout however, as long as it provides that information back as argument to the Event Handler as return reason. The Event Handler thread will then immediately call the `WAITINTDATA` again. The timeout is an alternative method used in drivers to assure that the ioctl is released to prevent a hang up of the system. The normal reason is of course is that an event has arrived, or the `BREAKWAITINTDATA` ioctl has been called, in which case the return reason should be data available.

- The call to ioctl with command `OS_IOCTL_GETIRQ` is issued when the event handler is installed. If implemented, then this ioctl is to return the IRQ number used for interrupts sent by this driver. This IRQ number is used by EuroSim to ensure that the interrupts go only to the CPU where the event handler is running.

26.3.4.3 EuroSim Compatible Plugin

The alternative for using a modified device driver is to implement an event handler plugin. The plugin code should include the esimEH.h header file, implement the prototyped plugin functions and link this into a dynamic library. EuroSim will on startup load the dynamic library from the path that is defined in the Event Handler Configuration dialog in the Schedule Editor and resolve the implemented functions such that they are called from the Event Handler thread.

Following are the prototypes of the to be implemented functions as defined in the esimEH header file:

```
int esimEventHandlerSetup(const char *handlername, int procesor,int *irq
,void **userarg, int (*esimreport)(int Severity, const char *fmt, ...));

int esimEventHandlerWait(const char *handlername, void *msg, int *size
,void *userarg,  int (*esimreport)(int Severity, const char *fmt, ...));

int esimEventHandlerWakeup(const char *handlername, unsigned *timeout
,void *userarg, int (*esimreport)(int Severity, const char *fmt, ...));

int esimEventHandlerClose(const char *handlername
,void *userarg, int (*esimreport)(int Severity, const char *fmt, ...));
```

Following elaboration of the functions explains the purpose and arguments of the functions. In all the functions the pointer userarg is a pointer to communicate private data amongst the EventHandler functions. Furthermore report is a function pointer to the eurosim esimReport function. With this function pointer the user thus calls the esimReport and logs information to either the daemon log or the log in the Simulation Controller depending on the state of the initialisation.

- *esimEventHandlerSetup* The Setup routine is called once during the initialisation of the scheduler to allow the user to setup the device that the event handler relates to. There can be multiple handlers active that use the same plugin potentially, therefore the routing is passed the name of the eventhandler for which it is called (defined in the Schedule Editor). Subsequently the user is provided the processor on which the event handler executes. Note that if such processor is 0, than the simulation is not running realtime. The irq number must be provided to EuroSim by the user to allow EuroSim to optimize the interrupt routing. Such information generally must be retrieved from the device or via the /proc file system.

- *esimEventHandlerWait* When the eventhandler calls the Wait function it expects to be blocked untill an interrupt occurs. Typically this means waiting on an ioctl as performed by the device type event handlers, but in this case the user can program how to do that and use the ioctl that is already available in the driver or use the library provided by the manufacturer. If there is data to be fed back to the eventhandler, then such data can eb copied to the buffer pointed to by msg. The length ofthe buffer is provided by *size. The user has to set *size to the amount of bytes copied into the buffer.

- *esimEventHandlerWakeup* When the event handler calls the Wakeup, the user should force the Wait function to return. This for instance is required when the user presses Abort in the simulation controller. The user can set the timeout to inform EuroSim on return of the function how long it will take to achieve the release.

- *esimEventHandlerClose* The eventhandler calls the close function on termination of the simulator. The user should use this opportunity to close the device access and clean up and memory.

26.3.4.4 Event Handler Example

Device type 1

The AIM code already contains an interrupt handling mechanism which logically does not match EuroSim s need but contains solutions that can be used as foundation The AIM interrupt handling solution fills an interrupt loglist and then wake-ups a queue to release their interrupt related ioctl which then releases the waiting thread that the userland library creates. In a EuroSim Compatible Device Type 1 solution the loglist is irrelevant, but the wakeup of the mechanization is the foundation for the release that is needed for EuroSim ioctl 95. To avoid spending computer cycled on filling the loglist, the driver is not told that a thread is waiting as is performed in the AIM interrupt ioctl, but we do block waiting on the associated queue. In the case of the pci code in `aim_common_com_api.c` the AIM driver always performs the wakeup, regardless of whether it filles the loglist. In the implementation of ioctl 95 a wait on the queue is performed which is then released by the wakeup. Beware that the queue immediately evaluates the condition, hence the condition must be false the first time it is tested and thereafter true. The side effect via the counter is required. In the case of USB the code is similar with a minor change as driver implementation follows a slightly different style and the wakeup needs to be forced in some conditions. The ioctl 96 can now be implemented with a wakeup on the queue; the oict can return the irq number.

Device type 2

The device type two more complex, but at the same time more similar to the AIM interrupt ioct (AIM-INTGET) implementation, hence easier maintainable in the future. The difference is that AIM sets up the data that is input to the ioct specifically for their ioctl, which EuroSim cannot do as its interface must be applicable to more situations then just this AIM driver. The difference between the EuroSim 98 IOCtl and the AIM_INT_GET ioctl is thus that the maximum number of entries to get from the drivers loglist is set in the driver and not passed as argument in the userland library. Additionally the loglist memory is not dynamically allocated in user space and connected to the loglist in the AIM defined structure but starts per EuroSim specification at byte 9 from the start of the argument passed to ioctl 98. The difference between PCI and USB, as for type 1, is only in the location of code where the style differs between the PCI and USB driver.

Plugin solution

The plugin solution that is available per EuroSim Mk5.3 does not require changes in the AIM board support package. The plugin is part of the test software provided with the real-time driver as well as that it will be included in the EuroSim Mk5.3 distribution when released. The plugin uses the same interface as the AIM user land library for the interrupt ioctl. It is unlikely that such interface changes, but if it does the userland library source of the newer release will use such newer interface and hence provides the showcase for the necessary the EuroSim plugin change.

26.4 External Interface libraries

26.4.1 Introduction

External Interface libraries are userland libraries that provide a higher level API to interface boards or devices in the computer. Often these libraries are provided by the hardware vendor of interface cards such as for mor exotic busses such as Mil1553 that are not standard part of the computer. Additionally for more used busses generic open source drivers may be found such as for CAN. For commondevices as COM, USB and ethernet the code is part of the operating system. There can still however be good reason to provide a library with EuroSim. Performance can be a reason for instance because the library from the manufacturer is not suitable for realtime use, creating for instance threads to handle interrupts or using slow ioctls instead of memory maps. Alternatively, the manufacturer or open source liubrary aims at supporting a larger set of uses cases, where an extra layer may make the library easier to use in a specific context. Finally, a reason for EuroSim to include such libraries in the past was to separate the model code from manufacturer specific implementations.

In line with the approach to solve hardware interfaces together with the community rather than delivering integrated hardware support, EuroSim now provides interface libraries as part of the examples in source

code. Users can verify and adapt the software to their specific needs. Adaptations that are submitted to the EuroSim helpdesk can be integrated into then next release or even a patch release, such that users are sure that they will receive the code as part of future distributions. If desired we will honor contributors the code, and include a SoftwareRelease note to state the status and last verification of the software. The source code for the existing EuroSim Serial interface for RS232 and RS422 has been moved to the SerialInterface example. The esimMil1553 interface is replaced by the AimMil1553 interface, which is currently fairly basic but will be expanded in future releases, hopefully with support from the User community.

As a general hint on developing external interface libraries, there are a number of points to consider:

- How do you initialize and configure the interface
- Are read and write operation non-blocking, otherwise either such operations need to be performed in a non real-time task, or in a seperate thread
- Are read and write operations realtime? Even when non-blocking, read and write operations that read data via kernel operations damage the realtime performance of EuroSim
- What dependency is created on the specific interface card versions

The source code in the src directory of the EuroSim installation can be used by all EuroSim users in their EuroSim based projects without copyright restrictions, we also ask that this is honored when you provide improvements back to the EuroSim helpdesk.

26.4.2 Serial interface

The example SerialInterface that is included in the src directory of the EuroSim installation provides non-blocking read and write operations for standard serial devices. The Serial interface uses the standard serial device drivers that already supports non-blocking access. However, data must be buffered on read failures (when not enough data is available). The Serial interface provides the initialization of the drivers and the buffering of data.

Before usage you may have to copy the directory to your local directory, adjust the directory and file rights and build using the makefile. Alternatively you can do this within the src/SerialInterface fdirectory if you have root rights (administrator task). For detailed information, see the *esimSerial* manual pages contained in the example.

26.4.3 Mil1553 interface

For usage in the avionics testbench at the European Space Agency, Airbus Defence and Space integrated the Aim 1553 APX board with EuroSim. This interface board has a rich API and provides the capability to simulate the bus controller and remote terminals as wel as monitoring busses. The event handling interface to the Linux driver has already been elaborated in the Event Handler section of this chapter. Airbus Defence and Space in addition extended the driver with code to support memory mapped access to read and write date from the board as fast as possible into this Linux driver. Aim has acknowledged the request to integrate this memory mapped access into future releases. Currently the AimMil1553 directory that is in the src directory of your EuroSim example contains a patch file for the 11.20 revision of the APX Linux bsp which the user can download from the Aim website. The example however also includes a higher level API that allows the user to quickly setup remote terminals, buscontroller and event handling. The library reads the definition from the user and subsequently programs the card in accordance to this definition. The library will check if memory mapped access is available and utilise that for fast access when found. There are still areas to expand on, such as error injection and configuration of communciation aspects as gap, online and offline terminals etc. but in general the library makes a good starting point and will provide the user with a system that is running very quickly. The interface is not implemented as a library, but as source code that can be included in EuroSim projects.

The concept of the Mil1553 interface is based on transferring messages. The fact that the MIl1553 bus is a realtime bus affects the moment of transfer of messages and the size of messages. A configuration file defines the Remote Terminals and Bus Controller simulation, the messages (or transfers in Mil1553 language) that can flow from either a Remote Terminal sub address to a Bus Controller subaddress or vice versa, and the minor and major frame. All of the elements have a label which is a string to be able to find a specific transfer. Read and Write routines then allow the user to read the data of a transfer from the interface board, or write the date for a transfer to the board memory. The momentum that such transfer must be performed is connected to the scheduler via the event handler interface, where in the configuration file it can be stated if an event should be raised on transfer completion (this part is explaing in the event handlers section). The essence is that the runtime API is thus simple: Initialise the device and read the configuration file, subsequently read and write transfers, terminate the unit when done. The control is decoupled as it should be for realtime busses, the timing is connected to the scheduler.

Following listing shows an example of an example MIL1553 configuration file:

```
# Common Settings

# Bus Controller Definition: minor cycletime(msec), #major cycles (0=endless), bus
BC:  50, 0, PRIM

# Remote Terminal Definition: Name, Address, bus (PRIM, SEC, BOTH)
RT:  GYR1_RT,  7, BOTH
RT:  GYR2_RT,  8, BOTH
RT:  RWL1_RT, 12, BOTH
RT:  RWL2_RT, 13, BOTH
RT:  RWL3_RT, 14, BOTH
RT:  THRM_RT, 23, BOTH
RT:  POWR_RT, 24, BOTH
RT:  PAYL_RT, 25, BOTH
RT:  BRDCST_RT, 31, BOTH

# Transfer Definition:
#XferName, From_name (RTname or BC), From_SA, To_name (BC or RTname), To_SA,
#          number of words, INTON || INTOFF voor interruptgeneration by RT receptio
#
#Note: To send a modecode, use 0 for SAs, the wordcount should then
#      be the modecode number

XFER: SYNC, BC, 0, BRDCST_RT, 0, 17, INTON
# Sensors and Actuator measurements

XFER: GYR1SA2BCRT, GYR1_RT, 2, BC, 2, 12, INTOFF
XFER: GYR2SA2BCRT, GYR2_RT, 2, BC, 3, 12, INTOFF
XFER: RWL1SA2BCRT, RWL1_RT, 2, BC, 2, 12, INTOFF
XFER: RWL2SA2BCRT, RWL2_RT, 2, BC, 2, 12, INTOFF
XFER: RWL3SA2BCRT, RWL3_RT, 2, BC, 2, 12, INTOFF
XFER: RWL4SA2BCRT, RWL4_RT, 2, BC, 2, 12, INTOFF
XFER: THRMSA2BCRT, THRM_RT, 2, BC, 2, 32, INTOFF
XFER: POWRSA2BCRT, POWR_RT, 2, BC, 2, 32, INTOFF
XFER: POWRSA3BCRT, POWR_RT, 3, BC, 3, 17, INTOFF

#Sensors and Actuator commands
XFER: GYR1SA2RTBC, BC, 2, GYR1_RT, 2, 1, INTOFF
XFER: GYR2SA2RTBC, BC, 2, GYR2_RT, 2, 1, INTOFF
```



```
XFER: RWL1SA2RTBC, BC, 2, RWL1_RT, 2, 5, INTOFF
XFER: RWL2SA2RTBC, BC, 2, RWL2_RT, 2, 5, INTOFF
XFER: RWL3SA2RTBC, BC, 2, RWL3_RT, 2, 5, INTOFF
XFER: POWRSA2RTBC, BC, 2, POWR_RT, 2, 2, INTOFF
XFER: SSMMSA2RTBC, BC, 2, SSMM_RT, 2, 2, INTOFF
XFER: PAYLSA2RTBC, BC, 2, PAYL_RT, 2, 11, INTOFF


#Minor Frame definition: Name, <comma seperated xfername list>
MINOR: MINOR1, SYNC,
               GYR1SA2BCRT, GYR2SA2BCRT,
               RWL1SA2BCRT, RWL2SA2BCRT, RWL3SA2BCRT,
               THRMSA2BCRT, POWRSA2BCRT, POWRSA3BCRT,
               RWL1SA2RTBC, RWL2SA2RTBC, RWL3SA2RTBC,
               POWRSA2RTBC, SSMMSA2RTBC, PAYLSA2RTBC


#Major Frame definition (there can only be one) <comma seperated list of mino
MAJOR: MINOR1


The API contains the following functions:
TODO elaborate API


The configuration file defines the BusController, Remote Terminals, Transfers
Syntax is

BC: minor_cycle_time, major_cycles (0=continuous), bus
where: minor_cycle_time is float in msec, bus is PRIM | SEC
RT: RT_label, RT_address, bus(PRIM | SEC |BOTH)
Where: RT_label=max 16 char
XFER: <xfer nlabel>, From_name, From_SA, To_name, To_SA, wordcount, interrupt
Where: From_name/To_name= BC | RT_label and From_SA/TO_SA the associated suba
Where: wordcount is integer number of mil words to be transferred
Where: interrupt_generation_request= INTOFF | INTON, where INTON generates an
Where: modecode transmission is achieved by all SAs zero and wordcount is mod
MINOR: minor_label { ,xfer label>}
MAJOR: minor_label {, minor_label }
```

This configuration file allows an easy definition of the remote terminals, transfers, minor frames and major frames in the Mil Bus scenario. The MILSTD1553 software programss the AIM card accordingly for all RTs and the BC. Entrypoints in the software then allow the user to either setup (open) the device in loopback mode or in transformer coupled mode, and provides a start function to initiate the bus controller scenario if desired. (In most cases the bus controller will be external and transformer (normal) coupled mode will be used. The API offered by the software allows the user to read or write the transfers that have been setup. The user thereto has to find the transfer by label name through the provided find functions which return the handle for read or write access. Additionally, for debugging, functions are provided that allow the user to read and write to explicit device-SubAddress combinations.

Interrupt generation is implemented in combination with the euroSim Mk5.3 eventhandler capabilities. The unit automatically installs an eventhandlerfunction. This function checks if an interrupt has an associated AIM loglist (Compatible Device II, EventHandler Plugin), and if so matches the loglist against the transfers that had INTON defined in the configuration file. If so an event is raised with the name of the label of the Transfer in the configuration file.

Usage in a EuroSim project is shown in the Aim1553 example. This example allows the user to time the performance of the software and hardware related to the Aim 1553APX as well as Aim 1553 APU USB board. The MMI shows an upperbound for the latency and an accurate measurement for the jitter. (The latency can only be measured from starting the buscontroller scenario upon hadling the event in EuroSim. The goal should be to time the latency from transfer completion to event handling, however additional hardware is needed to synchronize the clock onboard the Mil1553 to the computer clock via Irig-B.

26.4.4 VMICVEM6000 1553 interface (deprecated)

Before EuroSim Mk5.3 the EuroSim product baseline included the esimMil1553 interface. This interface was not sufficiently generic, and only implemented for the VMICVME-6000 interface board of SGI systems. This interface is deprecated but still available if desired. Users transitioning from IRIX will miss the line item in the ModelEditor support options. If needed this line can be reinstated by the user by uncommenting the related VMIC section in the EuroSim.capabilities file included in the etc directory of your EuroSim installation. System administrator priviledges are required to edit the file. Please inform the EuroSim helpdesk that you are still using this section to postpone the final removal of this capability from the EuroSim product.

Chapter 27

C++ Client Interface reference

27.1 Introduction

This chapter provides details on the batch interface for the C++ programming language. Various C++ classes have been created that provide an interface to existing EuroSim libraries. This means that a batch application is no more than a normal C++ client application using EuroSim classes.

The provided C++ classes form an object oriented interface to monitor and control EuroSim. The C++ interface is the foundation for the Batch scripting languages where SWIG is used to generate wrapper code for the bindings to the selected scripting languages. The behavior will thus be identical, but more usefull for external programs written in a compiled languaged.

The batch interface for C++ consists of various classes. Each class (or group of classes) is described in a separate chapter. The most important classes are the Session and EventHandler classes.

To compile and link a client application that uses the C++ Batch interface include the esimClient.h in your code and build your application using:

```
g++ client.cpp -o client -I$(EFOROOT)/include \
   -I$(EFOROOT)/include/esim -L$(EFOROOT)/$(ARCH) -lesClient++
```

Where ARCH should contain lib for 32-bit and lib64 for 64-bit operating systems (Windows always 32-bit), and where client should be replaced with the name of the client application

27.2 Session class

This is the central class used to run simulations. It supports the complete network protocol required to control the running simulator executable. There is a function for each command you can send to the simulator. In order to handle messages sent from the simulator to the application you can install an instance of an EventHandler class (see Section 27.3). You can also wait synchronously for any message. The messages and responses are documented in detail in Chapter 28. The idea behind this class for batch control is that it is a replacement for the simulation controller. It can fully automate anything you can do with the simulation controller. At the same time this provides an easy to use interface for any program that wants to interface with the running simulator.

To start a simulator all you need to do is:

```
using namespace eurosim;
Session *s = new Session("some.sim"); // load simulation definition
s->init();                    // start simulator
```

The constructor of the Session class uses the information in the simulation definition file to start the simulator.

As you can see you pass similar information to these calls as needed by the simulation controller. In the simulation controller you open a simulation definition file and then you can click on the Init button which launches the simulator. The simulation controller automatically connects to the simulator, just like the `init` method does. This function also sets up a number of standard event handlers for incoming events (messages) from the simulator. The information is stored in the session class. The user can at any moment print the contents of this structure by calling the `print_session_parameters` method.

To install a new event handler you have to create a derived class from the EventHandler class. The constructor of the class also installs the event handler such that the event handler methods are automatically called on each incoming event. To remove the event handlers call the `remove` method of the event handler class. See Section 27.3 for detailed information on each event handler class method.

It is also possible to synchronously wait for an event you expect. In this case you call the `wait_event` method with the name of the event (same name as the method in the event handler class) and a time-out (in milliseconds).

To synchronously wait for some time to pass, you can call `wait_event` with an empty string as the event name.

27.2.1 Monitoring variables

In order to monitor variables you must call the method `monitor_add` with the variable you want to monitor. The variable parameter is in the form of a valid EuroSim data dictionary path. This method will add the variable to the list of variables monitored in EuroSim. The value of each variable will be updated with a frequency of 2 Hz if they change. If there is no change, no update is sent.

The values of the variables are stored in the Session class. To get the value of a variable use the following expression: `s.monitor_value(var_path)`. The value is always returned as a string.

To stop monitoring a variable you must call the function `monitor_remove` with the variable you want to stop monitoring.

If you only want to get the value of a variable once, it is better to call the function `get_value`. This function retrieves the value of the variable immediately from the simulator, but only once. The value of the variable is returned as a string.

27.2.2 Modifying variables

If you want to change the value of a variable in the simulator you can simply call `set_value` with the name and value (as a string) of the variable. The value will be set as soon as possible in the simulator. Calling `set_value` also works on an array variables.

27.2.3 Method reference

27.2.3.1 Constructors

```
Session()
Session(std::string sim)
Session(std::string sim, std::string hostname)
```

Description

Creates a EuroSim simulation session by loading the given simulation definition file *sim*. The simulation run will be started on the host with the given hostname or on the current host if not specified.

Parameters

sim the simulation definition file name

hostname the name of the host on which to run the simulator

27.2.3.2 Methods

`std::string` **`cwd`**`()`

Description

Returns the path name of the current working directory of the simulator. The value is set by the event handler for event `maCurrentWorkingDir`.

Return value

Path name of the current working directory

`std::string` **`dict`**`()`

Description

Returns the path name of the EuroSim data dictionary of the simulator. The value is set by the event handler for event `maCurrentDict`.

Return value

Path name of the EuroSim data dictionary

`std::string` **`outputdir`**`()`

Description

Returns the path name of the directory where the output files of the simulator are stored (journal file, recorder files, etc.) The value is set by the event handler for event `maCurrentResultDir`.

Return value

Path name of the output directory

`std::string` **`state`**`()`

Description

Returns the simulator state. Can be: unconfigured, initialising, stand-by, executing, exiting. The value is set by the event handler for the following events: `rtUnconfigured`, `rtInitialising`, `rtStandby`, `rtExecuting` and `rtExiting`.

Return value

Simulator state

`void` **`set_remote_path`**`()`

Description

If client and server have different paths (e.g. A Windows client launching a simulator on a linux server) `set_remote_path` can be used to set the root path of the simulator in the remote EuroSim server.

Return value

None

`std::string` **`journal`**`()`

Description

Returns the path name of the journal file.

Return value

Path name of the journal file

`std::string` **`schedule`**`()`

Description

Returns the path name of the schedule file.

Return value

Path name of the schedule file

`std::string` **`exports`**`()`

Description

Returns the path name of the exports file.

Return value

Path name of the exports file

`std::string` **`alias`**`(std::string alias)`

`std::string` **`alias`**`()`

Description

Set or get the alias file name.

Parameters

alias Override the alias file specified in the SIM file. If *alias* was not specified, then the alias file remains unchanged.

Return value

Path name of the alias file. If the simulation is running, then the value is set by the event handler for event `maCurrentAliasFile`.

`std::string` **`tsp_map`**`(std::string tsp_map)`

`std::string` **`tsp_map`**`()`

Description

Set or get the TSP map file name.

Parameters

tsp_map Override the TSP map file specified in the SIM file. If *tsp_map* was not specified, then the TSP map file remains unchanged.

Return value

Path name of the TSP map file. If the simulation is running, then the value is set by the event handler for event `maCurrentTSPMapFile`.

`std::string` **`model`**`()`

Description

Returns the path name of the model file.

Return value

Path name of the model file

`double` **`recording_bandwidth`**`()`

Description

Returns the recorder bandwidth in bytes/second. The value is set by the event handler for event `maRecordingBandwidth`.

Return value

Recorder bandwidth in bytes/second

`double` **`stimulator_bandwidth`**`()`

Description

Returns the stimulator bandwidth in bytes/second. The value is set by the event handler for event `maStimulatorBandwidth`.

Return value

Stimulator bandwidth in bytes/second

`double` **`speed`**`()`

Description

Returns the clock acceleration factor achieved by the simulator. Values larger than 1 indicate faster than real-time. Values smaller than 1 indicate slower than real-time. The value is set by the event handler for event `scSpeed`.

Return value

Acceleration factor

`double` **`sim_time`**`()`

Description

Returns the simulation time (as seen by the running simulator). The value is set by the event handler for event `dtHeartBeat`.

Return value

Simulation time in seconds

`double` **`wallclock_time`**`()`

Description

Returns the wallclock time (as seen by the running simulator). The value is set by the event handler for event `dtHeartBeat`.

Return value

Wallclock time in seconds

`double` **`wallclock_boundary`**`()`

Description

Returns the wallclock boundary time to be used for timed state transitions. If you add an integer number of times the main cycle time to this value it will produce a valid state transition boundary time.

Return value

Wallclock time boundary in seconds

`double` **`simtime_boundary`**`()`

Description

Returns the simulation time boundary to be used for timed state transitions. If you add an integer number of times the main cycle time to this value it will produce a valid state transition boundary time.

Return value

Simulation time boundary in seconds

`double` **`main_cycle`**`()`

Description

Returns the main cycle time of the current schedule. It can be used to calculate valid boundary times for timed state transitions.

Return value

Main cycle in seconds.

`bool` **`recording`**`()`

Description

Returns the flag indicating that recording is enabled or not. True means enabled, false means disabled. The value is set by the event handler for event `maRecording`.

Return value

Recording is enabled

`bool` **`write_access`**`()`

Description

Returns the flag to indicate whether this client is allowed to change variable values in the simulator. The value is set by the event handler for event `maDenyWriteAccess`.

Return value

Client is allowed to change variables

`int` **`time_mode`**`()`

Description

Returns the time mode. It can be relative or absolute (UTC). Relative is 0 and absolute is 1. The value is set by the event handler for event `maCurrentTimeMode`.

Return value

Time mode

`bool` **`realtime`**`(bool realtime)`

`bool` **`realtime`**`()`

Description

Set or get the realtime mode.

Parameters

realtime If the realtime mode is not specified, then the realtime mode is not set. If *realtime* is 0, then realtime mode is disabled, otherwise it is enabled. The new setting will not effect an already running simulation.

Return value

The realtime mode, true for realtime, false for non-realtime. If a simulation is running, then the value as was set by the event handler for event `scGoRT` is reported. Non-realtime is the default.

`bool` **`auto_init`**`(bool auto_init)`

`bool` **`auto_init`**`()`

Description

Set or get the auto initialization flag.

Parameters

auto_init If the auto initialization flag is not specified, then the auto initialization flag is not set. If *auto_init* is 0, then the simulator will not go automatically to initializing state on startup, otherwise it will go automatically to initializing (this is the default). The new setting will not effect an already running simulation.

Return value

The auto_init flag, true if the state transition to initializing state is performed automatically, false if it isn't.

Automatic state transition to initializing is the default.

`int` **`prefcon`**`(int prefcon)`

`int` **`prefcon`**`()`

Description

Set or get the preferred connection.

Parameters

prefcon The preferred connection. This can be used in a situation where you need to reconnect to an already running simulator. To start new simulation runs, this number is not used. If *prefcon* was not specified, then the preferred connection is not set.

Return value

Return the connection number of the current simulation session.

`int` **`startup_timeout`**`(int timeout)`

`int` **`startup_timeout`**`()`

Description

Set or get the startup timeout.

The startup timeout default is 5 seconds. If starting up a simulator takes longer than this you must change that default to a higher value.

If *timeout* was not specified, then the startup timeout is not set.

Parameters

timeout The startup timeout.

Return value

Return the startup timeout in seconds of the current simulation session.

`std::string` **`clientname`**`(std::string clientname)`

`std::string` **`clientname`**`()`

Description

Set or get the name under which this session is known to the simulator.

Parameters

clientname The client name of the current simulation session. The default is "esimbatch". If *clientname* was not specified, then the client name is not changed.

Return value

Return the client name of the current simulation session.

`vector_string` **`initconds`**`(vector_string initconds)`

`std::string` **`initconds`**`()`

Description

Set or get the initial condition files.

Parameters

initconds Override the initial condition files specified in the SIM file. If *initconds* was not specified, then the initial condition files remain unchanged.

Return value

Initial condition files. If the simulation is running, then the value is set by the event handler for event `maCurrentInitconds`.

`vector_string` **`calibrations`**`(vector_string calibrations)`

`std::string` **`calibrations`**`()`

Description

Set or get the calibration files.

Parameters

calibrations Override the calibration files specified in the SIM file. If *calibrations* was not specified, then the calibration files remain unchanged.

Return value

Calibration files. If the simulation is running, then the value is set by the event handler for event `maCurrentCalibrations`.

`std::string` **`workdir`**`(std::string workdir)`

`std::string` **`workdir`**`()`

Description

Set or get the work directory.

Parameters

workdir Use this directory as the work or project directory instead of the current directory.

Return value

The work directory.

`std::string` **`user_defined_outputdir`**`(std::string outputdir)`

`std::string` **`user_defined_outputdir`**`()`

Description

Set or get the user defined output directory.

Parameters

outputdir Use this output directory instead of the default *date/time* directory. If not set, then the user defined output directory is not changed.

Return value

The user defined output directory.

`std::string` **`hostname`**`(std::string hostname)`

`std::string` **`hostname`**`()`

Description

Set or get the EuroSim server hostname.

Parameters

hostname Use this EuroSim server. If not set, then the hostname is not changed.

Return value

The EuroSim server hostname.

```
std::string sim(std::string sim, std::string hostname)
```

```
std::string sim(std::string sim)
```

```
std::string sim()
```

Description

Set or get the simulation definition file.

This simulation definition file is used to start the simulator. Information derived from the simulation definition file is used to provide sensible defaults for all parameters.

Parameters

sim The simulation definition file. If not set, then the simulation definition is not changed.

hostname The EuroSim server hostname. If not set, then the local host is used instead.

Return value

The filename of the simulation definition file.

```
int init()
```

Description

Start a new simulation run.

Return value

1 on success, 0 on failure.

```
int join_channel(std::string channel)
```

Description

Join a channel of a simulation session. By default each session connects to all channels. The following channels are available: mdlAndActions, data-monitor, rt-control, sched-control. To join all channels use channel “all”.

Parameters

channel The channel to join.

Return value

1 on success, 0 on failure.

```
int leave_channel(std::string channel)
```

Description

Leave a channel of a simulation channel.

Parameters

channel The channel that you want to leave.

Return value

1 on success, 0 on failure.

`bool` **`wait_event`**`(std::string event, int timeout_ms)`

Description

Wait for an incoming event

This function is used to wait synchronously for the given *event*. The timeout is used to limit the amount of time to wait for this event.

Parameters

event The name of the event to wait for. If the event name is empty this function can be used to read all pending events while waiting for the given amount of time.

timeout_ms The timeout in milliseconds. A value of -1 means that this this function will wait until the event arrives for an unlimited amount of time. A value of 0 means that the function will return immediately even if the event has not arrived yet.

Return value

true if the event had arrived, false if it has not.

`int` **`monitor_add`**`(std::string var)`

Description

Monitor a variable.

The value of the variable is updated with 2 Hz.

Parameters

var The variable from the data dictionary that you want to monitor.

Return value

1 on success, 0 on failure.

`std::string` **`monitor_value`**`(std::string var)`

Description

Retrieve the value of a monitored variable

Parameters

var The name of the monitored variable.

Return value

the value of the variable

`int` **`monitor_remove`**`(std::string var)`

Description

Remove the monitor of a variable.

Parameters

var The variable from the data dictionary that should be removed from the monitor list.

Return value

1 on success, 0 on failure.

`long` **`create_session_list`**`(std::string hostname)`

`long` **`create_session_list`**`()`

Description

Create a list of all sessions and return the size of that list.

Parameters

hostname If set, then report the sessions running on that host. Otherwise report all sessions running on the subnet.

Return value

the number of sessions.

`SessionInfo` **`session_list`**`(long idx)`

Description

Return the session info for the session with the given index.

Parameters

idx The index in the session list.

Return value

The session info.

`int` **`esim_connect`**`()`

Description

Connect to a running simulation; a new journal file is opened.

Return value

1 on success, 0 on failure.

`void` **`esim_disconnect`**`()`

Description

Disconnect from the simulation session. The simulator will continue to run in the background.

`void` **`print_monitored_vars`**`()`

Description

Print a list of currently monitored variables and their current values. All variables in active monitors send values to the batch tool. A table with all variables is kept with their current values.

`void` **`print_session_parameters`**`()`

Description

Print a complete overview of all available parameters.

`void` **`print_event_list`**`()`

Description

Print a list of all events (messages) and parameters used in the communication between the test controller and the simulator.

`std::string` **`script_action`**`(std::string name, std::string script, std::string condition)`

`std::string` **`script_action`**`(std::string name, std::string script)`

Description

Create an MDL script text.

Parameters

name The action name.

script The action script.

condition The optional condition.

Return value

The fully composed action script.

`std::string` **`recorder_action`**`(std::string name, double freq, vector_string vars)`

Description

Create a recorder script.

Parameters

name The action name.

freq The recorder frequency.

vars A list of all variables to be recorded.

Return value

The fully composed recorder script.

`std::string` **`stimulus_action`**`(std::string name, std::string option, std::string filename, double freq, vector_string vars)`

Description

Create a stimulus script.

Parameters

name The action name.

freq The stimulus frequency.

option An option string (“soft”, “hard” or “cyclic”).

filename The stimulus filename.

vars A list of all variables to serve as stimulus.

Return value

The fully composed stimulus script.

`long` **`event_list_size`**`()`

Description

Return the size of the list of events present in the schedule. The value is set by the event handler for the following events: `scEventListStart`, `scEventInfo`, `scEventListEnd`.

Return value

The size of the list of events.

`EventInfo` **`event_list`**`(long idx)`

Description

Return the event info of the event with the given index.

The value is set by the event handler for the following events: `scEventListStart`, `scEventInfo`, `scEventListEnd`.

Parameters

idx The index in the event list (the first element has index 0).

Return value
Event info.

`long` **`where_list_size`**`()`

Description
Return the size of the current breakpoint list.

The value is set by the event handlers for the following events: `scWhereListStart`, `scWhereEntry`, `scWhereListEnd`. It is cleared by the following events: `scStepTsk` and `scContinue`.

Return value
The size of the list.

`WhereInfo` **`where_list`**`(long idx)`

Description
Return the current breakpoint with the given index.

The value is set by the event handlers for the following events: `scWhereListStart`, `scWhereEntry`, `scWhereListEnd`. It is cleared by the following events: `scStepTsk` and `scContinue`.

Parameters
idx The index in the current breakpoint list.

Return value
The breakpoint location.

`long` **`task_list_size`**`()`

Description
Return the size of the task list.

The value is set by the event handler for events `scTaskListStart`, `scTaskStart`, `scTaskEntry`, `scTaskEnd` and `scTaskListend`. Each task consists of a number of entry points and a flag called disable. The disable flag is set by the event handler of `scTaskDisable`.

Return value
The size of the task list.

`TaskInfo` **`task_list`**`(long idx)`

Description
Return the task info for the task with the given index.

The value is set by the event handler for events `scTaskListStart`, `scTaskStart`, `scTaskEntry`, `scTaskEnd` and `scTaskListend`. Each task consists of a number of entry points and a flag called disable. The disable flag is set by the event handler of `scTaskDisable`.

Parameters
idx The index in the task list.

Return value
The task info

`long` **`find_task_index`**`(std::string taskname)`

Description
Convert task name to index number.

Parameters

taskname The name of the task.

Return value

The index in the task list.

`vector_string` **`mdl_list`**`()`

Description

Return a list of all loaded MDL files.

MDL files are loaded at start-up when a .sim file is loaded or during run-time when extra MDL files are loaded. Extra files can be loaded by the event handler for event `maNewMission` or by manually adding MDL files with new_scenario.

Return value

The list of MDL files.

`vector_string` **`action_list`**`(std::string mdl)`

Description

Return a list with the names of all the actions.

Parameters

mdl The name of the MDL file.

Return value

The list of action names.

`vector_string` **`monitored_vars`**`()`

Description

Return a list of all monitored variables.

Return value

The list of variables.

`long` **`event_type_list_size`**`()`

Description

Return the size of the event messages table.

Return value

The number of event messages.

`EventTypeInfo` **`event_type_list`**`(long idx)`

Description

Return the event type info of event message *idx*.

Parameters

idx The index in the event messages table.

Return value

The event type info.

`std::string` **`sev_to_string`**`(int sev)`

Description

Return a string respresentation of a message severity

Parameters

sev Message severity

Return value

std::string representation of severity

```
int go(int sec, int nsec)
```

```
int go(int sec)
```

```
int go()
```

Description

Change the simulator state from stand-by to executing. Equivalent to the Go button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is specified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

```
int stop(int sec, int nsec)
```

```
int stop(int sec)
```

```
int stop()
```

Description

Stop the simulation run. Equivalent to the Stop button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

```
int pause(int sec, int nsec)
```

```
int pause(int sec)
```

```
int pause()
```

Description

Change the simulator state from executing to stand-by. Equivalent to the Pause button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

`int` **`freeze`**`(int sec, int nsec)`

`int` **`freeze`**`(int sec)`

`int` **`freeze`**`()`

Description

Change the simulator state from executing to stand-by. Equivalent to the Pause button of the test controller. The variant specifying the time is used for timed state transitions. The wallclock time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Wallclock time (seconds)

nsec Wallclock time (nanoseconds)

Return value

1 on success, 0 on failure.

`int` **`freeze_at_simtime`**`(int sec, int nsec)`

`int` **`freeze_at_simtime`**`(int sec)`

Description

Change the simulator state from executing to stand-by on the specified simulation time. The simulation time is secified as *sec* seconds and *nsec* nanoseconds.

Parameters

sec Simulation time (seconds)

nsec Simulation time (nanoseconds)

Return value

1 on success, 0 on failure.

`int` **`step`**`()`

Description

Perform one main scheduler cycle. Equivalent to the Step button of the test controller.

Return value

1 on success, 0 on failure.

`int` **`abort`**`()`

Description

Abort the current simulation run. Equivalent to the Abort button of the test controller.

Return value

1 on success, 0 on failure.

`int` **`health`**`()`

Description

Request a health check of the running simulator. Prints health information to the test controller.

Return value

1 on success, 0 on failure.

`int` **`reset_sim`**`()`

Description

Restart the current simulation with the current settings. Equivalent to the Reset button of the test controller.

Return value

1 on success, 0 on failure.

`int` **`new_scenario`**`(std::string scen)`

Description

Create a new scenario in the simulator. This new scenario is only a container for new actions. It is not a file on disk. It is a pure in core representation.

Parameters

scen The scenario name.

Return value

1 on success, 0 on failure.

`int` **`open_scenario`**`(std::string scen)`

Description

Open a new scenario file in the simulator with file name *scen*. The file must be on disk and readable.

Parameters

scen Scenario file name.

Return value

1 on success, 0 on failure.

`int` **`close_scenario`**`(std::string scen)`

Description

Close a currently opened scenario with name *scen* in the simulator.

Parameters

scen Scenario file name.

Return value

1 on success, 0 on failure.

`int` **`new_action`**`(std::string scen, std::string action_text)`

Description

Add a new action in the scenario file with name *scen*. *action_text* is the complete action text. There are a few utility functions to generate those actions.

Parameters

scen The scenario file name.

action_text The action text.

Return value

1 on success, 0 on failure.

`int` **`delete_action`**`(std::string scen, std::string action)`

Description

Delete an action from scenario *scen* with name *action*.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

`int` **`action_execute`**`(std::string scen, std::string action)`

Description

Trigger the execution of the action with name *action* in scenario with name *scen*. This is equivalent to triggering an action manually on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

`int` **`action_activate`**`(std::string scen, std::string action)`

Description

Make action with name *action* in scenario with name *scen* active in the running simulator. The action must already be defined in the scenario. This is equivalent to activating an action on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

`int` **`action_deactivate`**`(std::string scen, std::string action)`

Description

Deactivate action with name *action* in scenario with name *scen* in the running simulator. This is equivalent to deactivating an action on the scenario canvas of the Simulation Controller.

Parameters

scen The scenario file name.

action The action name.

Return value

1 on success, 0 on failure.

`int` **`snapshot`**`(std::string filename, std::string comment)`

`int` **`snapshot`**`(std::string filename)`

`int` **`snapshot`**`()`

Description

Make a snapshot of the current state of the variables in the data dictionary. The *comment* string is optional. If you omit the filename, a filename is chosen of the form snapshot *simtime*.snap. The snapshot is saved in the output directory, unless the filename is absolute. This is equivalent to the "Take Snaphot..." menu option in the "Control" menu of the test controller.

Parameters

filename Path name of the snapshot file.

comment Comment string

Return value

1 on success, 0 on failure.

`int` **`mark`**`(std::string comment)`

`int` **`mark`**`()`

Description

Make a mark in the journal file. The *comment* string is optional. This is equivalent to the "Mark Journal" and "Comment Journal Mark" menu options in the "Insert" menu of the Simulation Controller.

Parameters

comment Comment string

Return value

1 on success, 0 on failure.

`int` **`sim_message`**`(std::string msg)`

Description

Send a message to the simulator for distribution to all clients. This is useful if your client application is not the only client of the simulator. The message is broadcasted to all clients.

Parameters

msg Message string

Return value

1 on success, 0 on failure.

`int` **`suspend_recording`**`()`

Description

Suspend recording in the simulator. This is equivalent to unchecking the "Enable Recordings" menu item of the "Control" menu of the Simulation Controller.

Return value

1 on success, 0 on failure.

`int` **`resume_recording`**`()`

Description

Resume recording in the simulator. This is equivalent to checking the "Enable Recordings" menu item of the "Control" menu of the Simulation Controller.

Return value

1 on success, 0 on failure.

`int` **`recording_switch`**`()`

Description

Switch all recording files of a simulation run. All currently open recorder files are closed and new recorder files are created. Recording will continue in the new recorder files.

Return value

1 on success, 0 on failure.

```
int reload(std::string snapfile, std::string hard)
```

```
int reload(std::string snapfile)
```

Description

Load initial condition file or snapshot file with file name *snapfile* into the running simulator. Parameter *hard* is by default "off". This means that the simulation time stored in the snapshot file is ignored. If *hard* is set to "on", the simulation time is set to the value specified in the snapshot file.

Parameters

snapfile Path name of snapshot file.

hard "on" or "off".

Return value

1 on success, 0 on failure.

```
int set_value(std::string var, std::string value)
```

Description

Set the value of a variable.

Parameters

var The data dictionary path name of variable you want to change.

value The new value as string. To set an array variable write the value as a comma seperated list between curly brackets. For example:

```
::s set_value "/Thrusters/force" "{1,2, 2, 3, 4, 5, 6, -2, 2}"
```

Return value

1 on success, 0 on failure.

```
std::string get_value(std::string var)
```

Description

Get the value of a variable.

Parameters

var The data dictionary path name of the variable

Return value

The value, empty on failure

```
int cpuload_set_peak(int cpu, int peak_time)
```

Description

Configure the CPU load monitor peak time in msecs.

Parameters

cpu CPU number

peak_time Peak time in seconds.

Return value

1 on success, 0 on failure.

```
int set_breakpoint(std::string taskname, int entrynr, bool enable)
```


Description

Set a breakpoint on entry nr *entrynr* in task *taskname* in the scheduler. If parameter *enable* is set to true the breakpoint is enabled. To disable it again set the parameter to false.

Parameters

taskname Name of the task.

entrynr Entry point number

enable true to enable, false to disable

Return value

1 on success, 0 on failure.

`int` **`set_trace`**`(std::string taskname, int entrynr, bool enable)`

Description

Enable/disable tracing of entry points. Entry points are defined by specifying the number of the entry point *entrynr* (numbering starts at 0) and the name of the task *taskname*. To enable a trace set *enable* to true, to disable it set it to false. Tracing an entry point means that messages are printed to the journal window.

Parameters

taskname Name of the task.

entrynr Entry point number

enable true to enable, false to disable

Return value

1 on success, 0 on failure.

`int` **`where`**`()`

Description

Request the current position when the scheduler has stopped on a break point. The reply to the message is automatically stored and can be retrieved by using *where_list*. Normally the position is sent to the client whenever the scheduler hits a breakpoint. So there is rarely any need to request the position manually if you store the position on the client side (as is done in this tool.)

Return value

1 on success, 0 on failure.

`int` **`step_task`**`()`

Description

Perform one step (=one entry point) in the scheduler debugger.

Return value

1 on success, 0 on failure.

`int` **`cont`**`()`

Description

Continue executing upto the next breakpoint in the scheduler debugger.

Return value

1 on success, 0 on failure.

`int` **`task_disable`**`(std::string taskname)`

Description

Disable task with name *taskname* in the current schedule of the simulator.

Parameters

taskname Name of the task.

Return value

1 on success, 0 on failure.

`int` **`task_enable`**`(std::string taskname)`

Description

Enable task with name *taskname* in the current schedule of the simulator.

Parameters

taskname Name of the task.

Return value

1 on success, 0 on failure.

`int` **`clear_breaks`**`()`

Description

Remove all breakpoints in the current schedule of the simulator.

Return value

1 on success, 0 on failure.

`int` **`clear_traces`**`()`

Description

Remove all traces in the current schedule of the simulator.

Return value

1 on success, 0 on failure.

`int` **`set_simtime`**`(int sec, int nsec)`

`int` **`set_simtime`**`(int sec)`

Description

Set the simulation time to *sec* seconds and *nsec* nanoseconds. This can only be done in stand-by state.

Parameters

sec Simulation time in seconds.

nsec Simulation time in nanoseconds.

Return value

1 on success, 0 on failure.

`int` **`enable_realtime`**`()`

Description

Switch to real-time mode. This can only be done when the simulator has started off in real-time mode, and has switched to non-real-time mode.

Return value

1 on success, 0 on failure.

`int` **`disable_realtime`**`()`

Description

Switch to non-real-time mode.

Return value

1 on success, 0 on failure.

`int` **`list_tasks`**`()`

Description

Request a list of all tasks in the current schedule of the simulator. The list is also sent automatically upon joining the "sched-control" channel.

Return value

1 on success, 0 on failure.

`int` **`list_events`**`()`

Description

Request a list of all events in the schedule of the simulator in all states. The list is automatically sent to the client when subscribing to the "sched-control" channel at start-up.

Return value

1 on success, 0 on failure.

`int` **`raise_event`**`(std::string eventname, SWIGTYPE_p_void data, int size)`

`int` **`raise_event`**`(std::string eventname)`

Description

Raise event with name *eventname* in the scheduler. An event is defined by the input connector on the scheduler canvas. The event is handled as fast as possible. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

`int` **`raise_event_at`**`(std::string eventname, int sec, int nsec, SWIGTYPE_p_void data, int size)`

`int` **`raise_event_at`**`(std::string eventname, int sec, int nsec)`

`int` **`raise_event_at`**`(std::string eventname, int sec)`

Description

Raise event with name *eventname* in the schedler at a specified wallclock time. The wallclock time is specified as *sec* seconds and *nsec* nanoseconds. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

sec Wallclock time in seconds.

nsec Wallclock time in nanoseconds.

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

```
int raise_event_at_simtime(std::string eventname, int sec, int nsec, SWIGTYPE_p_void
data, int size)
```

```
int raise_event_at_simtime(std::string eventname, int sec, int nsec)
```

```
int raise_event_at_simtime(std::string eventname, int sec)
```

Description

Raise event with name *eventname* in the schedler at a specified simulation time. The simulation time is specified as *sec* seconds and *nsec* nanoseconds. Event *data* with a given *size* can optionally be passed together with the event.

Parameters

eventname Name of the event

sec Simulation time (seconds)

nsec Simulation time (nanoseconds)

data Data

size Size of data in bytes.

Return value

1 on success, 0 on failure.

```
int set_speed(double speed)
```

Description

Set the acceleration/deceleration of the scheduler of the simulator. Values smaller than 1 will cause a proportional deceleration of the scheduler clock. Values larger than 1 will cause a proportional acceleration of the scheduler clock. Magical value -1 means that the scheduler will run in an optimized as-fast-as-possible mode.

Parameters

speed acceleration factor

Return value

1 on success, 0 on failure.

```
int add_MDL(std::string mdlname)
```

Description

Load (another) new MDL file in the session.

Parameters

mdlname Path name of the MDL file.

Return value

1 on success, 0 on failure.

```
int sync_send(int token)
```

Description
Send sync token to simulator

Parameters
token synchronization token id

Return value
1 on success, 0 on failure

`int` **`sync_recv`**`(int token)`

Description
Wait for sync token from simulator

Parameters
token synchronization token id

Return value
1 on success, 0 on failure

`int` **`kill`**`(int signal)`

`int` **`kill`**`()`

Description
Kill the simulator with signal *signal*. By default the simulator is killed with SIGTERM.

Parameters
signal Signal to send to the simulator

Return value
1 on success, 0 on failure

27.3 EventHandler class

The EventHandler class is used to handle events coming from the simulator. The user must derive from this class and implement the methods for the events that must be handled.

When a messsage from the simulator is received, first the built-in message handling is performed followed by the user defined message handlers. The message handlers are installed by instantiating the handler. The message handler is removed by calling the `remove` method.

To define a user defined message handler all you need to do is:

```
class ExampleEventHandler:: public EventHandler {

   // constructor
   ExampleEventHandler(Session s)
   {
      super(s);
   }

   // handler for maMessage events
   void maMessage(int simtime_sec, int simtime_nsec,
                  int runtime_sec, int runtime_nsec,
                  int sev, std::string procname, std::string msg)
   {
      System.out.println(procname + " " + msg);
   }
}
```

```
ExampleEventHandler eh;

// instantiate event handler (implicitly installs it)
void example_handler_init(Session s)
{
   eh = new ExampleEventHandler(s);
}

// remove event handler
void example_handler_remove(Session s)
{
   eh.remove();
}
```

27.3.1 Method reference

27.3.1.1 Constructors

`public` **`EventHandler`**`(Session s)`

Description

Construct a new EventHandler and install the handler.

Parameters

s The simulator session

27.3.1.2 Methods

`Session` **`session`**`()`

Description

Return the session for this event handler.

Return value

The simulator session.

27.3.1.3 Event Handler Methods

In order to create a user defined event handler, one or more methods must be implemented.

`void` **`maNewMission`**`(std::string mission)`

Description

A new mission (MDL) is created.

Parameters

mission The name of the mission.

`void` **`maOpenMission`**`(std::string mission)`

Description

A mission (MDL) file is opened.

Parameters

mission The filename of the mission file.

`void` **`maCloseMission`**`(std::string mission)`

Description

A mission (MDL) file is closed.

Parameters

mission The filename of the mission file.

`void` **`maSimDef`**`(std::string simdef)`

Description

Inform that client which simulation definition file is currently loaded.

Parameters

simdef The filename of the simulation definition file.

Return value

`void` **`maCurrentDict`**`(std::string dict)`

Description

Inform the client which data dictionary file is currently loaded.

Parameters

dict The filename of the data dictionary file.

Return value

`void` **`maCurrentWorkingDir`**`(std::string cwd)`

Description

Inform the client what the current working directory of the simulator is.

Parameters

cwd The path name of the current working directory.

`void` **`maCurrentResultDir`**`(std::string result_dir)`

Description

Inform the client what the result directory is. The result directory contains all the journal files, recorder files, snapshots and timings file.

Parameters

result_dir The path name of the result directory.

`void` **`maCurrentAliasFile`**`(std::string filename)`

Description

Inform the client what the alias file is. The alias file contains the data dictionary aliases.

Parameters

filename The path name of the alias file.

`void` **`maCurrentTSPMapFile`**`(std::string filename)`

Description

Inform the client what the TSP map file is. The TSP map file contains the TSP data dictionary path name map.

Parameters

filename The path name of the TSP map file.

`void` **`maNewAction`**`(std::string mission, std::string actiontext)`

Description

Inform the client that a new action has been created.

Parameters

mission The name of the mission.

actiontext The new action.

`void` **`maDeleteAction`**`(std::string mission, std::string actionname)`

Description

Inform the client that an action has been deleted.

Parameters

mission The name of the mission.

actionname The name of the action.

`void` **`maActionExecute`**`(std::string mission, std::string actionname)`

Description

Inform the client that an action is being executed.

Parameters

mission The name of the mission.

actionname The name of the action.

`void` **`maActionExecuteStop`**`(std::string mission, std::string actionname)`

Description

Inform the client that an action is no longer being executed.

Parameters

mission The name of the mission.

actionname The name of the action.

`void` **`maActionExecuting`**`(std::string mission, std::string actionname)`

Description

Inform a newly connected client that the action is currently executing.

Parameters

mission The name of the mission.

actionname The name of the action.

`void` **`maActionActivate`**`(std::string mission, std::string actionname)`

Description

Inform the client that an action has been activated. I.e. is allowed to execute.

Parameters

mission The name of the mission.

actionname The name of the action.

`void` **`maActionDeActivate`**`(std::string mission, std::string actionname)`

Description

Inform the client that an action has been deactivated. I.e. is no longer allowed to execute.

Parameters

mission The name of the mission.

actionname The name of the action.

`void` **`maExecuteCommand`**`(std::string name, std::string command, int action_mgr_nr`

Description

Inform the client that a one shot action has been executed.

Parameters

name The name of the action.

command The commands of the action.

action_mgr_nr The number of the action manager that has executed the action.

`void` **`maSnapshot`**`(std::string snapshot, std::string comment)`

Description

Handle maSnapshot event. This event is sent after a snapshot of the current simulator state has been made.

Parameters

snapshot Path name of the snapshot file.

comment Comment describing the snapshot.

`void` **`maMark`**`(std::string message, int marknumber)`

Description

Inform the client that a mark has been made in the journal file.

Parameters

message The descriptive message of the mark.

marknumber The number of the mark.

`void` **`maMessage`**`(int simtime_sec, int simtime_nsec, int runtime_sec, int runtime`
`int sev, std::string process, std::string msg)`

Description

Inform the client that a message has been generated in the simulator. This message is also automatically logged in the journal file by the simulator.

Parameters

simtime_sec Simulation time stamp (seconds part)

simtime_nsec Simulation time stamp (nanoseconds part)

runtime_sec Wallclock time stamp (seconds part)

runtime_nsec Wallclock time stamp (nanoseconds part)

sev Severity of the message. The name of the severity can be retrieved by using the `sev_to_string()` method of the Session class.

process Name of the simulator thread from where the message was generated.

msg The message text.

`void` **`maRecording`**`(std::string on_off)`

Description

Inform the client that recording has been globally enabled/disabled.

Parameters

on_off If the string is equal to “on”, recording is enabled. If it is “off” it is disabled.

`void` **`maRecordingBandwidth`**`(double bandwidth)`

Description

Report the bandwidth used to record data to disk.

Parameters

bandwidth Number of bytes per seconds written to disk.

`void` **`maStimulatorBandwidth`**`(double bandwidth)`

Description

Report the bandwidth used to read data from disk for stimulation.

Parameters

bandwidth Number of bytes per second read from disk.

`void` **`maRecorderFileClosed`**`(std::string filename)`

Description

Inform the client that a recorder file has been closed and can be used for further processing.

Parameters

filename The file name of the recorder file.

`void` **`maDenyWriteAccess`**`(bool denied)`

Description

Inform the client that the write access to variables is denied. This is the case if the client has the role of observer.

Parameters

denied Flag to indicate denial of write access to the simulator variables.

`void` **`maCurrentInitconds`**`(std::string simdef, std::string initconds)`

Description

Inform the client of the current list of initial conditions as used for the initialization of the simulator.

Parameters

simdef The name of the simulation definition file.

initconds The list of initial condition files (space separated).

`void` **`maCurrentCalibrations`**`(std::string simdef, std::string calibrations)`

Description

Inform the client of the current list of calibration definition files as used by the simulator.

Parameters

simdef The name of the simulation definition file.

calibrations The list of calibration files (space separated).

`void` **`maCurrentTimeMode`**`(int time_mode)`

Description

Inform the client of the current time mode. The time mode can be relative time or absolute time (UTC mode).

Parameters

time_mode The time mode, 0 is relative time mode, 1 is absolute time mode (UTC mode).

`void` **`maNewSeverity`**`(int sev, std::string sev_name)`

Description

Inform the client about a new user-defined message severity. This message is automatically handled. The severity identifier can be mapped to its symbolic name using the `sev_to_string()` method of the Session class.

Parameters

sev The severity numerical identifier.

sev_name The symbolic name of the severity.

`void` **`rtUnconfigured`**`()`

Description

Inform the client that the state of the simulator is `unconfigured`. This state means that the simulator is either still starting up, or is in its final clean up phase. This is a transient state. When starting up, the next state will be `Initialising`. When cleaning up the last event will be `evShutdown`.

`void` **`rtInitialising`**`()`

Description

Inform the client that the state of the simulator is `initialising`. Depending on the schedule definition, this state will automatically be followed by the `standby` state. Otherwise you have to manually change the state to `standby` using the `eventStandby()` method of the Session() class.

`void` **`rtStandby`**`()`

Description

Inform the client that the state of the simulator is `standby`.

`void` **`rtExecuting`**`()`

Description

Inform the client that the state of the simulator is `executing`.

`void` **`rtExiting`**`()`

Description

Inform the client that the state of the simulator is `exiting`. This is a transient state. The next state will be the `unconfigured` state.

`void` **`rtTimeToNextState`**`(int sec, int nsec)`

Description

Report the time to the next state transition. This is useful when the major cycle is quite long (more than a couple of seconds). This can be the case if the schedule definition contains a clock with a very low frequency or when the lowest common denominator of the clocks results in a long major cycle.

Parameters

sec Time to next state (seconds part)

nsec Time to next state (nanoseconds part)

`void` **`rtMainCycle`**`(int sec, int nsec)`

Description

Report the length of the main cycle of the schedule.

Parameters

sec Main cycle (seconds part)

nsec Main cycle (nanoseconds part)

`void` **`scSetBrk`**`(std::string taskname, int entrynr, int enable)`

Description

Inform the client about the enabling/disabling of a break point on a specific entry point in a task in the schedule.

Parameters

taskname The name of the task.

entrynr The number of the entry point (counting starts at 0).

enable Whether the break point is enabled (1) or disabled (0).

`void` **`scStepTsk`**`()`

Description

Inform the client that a step to the next task has been performed in debugging mode.

`void` **`scContinue`**`()`

Description

Inform the client that the execution is now continued after being stopped on a break point in debugging mode.

`void` **`scGoRT`**`(bool enable)`

Description

Inform the client that the real-time mode has changed.

Parameters

enable Real-time mode is enabled (true) or disabled (false).

`void` **`scTaskDisable`**`(std::string taskname, bool disable)`

Description

Inform the client that a task has been disabled. This means that the task is no longer executed.

Parameters

taskname The name of the task.

disable The task is disabled (true), or enabled again (false).

`void` **`scSetTrc`**`(std::string taskname, int entrynr, bool enable)`

Description

Inform the client that a trace has been set on an entry point in a task.

Parameters

taskname The name of the task.

entrynr The number of the entry point in the task (counting starts at 0).

enable The trace is enabled (true), or disabled (false).

`void` **`scSpeed`**`(double speed)`

Description

Report the speed of the scheduler clock. This is only relevant in non-real-time mode when going slower or faster than real time.

Parameters

speed Speed factor. 1 means real-time, less than 1 means slower than real-time, more than 1 means faster than real-time. E.g. 2 means two times faster than real-time.

`void` **`scTaskListStart`**`()`

Description

Start the description of the list of tasks.

`void` **`scTaskStart`**`(std::string taskname, bool enabled)`

Description

Start the description of a task. This is followed by a number of scTaskEntry events, one for each entry in the order of execution in the task.

Parameters

taskname The name of the task

enabled The task is enabled (true), or disabled (false).

`void` **`scTaskEntry`**`(std::string entryname, bool breakpoint, bool trace)`

Description

Report information of an entry point in a task.

Parameters

entryname The name of the entry point.

breakpoint The entry point has a break point set (true) or not set (false).

trace The entry point is traced (true) or not (false).

`void` **`scTaskEnd`**`()`

Description

Report the end of the task information.

`void` **`scTaskListEnd`**`()`

Description

Report the end of the list of tasks.

`void` **`scEventListStart`**`()`

Description

Report the start of the list of schedule events.

`void` **`scEventInfo`**`(std::string eventname, int state, bool is_standard)`

Description

Report all information about a specific schedule event.

Parameters

eventname The name of the event.

state The state in which it is present.

is_standard Whether or not it is a built-in (standard) event (true), or a user defined event (false).

`void` **`scEventListEnd`**`()`

Description

Report the end of the list of events.

`void` **`scWhereListStart`**`()`

Description

Report the start of the list of places where the scheduler has stopped execution when reaching a break point. As there are possibly more than 1 executers executing tasks, there can be multiple places where the execution has stopped.

`void` **`scWhereEntry`**`(std::string taskname, int entrynr)`

Description

Report a location where the execution has stopped.

Parameters

taskname The name of the task.

entrynr The number of the entry point (counting starts at 0).

`void` **`scWhereListEnd`**`()`

Description

End of the list of locations where the execution has stopped.

`void` **`scEntrypointSetEnabled`**`(std::string entrypointname, bool enabled)`

Description

Report the enabling or disabling of the execution of an entry point. The execution of the entry point is disabled for all tasks and also when executing the entry point from MDL scripts.

Parameters

entrypointname The name of the entry point.

enabled Whether the entry point is enabled for execution (true), or disabled (false).

`void` **`dtLogValueUpdate`**`(std::string var, std::string value)`

Description

Report an updated value for a logged variable.

Parameters

var The name of the variable.

value The value of the variable.

`void` **`dtHeartBeat`**`()`

Description

This event is sent at 2 Hz by default and indicates that the simulator is still alive. It is also the last event sent after a series of dtLogValueUpdate events.

`void` **`dtCpuLoad`**`(int cpu, double average, double peak)`

Description

Report the load of a CPU.

Parameters

cpu CPU number

average Average load over a main cycle.

peak Peak load over a minor cycle.

`void` **`evLinkData`**`(std::string link_id)`

Description

Event that is used internally to transmit (TM/TC) packets. The actual data of the packet is not passed to this callback function. It is stored internally and can be retrieved using the `read()` method of the TmTcLink class.

Parameters

link_id The symbolic name of the link.

`void` **`evExtSetData`**`(std::string view_id)`

Description

Event that is used internally to update External Simulator Access views. The actual data of the event is not passed to this callback function. It is decoded and stored in the view variables and can be retrieved with the `get()` method of the ExtSimVar* classes.

Parameters

view_id The symbolic name of the view.

`void` **`evShutdown`**`(int error_code, std::string error_string)`

Description

Event that is received when the connection with the simulator is lost.

Parameters

error_code The value of errno at the time the connection was terminated. This value is zero when the connection was terminated in a normal way.

error_string The description of the error code.

`void` **`evEventDisconnect`**`()`

Description

Event that is received when the connection with the simulator is closed. This is normally done using the method `esim_disconnect()`.

27.4 eurosim class

This class contains a couple of utility methods that are not linked to a session.

27.4.1 Method reference

`static` **`vector_string host_list`**`()`

Description

Return the list of EuroSim hosts.

Return value

The list of hosts.

`static int` **`session_kill_by_name`**`(std::string simname, int signal, std::string hostname)`

`static int` **`session_kill_by_name`**`(std::string simname, int signal)`

`static int` **`session_kill_by_name`**`(std::string simname)`

Description

Kill a simulation session by name.

Parameters

simname The name of the session. This is normally the basename of the executable.

signal The signal to send to the session (default = SIGTERM)

hostname The name of the host where the session runs (default = localhost)

Return value

-1 if creating the connection with the EuroSim daemon on the host failed, 0 on success, otherwise the result is the value of errno of the failed kill system call or EPERM if you do not have the right permissions to kill the simulator or ESRCH if the simulator with the specified name could not be found.

`static int` **`session_kill_by_pid`**`(int pid, int signal, std::string hostname)`

`static int` **`session_kill_by_pid`**`(int pid, int signal)`

`static int` **`session_kill_by_pid`**`(int pid)`

Description

Kill a simulation session by pid.

Parameters

pid The process id of the session.

signal The signal to send to the session (default = SIGTERM)

hostname The name of the host where the session runs (default = localhost)

Return value

-1 if creating the connection with the EuroSim daemon on the host failed, 0 on success, otherwise the result is the value of errno of the failed kill system call or EPERM if you do not have the right permissions to kill the simulator or ESRCH if the simulator with the specified pid could not be found.

`int` **`open_log`**`()`

Description

Allows the client to log to a file. After opening the log file everything that is sent to stdout and to stderr is also logged to the spedified file.

Return value

0 if succeeded.

`int` **`close_log`**`()`

Description

Closes the log file created by `open_log`.

Return value

0 if succeeded.

27.5 EventInfo class

The EventInfo data is return by the `event_list` method of the Session class. The methods allow you to retrieve the individual attributes of a scheduler event.

27.5.1 Method reference

`std::string` **`name`**`()`

Description

Get the name of the event.

Return value

The name of the event

`int` **`state`**`()`

Description

Get the number of the state where this event is defined.

Return value

The number of the state.

`std::string` **`state_name`**`()`

Description

Get the name of the state where this event is defined.

Return value

The name of the state.

`bool` **`is_standard`**`()`

Description

Whether the event is a standard event or a user defined event.

Return value

true if it is a standard event, false if it is a user defined event.

27.6 WhereInfo class

The WhereInfo data is return by the `where_list` method of the Session class. The methods allow you to retrieve the individual attributes of a scheduler break point location.

27.6.1 Method reference

`std::string` **`name`**`()`

Description

Get the name of the task where the scheduler is currently stopped.

Return value

The task name.

`int` **`entrynr`**`()`

Description

Get the entry point number of the current break point within the task.

Return value

The entry point number. Counting starts at 0.

27.7 EntryInfo class

The EntryInfo data is return by the `entry_list` method of the TaskInfo class. The methods allow you to retrieve the individual attributes of an entry point in a task.

27.7.1 Method reference

`std::string` **`name`**`()`

Description

Get the name of the entry point.

Return value

The name of the entry point.

`bool` **`breakpoint`**`()`

Description

Get the break point status of the entry point.

Return value

True if a break point is set, false if not.

`bool` **`trace`**`()`

Description

Get the trace status of the entry point.

Return value

True if a trace is set, false if not.

27.8 TaskInfo class

The TaskInfo data is return by the `task_list` method of the Session class. The methods allow you to retrieve the individual attributes of a task.

27.8.1 Method reference

`std::string` **`name`**`()`

Description

Get the name of the task.

Return value

The name of the task.

`bool` **`disabled`**`()`

Description

Get the disabled state of the task.

Return value

True if the task is disabled, false if it is enabled.

`long` **`entry_list_size`**`()`

Description

Get the number of entry points of the task.

Return value

The number of entry points.

`EntryInfo` **`entry_list`**`(long idx)`

Description

Get the entry point information of the entry point with the given index.

Parameters

idx The entry point index (counting starts at 0).

Return value

The entry point information.

27.9 EventTypeInfo class

The EventTypeInfo data is return by the `event_type_list` method of the Session class. The methods allow you to retrieve the individual attributes of a client/server message (called event internally).

27.9.1 Method reference

`std::string` **`name`**`()`

Description

Get the name of the message.

Return value

The name of the message.

`std::string` **`args`**`()`

Description

Get the argument types of the message. This is a character coded string with one character for each argument type.

Return value
The argument types.

`std::string` **`argdescr`**`()`

Description
Get a description of the arguments of the message.

Return value
The description of the arguments.

`int` **`id`**`()`

Description
Get the numerical identifier of the message.

Return value
The numerical identifier.

27.10 SessionInfo class

The SessionInfo data is return by the `session_list` method of the Session class. The methods allow you to retrieve the individual attributes of a simulation session.

27.10.1 Method reference

`std::string` **`sim_hostname`**`()`

Description
Get the host name running the simulation session.

Return value
The host name.

`std::string` **`sim`**`()`

Description
Get the simulation definition file.

Return value
The file name of the simulation definition file.

`std::string` **`workdir`**`()`

Description
Get the working directory.

Return value
The path name of the working directory.

`std::string` **`simulator`**`()`

Description
Get the simulator executable.

Return value
The path name of the executable.

`std::string` **`schedule`**`()`

Description

Get the simulator schedule.

Return value

The path name of the schedule file.

`vector_string` **`scenarios`**`()`

Description

Get the list of scenario (MDL) files.

Return value

The list with path names of the MDL files.

`std::string` **`dict`**`()`

Description

Get the data dictionary file.

Return value

The path name of the data dictionary file.

`std::string` **`model`**`()`

Description

Get the model file.

Return value

The path name of the model file.

`std::string` **`recorderdir`**`()`

Description

Get the recorder directory.

Return value

The path name of the recorder directory.

`vector_string` **`initconds`**`()`

Description

Get the list of initial condition files.

Return value

The list of path names of the initial condition files.

`vector_string` **`calibrations`**`()`

Description

Get the list of calibration files.

Return value

The list of path names of the calibration files.

`std::string` **`exports`**`()`

Description
Get the exports file.

Return value
The path name of the exports file.

`std::string` **`alias`**`()`

Description
Get the alias file.

Return value
The path name of the alias file.

`std::string` **`tsp_map`**`()`

Description
Get the TSP map file.

Return value
The path name of the TSP map file.

`std::string` **`timestamp`**`()`

Description
Get the time stamp.

Return value
The time stamp.

`int` **`prefcon`**`()`

Description
Get the connection number. Each session has a connection number that can be used to connect a client to that session.

Return value
The connection number.

`int` **`uid`**`()`

Description
Get the UNIX user id of the user who started the simulator.

Return value
The user id.

`int` **`gid`**`()`

Description
Get the UNIX group id of the user who started the simulator.

Return value
The group id.

`int` **`pid`**`()`

Description

Get the UNIX process id of the simulation session.

Return value

The process id.

`bool` **`realtime`**`()`

Description

Get the real-time state of the simulation session.

Return value

True if the simulator was started in real-time mode, false if it was started in non-real-time mode.

27.11 TmTcLink class

The TmTcLink class is used to create a packet link with a model in the simulator. The packet link can be used to send arbitrary packets (binary or not) to a simulator model and receive packets from a simulator model. Multiple packet links can be created. See Chapter 29 for detailed information on how to use the link.

27.11.1 Constructors

`public` **`TmTcLink`**`(std::string id, std::string mode)`

Description

Open one end of a TmTc link.

Parameters

id The symbolic name of the TmTc link.

mode Mode is “r”, “w” or “rw”, similar to the modes of the fopen() function in the standard C library.

27.11.2 Method reference

`int` **`connect`**`(Session s)`

Description

Connect the link to the other end in a running simulator.

Parameters

s The session of the running simulator.

Return value

-1 on failure, 0 on success.

`int` **`write`**`(std::string data)`

Description

Write a packet to the link.

Parameters

data The data (binary string).

Return value

The number of bytes sent or -1 on failure.

`std::string` **`read`**`()`

Description
Read data from the link.

Return value
The data read as a binary string.

27.12 InitCond class

This class is used for the manipulation of initial condition files. This allows the user to create a new initial condition file or modify an existing file. Individual values can be set or modified. It is also possible to merge two initial condition files.

27.12.1 Constructors

```
public InitCond(std::string filename, std::string dictfile)
```

Description
Create a new set of initial conditions from an existing file.

Parameters
filename The initial condition file.

dictfile The path of the data dictionary file.

27.12.2 Method reference

```
bool add(std::string filename)
```

Description
Merge an existing initial condition file with the current initial condition data.

Parameters
filename The path of the to-be-merged initial condition file.

Return value
true on success, false on failure.

```
bool write(std::string filename, bool binary)
```

Description
Write the initial condition data to a file.

Parameters
filename The path of the new initial condition file.

binary If true, write a binary file, otherwise write the data in human readable (ASCII) format.

Return value
true on success, false on failure.

```
double simtime()
```

Description
Return the simulation time of the initial condition file.

Return value
The simulation time.

```
std::string comment()
```


Description

Get the comment of in the initial condition file.

Return value

The comment string.

`std::vector_string` **`get_varlist_failed`**`()`

Description

Get the list of variables in the initial condition file which were successfully loaded into the data dictionary.

Return value

The list of variables.

`vector_string` **`get_varlist_set`**`()`

Description

Get the list of variables in the initial condition file which were successfully loaded into the data dictionary.

Return value

The list of variables.

`double` **`var_value_get`**`(std::string path)`

Description

Get the numerical value of a variable.

Parameters

path The data dictionary path.

Return value

The numerical value of the variable.

`std::string` **`var_string_get`**`(std::string path)`

Description

Get the string value of a variable.

Parameters

path The data dictionary path.

Return value

The string value of the variable.

`bool` **`var_value_set`**`(std::string path, double value)`

Description

Set the numerical value of a variable.

Parameters

path The data dictionary path name.

value The new value.

Return value

true on success, false on failure.

`bool` **`var_string_set`**`(std::string path, std::string value)`

Description

Set the string value of a variable.

Parameters

path The data dictionary path name.

value The new value.

Return value

true on success, false on failure.

```
vector_string list(std::string path)
```

```
vector_string list()
```

Description

Get a list of child node names beneath a parent node.

Parameters

path The path of the parent node (default the root "/").

Return value

The list of child node names.

27.13 ExtSimView class

This class wraps the External Simulator Access interface. Detailed information on the use of this interface can be found in Chapter 30.

27.13.1 Constructors

```
public ExtSimView(Session session, std::string id)
```

Description

Create a new External Simulator Access view.

Parameters

session The simulation session.

id The symbolic identifier of the view.

27.13.2 Method reference

```
int add(ExtSimVar var)
```

Description

Add a variable to this view.

Parameters

var The variable to add to the view.

Return value

0 on success, -1 on failure.

```
int connect(int rw_flags, double frequency, int compression)
```

Description

Create a new view with the variables previously added to the view.

Parameters

rw_flags Read/write flags, 1 is read, 2 is write.

frequency Update frequency in Hz.

compression Compression type to be used for the data transmission. 0 is no compression, 1 means that unchanched values in the view are not transmitted. Please note that in case the whole view is not changed, no update is sent in any case.

Return value

0 is success, -1 is failure.

`int` **`change_freq`**`(double frequency)`

Description

Parameters

Change the update frequency of the view.

frequency The update frequency in Hz.

Return value

0 is success, -1 is failure.

`int` **`send`**`()`

Description

Send the view with the updated values to the simulator.

Return value

0 is success, -1 is failure.

27.14 ExtSimVar class

This is the base class of the ExtSimVar* classes. It is not to be used directly.

27.14.1 Method reference

`ExtSimVar.extvar_t` **`type`**`()`

Description

Get the variable type.

Return value

The variable type.

`bool` **`is_array`**`()`

Description

Find out if the variable is an array variable.

Return value

true if it is an array.

`bool` **`is_fortran`**`()`

Description

Find out if the variable is a Fortran variable. Only relevant for arrays, as the Fortran column/row order is different from C/Ada.

Return value
true if it is a Fortran variable.

`int` **`nof_dims`**`()`

Description
Get the number of dimensions of the array variable.

Return value
The number of array dimensions.

`SWIGTYPE_p_int` **`dims`**`()`

Description
Get the dimensions of the array variable.

Return value
The array dimensions.

`std::string` **`path`**`()`

Description
Get the data dictionary path of the variable.

Return value
The data dictionary path.

`long` **`size`**`()`

Description
Get the size in bytes of the variable.

Return value
The size in bytes.

27.15 ExtSimVar* classes

Below are the derived classes of ExtSimVar described. All similar methods are grouped to reduce the amount of documentation that only repeats the same information again and again. Therefore only two different cases are documented. One for the single element case and one for the array case.
For both cases the following variants are possible: Char, Double, Float, Int, Long, Short, UnsChar, UnsInt, UnsLong and UnsShort.
The java types corresponding to the above types are: char, double, float, int, int, short, short, long, long and int.
For arrays there are two variants: ExtSimVar*Array and ExtSimVar*FortranArray.
To summarize for one type you can have the following classes: ExtSimVarChar, ExtSimVarCharArray and ExtSimVarCharFortranArray.

27.15.1 Constructors

```
public ExtSimVar*(std::string path)
public ExtSimVar*Array(std::string path, int dim0)
public ExtSimVar*Array(std::string path, int dim0, int dim1)
public ExtSimVar*Array(std::string path, int dim0, int dim1, int dim2)
public ExtSimVar*FortranArray(std::string path, int dim0)
public ExtSimVar*FortranArray(std::string path, int dim0, int dim1)
public ExtSimVar*FortranArray(std::string path, int dim0, int dim1, int
dim2)
```

Description

Create a new variable to be used in an ExtSimView.

Parameters

path The data dictionary path

dim0 The size of the first dimension.

dim1 The size of the second dimension.

dim2 The size of the third dimension.

27.15.2 Method reference

```
* get()
* get(int idx0)
* get(int idx0, int idx1)
* get(int idx0, int idx1, int idx2)
```

Description

Get the value of a single variable or single array element. The variant without the idx* parameters is for a single variable, the others are for 1, 2 and 3 dimensional arrays.

Parameters

idx0 Index in first dimension.

idx1 Index in second dimension.

idx2 Index in third dimension.

Return value

The value of the variable. The type of the return value depends on the type of the function. The type mapping is listed above in the introduction.

```
void set(* val)
void set(* val, int idx0)
void set(* val, int idx0, int idx1)
void set(* val, int idx0, int idx1, int idx2)
```

Description

Set the value of a single variable or single array element. The variant without the idx* parameters is for a single variable, the others are for 1, 2 and 3 dimensional arrays.

Parameters

val The new value. The type of the value depends on the type of the function. The type mapping is listed above in the introduction.

idx0 Index in first dimension.

idx1 Index in second dimension.

idx2 Index in third dimension.

Chapter 28

C Cient Interface reference

28.1 Introduction

The run-time interface of EuroSim is the C-Language interface which is used to communicate with the running simulator. The Simulation Controller tool and the batch utility use this interface to start a new simulation run and to control it.

This interface description provides a step by step description of how to start the simulator and what commands to send to control the simulator once it is running. The order of the chapters is the order of each step.

In Section 28.2 is explained how to start a simulator using the EuroSim daemon and how to connect to the new simulator. In order to receive autonomous messages from the simulator the client must subscribe to certain channels. This is explained in Section 28.3. The following 4 chapters describe each one channel. Shutdown and cleanup is described in Section 28.8. Finally, Section 28.9, gives an overview of the available manual pages on the subject.

28.2 Simulator start-up

On each host where a EuroSim simulation can run, a daemon must be started. This daemon is responsible for the starting of simulators (among other things). The interface to this RPC daemon is defined in `esimd.x` in `$EFOROOT/include/rpcsvc`. The header file can be found in `$EFOROOT/include/esim`. The details of the interface are described in manual page *esimd(3)*.

To start a simulator the RPC call `start_session_6()` must be done. The EuroSim daemon running on a EuroSim simulator host will launch the actual simulator executable. This call takes the following structure as argument:

Listing 28.1: session6_def structure

```
struct session6_def {
      file_def sim;
      char *work_dir;
      char *simulator;
      file_def schedule;
      struct {
            u_int scenarios_len;
            file_def *scenarios_val;
      } scenarios;
      char *dict;
      file_def model;
      char *recorderdir;
      struct {
            u_int initconds_len;
            file_def *initconds_val;
```

```
        } initconds;
        struct {
                u_int calibrations_len;
                file_def *calibrations_val;
        } calibrations;
        char *exports;
        char *alias;
        char *tsp_map;
        struct {
                u_int environment_len;
                env_item *environment_val;
        } environment;
        int prefcon;
        int umask;
        int flags;
        int uid;
};
struct file_def {
        char *path;
        char *vers;
};
```

The `file_def` structure is used to store the name of the file and an optional version string. Table 28.1 describes each member of the `session6_def` structure.

field	description
`sim`	The path and version name of the simulation definition file (.sim). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in `work_dir`.
`work_dir`	The path name of the current working directory of the simulator. The directory should exist and be accessible by the EuroSim daemon. Normally this is done by making the directory available through NFS in case the RPC call is performed from a different host.
`simulator`	The file name of the simulator executable (.exe). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in `work_dir`.
`schedule`	The file name of the simulator schedule file (.sched). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in `work_dir`.
`scenarios`	An array of scenario files (.mdl). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in `work_dir`.
`dict`	The file name of the data dictionary file (.dict). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in `work_dir`.
`model`	The file name of the model file (.model). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in `work_dir`. This file is not actually used by the simulator for reading. It used for tracing purposes as a reference.
`recorderdir`	the path name of the directory where all recordings are stored. It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in `work_dir`.
`initconds`	An array of initial condition files (.init). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in `work_dir`.

Table 28.1: session_def structure

field	description
calibrations	An array of calibration files (.cal). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in work_dir.
exports	the file name of the exports file (.exports). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in work_dir.
alias	the file name of the alias file (.alias). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in work_dir.
tsp_map	the file name of the TSP map file (.tsp). It can be an absolute or relative path name. If it is a relative path name, it is relative to the path in work_dir.
environment	an array of environment variables in the usual format VAR=value. Normally it is sufficient to copy the entire current environment into this array. If you want to start the simulator with a custom environment setting you have to set at least the following environment variables used by EuroSim in addition to the ones used by the simulator model software. EFOROOT should be set to the EuroSim installation directory. EFO_SHAREDMEMSIZE is the amount of memory reserved for dynamic memory allocation. Default is 4194304 (4 MB). This value can be set in the ModelEditor since Mk3rev2. EFO_STACKSIZE is the stack size reserved for each thread of the simulator. Default is 16k. This value can be set in the ModelEditor since Mk3rev2. PWD is the current working directory and is set to work_dir by the daemon if it is not present. LD_LIBRARY_PATH should be set to the path of the shared libraries of EuroSim. The value is normally $EFOROOT/lib.
prefcon	set to -1 under normal circumstances, a connection number is selected by the daemon and returned on successful start-up of the simulator. Put a positive value here if you want to force the new simulator to have a specific connection number.
umask	the umask used for creation of new files. See *umask(2)*.
flags	there are currently two flags defined: SESSION_REALTIME and SESSION_NO_AUTO_INIT. Flags shall be or-ed together. Add the SESSION_REALTIME flag for real-time runs, or do not set the flag for non-real-time runs. The SESSION_NO_AUTO_INIT flag can be set to prevent the EuroSim scheduler from automatically going into initializing state. This is used by the EuroSim Simulation Controller to set break points and traces and to disable tasks before the simulation goes into initializing state.
uid	Reserved. No action or data needed by the user in relation to this field.

Table 28.1: session_def structure

The following small example in C will show how to start a simulator using representative values for the parameters. We however recommend an easire method which is explained thereafter to fill the session structure.

Listing 28.2: tc_example.c

```
#include <rpc/rpc.h>
#define _RPCGEN_CLNT
#include <esimd.h>

int main(void)
{
  struct session6_def session;
  struct start6_result *result;
  env_item env[6];
  file_def scenario;
  file_def initcond;
```

```
  CLIENT *clnt;

  session.sim.path="Demo.sim";
  session.sim.vers="";
  session.work_dir="/home/user/projects/STD";
  session.simulator="Demo.exe";
  session.schedule.path="Demo.sched";
  session.schedule.vers="";
  scenario.path="Demo.mdl";
  scenario.vers="";
  session.scenarios.scenarios_len=1;
  session.scenarios.scenarios_val=&scenario;
  session.dict="Demo.dict";
  session.model.path="Demo.model";
  session.model.vers="";
  session.recorderdir="2000-04-01/00:00:01";
  initcond.path="Demo.init";
  initcond.vers="";
  session.initconds.initconds_len=1;
  session.initconds.initconds_val=&initcond;
  session.exports="Demo.exports";
  session.alias="Demo.alias";
  session.tsp_map="Demo.tsp";
  session.prefcon=-1;
  session.umask=022;
  session.flags=SESSION_REALTIME;
  env[0] = "LD_LIBRARY_PATH=/usr/EuroSim/lib";
  env[1] = "HOME=/home/user";
  env[2] = "EFO_HOME=/home/user/project/EfoHome";
  env[3] = "LD_LIBRARYN32_PATH=/usr/EuroSim/lib32";
  env[4] = "PWD=/home/user/project/STD";
  env[5] = "EFOROOT=/usr/EuroSim";
  session.environment.environment_len = 6;
  session.environment.environment_val = env;

  clnt = clnt_create("spiff", ESIM_PROG, ESIM_VERS6, "tcp");
  clnt->cl_auth = authunix_create_default();
  result = start_session_6(&session, clnt);
  if (result->status == ST_SUCCESS) {
    printf("simulator started at connection %d\n",
          result->start6_result_u.success.con);
    return 0;
  }
  else {
    error_array *errors;
    unsigned int i;

    printf("simulator failed to start:\n");
    errors = &result->start6_result_u.errors;
    for (i = 0; i < errors->error_array_len; i++) {
      printf("%s\n", errors->error_array_val[i]);
    }
    xdr_free((xdrproc_t)xdr_start_result, (char*)result);
    return 1;
  }
}
```

The above example can be compiled as follows:

```
gcc -Wall -I$(EFOROOT)/include -I$EFOROOT/include/esim \
   -o tc_example tc_example.c -L$EFOROOT/lib -lesClient -les
```


It is however easier if you use the `esimd_complete_session` function to fill in the missing pieces. You only have to provide the simulation definition and the other entries will be completed by the `esimd_complete_session`:

Listing 28.3: Example of the use of esimd_complete_session()

```
#include <esim.h>
#include <esimd.h>
#include <esimd_complete_session.h>
#include <esimd_clnt_launch.h>
#include <auxMemory.h>

int main(void)
{
  struct session6_def session;
  extern char **environ;
  char *err;
  int prefcon;
  pid_t pid,

  memset(&session, 0, sizeof(session));
  session.work_dir = ds("/home/user/projects/STD");
  session.sim.path = ds("Demo.sim");
  if (esimd_complete_session(&session, "localhost", environ) == 0) {
    /* start session */
    session.flags = SESSION_NO_AUTO_INIT;
    session.flags &= ~SESSION_REALTIME;
    if ((err=esimd_client_launch_6("localhost",&session,&prefcon, &pid))){
        printf("Client launch error: %s\n",err);
    }

    esimd_free_session(&session);
  }
}
```

Note that the example is using localhost as computer name. You can also fill in the name of the local machine or even the name of a remote machine. The example also uses a utility function to duplicate the string in heap memory `char *ds("const char*)`. This memory will be freed using the `esimd_free_session` function. The ds function is declared in the auxMemory.h file in the `include/esim` directoy of your EuroSim installation.

On a succesfull `esimd_complete_session` the session structure is filled with the correct data to launch a simulator with. The session flags are first set to set the simulation to non-real-time and avoid that the simulator automatically starts entering the initialising state after launch. Thereafter the `esimd_client_launch_6` call can be used to request the daemon to start the simulator.

After successfully launching the simulator a connection can be created to the running simulator executable. There is some time between launching the simulator and when a connection can be created. This time is normally less than a second, but depends on the size of the simulator and the model interfaces used (the CPP interface is slower to start then the C interface for instance). The eventProbe function can be used to check if the simulator is already running:

Listing 28.4: check simulator activity

```
int fd=0;

while(fd<=0) {
  fd=eventProbe("localhost",prefcon,0);
}
```

The eventProbe function returs the file descriptor on which the simulator with the passed prefcon number was found on host localhost. The third argument is for debugging and normally zero. If set to one, the eventProbe function prints status information.

To make a connection with the simulator the function `eventConnect()` must be called, or `eventConnectFd()` must be called. The latter accepts the file descriptor from eventProbe.

Listing 28.5: Connect to a simulator

```
#include <evClient.h>

Connection *conn;
void *userdata;

conn = eventConnectFd("localhost", "test-controller", fd, connClient,
               eventHandler, userdata, true, prefcon);;
```

The second parameter is the client name. In this example it has the value “test-controller”. If the string contains the sub-string “-observer”, the client is treated as a read-only client of the simulator. The client can monitor variables but not change them. The client cannot do anything which influences the simulator.

The parameter `eventHandler` is the callback function which is called when an event from the simulator has been received. Each event results in one call to the callback. The callback must determine the type of the message and decode its contents. The callback has one parameter called `userdata` which contains the value given when calling `eventConnect()`.

The following example in C code shows an implementation of the `eventHandler` callback.

Listing 28.6: Example of an eventHandler callback function

```
#include <evEvent.h>

int eventHandler(Connection *conn, const evEvent *event,
             void *userdata)
{
  size_t offset = evEventArgOffset();
  int sev;
  char *mesg, *thread;
  double speed;
  AuxTime simtime, wallclocktime;

  simtime = evEventSimTime(event);
  wallclocktime = evEventRunTime(event);

  switch (evEventType(event)) {
  case maMessage:
    evEventArgInt(event, &offset,&sev);
    evEventArgString(event, &offset,&thread);
    evEventArgString(event, &offset,&mesg);
    printf("%u: %s %s\n", sev, thread, mesg);
    break;

  case scSpeed:
    evEventArgDouble(event, &offset,&speed););
    printf("speed = %f\n", speed);
    break;
  }
  return 0;
}
```

The programmer can choose to use synchronous or asynchronous handling of events. The example above has chosen for asynchronous event handling. This means that each time an event arrives a signal (SIGIO)

is sent to the application. The library installs a signal handler which ultimately calls the `eventHandler` callback. If you select synchronous handling, the application has full control over when events are read. Using *select(2)* the programmer can determine if data is ready to be read and would then call `eventPoll()` to process all the available events. The function `eventPoll()` will call the `eventHandler` callback for each event.

28.3 Subscribing to channels

After connecting to the server, the simulator client can subscribe to several channels. When a client is subscribed to a channel it will receive events that are sent automatically without a previous client request. These messages are either generated by the models or by the simulator infrastructure. Each channel addresses a specific area of interest. At the moment of subscribing (or joining) a channel, the client will receive a number of messages describing the current state relating to that channel. The messages after joining a channel are described in the chapter dedicated to that channel. Table 28.2 describes each channel.

Channel	Channel Identifier	Define	Chapter
Real time control	rt-control	CONTROLCHANNEL	Section 28.4
Mission	mdlAndActions	MISSIONCHANNEL	Section 28.5
Monitor	data-monitor	MONITORCHANNEL	Section 28.6
Scheduler control	sched-control	SCHEDCONTROLCHANNEL	Section 28.7

Table 28.2: Channel Descriptions

To subscribe to a channel the function `eventJoinChannel()` must be called. Fruther extending the previous example, following lines must be added following the eventConnect call.

Listing 28.7: Join a channel

```
Connection *conn; /* must be set with eventConnect() */

  eventJoinChannel(conn,"sched-control");
  eventJoinChannel(conn,"mdlAndActions");
```

For a simulator client it is mandatory to join the mdlAndActions channel. After launching the simulator, the simulator waits with the further initialization until the first client joins this particular channel. The simulator can then send its messages to a client. This is particular useful when something goes wrong. It enables the user to read the messages and take corrective actions.

The following four chapters will describe each channel in detail. Each chapter will contain tables describing events coming from the simulator and commands which can be sent to the simulator. Each command is sent using an `event*` function. This function takes 2 or more arguments. The first two arguments are always the same. The first argument is the handle to the connection, the second argument is a pointer to an `AuxStamp` structure which can be a NULL pointer for clients.

28.4 Real time control channel

The real time control channel is used to request and report state changes of the simulator. The simulator client can request state changes and the simulator will report the new state as soon as it has been reached. Figure 28.1 shows the state transition diagram applicable to an external application controlling the simulator. Next to the arrows are the functions to be called for each state transition. In the boxes the name of the event is shown that is sent to the client when entering the state. The only exception is the `eventReset` command. This command performs a small scenario consisting of a state transition from standby state

to exiting state. from exiting to unconfigured, from unconfigured to initializing. In initializing state the automatic state transition to standby is performed as specified in the schedule.

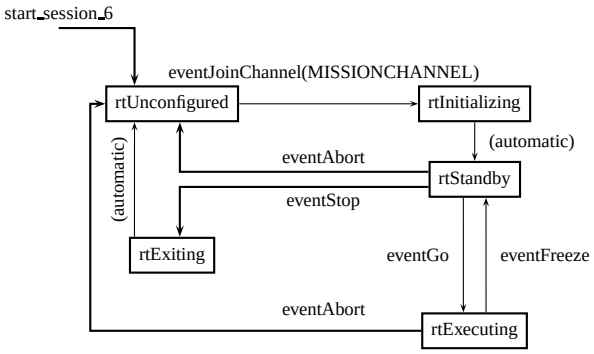


Figure 28.1: Simulator states

Table 28.3 lists the messages sent to the client after joining the real-time control channel.

Event	Description	Arguments
rtUnconfigured, rtInitializing, rtStandby, rtExecuting, rtExiting	Current state	-
rtMainCycle	Main cycle time of schedule	cycle time in timespec format (tv_sec and tv_nsec)

Table 28.3: Real time control channel join events

Table 28.4 shows the functions which can be used to request the change and the events sent back as a result.

Command	Description	Response
eventFreeze	Request state transition to standby state from initializing or executing state	rtStandby
eventFreezeAt <*wallclocktime*>	Same as previous but wait until a certain wallclock time.	rtStandby
eventFreezeAtSimtime <*simtime*>	Same as previous but wait until a certain simulation time	rtStandby
eventGo	Request state transition to executing state from standby state	rtExecuting
eventGoAt <*wallclocktime*>	Same as previous but wait until a certain wallclock time.	rtExecuting
eventStep	Request the execution of one main cycle.	rtExecuting rtStandby

Table 28.4: Real time control channel commands

Command	Description	Response
eventReset	Request reinitialization from standby state	rtExiting rtUnconfigured rtInitialising rtStandby (if performed automatically by the schedule configuration)
eventStop	Request the controlled termination from standby state.	rtExiting rtUnconfigured
eventAbort	Request immediate abort from any state.	rtUnconfigured
eventHealth	Request health check.	maMessage <*eurosimversion*> maMessage <*executable* `is healthy.`> maMessage <`executing "`*scenario*`" for "`*group*`"`> rtHealth

Table 28.4: Real time control channel commands

As state transitions may take some time, a `rtTimeToNextState` message is sent to the simulator client which contains the amount of time to the transition.

After joining the rt-control channel the current simulator state is sent. All state transitions from then on are sent to the client, including automatic state transitions, or transitions requested by another client. The standard time stamps of the state transition message can be used to calculate valid future state transition times which can be used to issue timed state transition commands. To calculate a valid future transition time take the wallclock or simulation time from the last state transition message and add an integer number of main cycle times.

The following example in C requests a state transition at midnight on April 1, 2001 (wallclock time):

Listing 28.8: Time state transition

```
Connection *conn; /* must be set with eventConnect() */
struct timespec tv;
struct tm tm;

tm.tm_sec = 0;
tm.tm_min = 0;
tm.tm_hour = 0;
tm.tm_mday = 1;
tm.tm_mon = 4;
tm.tm_year = 100; /* years since 1900 */
tm.tm_isdst = 0;
tv.tv_sec = mktime(&tm);
tv.tv_nsec = 0;
eventGoAt(conn, NULL, &tv);
```

At the indicated time an event `rtExecuting` is sent to the simulator client.

28.5 Mission channel

The mission channel is used for all activities relating to the manipulation of scenarios and actions. Scenarios are either loaded at start-up from disk or are created on the fly using the commands listed in this chapter. Scenarios loaded from disk can be modified in the simulator. The changes are only in the running simulator, not in the file on disk.

Table 28.5 lists the messages sent to the client after joining the mission channel.

Event	Description	Arguments
maDenyWriteAccess	Write access notification.	on/off
maCurrentWorkingDir	Working directory notification.	working directory
maCurrentDict	Current data dictionary notification.	dictionary file name
maSimDef	Current simulation definition file	simulation definition filename
maCurrentResultDir	Current result directory notification.	result directory
maCurrentAliasFile	Current alias file notification.	alias file
maCurrentTSPMapFile	Current TSP map file notification.	TSP map file
maCurrentTimeMode	Current time mode notification.	0 = relative 1 = UTC
maCurrentInitconds	Current list of initial condition files notification.	initial condition file(s)
maCurrentCalibrations	Current list of calibration files notification.	calibration file(s)
maRecording	Recording status notification.	on/off

Table 28.5: Mission channel join events

Table 28.6 shows the events which can be sent to the simulator and the responses they send back. Arguments are enclosed in angled brackets. Literal messages are in courier where variant parts are in italic. Wherever you see the word *file* (as in scenario file) a file on disk is meant. All other references to scenario are to the run-time data structure inside the simulator.

Command	Description	Response
eventNewMission <*scenario*>	Create a new (virtual) scenario	maNewMission <*scenario*> maMessage <`scenario "`*scenario*`" created for "`*group*`"`>
eventOpenMission <*scenariofile*>	Open an existing scenario file	maOpenMission <*scenariofile*> maMessage <`scenario "`*scenariofile*`" opened for "`*group*`"`>
eventCloseMission <*scenario*>	Close a scenario	maMessage <`scenario "`*scenario*`" owned by "`*group*`" closed`> maCloseMission <*scenario*>
eventNewAction <*scenario*> <*actiontext*>	Create a new action in a scenario	maNewAction <*scenario*> <*actionname*> maMessage <`new active action "`*actionname*`" in "`*scenario*`"`>
eventDeleteAction <*scenario*> <*actionname*>	Delete an action in a scenario	maDeleteAction <*scenario*> <*action*> maMessage <`deleted action "`*action*`" from "`*scenario*`"`>
eventActionExecute <*scenario*> <*actionname*>	Execute (trigger) an action in a scenario	maActionExecute <*scenario*> <*action*> maActionExecuteStop <*scenario*> <*action*> maMessage <`manually triggered action "`*action*`"`>[1]

Table 28.6: Mission channel commands

[1] In case a monitor action (obsolescent) is executed various messages from the monitor channel are generated. These can be found in Table 28.9

Command	Description	Response
eventActionActivate <*scenario*> <*actionname*>	Make an action active in a scenario	maActionActivate <*scenario*> <*action*> maMessage <`action "`*action*`" activated`>
eventActionDeActivate <*scenario*> <*actionname*>	Make an action inactive in a scenario	maActionDeActivate <*scenario*> <*action*> maMessage <`action "`*action*`" deactivated`>
eventExecuteCommand <*name*> <*command*> <*action_mgr_nr*>	Execute a single shot MDL command. This shall be used for MDL commands that need to be executed only once.	maExecuteCommand <*name*> <*command*> <*action_mgr_nr*> maMessage <`executed command '`*name*`'`>
eventCurrentAliasFile <*alias definition file*>	Set a new alias definition file.	maCurrentAliasFile <*alias definition file*>
eventCurrentTSPMapFile <TSP *map file*>	Set a new TSP map file.	maCurrentTSPMapFile <TSP *map file*>
eventCurrentInitconds <*initial condition files(s)*>	Sets a new list of initial conditions files.	maCurrentInitconds <*initial condition file(s)*>
eventCurrentCalibrations <*calibration file(s)*>	Sets a new list of calibration files.	maCurrentCalibrations <*calibration file(s)*>
eventSnapshot <*filename*> <*comment*>	Make a snapshot.	maMessage <`snapshot made for` *filename*> maSnapshot <*snapshot filename*> <*comment*>
eventReload <*snapshot filename*> <*set simtime*>	Reload a snapshot file. The second argument *set simtime* can be set to on or off. When it set to on, the simulation time is set to the value present in the snapshot file.	maReload <*snapshot filename*> <*set simtime*> If snapshot is loaded with simtime: scSimtime <*simtime*> <*wallclocktime*> maMessage <`new simulation time:` *simtime*> In all cases: maMessage <`loaded` *filename*`:` *comment*>
eventMark <*marktext*> <*number*>	Create a mark.	maMark <*mark string*> <*mark count*>
eventMessage <*text*>	Send a message to the simulator client	maMessage <*text*>
eventRecording <*on/off*>	Suspend/resume recording.	When switching off: maRecording <*off*> maMessage <`suspended recordings`> When switching on: maRecording <*on*> maMessage <`resumed recordings`>
eventRecordingSwitch	Switch recorder files.	For each recorder file: maRecorderFileClosed <*recorderfilename*> maMessage <`Switching recorder files`>

Table 28.6: Mission channel commands

Table 28.7 shows the events relating to messages which can be sent from the model code or the simulator infrastructure.

Event	Description	Arguments
maMessage	Message	severity, message

Table 28.7: Message events

Table 28.8 shows the messages sent autonomously every 2 seconds.

Event	Description	Arguments
maRecordingBandwidth	Current recording bandwidth consumption notification.	bandwidth (bytes/sec)
maStimulatorBandwidth	Current stimulator bandwidth consumption notification.	bandwidth (bytes/sec)

Table 28.8: Mission channel autonomous messages

The following example in C requests the loading of a scenario file into the simulator.

Listing 28.9: Load an MDL file into the simulator

```
Connection *conn; /* must be set with eventConnect() */

eventOpenMission(conn, NULL, "/home/eurosim/project/proj.mdl");
```

The result will be a `maMessage` event informing about the successful opening of the scenario file.

28.6 Monitor channel

The monitor channel is used to manipulate monitors. Table 28.9 shows the messages which are sent when triggering a monitor action (obsolescent). The event `dtMonitor` is sent at the start to mark the beginning of a new monitor. If one monitor action monitors multiple variables, the `dtMonitorVar` event is sent once for each variable. The event `dtMonitorDone` ends the list. The client application can then set up the display for the new monitor. The client must send a `eventAdd2LogList` command for each variable. After that every 0.5 seconds (2 Hz) an update (`dtLogValueUpdate`) is sent from the simulator to the client.

The frequency can be changed to a higher or a lower frequency by passing an option -f to the EuroSim daemon esimd with the required frequency. Using this command line option for the daemon sets the frequency for all simulators. The frequency may be a floating point number.

The frequency can be changed to a lower frequency by passing an option -d to the EuroSim daemon with a divisor. This option reduces the frequency of the monitor updates etc. with the specified integer factor. This option affects all simulators started with the daemon.

The order of messages periodically sent by the simulator to the client is as follows:

- monitor values
- heartbeat
- cpu load (optionally)

Alternatively it is possible to retrieve the value of a variable only once by using the `dtGetValueRequest` command.

Event	Description	Arguments
dtMonitor	Start new monitor	scenario, action name
dtMonitorVar	Monitor variable	variable name
dtMonitorDone	Finish new monitor	attributes

Table 28.9: Monitor events on monitor action (obsolescent) execution

Table 28.10 shows the event sent periodically at 2 Hz for each variable in an active monitor.

Event	Description	Arguments
dtLogValueUpdate	Monitor value update	variable name, value

Table 28.10: Monitor update event

Table 28.11 shows the commands which can be sent.

Command	Description	Response
eventAdd2LogList <*variable name*>	Add variable to list of monitored variables	dtAdd2LogList <*variable name*> dtLogValueUpdate <*variable*> <*value*>
eventRemoveFromLogList <*variable name*>	Remove variable from list of monitored variables	dtRemoveFromLogList <*variable name*>
eventSetValueRequest <*variable name*> <*value*>	Set variable to value	dtSetValueRequest <*variable name*> <*value*> maMessage <`set "`*variable*`" to "`*value*`"`> If variable is monitored at that moment: dtLogValueUpdate <*variable*> <*value*>
eventSetMultipleValueRequest <*varvals*> <*n_vars*>	Atomically set multiple variables to a new value. This differs from calling multiple times eventSetValueUpdate in that it is guaranteed that all variables are updated in the same simulation cycle.	For each variable: dtSetValueRequest <*variable name*> <*value*> maMessage <`set "`*variable*`" to "`*value*`"`> If variable is monitored at that moment: dtLogValueUpdate <*variable*> <*value*>
eventCpuLoadSetPeak <*processor*> <*peak_time (ms)*>	Monitor the CPU load of a specific CPU	dtCpuLoadSetPeak <*processor*> <*peak_time (ms)*> At a frequency of 2 Hz: dtCpuLoad <*processor*> <*average*> <*peak*>
dtGetValueRequest <*variable name*>	Get the value of a variable once	dtLogValueUpdate <*variable name*> <*value*>

Table 28.11: Monitor channel commands

Table 28.12 shows the messages sent on the mission channel autonomously with a frequency of 2 Hz.

Event	Description	Arguments
dtHeartBeat	Heartbeat	count

Table 28.12: Monitor channel autonomous events

The following example in C requests the monitoring of a specific variable in the data dictionary of the running simulator.

Listing 28.10: Start monitoring a variable

```
Connection *conn; /* must be set with eventConnect() */

eventAdd2LogList(conn, NULL, "/model/file/var");
```

From this moment on `dtLogValueUpdate` messages will be sent to the simulator client with 2 Hz. To stop these messages call:

Listing 28.11: Stop monitoring a variable

```
eventRemoveFromLogList(conn, NULL, "/model/file/var");
```

28.7 Scheduler control channel

The scheduler control channel is used to manipulate and monitor the EuroSim scheduler. Table 28.13 lists the messages sent to the client after joining the mission channel.

Event	Description	Arguments
scTaskListStart	Beginning of task list	-
scTaskStart	Beginning of entry point list of a task	*taskname*, *enabled*
scTaskEntry	Entry point description	*entryname*, *breakpoint*, *trace*
scTaskEnd	End of entry point list of a task	-
scTaskListEnd	End of task list	-
scEventListStart	Beginning of event list	-
scEventInfo	Event description	*eventname*, *state*, *is_standard*
scEventListEnd	End of event list	-
scGoRT	Real-time mode notification	*enable*

Table 28.13: Scheduler control join events

Table 28.14 lists the available commands.

Command	Description	Response
eventSetBrk <*taskname*> <*entrynr*> <*enable*>	Set breakpoint The where-list is only sent if the simulator state is rtExecuting.	scSetBrk <*taskname*> <*entrynr*> <*enable*> maMessage <`debugging task: break on task "`*task*`" entry point "`*entrypoint*`" enabled/disabled`> scWhereListStart scWhereEntry <*taskname*> <*entrynr*> scWhereListEnd
eventStepTsk	Step to next entry point	scWhereListStart scWhereListEnd scStepTsk scWhereListStart scWhereEntry <*taskname*> <*entrynr*> scWhereListEnd maMessage <`STEP on `*task*`:`*entrypoint*>
eventContinue	Continue execution up to next breakpoint	scWhereListStart scWhereListEnd scContinue scWhereListStart scWhereEntry <*taskname*> <*entrynr*> scWhereListEnd
eventGoRT <*enable*>	Switch between real-time and non-real-time.	scGoRT <*enable*>
eventListTasks	Request task list	scTaskListStartscTaskStart <*taskname*> <*enabled*> scTaskEntry <*entryname*> <*breakpoint*> <*trace*> scTaskEndscTaskListEnd
eventEntrypointSetEnabled <*entrypoint*> <*enabled*>	Enabled or disable an entry point.	scEntrypointSetEnabled <*entrypoint*> <*enabled*>
eventTaskDisable <*taskname*> <*disable*>	Disable a task	scTaskDisable <*taskname*> <*disable*> maMessage <`task "`*taskname*`" disabled/enabled`>
eventSetTrc <*taskname*> <*entrynr*> <*enable*>	Enable/disable tracing of an entry point	scSetTrc <*task.entrypoint*> <*enable*>
eventClearBrks	Clear all breakpoints	scClearBrks
eventClearTrcs	Clear all traces	scClearTrcs
eventWhere	Request current position in schedule	scWhereListStart scWhereEntry <*taskname*> <*entrynr*> scWhereListEnd
eventListEvents	Request event list	scEventListStartscEventInfo <*eventname*> <*state*> <*is_standard*> scEventListEnd
eventRaiseEvent <*event*>	Raise event	scRaiseEvent <*event*>

Table 28.14: Scheduler control commands

Command	Description	Response
eventSimtime <*simtime*>	Set simulation time	scSimtime <*simtime*> maMessage <`new simulation time:` *simtime*>
eventRaiseEventAt <*event*> <*sec*> <*nsec*>	Raise event at wallclock time	scRaiseEventAt <*event*> <*sec*> <*nsec*>
eventRaiseEventAtSimtime <*event*> <*sec*> <*nsec*>	Raise event at simulation time	scRaiseEventAtSimtime <*event*> <*sec*> <*nsec*>
eventSpeed <*speed*>	Set relative clock speed Only when running non-realtime. When speed is set to -1, the simulator will run as fast as possible.	scSpeed <*speed*>

Table 28.14: Scheduler control commands

There are three groups of events which need additional attention. These groups of events are used to transmit complicated data structures to the client:

- task list
- event list
- debugger position list

The task list uses 5 events which are sent in a nested fashion.
The task list starts with `scTaskListStart` and ends with `scTaskListEnd`. After `scTaskListStart` one or more tasks are sent. Each task starts with `scTaskStart` and ends with `scTaskEnd`. After `scTaskStart` one or more entry points are sent. Each entry point is sent using `scTaskEntry`.

The event list starts with `scEventListStart` and ends with `scEventListEnd`.

After `scEventListStart` one or more event descriptions are sent. Each event is sent using `scEventInfo`. The debugger position list, also called *where* list, starts with `scWhereListStart` and ends with the response `scWhereListEnd`. After `scWhereListStart` zero or more positions are sent. Each position is sent using `scWhereEntry`.

Table 28.15 shows the messages sent autonomously every 2 seconds.

Event	Description	Arguments
scSpeed	Relative clock speed. Only when running non-real-time.	speed

Table 28.15: Scheduler control autonomous messages

The following example in C sets the speed of a non-realtime simulator to run as fast as possible.

Listing 28.12: Let the simulator run as fast as possible

```
Connection *conn; /* must be set with eventConnect() */

eventSpeed(conn, NULL, -1);
```

From now the scheduler from EuroSim will execute all models as fast as possible. The event `scSpeed` is sent at 2 Hz. The value of the speed parameter will reflect the actual acceleration achieved.

28.8 Simulator shutdown

At the moment a simulator executable exits, all clients are automatically disconnected. In that case event `evShutdown` is received. This is a pseudo event which is not sent by the simulator but is generated as soon as a socket shutdown is detected. The socket has been destroyed by then and it is not possible to send messages to the simulator anymore.

It is also possible to actively terminate the simulator connection by calling `eventDisconnect()`:

Listing 28.13: Disconnect from the simulator

```
Connection *conn; /* must be set with eventConnect() */

eventDisconnect(conn);
```

After disconnecting from the simulator it is not possible to send messages to the simulator. However it is possible to reconnect to the simulator using the functions described in Section 28.2.

28.9 Manual pages

Table 28.16 shows an overview of the on-line available manual pages of EuroSim. These pages are the ultimate reference for all events.

Man Page	Description
events(3)	Retrieval system for information about all available EuroSim events
evEvent(3)	Event construction, access and I/O functions
rt-control(3)	Real-time control events
data-monitor(3)	Monitor events
sched-control(3)	Scheduler control events
mdlAndActions(3)	Scenario events
esimd(3)	EuroSim daemon RPC client interface functions and types
evc(3)	Functions for clients to setup multi bi-directional event driven connections
evHandler(3)	Functions for server and client to create handlers for incoming events
extClient(3)	Functions for an external client to establish and control access to a EuroSim simulator
extView(3)	Functions to create, control and destroy data views.
extMdl(3)	Functions for an external client to manage scenarios and actions running on a EuroSim simulator
extMessage(3)	Functions for an external client to send messages to a EuroSim simulator.
esimLink(3)	Functions for creating and manipulating simulated satellite communication links

Table 28.16: Overview of relevant manual pages.

Chapter 29

TM/TC Link reference

29.1 Introduction

With EuroSim the possibility exists to model a telemetry/telecommand link at run time either between two sub-models within a EuroSim simulator, or between EuroSim and another (external) computer.

The main feature of this library is to simulate the bandwidth and time-delay that characterize a long-range communication link, such as the TM/TC link between a ground station and a satellite. By default this delay is disabled and packets are forwarded without any delay. Note that the TM/TC link interface is included in the C++ Batch interface (see Chapter 27) which for external clients may be a preferable interface for setting up and establishing the TM/TC connection.

The TM/TC mechanism uses a central server process running within EuroSim, via which the two terminators (or clients) can communicate. The server can maintain one or more client-to-client links; links are bidirectional and can be established between any two internal clients or between an internal and an external client. For the latter, use is made of TCP/IP. No link can be established between two external clients.

EuroSim has the flexibility to handle any data structure as a packet: "packets" do not have to be compliant with ECSS PUS [Sec03] standards in order to be sent and received over the TM/TC link. An ECSS PUS support library to pack and unpack PUS packets however is included with EuroSim. In Figure 29.1 a schematic of a TM/TC link between an external simulator and a EuroSim simulator is provided.

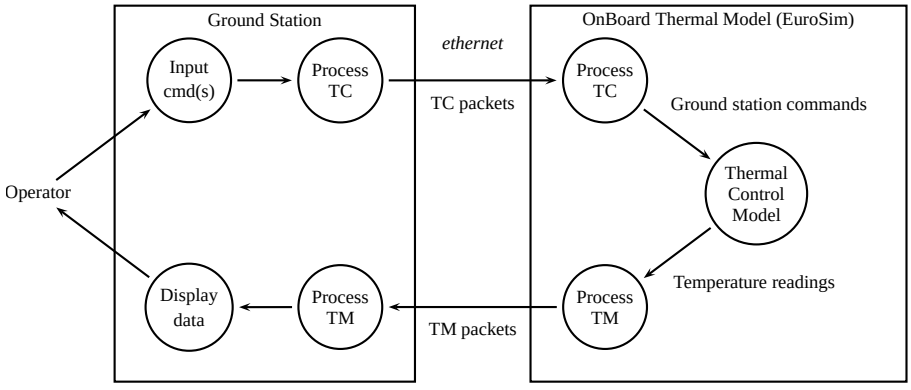


Figure 29.1: External TM/TC Link Schematic

In the case of an internal TM/TC link, i.e. between two or more sub-models within an EuroSim application, the link needs to be set up, customized and then used.

In the case of an external TM/TC client, the only difference is first to connect the external client over TCP/IP to the EuroSim server. Then the setting up and use of the link uses exactly the same routines. The

EuroSim routines are intended to be usable within a heterogeneous environment, and should be suitable for any UNIX based simulators.

29.2 Characteristics of the TM/TC Link

Various characteristics of the link can be changed by calling `esimLinkIoctl` to customize the transmission of packets: some of the possible arguments for `esimLinkIoctl` are:

- LINKDELAY *integer*: sets the delay of the packages to the given number of milliseconds;
- LINKDELAYPROC *procname*: the given function will be called for each time a new package is put on the link with the call `link_write()`. Its return value is used as the delay for the given package. The arguments it gets are the Link identifier for which the delay is requested, and the last delay returned by this function for this Link;
- LINKBANDWIDTH *integer*: indicates the number of bytes which can be sent over the link per second. A negative number indicates 'Unlimited' (default) and will pose NO extra delay. When this value is set to 100, and 200 bytes are sent over, the package will take 2 seconds + the LINKDELAY to arrive at the other side. Note that the package will arrive as a single entity and therefore will not be visible (and cannot be read) as long as the complete package has not arrived;
- LINKMAXTIME_PENDING *integer*: indicates how many milliseconds data may be overdue in the queue before it is discarded. When a value less than zero is given, the packages will never be discarded (default).

The `esimLinkIoctl` procedure can be called at runtime, so can be used to introduce a variable delay time, for example in order to mimic an elliptical orbit or to simulate communications with a set of ground stations where the delay time is a function of the current location of the satellite.

Both TM/TC clients can set their own characteristics so that the upward and downward links can differ accordingly.

The *esimLink* manual page or [MAN15] provides more information on creating and customizing TM/TC links.

29.3 Summary of procedure

The following steps summarize how to set up and use a TM/TC link between two simulated stations:

1. If one of the simulators is external to EuroSim, set up a connection to the EuroSim server;
2. Create and customize the link between the two clients;
3. Send packets;
4. Receive packets;
5. Close the link.

29.4 Case study: setting up a TM/TC link

This section provides examples of how the procedure is implemented. The examples are taken from complete demonstration models (installed in `$EFOROOT/src/TmTc+ExtSimModel`).

29.4.1 Set up the external simulator as a EuroSim client

This only needs to be done if one of the clients for the TM/TC link is not a EuroSim application. The external simulator is firstly linked to the EuroSim simulator as a client.

```
#include <extSim.h>

tmtcClient = extConnect(hostname, clientname, eventHandler, userdata,
                  async_flag, prefcon);
```

and takes the arguments:

- hostname: simulator host running target EuroSim simulator;
- clientname: name by which this client is to be known to the EuroSim server, e.g. “TMTC_Client”;
- eventHandler: name of procedure in external simulator code which will process events coming from EuroSim simulator (flags indicating data updates and state changes are received as “events”)
- userdata: pointer to user defined data. This pointer is passed to the eventHandler callback function.
- async_flag: flag to indicate that on incoming data the eventHandler callback function is to be called via a signal handler. If the flag is set to false, the user must call `extPoll()` whenever data arrives or periodically.
- prefcon: preferred connection on the EuroSim server; should be used to select between simulators when more than one is currently active on the server (default of 0 is sufficient if only one simulator is active)

29.4.2 Create and customize a link between the two TM/TC clients

The next step is to establish a (simulated) TM/TC link between the two “systems”, i.e. either between the external client and EuroSim, or between two sub-models within a EuroSim application. In both cases, the link is set up and used in almost the same way.

The link needs to be created on both sides with `esimLinkOpen`. The function `esimLinkOpen` will initialize a link with the supplied name. A point-to-point link is not established until the other side has also called `esimLinkOpen` with the same link name. The pointer returned by `esimLinkOpen`(e.g. `tmtcLink` in the following example) is used as an identifier for the link in all future calls, e.g. read, write, close.

An external client needs to call `esimLinkConnect()` to connect the link to the simulator.

Various options can be set using `esimLinkIoctl`(see Section 29.2). In the first example here, the link for the ground station is set up and customized to “lose” packets if they arrive after a certain time delay:

```
#include <esimLink.h>

#define TMTC_CONNECTION_NAME "tmtc_connection"
#define REQ_FREQUENCY 10

static int gFrequency = REQ_FREQUENCY;

static void do_client(int signal)
{
  .....
 tmtcLink = esimLinkOpen(TMTC_CONNECTION_NAME, "rw");
 esimLinkIoctl(tmtcLink, LINKMAXTIME_PENDING, (1000/gFrequency)+100);
  .....
}
```

The following lines from the SpaceStation model give an example of setting up the link and using `esimLinkIoctl` to set the default delay for packets being transmitted:

```
#include "esimLink.h"
#include "esim.h"

#define TMTC_CONNECTION_NAME "tmtc_connection"

int requiredDelay = 300;  /* msec delay for link to ground */

void tmtcInit(void)
{
  ....
  tmtcLink = esimLinkOpen(TMTC_CONNECTION_NAME, "rw");
  if (tmtcLink == NULL) {
    esimMessage("Couldn't establish TmTc Link");
    return; /* Nothing possible */
  }
  esimLinkIoctl(tmtcLink, LINKDELAY, requiredDelay);
   ....
}
```

29.4.3 Sending packets

The packets are sent using `esimLinkWrite`, providing arguments for the link identifier, the data packet buffer, and the size of the buffer; e.g.:

```
send_packet(packet);

static int send_packet(EGSE_uns8 *pus)
{
   PUS_P_Header *header;

   header = (PUS_P_Header *)pus;
   return (esimLinkWrite(tmtcLink, (char *)pus,
            header->Packet_Length + PUS_P_HEADER_SIZE));
}
```

The packet is then available for the "other" client to read after a certain time delay, the length of the delay being dependent on the characteristics defined by `esimLinkIoctl`.

29.4.4 Receiving packets

Internal Client

In the example code for the EuroSim SpaceStation application model, a task is created which is scheduled at 5 Hz, and which calls a procedure which reads the (incoming telecommand) packets. The actually reading of the packets is done using `esimLinkRead`, the information being put into `tmtcPacket`. The return code `ret` is used to check on the success of the read:

```
#include "esim.h"
#include "esimLink.h"

#define PUS_P_HEADER_SIZE (sizeof(PUS_P_Header))
#define PUS_DATA_SIZE  512

static EGSE_uns8 *tmtcPacket = NULL;

void decodeTelecommand (void)
{
  int ret;
   ......
```



```
  ret = esimLinkRead(tmtcLink, (char *)tmtcPacket,
                PUS_P_HEADER_SIZE + PUS_DATA_SIZE);
  if (ret <= 0) {
    if (ret < 0) {
      /* incoming package is bigger than allocated data area */
      esimMessage("Fatal: TmTc command too big to read");
    }
    /* value of zero means no data to read */
    return;
  }
  PUS_P_Decompose_Packet_Header(tmtcPacket, &VersionNumber, &Type,
                          &DataFieldHeaderFlag,
                          &ApplicationProcessId,
                          &SegmentationFlags,
                          &SourceSequenceCount,
                          &PacketLength);
   ....
}
```

External Client - polling for packets

An external client has two possibilities to get packets. The first is to use the polling method as described above, i.e. regularly calling `esimLinkRead` to check if there are any incoming packets available. In the Ground Station TM/TC example code, incoming telemetry packets are checked for at 10Hz:

```
#include "esimLink.h"

#define REQ_FREQUENCY 10

static int gFrequency = REQ_FREQUENCY;
startTimer(gFrequency, do_client);

static void do_client(int signal)
{
  char buf[BUFSIZ];
  int n;
   .....
  n = esimLinkRead(tmtcLink, buf, BUFSIZ);
  if (n != 0) {
    browse_pus(buf, n);
  }
   .....
}
```

External Client - event driven response

Alternatively, use can be made of the events which are sent from the EuroSim server to the client to trigger a response directly as a result of an incoming packet. After `extClientConnect` or `evcConnect` has been called (see Section 29.4.1), the client automatically receives events signalling new link data (event-> type of `evLinkData`). These incoming events are passed to the procedure which was specified as part of the connect call. In this example, this facility is not used, but an action to do something with the incoming packet could easily be defined in the client's eventhandler (e.g. replacing the `DEBUGSTR` statement in the following extract):

```
static int eventHandler(Connection *conn,
                  const evEvent *command, void *data)
{
   switch (evEventType(command)) {
     case evShutdown:
```

```
        fprintf(stderr, "\nServer sent abort()\n");
        cleanup(0);
      case evLinkData:
        DEBUGSTR(("Incoming data"));
        break;
      default:
        DEBUGSTR(("Incoming unknown event `%d'",
               evEventType(command)));
    }
    return 0;
}
```

29.4.5 Close down link

If one of the clients is an external simulator, then the appropriate disconnect should be called (depends on which version of connect was used at the beginning (see Section 29.4.1):

```
#include <extClient.h>

extDisconnect(sim);
```

Then the TM/TC link can be closed:

```
#include "esimLink.h"

esimLinkShutdown();
```


Chapter 30

External Simulator Access reference

30.1 Introduction

With EuroSim the possibility exists to share simulation data at run time between EuroSim and another (external) simulator. This is achieved by linking external (local in the client) variables to (a subset of) the EuroSim data dictionary variables. During the simulation, EuroSim tools ensure that the values in the two data dictionaries are "mirrored" (the update frequency being a user definable parameter). In Figure 30.1 a schematic of the connection and associated functions for handling the data dictionary values is provided.

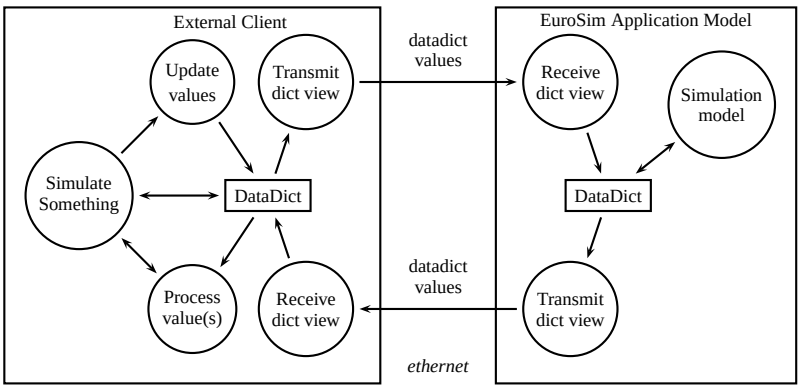


Figure 30.1: External Simulator Access Schematic

The two simulators need to be connected via a TCP/IP link. The EuroSim extSimAccess routines are intended to be usable within a heterogeneous environment, and should be suitable for any UNIX based simulators.

In addition to the specified data dictionary values, the external simulator also receives the simulation time, (elapsed) wall clock time and simulation state from EuroSim.

Note that the C++ Batch interface (see Chapter 27) provides an object oriented interface on top of the External Simulator Access library. This provides the same capabilities as part of an object oriented interface in C++ usable by client programs to estabish simulator client connections. It is up tot he user select either the C++ interface or the lower level C library interface documented in this chapter on the client program.

30.2 Selection of shared data items

It is possible to make all EuroSim data dictionary items accessible between the two simulators, but for performance, security or other reasons, it is often a requirement to limit the number of data items which are shared between the two. There are two levels of filter which can be applied:

- The EuroSim application decides which data dictionary items are to be visible to an external simulator, and whether with read and/or write access (defined in an `exports` file).
- The external simulator application decides which data dictionary items are to be used from those made available from EuroSim, and the type of access (defined in a data view).

An example is shown in Figure 30.2. The first box shows all the API items in the EuroSim data dictionary, i.e. all possible data items which can be shared between the two simulators. The middle box shows that by listing a subset of these items in a `exports` file, the EuroSim application can limit the number of data items which it wants the external simulator to share. In addition, read/write access can be limited. And finally, the third box for the external client shows how only some of the "public" data variables are actually referenced by the external simulator for his own internal use.

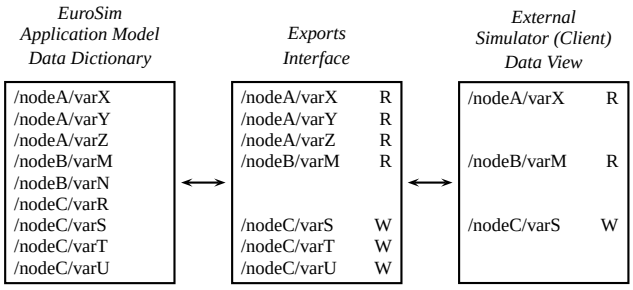


Figure 30.2: Filtering of Data Dictionary Items

30.3 Exports file

To share data between a EuroSim application and an external simulator, an additional file is needed. This file shall have the extension `.exports`, e.g `thermo.exports` and shall be included in the simulation definition file for this simulator.

The `exports` file specifies the EuroSim data dictionary items which will be made accessible at runtime to the external simulator (see Section 30.2). It is a text file and the contents can contain any number of lines of either of the following formats:

```
# this is an optional comment line;
# the next line can be tab or space separated
dict_node_ref  viewName  accessType
```

The `dict_node_ref` is a reference to a node or individual data item within the data dictionary hierarchy. Hence `/myNode/file.c/stateVariableA` is a legal reference which allows a particular variable to be accessed explicitly, as is `/myNode` which implicitly allows access to all of the data items under the named node in the data dictionary hierarchy.

The "`viewName`" provides a symbolic name for this set of data items, which needs to be referenced later on when creating a local data view for the external simulator. Each "`viewName`" has to be unique. It is generally recommended to make at least two views, one allowing read and one allowing write access. By choosing the views so that they contain different sets of data, this approach helps to reduce potential data inconsistencies which could be caused by simultaneous read/writes. Additional views may also be created for the purposes of data hiding, e.g. defining two views which give read access for nodes /A and /C, leaving node /B inaccessible to an external simulator.

The `accessType` indicates the type of access ("R" or "W") which the external simulator is given to the specified variables.

30.4 Creating multiple local data views

Instead of providing the external simulator with a single view of the shared EuroSim data (which is the situation implied in Figure 30.2 above), it can sometimes be advantageous to create and use several local data views. This is often useful when the external simulator is complex, and there are a significant number of shared data items. Two particular circumstances where multiple data views are recommended are:

- Data items need to be read/written at a wide range of frequencies, and therefore it is more efficient to split data items into views which can be given high and low update frequencies as required.
- The simulator model uses an object-oriented approach, and creating a data view per "object" continues to support this methodology.

Each local data view is created from (i.e. maps to) a single EuroSim data view (i.e. a single line as defined in the `exports` file). However, there can be several local data views mapping to a single EuroSim data view, for example to provide the possibility to read new values at different frequencies as mentioned above.

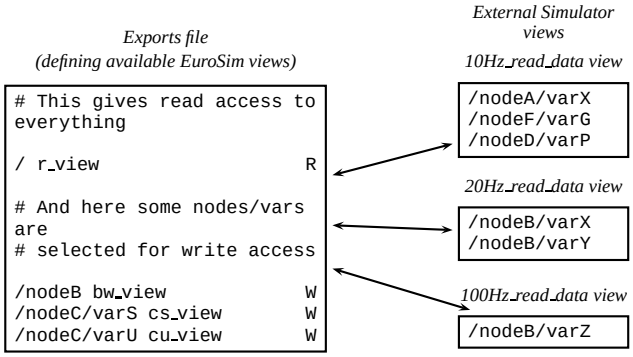


Figure 30.3: Mapping of EuroSim and Local Data Views

30.5 Synchronization

The external simulator access link can also be used to synchronize the client and the simulator with each other. If either the client or the simulator is slower than the other, the other side waits until the slowest side is finished. Also if one side stops for some reason, hitting a breakpoint or going to standby state for instance, the other side is halted as well.

The synchronization mechanism is coupled with the data being exchanged over the link so that data integrity is also ensured. At the simulator side this is done implicitly, but at the client side the user has to make sure to call `extViewSend()` before sending the synchronization token.

The synchronization token should be a unique token for each synchronization point in a simulator. It is possible to have multiple synchronization points in a simulator, possibly with multiple clients. It is the responsibility to make sure that the numbers are unique. If the same token number is used by multiple clients the simulator and/or one of the clients will very likely become blocked.

At startup the client shall connect to the simulator before the first synchronization token is sent from the simulator to the client. Sending synchronization tokens by the simulator is done by broadcasting as it is not possible to know in the simulator which client is performing synchronization (external simulator access clients are anonymous at the simulator side). So if the simulator sends the synchronization token before the client is connected, the token gets lost and the synchronization mechanism at the client side will have missed one token, resulting in a blocked client.

At the client side there are two functions for synchronization purposes. The function `extSyncSend()` sends the synchronization token to the simulator. The function `extSyncRecv()` waits for the synchronization token from the simulator.

The following example shows how to use the functions in a typical application where the client is two-way synchronized to the server.

```
#define SYNC_TOKEN 1234

extViewSend(write_view); /* send data to the simulator */
extSyncSend(sim, SYNC_TOKEN); /* send the synchronization token */
extSyncRecv(sim, SYNC_TOKEN); /* wait for the synchronization token */
```

At the simulator side there are two functions for synchronization purposes which are the counterparts of the functions on the client side. They differ from the client side functions by the fact that they do not have an argument to specify the connection. The function `esimExtSyncSend()` broadcasts the synchronization token to all clients. The function `esimExtSyncRecv()` waits for the synchronization token from the client.

The following example shows how to use the functions in a typical application where the simulator is two-way synchronized to a client.

```
#define SYNC_TOKEN 1234

esimExtSyncSend(SYNC_TOKEN); /* send the synchronization token */
esimExtSyncRecv(SYNC_TOKEN); /* wait for the synchronization token */
```

Please note that this method of synchronization cannot be used in a situation where hard-real-time performance is needed. The calls which wait for the synchronization token (`extSyncRecv()` and `esimExtSyncRecv()`) may block for a long time if the other side is stopped.

In Figure 30.4 a sequence diagram of the exchange of tokens is shown. Please note that the client as well as the simulator are always blocked from the point where they wait for the token until the next token is received. This is the essence of the synchronization mechanism.

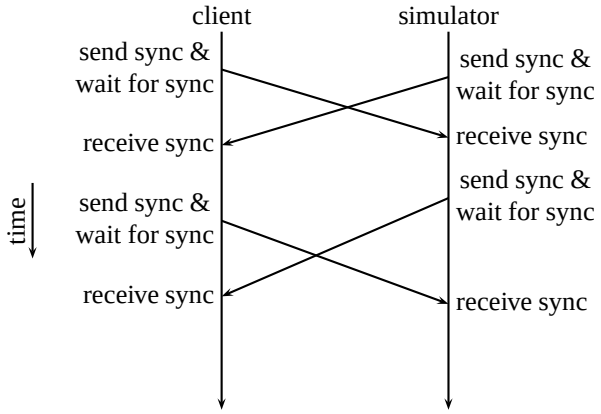


Figure 30.4: Synchronization sequence of a client and a simulator

30.6 Summary of procedure

The following steps summarize how to set up and use the connection between a EuroSim simulator and another (external) simulator:

1. Create an .exports file to specify which EuroSim data dictionary (API) items are visible to the external simulator.

2. Add calls to the external simulator code to link to EuroSim as a client at runtime.
3. Add calls to the external simulator code to make local data view(s) linking EuroSim data items to local variables.
4. Add calls to receive and send shared data at runtime.
5. Close the connection.

30.7 Case study: setting up shared data to another simulator

This section provides examples of how the procedure is implemented. The examples are taken from complete demonstration models (installed in `$EFOROOT/src/TmTc+ExtSimModel`).

30.7.1 Create an exports file

No changes need to be made to the EuroSim application model itself, but an additional file (`thermo.exports`) must be created and added to the simulation definition file using the simulation controller. The given example has the following lines in the `thermo.exports` file:

```
/        r_view          R
/SPARC   w_view          W
```

The first line in the export file specifies that all data items (i.e. from the root of the data dictionary downwards) are to be available to an external simulator with read only access and under the id of `r_view`. A specific node or data item can be referenced individually if required; however the "/" symbol is a useful shorthand to allow all data items to be referenced in one go.

The second line specifies that all data items under the SPARC node in the data dictionary are to be available under the id of `w_view` with write only access for the external simulator. As the SPARC node has also been included in the "/" specification for `r_view`, all data items under this note have effectively been given RW access and care should be taken when accessing their values.

In this example, two separate views are created for the external simulator: one containing data for reading, one containing data for writing. This is recommended to limit potential data inconsistency problems when allowing simultaneous read/write access.

30.7.2 Link the external simulator as a EuroSim client

The external simulator access library is initialized with the following call in the external simulator source code:

```
#include <extSim.h>

extInit();
```

Note that this only needs to be called once in your main() function.

Next, the link is set up with the following call in the external simulator source code:

```
#include <extSim.h>

sim = extConnect(hostname, clientname, eventHandler, userdata,
            async, prefcon);
```

and takes the arguments:

hostname
: Simulator host running target EuroSim simulator.

clientname
Name by which this client is to be known to the EuroSim server, e.g. “TRPClientTester”.

eventHandler
Name of procedure in external simulator code which will process events coming from EuroSim simulator (flags indicating data updates and state changes are received as “events”).

userdata
Pointer to user defined data. This pointer is passed as a parameter to the eventHandler procedure.

async Flag to indicate signal driven event handling versus polled event handling (see also extPoll).

prefcon Preferred connection on the EuroSim server; should be used to select between simulators when more than one is currently active on the EuroSim simulation server (default of 0 is sufficient if only one simulator is active).

A pointer is returned which identifies the simulator, and which you need to reference later on (e.g. when setting up the local view of the data dictionary). The `extClient` manual pages or [PMA14] provide more information on connection and disconnecting a client.

30.7.3 Determine host byte order

When accessing a simulator running on a host with a different byte order than the client the bytes need to be swapped. In order to facilitate the detection of this difference in byte order, a message is sent to the client which allows you to determine the simulator byte order. Comparing the byte order to your own byte order will detect any differences. Below you find an example of such a detection routine:

```
int needs_swap = 0; /* set to 0 if the byte order is the same */

int eventHandler(Connection *conn, const evEvent *event,
             void *userdata)
{
  switch (evEventType(event)) {
    case evExtByteOrder:
    {
      int size;
      int *magic;
      evEventArg(event, &offset, EV_ARG_RAW(&size, &magic));
      needs_swap = (*magic != EXT_BYTE_ORDER_MAGIC);
    }
  }
}
```

30.7.4 Set up local data view with links to EuroSim data

Overview

Once the client link is set up, local data view(s) can be created which link external and EuroSim data items. The views can contain all or a subset of the data items which were “exported” from EuroSim as described in Section 30.7.1.

There are three steps necessary, as shown in the following extract:

- Use of `extViewCreate` to create a local view.
- Use of `extViewAdd` to add a data item (local name + EuroSim name) to the view.
- Use of `extViewConnect` to connect the local view to the EuroSim simulator.

The `extView` manual pages or [PMA14] provide more information on data views.


```
#include "extSim.h"

#define VAR_VERBOSE_FLAG "Verbose"     /* Wonly */

void main(int argc, char *argv[])
{
  int ext_verbose = 0;
  ....
  w_view_ext = extViewCreate(sim, "w_view");
  ....
  extViewAdd(w_view_ext, VAR_VERBOSE_FLAG, &ext_verbose, extVarInt);
  .....
  extViewConnect(w_view_ext, EXT_DICT_WRITE, frequency,
              COMPRESS_NONE);
  ....
}
```

Creating a Local Data View

In this example, only one local view (`w_view_ext`) is being created from the EuroSim `w_view` defined in the `model.exports` file. It is possible to make several views: for example `w_view_sensors`, `w_view_actuators`, each local view then having added to it a subset of the dict items available in the referenced `w_view` (see Section 30.4 for more information).

Linking EuroSim Variables, Local Variables in the Local Data View

In this case, the local view is to contain just one item: the EuroSim dictionary variable "Verbose". A define is used to make a symbolic name from the data dictionary variable name[1].

The link between the data dictionary (symbolic) name `VAR_VERBOSE_FLAG` and the local variable `ext_verbose` is made with the `extViewAdd` call. The type of the variable also needs to be made known when adding it to the view (e.g. `extVarInt`); the different types possible are listed in the `extView` manual pages, which also provides more detailed information on setting up data views.

Connecting the View to EuroSim

The final step is to define the connection characteristics for the local data view.
The given frequency in `extViewConnect` is only useful for views which are requested with `EXT_DICT_READ` permission. It indicates how many times per second a view must be sent over. The maximum frequency is the maximum frequency of the EuroSim scheduler (currently 200Hz). This frequency can be changed with a call to `extViewChangeFrequency`.
The last argument in `extViewConnect` indicates if compression should be used. For now only one compression method is available which simply discards values that are not changed since the last update and has minimal effect on process time.

Alternative Method to Create/Use a Local Data View

An alternative way of setting up a local data view requires access to EuroSim dict access routines, and the example code (as provided in `$EFOROOT/src/TmTc+ExtSimModel`) uses this technique to set up the write view. The method described above is generally preferred, as it can be used by any external simulator independently of EuroSim, the only knowledge of EuroSim then being required is a list of data dictionary items.

[1] At the moment the only way to find the correct data dictionary variable names is to get the information on-line from the *info* menu option in the Model Editor or DictBrowser, or to look in the model *.dict file.

30.7.5 Receiving and sending shared data at runtime

Receiving Data Updates from the EuroSim Simulator

When the view is connected, events from the EuroSim server arrive automatically and are passed through the *eventHandler* which was specified when `extConnect` was called (see Section 30.7.2). Incoming events can either indicate that the data view has just been updated (`event->type` of `evExtSetData`) or that a state change command has been issued by EuroSim (`evEventType(event)` of `rtExecuting`, `rtStandby`, etc.). Each event is timestamped with simtime and runtime (`evEventSimTime(event)` and `evEventRunTime(event)` respectively).

In the given example external simulator code, an incoming evExtSetData event is used to trigger a display of the data (the data being read from local memory by the `curses_print` procedure). Similarly, any state events trigger the procedure `curses_state` which prints the state to screen together with the time-stamps. With this mechanism, if the update frequency is set to 10Hz, then the `curses_print` procedure is effectively being scheduled at 10Hz:

```
static int eventHandler(Connection *conn, const evEvent *command,
                  void *userdata)
{
  char buf[50];
  evArgRec *pt;

  switch (evEventType(command)) {
    case evExtSetData:
      curses_print(command);
      break;

    case rtExecuting:
    case rtStandby:
      .....
      curses_state(command);
      .....
  }
  ...
}
```

However the events can be ignored: it is also possible to schedule (local) tasks which access the local data as and when required, rather than waiting for a data update to trigger processing.

Sending Updated Data Views

When the view is opened with write permission, the external simulator can send an update to the EuroSim simulator with a call to `extViewSend`. This will result in an event being sent to the EuroSim server (unless the data has not changed since the last call to `extViewSend`). The following example shows the verbose data item being toggled and the updated view being sent:

```
ext_verbose = !ext_verbose;
extViewSend(w_view_ext);
```

30.7.6 Close the connection

To close the connection between the client and the server, call the disconnect on exiting, for example:

```
installSignalHandler(SIGQUIT, cleanup);

static void cleanup(int signal)
{
  ...
  extDisconnect(sim);
```



```
  if (signal)
    exit(1);
  exit(0);
}
```

30.8 Performance

The External Simulator Access protocol is based on TCP/IP. This means that each data packet has some protocol overhead. When an isolated (peer to peer) Ethernet "network" is used (i.e. two computers connected by means of an Ethernet cross-over cable), then a theoretical throughput of 10 MByte/s can be achieved when using quality 100 Mbit/s network adapters and cable.

The above figure can be affected in a negative way by a number of causes:

- Cheap network cards that saturate the CPU at an interrupt rate that allows only a few MByte/s on a 100 Mbit/s network,
- Overhead and latency introduced by routers,
- Operating system,
- Driver implementation,
- Collisions in a non-isolated network,
- Configuration (tuning of TCP/IP parameters).

The latter point needs some explanation. On most systems, the default transmit and receive buffer size for TCP/IP sockets is only 16384 bytes. On Linux, you can use the `sysctl(8)` command to increase buffer sizes.

30.8.1 Maximum throughput

When using an non-isolated network, you must be aware of network "collisions" that affect the average throughput. Collisions are caused by multiple network nodes trying to access the medium (i.e. send a packet) at the same time. Each node will retry after a random interval. For that reason, a safe rule of thumb is to take one third (1/3) of the theoretical maximum as a basis for your calculations.

In practice this means that you can transfer 3 MBytes/s on a 100 Mbit/s network or, in EuroSim terms, have a view of 7500 long integers (4 bytes each) updated at 100 Hz. Be aware though that any network "hiccup" will cause buffer overflows at such high data rates.

30.9 Building the client

30.9.1 Unix and Linux

The external simulator access libraries are provided as dynamic shared objects (DSO's) and are part of the standard EuroSim distribution. The include files are located in the `include` subdirectory of the directory where EuroSim is installed.

30.9.2 Windows

When using the Cygwin environment, you can use the mingw gcc compiler and the external simulator access libraries as provided in the `lib` subdirectory of the directory where EuroSim is installed. If you prefer to use the Microsoft development tools, then you can use the DLL's. To link your client application with the DLL's, you must first create import libraries from the `.def` files in the `lib` subdirectory, for example:

```
lib /DEF:c:/eurosim/lib/libes.def
lib /DEF:c:/eurosim/lib/libesClient.def
```

The above commands create `libes.lib` and `libesClient.lib`, which you can use to link your client application with. Make sure that the DLL's can be found on the PATH before you execute your client application.

Chapter 31

COM Interface reference

31.1 Introduction

The EuroSim COM interface allows Windows scripting clients, such as Visual Basic for Applications (VBA) supported by MS-Excel, to launch and/or connect to an EuroSim simulator and control this simulator from your client application.

31.2 Installation

31.2.1 VBA

When you plan to use this interface only with VBA, then you only need to install the esimcom.dll (the actual component) and esimcom.tlb (the type library). If you have an installation of EuroSim for Windows, then these files have already been copied for you. If you want to use your own client applications on a PC that does not have EuroSim installed, then you can manually install the COM interface:

- Copy the esimcom.dll and esimcom.tlb files from the EuroSim bin subdirectory to an appropriate directory (this can be the system directory, usually `C:\windows\system32`).
- Copy the files pthreadGC.dll and oncrpc.dll to the system directory, if they are not installed on the target system yet (you can find these files in the system directory of a system that has EuroSim for Windows installed.
- Open a command shell and go to the directory where you just copied the two files.
- Type the following command at the prompt:

  ```
  regsvr32 esimcom.dll
  ```

  followed by the `Enter` key.

31.2.2 C++

When you plan to develop C++ clients, then you need the esimcom.h (the header file) and the esimcom_if.c files in your development environment. Copy those files from the EuroSim include directory into an appropriate directory and make sure you add an include path to the esimcom.h file. The esimcim_if.c file should be compiled and linked in with the other files of your client program.

If you get errors at compile time about MIDL versions, you may need to use the esimcom_vc6.h header file instead of esimcom.h.

31.3 Programmers reference

The complete reference is installed as HTML pages in the doc subdirectory of the directory where EuroSim is installed. For background information on COM/DCOM programming, see [COM98].

31.4 Use case – Excel example

In this chapter we will guide you through the EuroSim COM interface by means of a use case. We have a simulation, which is kept very simple for demonstration purpose and a client application, based on Microsoft Excel and Visual Basic for Applications, which will launch the simulator, monitor the state of variables in the model code of the simulator, monitor wallclock time, simulation time and the state of the simulator. As a last example, the client will change the value of the variables in the model code.

31.4.1 The simulator

First we build the simulator from the src/com/counter directory. Start up the EuroSim project manager (either double click the EuroSim icon on the desktop or run **`esim`** from the command line). You may want to refer to the approriate section of the SUM if you are not yet familiar with the following steps:

- Create a project called ‘Counter’ and give it a directory.
- Copy the files from the src/com/testsim directory into your project directory.
- Add the Counter.sim and Counter.model files to the project.
- Double click the Counter.model file in the project manager and build (F8 key) the simulator with the Model Editor.
- Double click the Counter.sim file in the project manager and run the simulator by clicking the ‘Init’ button of the Simulation Controller. If all went well, you should see some messages in the log window of the Simulation Controller indicating that the simulation is running.
- Stop the simulation by clicking the ‘Stop’ button of the Simulation Controller.

At this point we have a working simulator, which we can use to test the MS Excel based client application.

31.4.2 The MS Excel client application

We create the MS Excel client application in a couple of steps. Open a new MS-Excel sheet and open the Visual Basic (VB) editor: Menu: *Tools:Macro:Visual Basic Editor*. Open the references dialog box in the VB editor: Menu: *Tools:References...* and check the box in front of the ‘EuroSim SimAccess Type Library’, see Figure 31.1. Press the ‘OK’ button of this dialog to accept the changes and close the dialog.

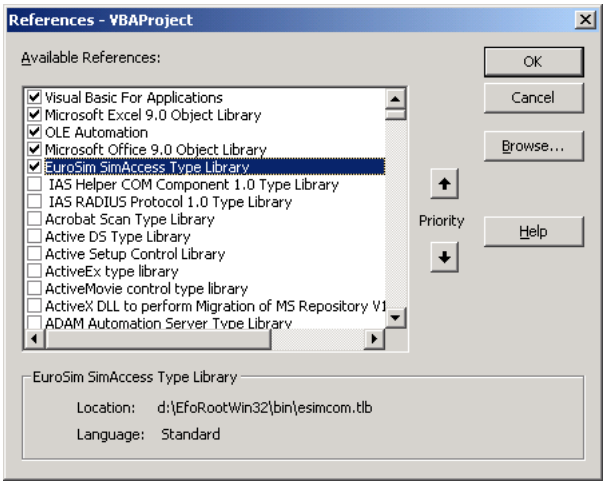


Figure 31.1: Adding a reference to the EuroSim type library

Now we will add a declaration that creates an instance of the EuroSim COM interface. Create a new module by right-clicking the VBAProject tree and selecting *Insert:Module*. Then type the following in the code section of the new module:

```
Public Sim As New EuroSim.SimAccess
```

Your VB editor should now look similar to Figure 31.2.

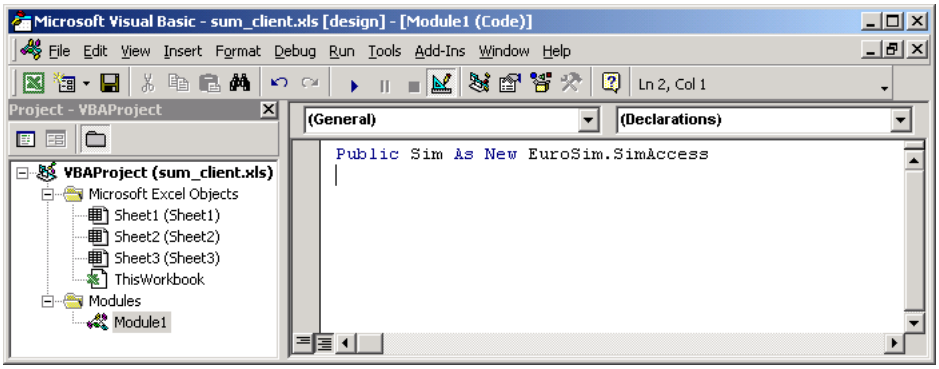


Figure 31.2: Declare an instance of the interface

Go back to the Excel sheet and make sure you have a 'Control Toolbox' toolbar, see Figure 31.3 (if not, goto menu: *View:Toolbars* and check the 'Control Toolbox'). Place a command button on the sheet and change its name to 'Init' (right click the command button and select: *CommandButton Object:Edit*). Hit the `Esc` key on the keyboard and double-click the command button. Enter the following code in the CommandButton1_Click subroutine:

```
Private Sub CommandButton1_Click()
   On Error Resume Next
   Sim.Launch "localhost", "C:\mysims\Counter", _
              "Counter.sim", "TestClient", 0
   If Err <> 0 Then
      MsgBox ("Error: " & Err.Description)
   Else
      [A5].Value = "Launch successful"
   End If
End Sub
```

Instead of "C:\mysims\Counter" for the working directory, you should fill in the path that you used when creating the simulator project, i.e. the directory where the Counter.sim and Counter.model files are located.

In a similar way add the 'Go' button with the following code:

```
Private Sub CommandButton2_Click()
   On Error Resume Next
   Sim.Go
   If Err <> 0 Then
      MsgBox ("Error: " & Err.Description)
   Else
      [A5].Value = "Started"
   End If
End Sub
```

And a 'Stop' button with the following code:

```
Private Sub CommandButton3_Click()
   On Error Resume Next
   Sim.Abort
   If Err <> 0 Then
```

```
        MsgBox ("Error: " & Err.Description)
    Else
        [A5].Value = "Stopped"
    End If
End Sub
```

Your client should now look similar to Figure 31.3.

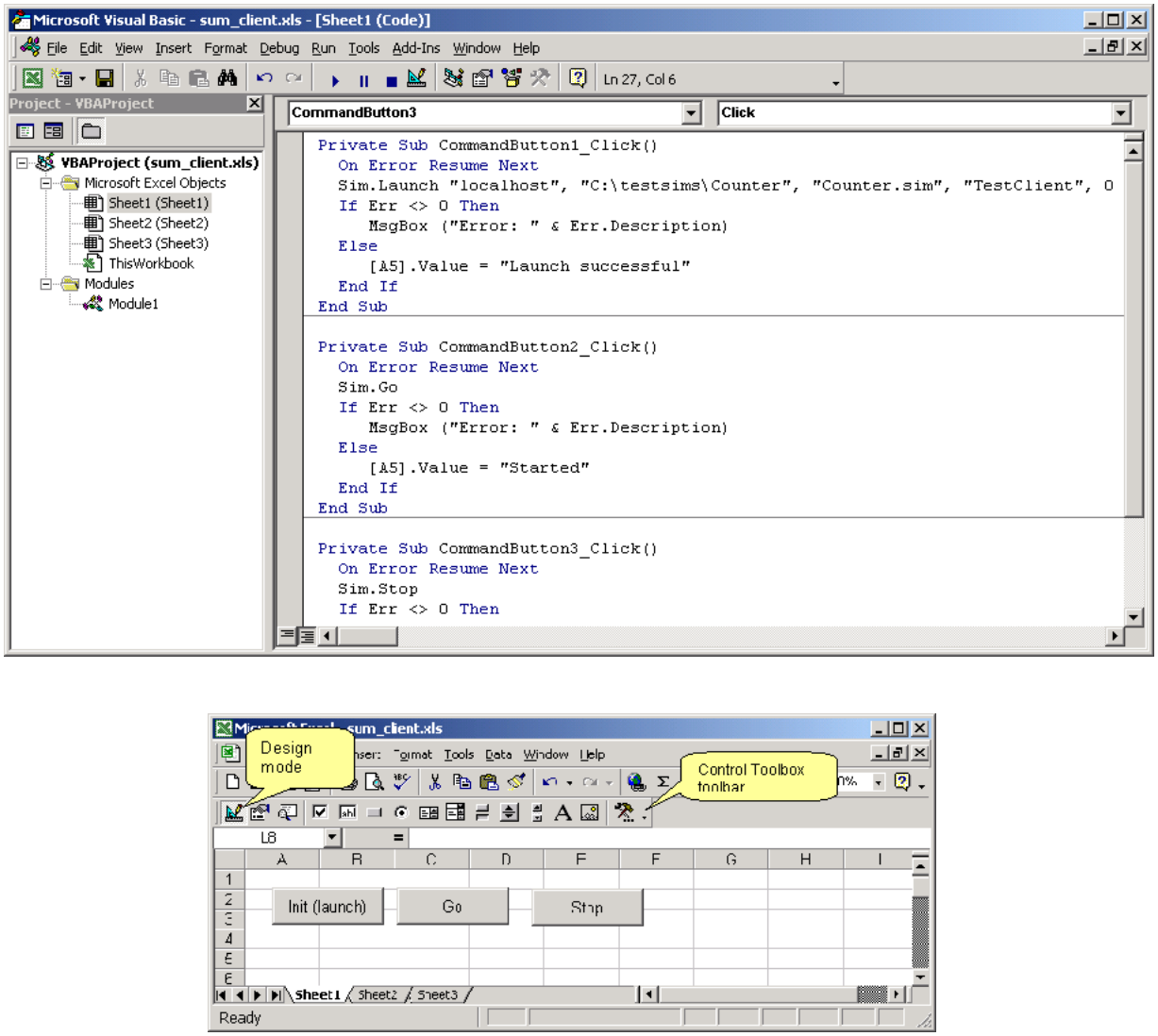


Figure 31.3: The basic test client

The client is ready for a first test. Leave design mode (the left-most button on the Control Toolbox toolbar), click the 'Init' button and wait for the text "Launch successful' to appear. You can also verify that the simulator is running by executing the `efoList` utility from the command line, see Section 22.7.1. Click the 'Stop' button in the Excel sheet to stop the simulator.

The Windows Application Event Log may give you a clue in case you encounter problems.

31.4.3 Adding a View

The example simulator has been build with the 'External Simulator Access' build option set in the Model Editor. This means that at simulator startup a `.exports` file, with the same basename as the simulator, will be searched for. This file specifies which nodes of the data dictionary will be available for reading and writing using so called 'views'. More information can be found in the `extExport(3)` man page. The `Counter.exports` file looks like this:

```
/Counter readview  R
/Counter writeview W
```

This means that all variables in the /Counter node — the Counter.c file — are available for reading when a view is created with the name “readview” and they can be written when using a view that was created with the name “writeview”. The following paragraphs describe how to create views in the MS Excel based client application.

Go to the VB editor and double click ‘Module1’ in the VBAProject tree. Add the following lines to the declarations:

```
Public ReadView As EuroSim.IvarView
Public dCounter As Double
```

Then add a ‘Create View’ button with the following code:

```
Private Sub CommandButton4_Click()
   On Error Resume Next
   Set ReadView = sim.CreateVarView ("readview")
   If Err <> 0 Then
      MsgBox ("Error: " & Err.Description)
   Else
      ReadView.AddDouble "dCounter", dCounter
      ReadView.Connect EuroSim.Read, 10
   End If
End Sub
```

That is all the code needed to have EuroSim copy the value of simulator variable ‘dCounter’ to the client variable ‘dCounter’. The updates will occur at a frequency of 10 Hz.

Now we want to display the value of ‘dCounter’ in a cell of the sheet. We could add a button that invokes some code that copies the value of ‘dCounter’ into a cell, but there is a more sophisticated means to achieve this, which is described in the next paragraphs.

31.4.4 Receiving updates from the simulator

So far, the client has been calling the methods on the simulator interface of the EuroSim component. This is depicted in Figure 31.4.

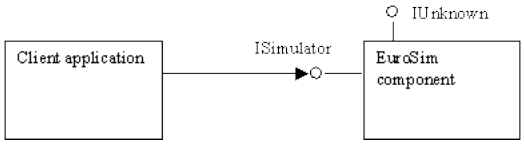


Figure 31.4: Client calling methods on the ISimulator interface

If the client application wants to keep track of changes in simulator variables, it could simply poll. However, if this is done from VBA code in, for example, an Excel spreadsheet, the complete Excel application would not be responsive to user input while polling. To solve this problem, the EuroSim COM interface provides an event callback mechanism.
Note that the client application has to implement an interface that the EuroSim component makes calls on. However, the EuroSim component specifies this interface in the type library. Since the component is the source of the calls on this outgoing interface, this interface is called a *source* interface. The client is called the *sink* for calls on this interface. The next paragraphs describe how to set-up a sink, or event handler, in VBA.

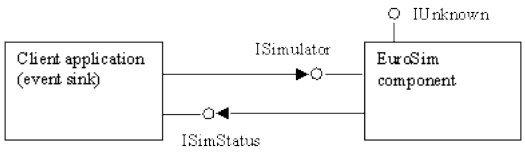


Figure 31.5: Component calling methods on the client interface

31.4.5 Creating an event handler in VBA

Right click the VBAProject tree and *Insert:Class* module. Select the new class and press F4 to display the properties window. Rename the class to 'EsimEventClass'. Enter the following declaration in the code window of the new class:

```
Public WithEvents Simulator As EuroSim.SimAccess
```

This will declare an object named Simulator as an instance of the EuroSim.SimAccess class. The `WithEvents` statement tells VB that it receives events.
At the top of the code window, there are two drop down edit boxes. In the one on the left, select **Simulator** from the list. Since there is only one method, **Changed**, the VB editor automatically creates a subroutine called 'Simulator_Changed'. Add the following line to this new subroutine:

```
If Reason = VarChanged Then
   [A6].Value = dCounter
End If
```

The above line of code writes the value of 'dCounter' to cell A6 on the sheet, each time the interface notifies our client that something has changed in the external simulator. Your VB editor should look similar to Figure 31.6.

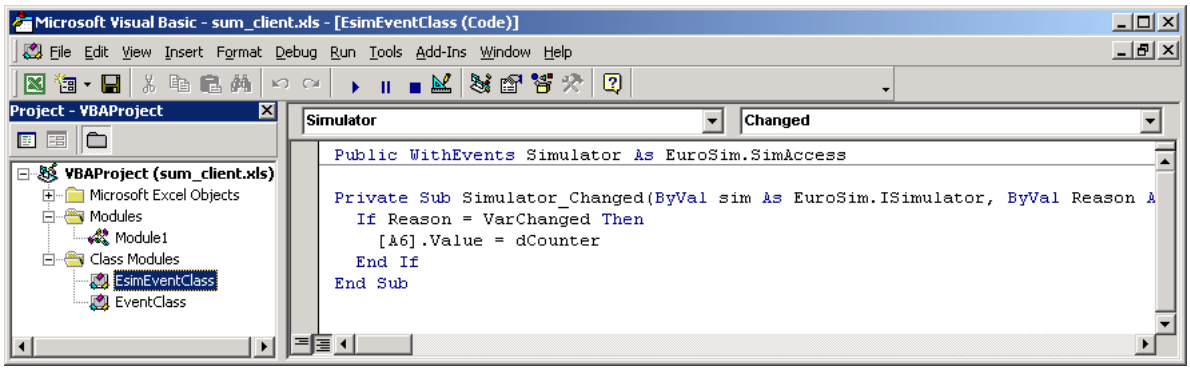


Figure 31.6: Creating an event handler

We also need an instance of the event class: select 'Module1' and add the following line

```
Public EsimClass As New EsimEventClass
```

to the global declarations so that it looks like the code below:

```
Public sim As New EuroSim.SimAccess
Public ReadView As EuroSim.IvarView
Public dCounter As Double
Public EsimClass As New EsimEventClass
```

The last step is to install the sink. Go to the CommandButton1_Click subroutine and add the following line


```
Set EsimClass.Simulator = sim
```

so that it looks like the code below:

```
Private Sub CommandButton1_Click()
   On Error Resume Next
   sim.Launch "localhost", "C:\mysims\Counter", _
              "Counter.sim", "TestClient", 0
   If Err <> 0 Then
      MsgBox ("Error: " & Err.Description)
   Else
      [A5].Value = "Launch successful"
      Set EsimClass.Simulator = sim
   End If
End Sub
```

31.4.6 Sending updates to the simulator

This chapter will help you to modify your Excel application so that when you modify cells on your worksheet, these modified values are sent to the EuroSim simulator.

First, we need a view with write permissions. Add the following declarations to Module1:

```
Public WriteView As EuroSim.IvarView
Public newCounter As Double
```

Then add the following code to the CommandButton4_Click (CreateView button) subroutine:

```
Set WriteView = sim.CreateVarView("writeview")
If Err <> 0 Then
   MsgBox ("Error: " & Err.Description)
Else
   WriteView.AddDouble "dCounter", newCounter
   WriteView.Connect EuroSim.Write, 0
End If
```

The above code creates a relation between the local variable ‘newCounter’ and the simulator variable ‘dCounter’, which we monitor using the readview.

Excel Worksheet and Workbook level events are contained by the Worksheet and Workbook objects, respectively. However, there is no similar object to contain the Excel Application level events. Therefore you must use a Class Module to create an object that can accept and handle Application level events.

Open the VB Editor, and choose Class Module from the Insert menu to create a new Class Module. Select the class module and insert the following statement as a global declaration:

```
Public WithEvents App As Application
```

This will declare a variable named App as an instance of the Application class. The WithEvents statement tells Excel to send Application events to this object.

At the top of the code window, there are two drop down edit boxes. In the one on the left, select **App**, and in the one on the right, select the **SheetChange**. The VB editor will automatically insert the `Private Sub` and `End Sub` statements into the module. Add the following code to the app_SheetChange event handler:

```
On Error Resume Next
Application.EnableEvents = False
If Target.Address = "$B$6" Then
   newCounter = Target.Value
WriteView.Send
   If Err <> 0 Then
      MsgBox Err.Description
   End If
End If
Application.EnableEvents = True
```

Each time cell B6 is changed, i.e. the user types a value, its value is copied to the variable called newCounter. This value is sent to the simulator variable 'dCounter' using the Send method on the WriteView object.

Press F4 to display the Properties window, and change the name of the class module to `EventClass`, see Figure 31.7.

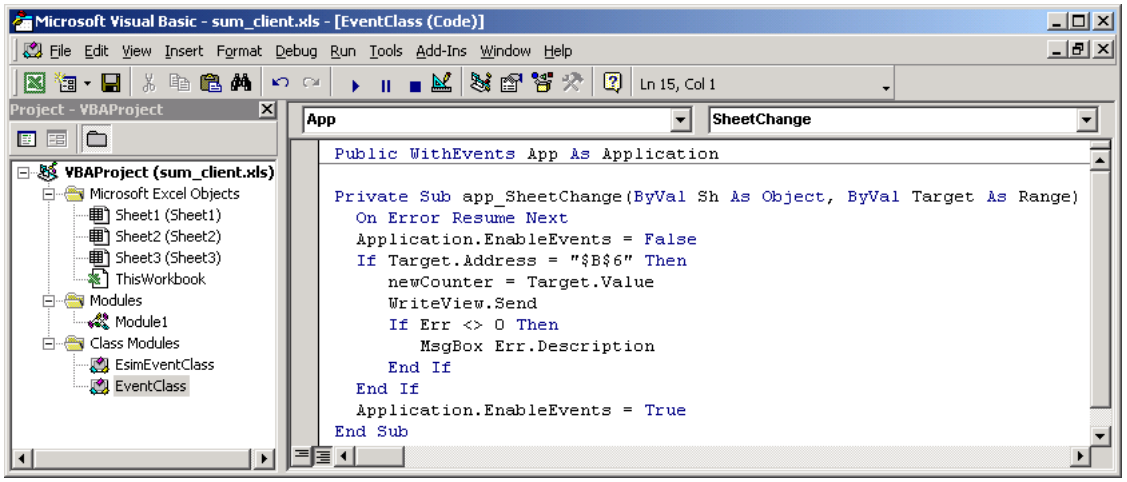


Figure 31.7: The application event handler

Next, add the following line

```
Public AppClass As New EventClass
```

to the global declarations in Module1 so that it looks like the code below:

```
Public sim As New EuroSim.SimAccess
Public ReadView As EuroSim.IvarView
Public WriteView As EuroSim.IvarView
Public dCounter As Double
Public EsimClass As New EsimEventClass
Public AppClass As New EventClass
```

This will create an object called AppClass as a new instance of EventClass.

In order to receive application events, the App variable of the AppClass object must be set to the actual Excel application. One place to do this is in the CommandButton1_Click subroutine, using the following statement:

```
Set AppClass.App = Application
```

Your VB editor should now look similar to Figure 31.8.
The MS Excel based client application is ready for another test. Leave design mode, launch the simulator, create the views and type a numeric value in cell B6. After pressing the `Enter` key, the application event handler will be called, which will send the value of cell B6 to the simulator.

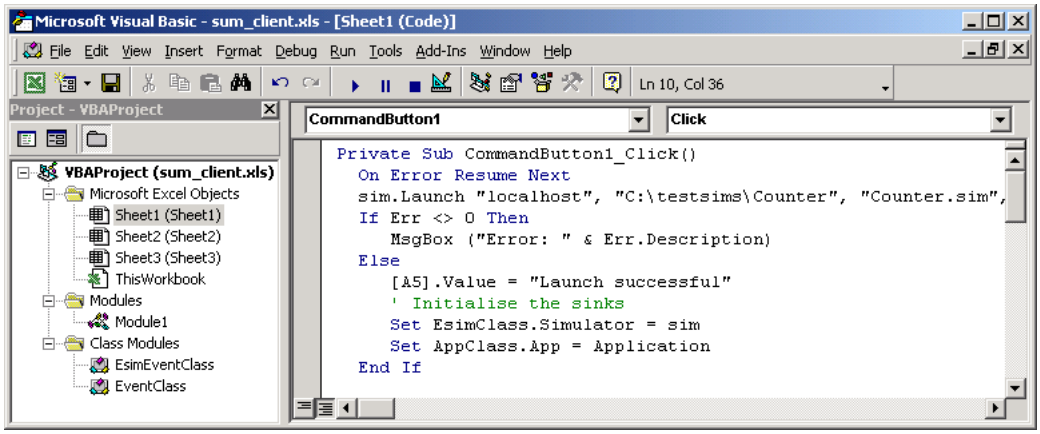


Figure 31.8: Setting the AppClass.App

Chapter 32

Web Interface reference

32.1 Introduction

This document describes how to setup and use the EuroSim Web Interface. The two main components of the web interface are

- the server
- the monitor
- the classes that describe the JAVA applet (client)

The server is the central component of the system. It communicates with client-side software (typically web browsers), with the monitor application, and with simulators (via the monitor).

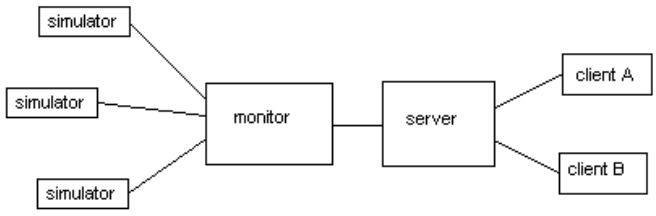


Figure 32.1: EuroSim Web Interface

The server communicates with the clients using the HTTPS protocol (HTTP over SSL). The server uses the EuroSim protocol for communication with the simulators. Instead of letting the server connect directly to the simulator, the monitor sets up connections to the simulator and the server, after which it does nothing more than forward data between the two.

The monitor is installed on the same network as the simulators it has to watch. The server can request the monitor to scan its local network for simulators, and request a connection to a simulator.

How to use these applications is explained in more detail in the following chapters.

32.2 Monitor

This chapter explains how to use the monitor application.

32.2.1 User interface

The monitor has a simple graphical user interface (see Figure 32.2). It allows the user to connect to the server, disconnect from the server and to change the configuration. It also displays the state of the connection with the server and a list of connections to simulators.

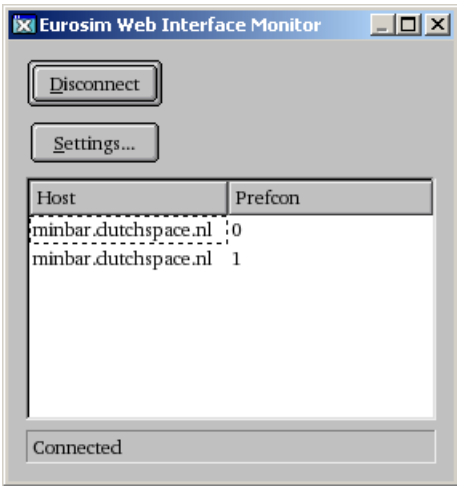


Figure 32.2: The Monitor GUI

By pressing the **Connect** button, the user initiates a connection to the server. This can be a direct connection, or via a proxy. The state of the connection is displayed on the bottom of the window. When the connection succeeds, the status message changes to 'Connected'.

On successful connection, the caption of the connect button changes to **Disconnect**. Pressing the button in this state closes the connection.

The **Settings** button brings up a configuration dialog, where the monitor settings can be adjusted. This is explained in more detail in the next section.

The listview below the buttons displays the simulator connections that are currently open.

32.2.2 Settings

The settings dialog has two tabs where several important configuration parameters can be adjusted.

The 'Server hostname' is where the server can be found. This can be in the form of a hostname (for example 'www.eurosim.nl', or an IP address in so called 'dotted decimal notation', as shown in Figure 32.3.

The 'Server port' is the port number of the server. This is usually 443, the standard port for HTTPS (which is the protocol used by the server).

Next up are the proxy settings. If web access requires a proxy at the location where the monitor is installed, check the 'Use proxy' checkbox. This enables the 'Proxy hostname' and 'Proxy port' fields, which have the same meaning for the proxy as the 'Server hostname' and 'Server port' have for the server. The standard port for proxies is 8080.

The 'Certificate file' is the file that contains the certificates for 'Certificate Authorities'. On Linux systems, this typically is '/usr/share/ssl/cert.pem'. See Section 32.4 for a more detailed explanation of certificates.
The EuroSim baseport is normally 4850. This value gets added to the 'prefcon' value for simulator connections, to give the actual TCP port number.

The 'Monitor login' and 'Monitor password' are necessary to establish the connection to the server. Without a valid username and password it is not possible to use the web interface.

Figure 32.3: The Monitor Settings (first tab)

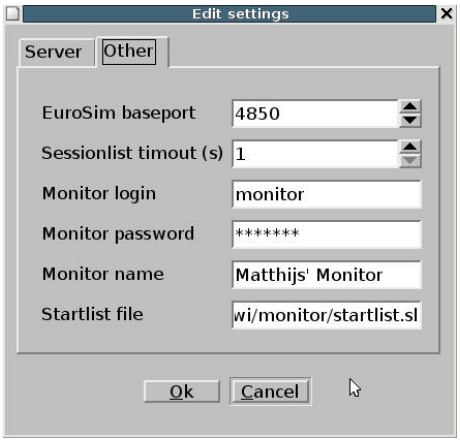


Figure 32.4: The Monitor Settings (second tab)

The ‘Monitor name’ is the name that appears in the monitor list that is sent to the client.

The ‘Startlist file’ is the path and filename to the file that describes the known simulators that can be started by the EuroSim Web Interface via this monitor.

The values of these settings are stored in the file $HOME/.qt/esimwebrc.

32.2.3 Startlist XML-file

Next to querying the local network for running simulators, the monitor also reads an xml-file to generate a startlist. The path to the startlist can be defined on the settings tab of a monitor.

An example of such a startlist file is given below.

```
<?xml version="1.0"?>
<startlist>
 <simulation>
  <id>Demo1</id>
  <name>Atos Origin Nederland Demo 1</name>
  <simfile>/home/nl27111/demo1/demo1.sim</simfile>
  <host>nwgesim002.nl.int.atosorigin.com</host>
 </simulation>
```

```
 <simulation>
  <id>Demo2</id>
  <name>Atos Origin Demo 2</name>
  <simfile>/home/nl27111/demo2/demo2.sim</simfile>
  <host>nwgesim002.nl.int.atosorigin.com</host>
 </simulation>
</startlist>
```

The file always has one startlist element, with one or more simulation elements. Every simulation has four child elements: id, name, simfile and host.

Note: The id field of a simulation has to be *one* word, without spaces.

32.3 Server

This chapter explains how to use the server application.

32.3.1 Startup

Starting the server can be done in 2 ways: via the command line, or via the internet daemon 'xinetd' (which is the preferred way).

32.3.1.1 Command line

When starting the server on the command line (for testing purposes), the option '—test' should be given. This makes the server listen on the port specified in the settings file, and sends all logging information to the console.

32.3.1.2 Using xinetd

The preferred way of running the server is via xinetd. This is a 'superserver' process that listens on the specified port on behalf of the server, and starts the server when there's an incoming connection on that port. The following configuration file could be used. Adjust the 'server' entry to point to the location where the server is installed, and copy the file to the /etc/xinetd.d/ directory.

```
service esimweb
{
  type = UNLISTED
  id = esimweb
  socket_type = stream
  user = root
  server = /usr/local/esimweb/server
  wait = yes
  protocol = tcp
  port = 443
  disable = no
}
```

32.3.1.3 Settings

Like the monitor, the configuration of the server is stored in a file in $HOME/.qt/esimwebrc. The table below lists the settings that can be adjusted in the file:

DefaultPage
: The page that should be opened when the user does not request a specific page. Default is 'index.html'.

DocumentRoot
: The root of the directory tree that contains the files that the user can browse.

ListenPort
: The tcp/ip port number that the server should listen on. This only has effect if the server is started with the '—test' option, otherwise it uses file descriptor 0. which it assumes to be initialized by xinetd to the file descriptor on which to accept a new connection.

PathToCertificate
: The path to the servers certificate file.

PathToPrivateKey
: The path to the servers private key file.

32.3.2 Authentication

The authentication information for clients and monitors is kept in a file called 'auth.xml' in the same directory as the server executable. It contains all valid user / password combinations.

Access control is divided into 2 'realms' (this term is used in the HTTP basic authorization scheme): one for clients, and one for monitors. The name of the client realm is "EuroSim Web Interface Client", and the name for the monitor realm is "EuroSim Web Interface Monitor". These names are hardcoded in the server, and should match exactly.

Below is an example of such an authentication file:

```
<authinfo>
 <realm name="EuroSim Web Interface Client">
  <user login="eurosim" password="hard2guess"/>
  <user login="johndoe" password="2hard4u"/>
 </realm>
 <realm name="EuroSim Web Interface Monitor">
  <user login="demo" password="xyz123"/>
 </realm>
</authinfo>
```

This file would give access to 2 clients: one with username 'eurosim' and password 'hard2guess', and one with username 'johndoe' and password '2hard4u'. Access is also granted for a monitor with username 'demo' and password 'xyz123'.

32.4 Certificates

This chapter will try to explain the basics of certificates.

32.4.1 What is a certificate?

(This section was taken from the QtSSLSocket documentation)

A certificate is a document which describes a network host's identity. It contains, among others, the DNS name of the host, the name and ID of the certificate issuer, an expiry date and a digital signature.

Certificates are created together with a host's private key. The certificate is either self-signed or signed by a certification authority (CA). Safe communication requires the certificate to be signed by a CA. Basically, a self-signed certificate can never be used to verify the identity of a server, but it can be used to seed the ciphers used to encrypt communication. For this reason, self-signed certificates are often used in test systems, but seldom in production systems.

Official CAs sign public certificates for a certain price. Two well-known official CAs are Thawte and Verisign. To obtain a CA signed certificate, a ”certificate request” (unsigned certificate) is generated and posted to certain forms on the CAs’ home pages.

It is quite possible to set up one’s own local CA and use that to sign servers’ certificates. Although this avoids the expense of using an official CA, all clients must then have a local copy of your own CA’s SSL certificate.

32.4.2 Creating a self-signed certificate

It is possible to use the openssl utility to create a self-signed certificate and the corresponding private key. Of course this is only useful for testing purposes. Use the following command:

```
openssl.exe req --x509 -newkey rsa:1024 -keyout server.key -nodes -days
365 -out server.crt
```

This creates a 1024 bit RSA private key, and a certificate that is valid for 365 days. Make sure the server can find these files by specifying their locations in the configuration file.

32.5 JAVA applet interface

This chapter describes the JAVA applet of the EuroSim Web Interface.

32.5.1 Start screen

When visiting the main URL for the web interface, you will probably be presented with a warning about the servers certificate. This is because at this moment, the server uses a self-signed certificate, instead of one issued by a genuine certificate authority (CA). For the moment, this warning can be ignored.
Note: To run an applet it is necessary to have a JAVA Virtual Machine (JVM) installed and enabled in your browser.
After this, the JAVA applet will be presented (see Figure 32.5).

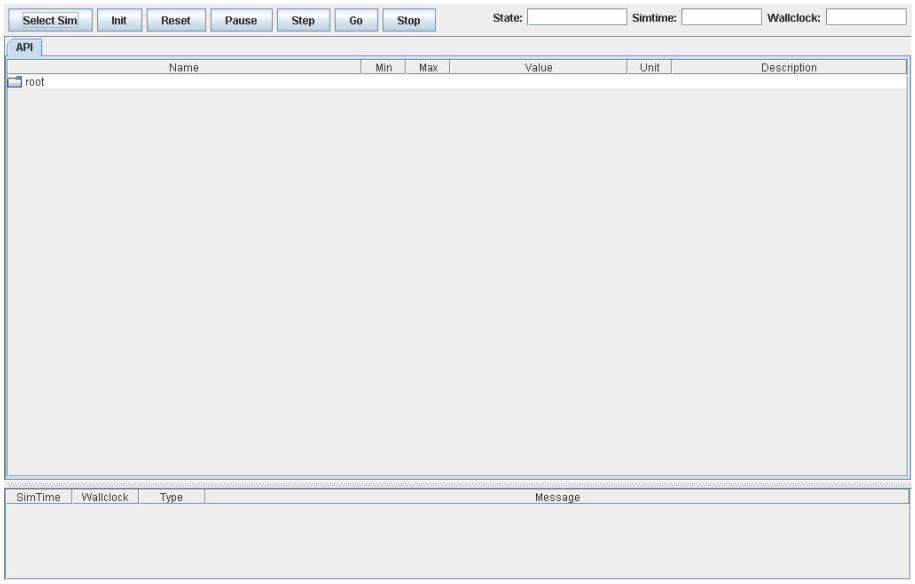


Figure 32.5: Java applet start screen

32.5.1.1 Control buttons

The control buttons are located on top of the screen. These buttons have the same functionality as the buttons on the toolbar of the Simulation Controller.

32.5.1.2 Status information

Displayed next to the control buttons are three fields with status information.
At first the current state of the simulator, second the simulation time and third the wall clock time.

32.5.1.3 Message window

Located at the bottom of the screen is the message pane. On the message pane all messages are displayed. This includes messages generated by the simulator (e.g. when starting the simulator, or when pausing it), errors from the scheduler.

32.5.2 Select Simulator

Clicking on the button 'Select Sim' will pop-up a dialog with a list of available monitors. Before this list is shown however, it is necessary that you login using a username and a password (see Figure 32.6).

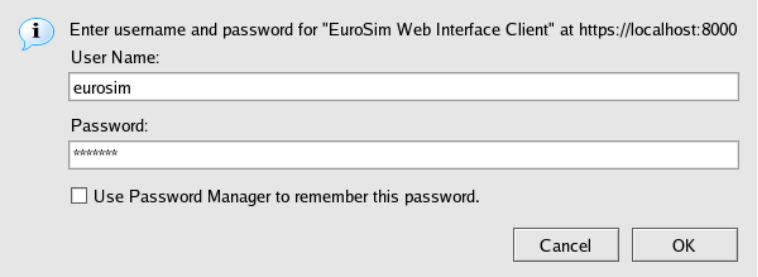


Figure 32.6: Login dialog

When your input is accepted, you will be taken to the monitor list. Otherwise, the login dialog will keep asking you for you credentials. Pressing **Cancel** will stop this, resulting in a '401 Unauthorized' message.

32.5.3 Monitor list dialog

After you have successfully logged in, you will see a dialog as shown in Figure 32.7.

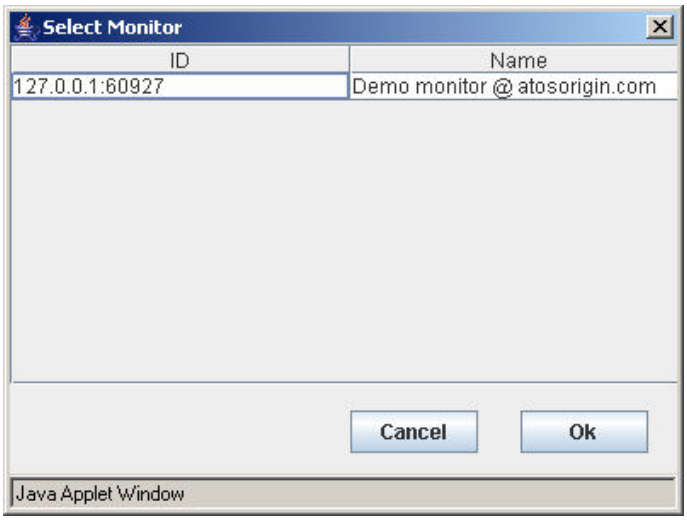


Figure 32.7: Monitor list dialog

This shows a list of all monitors that are currently connected to the server. To retreive the sessionlist/s-tartlist of a monitor, select a row and click 'Ok'.

32.5.4 Session list dialog

The session list dialog looks like Figure 32.8.

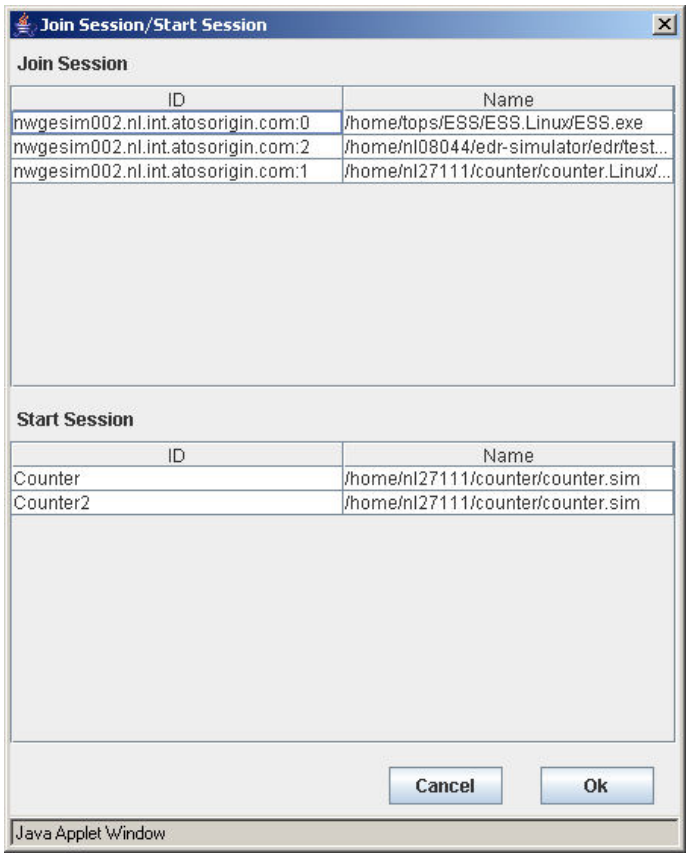


Figure 32.8: Session list dialog

It shows a list of all sessions that are currently running on the monitors local network and a list of simulators that can be started. Each running session is represented on a row in the upper table that contains its hostname, prefcon number and the name and path of the simulator executable. The lower table contains a short name and the name and path for sessions that can be started.

Join or start a session by selecting the row and pressing the **Ok** button.

32.5.5 API Tab

After joining or starting a session the JAVA applet fills the API tab with all the variables and the tab will look like Figure 32.9.
The API tab page is a Dictionary Browser with some extra functionality. When no simulation is running it just shows the dictionary with a few extra columns to show the minimum and maximum values, the unit of the value, and the description of the variable.

As long as a connection to the simulator is active this column will show the current value of that variable just like a monitor in an MMI tab page. By clicking on the value you can edit it and set the variable to a new value.

32.5.6 MMI Tab

When the applet is finished filling up the API tab with variables, the applet generates the MMI (Man Machine Interface) tabs as they were designed in the Simulation Controller.
An example of a MMI tab is given in Figure 32.10
A MMI tab page is a canvas on which monitors are displayed to monitor variables in the simulation.

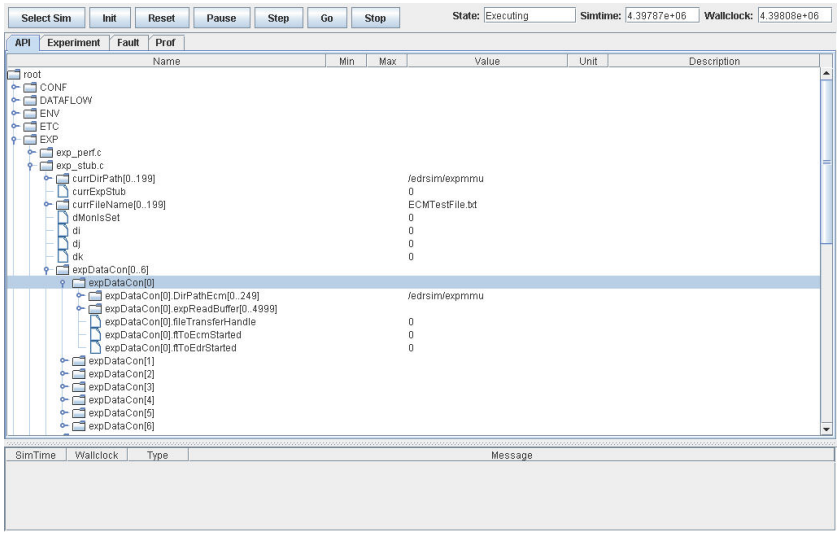


Figure 32.9: API tab

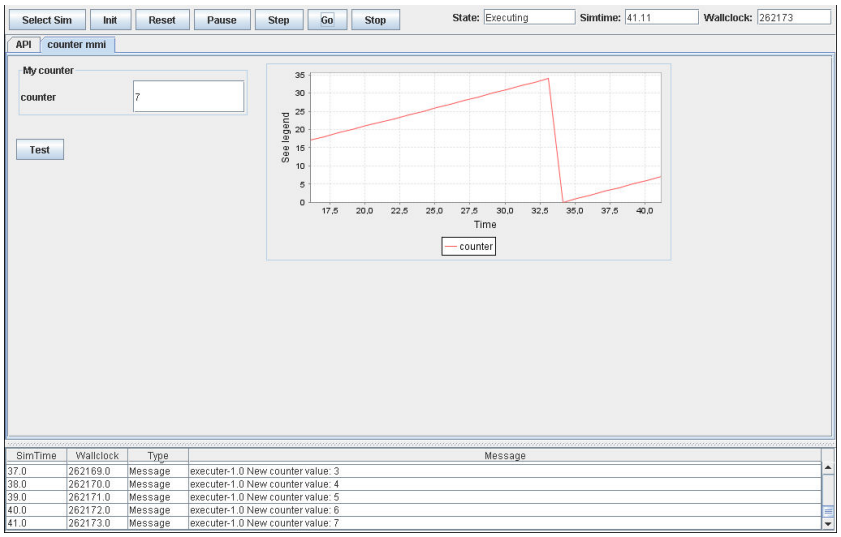


Figure 32.10: MMI tab

There are two basic types of monitors: alpha numerical, i.e. each variable is presented as a caption followed by the value, and the graph monitor, where each variable is tracked over time (or possibly against another variable) and plotted on a graph. Besides monitoring variables you can also have Action Buttons to execute MDL scripts or to enable/disable recorders or stimuli.

32.5.6.1 Alpha numerical monitors

Alpha numerical monitors display a window in the MMI tab page in which the current value of one or more variables will be presented. These values will be updated every second.

32.5.6.2 Graphical monitors

Graphical monitors use one of three types of graphs to display the values of variables:

XY Plot One or more variables against an independent variable.

Simulation Time
Plot one or more variables against the simulation time.

Wall Clock Time
Plot one or more variables against the wall clock time.

32.5.6.3 Action buttons

Action buttons are used to execute MDL scripts or to enable/disable recorders or stimuli.

32.6 Reference

This chapter provides a reference to the methods of the server interface, and a description of the XML formats that are used.

32.6.1 Server interface

The following sections describe how to call the methods of the server interface from clients. Method calls are performed by requesting a URL with the method name and parameters encoded in it. For example, to request the monitor list from a server located at www.hostname.com, the following URL is used:
https://www.hostname.com/esim?method=getMonitorList

Additional parameters are encoded the same way, for example:
https://www.hostname.com/esim?method=getSessionList&monitorId=localhost:0

The result format can be specified by the format parameter. It can either be 'xml' or 'html', and defaults to 'xml'. The html version is of course better suited for a web browser interface, while the xml version will probably be used more from scripts. An example of requesting the session list in html:
https://www.hostname.com/esim?method=getSessionList&monitorId=localhost:0&format=html

32.6.1.1 Retrieving the monitor list

Clients can request a list of the monitors that are currently connected to the server. This list contains the id and the name of the monitors. The monitor id is particularly useful, since it is used in subsequent calls to refer to the monitor.

This method cannot fail.

Method	**getMonitorList**	
Parameters	None	-
Return	A monitor list on success, or an error if something went wrong.	

Example:
To request the monitor list from a server at address hostname, use the following URL:
https://hostname/esim?method=getMonitorList

32.6.1.2 Retrieving the session list

The session list is a list of session-info structures of simulators that are running on the same local network as the monitor. It contains parameters of each session, such as simulator name, path of the data dictionary, etc. If the monitor is able to read the dictionary, each session-info also contains a list of variables of the simulator. Because the session list is specific for a certain monitor, it is necessary to pass the monitor id to the method.

This method could fail if the specified *monitorId* is unknown.

Method	**getSessionList**	
Parameters	monitorId	The id of the monitor whose session list is requested.
Return	A session list on success, or an error if something went wrong.	

Example:
To request the session list for a monitor with id localhost:0, from a server at address hostname, use the following:

https://hostname/esim?method=getSessionList&monitorId=localhost:0

32.6.1.3 Retrieving the view list

The server keeps a list of views for each user. The user is tracked by the server using cookies containing a session id. The view list contains for each defined view a list of variables and their values, and the simulator state, simtime and runtime.

This method cannot fail.

Method	**getViewList**	
Parameters	None	-
Return	A view list on success, or an error if something went wrong.	

Example:
To request the list of views currently in your session at server hostname, use the following URL:
https://hostname/esim?method=getViewList

32.6.1.4 Adding a view

The user can add a view to the view list by using the addView method. The name of the new view is specified by the 'viewId' parameter. The 'monitorId' and 'simId' parameters are used to identify the simulator for which the view is constructed.

This method could fail if any of the specified ids are unknown, or if the user has already defined another view with the same name.

Method	**addView**	
Parameters	monitorId simId viewId	The id of the monitor. The id of the simulator . The name of the view that is to be created.
Return	A viewlist on success, or an error if something went wrong.	

Example:
To add a view 'DemoView' to the simulator with id 'sim:0' on monitor 'localhost:0', use the following URL:
https://hostname/esim?method=addView&monitorId=localhost:0&simId=sim:0&viewId=DemoView

32.6.1.5 Deleting a view

Views can also be deleted from the view list. This is done using the delView method, which takes the same parameters as the addView method discussed above.

This method could fail if any of the ids are unknown.

Method	**delView**	
Parameters	monitorId	The id of the monitor
	simId	The id of the simulator
	viewId	The name of the view that is to be created
Return	A viewlist on success, or an error if something went wrong.	

Example:
To delete a view 'DemoView' on the simulator with id 'sim:0' on monitor 'localhost:0', use the following URL:
https://hostname/esim?method=delView&monitorId=localhost:0&simId=sim:0&viewId=DemoView

32.6.1.6 Adding a variable

Adding variables to a view is done using the addVariable method. This method takes 4 parameters: the monitorId, simId and viewId have the same meaning as above, and the varName parameter contains the name of the variable that is to be added.

This method could fail if any of the ids (*monitorId*, *simId* and *viewId*) are unknown, or if the view already contains a variable with the specified name.

Method	**addVariable**	
Parameters	monitorId	The id of the monitor
	simId	The id of the simulator
	viewId	The name of the view where the variable has to be added
	varName	The name of the variable to be added
Return	A view list on success, or an error if something went wrong.	

Example:
To add a variable 'Altitude' to view 'DemoView' for simulator 'sim:0' on monitor 'localhost:0', use the following URL:

https://hostname/esim?method=addVariable&monitorId=localhost:0&simId=sim:0&viewId=DemoView&varName=Altitude

32.6.1.7 Deleting a variable

Deleting a variable from a view is done using the delVariable method. It takes the same parameters as the addVariable method above.
This method could fail if any of the specified ids are unknown.

Method	**delVariable**	
Parameters	monitorId	The id of the monitor
	simId	The id of the simulator
	viewId	The name of the view where the variable has to be deleted
	varName	The name of the variable to be deleted
Return	A view list on success, or an error if something went wrong.	

Example:
To delete the variable 'Altitude' from view 'DemoView' for simulator 'sim:0' on monitor 'localhost:0', use the following URL:

https://hostname/esim?method=delVariable&monitorId=localhost:0 &simId=sim:0&viewId=DemoView&varName=

32.6.2 XML formats

This section contains DTD and examples for all XML formats used in the web interface.

32.6.2.1 The monitor list

The monitor list is a structure that contains multiple monitor elements, all consisting of an id and a name element.

Format:

```
<!ELEMENT id (#PCDATA)>
<!ELEMENT monitor (id, name)>
<!ELEMENT monitorlist (monitor*)>
<!ELEMENT name (#PCDATA)>
```

Example:

```
<?xml version="1.0"?>
<monitorlist>
 <monitor>
  <id>127.0.0.1:36506</id>
  <name>Demo monitor {\@} atosorigin.com</name>
 </monitor>
</monitorlist>
```

32.6.2.2 The session list

The session list structure contains multiple session elements, all consisting of a hostname, prefcon and simulator element.

Format:

```
<!ELEMENT hostname ({\#}PCDATA)>
<!ELEMENT prefcon ({\#}PCDATA)>
<!ELEMENT session (hostname, prefcon, simulator)>
<!ATTLIST session
 simid CDATA {\#}REQUIRED
>
<!ELEMENT sessionlist (session*)>
```

```
<!ATTLIST sessionlist
 monitorid CDATA {\#}REQUIRED
 monitorname CDATA {\#}REQUIRED
>
<!ELEMENT simulator ({\#}PCDATA)>
```

Example:

```
<?xml version="1.0"?>
<sessionlist monitorid="127.0.0.1:36506" monitorname="Demo monitor @ foobar.com">
<session simid="demo.foobar.com:0">
<hostname>demo.foobar.com</hostname>
<prefcon>0</prefcon>
<simulator>/home/demo/foo/ESS.Linux/ESS.exe</simulator>
</session>
<session simid="demo.example.com:0">
<hostname>demo.example.com</hostname>
<prefcon>0</prefcon>
<simulator>/home/test/bar/xyz.Linux/xyz.exe</simulator>
</session>
</sessionlist>
```

32.6.2.3 Sessioninfo

The session info structure contains session parameters (like the dictionary path, working directory, etc) and a list of available variables.

Format:

```
<!ELEMENT description (#PCDATA)>
<!ELEMENT dict (#PCDATA)>
<!ELEMENT exports EMPTY>
<!ELEMENT gid (#PCDATA)>
<!ELEMENT hostname (#PCDATA)>
<!ELEMENT initconds (item)>
<!ELEMENT item (#PCDATA)>
<!ELEMENT max (#PCDATA)>
<!ELEMENT min (#PCDATA)>
<!ELEMENT model (#PCDATA)>
<!ELEMENT name (#PCDATA)>
<!ELEMENT pid (#PCDATA)>
<!ELEMENT prefcon (#PCDATA)>
<!ELEMENT recorderdir (#PCDATA)>
<!ELEMENT scenarios (item+)>
<!ELEMENT schedpath (#PCDATA)>
<!ELEMENT sessioninfo (hostname, simpath, workdir, simulator, schedpath,
dict, model, recorderdir, exports, initconds?, scenarios?, prefcon, uid,
gid, pid, variables)>
<!ATTLIST sessioninfo
 simid CDATA #REQUIRED
 monitorid CDATA #REQUIRED
>
<!ELEMENT simpath (#PCDATA)>
<!ELEMENT simulator (#PCDATA)>
<!ELEMENT type (#PCDATA)>
```



```
<!ELEMENT uid (#PCDATA)>
<!ELEMENT unit (#PCDATA)>
<!ELEMENT var (name, type, unit, min, max, description)>
<!ELEMENT variables (var+)>
<!ELEMENT workdir (#PCDATA)>
```

Example:

```
<?xml version="1.0"?>
<sessioninfo simid="demo.foobar.com:0" monitorid="127.0.0.1:36506">
 <hostname>nwgesim002.nl.int.atosorigin.com</hostname>
  <simpath>/home/demo/foo/ESS.sim</simpath>
  <workdir>/home/demo/foo</workdir>
  <simulator>/home/demo/foo/ESS.Linux/ESS.exe</simulator>
  <schedpath>/home/demo/foo/ESS.sched</schedpath>
  <dict>/home/demo/foo/ESS.Linux/ESS.dict</dict>
  <model>/home/demo/foo/ESS.model</model>
  <recorderdir>/home/demo/foo/2005-02-18/12:09:37</recorderdir>
  <exports/>
  <initconds>
   <item>/home/demo/foo/ESS.init</item>
  </initconds>
  <scenarios>
   <item>/home/demo/foo/Prof.mdl</item>
   <item>/home/demo/foo/Etc.mdl</item>
   <item>/home/demo/foo/Fault.mdl</item>
   <item>/home/demo/foo/Rec.mdl</item>
  </scenarios>
  <prefcon>0</prefcon>
  <uid>1005</uid>
  <gid>1005</gid>
  <pid>14686</pid>
  <variables>
  <var>
   <name>speed</name>
   <type>int</type>
   <unit>m/s</unit>
   <min>0</min>
   <max>100</max>
   <description>The speed of the object</description>
  </var>
  <var>
   <name>acceleration</name>
   <type>int</type>
   <unit>m/s2</unit>
   <min>-10</min>
   <max>10</max>
   <description>The acceleration of the object</description>
  </var>
 </variables>
</sessioninfo>
```

32.6.2.4 The view list

The view list structure contains multiple view elements, all consisting of a name, simstate, simtime and runtime element, and a list of variables.

Format:

```
<!ELEMENT name (#PCDATA)>
<!ELEMENT runtime (#PCDATA)>
<!ELEMENT simstate (#PCDATA)>
<!ELEMENT simtime (#PCDATA)>
<!ELEMENT value (#PCDATA)>
<!ELEMENT var (name, value)>
<!ELEMENT variables (var*)>
<!ELEMENT view (name, simstate, simtime, runtime, variabless)>
<!ATTLIST view
monitorid CDATA #REQUIRED
simid CDATA #REQUIRED
>
<!ELEMENT viewlist (view)>
```

Example:

```
<?xml version="1.0"?>
<viewlist>
 <view monitorid="127.0.0.1:36506" simid="demo.example.com:0">
  <name>DemoView</name>
  <simstate>Executing</simstate>
  <simtime>6.90288e+06</simtime>
  <runtime>6.90307e+06</runtime>
  <variables>
   <var>
    <name>ball{\_}{\_}height</name>
    <value>123.456</value>
   </var>
   <var>
    <name>ball{\_}{\_}velocity</name>
    <value>3.1415</value>
   </var>
  </variables>
 </view>
</viewlist>
```

32.6.2.5 Errors

Errors can occur for a number of reasons, for example because a specified id (monitorId, viewId, simId) is unknown, or because an addVariable command is issued for a variable that is already present in the view. Errors simply contain a message about what went wrong.

Format:

```
<!ELEMENT error (message)>
<!ELEMENT message (#PCDATA)>
```

Example:


```
<?xml version="1.0"?>
<error>
 <message>An unknown error occurred</message>
</error>
```


Chapter 33

Transport Sample Protocol Interface[1]

33.1 Introduction

The Transport Sample Protocol (TSP) provides a standard interface for data distribution between a provider (EuroSim in this case) and several consumers on different hosts.

The TSP protocol is based on TCP/IP. It allows a client to register to a TSP provider for synchronous (or asynchronous) sample delivery. The client can subscribe to a list of variables at various frequencies. More information can be found on the TSP home page.

33.2 Implementation notes

EuroSim implements a TSP provider. The provider has the following properties:

1. The sampling happens in the `ACTIONMGR` task (or `ACTIONMGR_0` task in case you have multiple action managers). This means that the basic frequency is equal to the frequency of the `ACTIONMGR` task.
2. The symbols provided by the implementation are as follows:
   (a) a small number of fixed variables (the simulation time and wallclock time currently)
   (b) a flattened data dictionary. As it is not possible to publish complex types, all data structures and arrays of structures are currently expanded to their individual elements. The convention used is the same as used to specify variables in recorders, monitors, etc. I.e. using slashes as separators (e.g. `/modela/file.c/struct.var`). Some TSP clients cannot handle slashes, such as the tspfs (TSP filesystem).
3. The extended information for samples is not implemented:
   (`TSP_consumer_request_extended_information()` and
   `TSP_consumer_get_extended_information()`).
4. The following features are not supported: async sample reading and writing:
   (`TSP_consumer_request_async_sample_read()` and
   `TSP_consumer_request_async_sample_write()`).

33.3 Enabling TSP

The user must check the Transport Sample Protocol support option in the Support tab of the Model Options dialog box of the Model Editor (see Figure 7.7).

[1] Only supported in the Linux version.

33.4 Defining TSP map file

The user can optionally define a TSP map file to select the variables in the data dictionary tree that are to be exported by the TSP provider.
The TSP map file is defined in the Simulation Controller (see Section 12.2). The file format is described in Section A.8.

33.5 Troubleshooting

33.5.1 TSP provider fails to start up

The RPC program number for the TSP provider remains registered when the simulator gets killed or has crashed. If this happens too often the registration fails and the provider refuses to start up. A command line tool `tsp_rpc_cleanup` will remove all registrations of all TSP providers.

33.5.2 TSP library messages

The reason for the failures of the TSP provider can be found in the `esimd.log` file.

Part VI

Appendices

Appendix A

Files and formats

In this appendix an overview is given of the various files which are used and created by EuroSim. Also, for a number of files, their format is given.

A.1 EuroSim project files

In this section, each of the files which can be part of a EuroSim project is described briefly. Files used in a project can be identified by their extension:

Extension(s)	Short description
`adb`	Ada body source file.
`ads`	Ada spec source file.
`alias`	Alias file.
`c`	C source file.
`cc`, `cpp`, `C`	C++ source file
`cal`	Calibration file.
`cat`	SMP2 catalog(ue) file.
`dict`	Data dictionary; this derived file contains all API information for the simulator. It is generated by the Model Editor.
`env`	Environment description file
`EsimJournal.txt`	Human readable journal file; this file contains the logging of a simulation run.
`EsimJournal.xml`	Machine readable journal file; this file contains the logging of a simulation run.
`esb`	EuroSim SMP2 assembly file.
`exe`	Simulator executable; this derived file is generated by the Model Editor.
`exports`	Exports file; contains variable nodes exported to simulation clients.
`f`, `F`	Fortran source file.
`h`	C header file.
`init`	Initial condition; this file contains initial conditions for a simulator. It is generated by the initial condition editor, which is integrated in the Simulation Controller.
`java`	Java source file
`make`	Model makefile; this derived file controls the model building and is generated by the Model Editor.

Extension(s)	Short description
`md`	Model Description file; Describes which variables of a model should be copied to the datapool. To edit a model description file, start the Model Description Editor (from the Model Editor).
`mdl`	Scenario file; this file contains an MDL scenario containing monitor (obsolescent), recording and stimuli definitions. It is generated by the Simulation Controller.
`mmi`	Man-Machine Interface definition; this file describes the contents of an MMI tab page in the Simulation Controller. The contents consists of one or more monitors. This file replaces the use of monitors in the scenario (`mdl`) file.
`model`	Model file; contains all components for a simulator. To edit a model file, start the Model Editor.
`plt`	TestAnalyzer file; contains plot descriptions. To edit a plot file, start the Test Anzlyzer.
`px`	Parameter Exchange file; Describes exchanges of data in the datapool. To edit a parameter exchange file, start the Parameter Exchange Editor.
`rec`	Recording file; this file contains data written by recording actions in the corresponding EuroSim scenario.
`sched`	Schedule file; contains all timing information for a simulator. The following files are referenced: the model and zero or more Parameter Exchange files. To edit a schedule, start the Schedule Editor.
`sim`	Simulation Definition file; contains references to all files needed to create and run a successful simulation. The following files are referenced: the model, the schedule, the optional exports, zero or more scenario files, initial condition files, MMI definitions or User Defined Program files. To edit Simulation Definition, start the Simulation Controller.
`snap`	Snap shot file; this file contains an full image of all API variables of an EuroSim simulator.
`timings`	Timings file; contains timings made during a simulation run. Can be imported by the Schedule Editor.
`tr`	Test result file; this file contains a list of all recordings performed by the corresponding EuroSim scenario.
`tsp`	TSP map file.
`usr`	User Defined Program; contains all data necessary to launch a user defined program as client of the simulator.

The `tr`, `rec`, `timings`, `EsimJournal.txt` and `EsimJournal.xml` files are stored in directories representing the date and time of the simulation. The `exe` and `dict` files are created in a temporary directory that is made up of the basename of the model file and extension of the operating system (f.i. MyModel.Linux). All other files are in user-specified directories.

A.2 EuroSim Configuration file format

Most of the tunable settings of the EuroSim tools are controlled by settings in the system-wide configuration file which is stored in the file: `$EFOROOT/etc/esim_conf`.

If a user wants to have settings differently from these system-wide settings, he can copy the file `$EFOROOT/etc/esim_conf` to his home directory. At startup, the system-wide configuration file is read first, followed by the user's configuration file (if available).

Please note that a personal configuration file overrides any system-wide settings, so it is best only to include those settings that are actually changed.

The EuroSim configuration file is divided into two sections, the first section contains key-value pairs, the second section contains file type settings. Comment-lines are started with the # character.

A.2.1 Keys

Keys are defined with the format:

```
<key> = <value string>
```

The following keys are currently used by EuroSim:

UndoHistory
: (the number of commands to remember for undo)

MakeCommand
: (the command used to call GNU-make)

EuroSimOnlineHelp
: (location of the help index)

ProjectManagerOnlineHelp
: (location of Project Manager help)

ModelEditorOnlineHelp
: (location of Model Editor help)

ModelDescriptionEditorOnlineHelp
: (location of Model Description Editor help)

ParameterExchangeEditorOnlineHelp
: (location of Parameter Exchange Editor help)

CalibrationEditorOnlineHelp
: (location of Calibration Editor help)

SMP2EditorOnlineHelp
: (location of SMP2 Editor help)

ScheduleEditorOnlineHelp
: (location of Schedule Editor help)

SimulationCtrlOnlineHelp
: (location of Simulation Controller help)

TestAnalyzerOnlineHelp
: (location of Test Analyzer help)

MDLOnlineHelp
: (location of MDL help)

A.2.2 File types

The definition of file types starts after the keyword "`FileTypes:`".
The format for file type entries:

```
<ID-string> : <description> : <extensions> : <editor cmd> : \
<viewer cmd> : <icon>
```

ID-string
: uniquely identifying string

description
short description of the file type

extensions
the file extensions for the file type (comma separated)

editor cmd
the command used to edit the file

viewer cmd
the command used for read-only access to the file

icon the icon for the file type

The `<ID-string>` is mandatory, the other settings are optional. As an example follows an entry for the Simulation Defintion file type:

```
SIM_FILE : Simulation Definition : sim : SimulationCtrl : :
```

(Note: On the Windows platform, the EuroSim utility "`open.exe`" can be specified as an editor/viewer command to call the default editor defined under Windows.)

A.3 Recorder file format

The files written by the MDL `record` command and the files read by the MDL `stimulate` command both have the same file format.

Each file can contain input/output data for a number of variables. The number of variables in a particular file is stated at the beginning of the file. Following the line denoting the number of variables, is a set of lines, one for each variable, stating the variable name, variable type and variable dimension. The `<type>` field in the header is a basic type as defined in the C language, FORTRAN or Ada.

```
[Mission: <missionname.mdl>]
[Record size: <number of bytes>]
[Dict: <dictname.dict>]
[SimTime: <simtime_varname>]
[TimeFormat: relative/UTC]
Number of variables: <number>
{<variable_path> <type> {<variable_path_dimension>}}
```

Figure A.1: Syntax of EuroSim recording files.

Following these definitions is a set of lines, one for each input timepoint, stating the stimuli data to be inserted, or register data generated-, for each of the variables. The order of the values of the variables is the same as the definitions given for the variables.

The files all contain binary data for the `<variable_value>` records of the variable values. The headers of the files are in ASCII. In Figure A.1 (part of) the syntax definition is shown. When the file is generated by the `record` command, the first variable/column in the file will always be the simulation time variable[1]. Each invocation of the `record` command results in one record of variable values (see example in Figure A.2).

[1] The variable for the simulation time can be specified by an environment variable.

```
Mission: Demo48hr.mdl
Record size: 20
Dict: Demo48hr.dict
SimTime: /simulation_time
TimeFormat: relative
Number of variables: 3
/simulation_time: double
/BouncingBall/ballF77.f/balf77/ballvar$height: float
/BouncingBall/ballC.c/ballC/Velocity: double
```

Figure A.2: An example of a EuroSim recorder file.

The naming conventions for EuroSim recorder files are the following:

- for the files read and processed by the stimulation process any file name can be specified with the MDL `stimulate` command.
- for the files generated by the recording process a filename can be specified in the MDL `record` command[2], *or*
- for the files generated by the `record` command, when no file name is specified in the MDL `record` command, a file name is generated[3] with the name rec`-X-1.rec`.

A.4 The test results file

The data recording process produces an `index` file in which all recorded Application model variables names are logged, including the name of the file where their values can be found. In Figure A.2 an example of an `index` file is shown. This file can be used to get a quick overview/index of the various variables recorded to disk during real-time simulation. It is meant to be used during off-line analysis of the recorded data.

The name of the index file is derived from the name of the ready-to-run simulator executable filename. If that is `SUM.exe` then the index file will get the filename `SUM.exe.tr`.

```
Filename            Variable
SateliteDecayTest.rec /simulation_time
SateliteDecayTest.rec /Altitude/altitude
SateliteDecayTest.rec /Thruster/thrusterOnOff
SateliteDecayTest.rec /Altitude/decaySpeed
```

Figure A.3: An example of a test results file.

A.5 Exports file format

The exports file describes which part of the EuroSim data dictionary may be accessed by external (non-EuroSim) simulators. For each part that should be accessible for external simulators, one can indicate how it can be accessed (read, write, or both) and by whom.

The exports file consists of a number of lines, each line describing one part of the data dictionary that may be exported. Empty lines and lines beginning with `#` are ignored. Data following a `#` is considered to be a comment. Each non-empty line has the following layout:

```
path id mode users
```

[2]This way registration to a named file, and subsequent stimulation from a named file is possible within the same simulation run. For named registration the user should use `record "filename"` in MDL, for ”blind“ unnamed registration `record` suffices.

[3]Note that when the user changes an action containing registration commands the original registration file produced may be overwritten.

Where `path` is the path to the data dictionary which should be exported, `id` is the name under which this path should be exported, `mode` is the operation that can be performed (`R`, `W` or `RW`) and `users` is a list of clients that may request access.

The given path that is exported means that every subtree or variable that is located underneath that path may be requested in a view. A simple way therefore to export every variable is to export the `/`. The `id` under which the path is exported is the name which the external simulator must use in his access request.

The access mode `RW` is not yet implemented. However, it is possible to add separate read and write export lines.

When no users are specified the export operation is valid for all users. For more information, see also the `exports(4)` man page of EuroSim, and chapter Chapter 30.
Example exports file:

```
#
# Example file
#
/space/station/era    era       R
/space/stars          stars     RW
/space/rockets/ariane esarocket W
```

Figure A.4: An example of an export file.

A.6 Alias file format

The alias file defines aliases for variables in the data dictionary. An alias can refer to any variable even if it is an element of a structure or array.

The alias file format is line oriented. Empty lines are ignored. Comments start with the `#` sign. Each non-empty line has the following layout:

```
alias    path
```

where `alias` is the alias name of the variable indicated by the data dictionary element `path`. An alias name must start with an alphabetic character and may be followed by zero or more alphanumeric characters or underscores.

White space is used as a separator and is not significant otherwise.

```
#
# Example alias file
#
XCAD1002   /SPARC/ControlStatus
XZCY2945   /SPARC/setpoints

a          /SPARC/setpoints[2]
b_2        /SPARC/setpoints[3][3]
```

Figure A.5: An example of an alias file.

A.7 Initial Condition file format

The Initial Condition file format is either ASCII or binary. The extensions of these files are `.snap` or `.init`.

The file consists of a header section and a data section. Empty lines and lines starting with `#` in the header section are ignored as comment lines. However, when the rest of the line following a `#` character contains valid keyword/value pairs, it is interpreted. Keyword/value line have the form:

```
#keyword = value
```

Valid keywords are:

comment
: the comment that was passed when the file was written. May be omitted.

format either ASCII or binary. When omitted the file is interpreted as being ASCII.

simtime the simulation time at the time the snapshot was taken.

dict the EuroSim data dictionary file from which this file was written. The path to the data dictionary is relative to the place where it can be found. May be omitted.

reference
: an optional version control reference for the state of the model this file's data dictionary was generated from.

Any other keywords can be generated by `dictdump`, or by the user, but they are not interpreted. Every initial condition or snapshot file written by EuroSim also contains a comment line indicating the type of snapshot or initial condition file written. It is either:

```
# contains only differences wrt dict default values
```

or

```
# contains all current dict values at <date>
```

which indicates whether it is a partial snapshot (or initial condition) file or a complete snapshot containing all the variables in the data dictionary.

When the format of the file is binary there is at least one mandatory empty line following the header.

The data section of a binary file contains records for each data dictionary symbol as follows:

```
{ symbol_length+1, symbol, value_length, value }
```

where the symbols are fully qualified data dictionary paths and the values for the symbols are of course in 'binary' form (no formatting).

When the format of the file is ASCII the records of the data section look like:

```
{ "InitialCondition: ", symbol, "=", value }
```

Again the symbols are fully qualified data dictionary paths, the values for the symbols are formatted. The records may extend several lines but the carriage return '`\n`' is then escaped with a `\` backslash, so in there is in principle one record per line. Values of arrays and structures (possibly nested) are grouped using curly braces `{` and `}`, identical to the syntax of the C language to initialize those values.

The following example shows a typical layout of a full (ASCII) initial condition file:

```
# EuroSim initial condition file
# version = @(#)Header: dumpfile
# dict   = thermo.dict
# comment = complete ascii dump
# format  = ascii
# contains all current dict values at Mon Jan 27 14:15:24 1997
#
InitialCondition: /thermo.f/thermo$celltemp = "{ { 0, 0, 0},\
{ 0, 0, 0}, { 0, 0, 0}, { 0, 0, 0}}"
InitialCondition: /thermo.f/initthermo/thermo$capa = "{ { 0,\
0, 0}, { 0, 0, 0}, { 0, 0, 0}, { 0, 0, 0}}"
InitialCondition: /thermo.f/initthermo/thermo$condfac = "0"
InitialCondition: /thermo.f/initthermo/thermo$emisfac = "0"
```

A.8 TSP map file format

The TSP map file defines the list of variables exported by the TSP provider. In case the TSP map file is not provided, all variables are exported.

The TSP map file format is line oriented. Empty lines are ignored. Comments start with the # sign. Each non-empty line has the following layout:

```
dictpath = replacement
```

where `dictpath` is the data dictionary path to a variable or to a sub-tree node in the hierarchy containing variables. In the case that the `dictpath` points to a variable, the replacement may not be empty. The `replacement` string is used to replace the beginning of the `dictpath` with something else or even nothing.

A typical use case is to map the entire alias sub-tree and replace the /alias/ prefix with nothing so that all the aliases are shown as short names.

White space is used as a separator and is not significant otherwise.

```
#
# Example TSP map file
#
/SPARC/ControlStatus=XCAD1002
/SPARC/setpoints=XZCY2945
/alias/=
```

Figure A.6: An example of a TSP map file.

A.9 Simulation Definition file format

The format of the `.sim` file (and also of the `.mmi` and `.usr` files) is a simple keyword-value format:

```
keyword value;
```

where `value` is either a number or a text between double quotes. To embed a double quote in the text you have to prefix it with a backslash. To embed a backslash in the text you also have to prefix it with a backslash. Examples:

```
foo 1;
bar "text example";
escape "quote \" backslash \\";
```

A keyword can also start a nested set of keyword-value pairs. Example:

```
nested_keyword {
 key1 value1;
 key2 value2;
}
```

The simulation definition file supports the following keywords:

version the version number of the file format

server the server to use for the simulator

resultsPath
: the directory where the result files are stored.

createSubDir
: if `1`, then create

defaultTab
the name of the tab page shown on top <date>/<time>subdirectories in the `resultsPath` directory and store the result files there. If `0`, then do not create these subdirectories.

model start a nested section for a model file. See below for valid keywords.

schedule
start a nested section for a schedule file. See below for valid keywords.

export start a nested section for an exports file. See below for valid keywords.

alias start a nested section for an alias file. See below for valid keywords.

mdl start a nested section for a scenario file. See below for valid keywords. This keyword can be used more than once.

mmi start a nested section for an mmi file. See below for valid keywords. This keyword can be used more than once.

usr start a nested section for an usr file. See below for valid keywords. This keyword can be used more than once.

ic start a nested section for an initial condition file. See below for valid keywords. This keyword can be used more than once.

message_tab
start a nested section for a message tab. See below for valid keywords. This keyword can be used more than once.

Valid keywords for the `model`, `schedule`, `export`, `alias` and `usr` nested sections:

path the path of the file

required
the required version of the file

Valid keywords for the `mdl` nested section:

path the path of the scenario file

required
the required version of the file

caption the caption of the corresponding tab page

active if `1`, then the scenario is active, otherwise it is inactive

iconView
if `1`, then represent the scenario using an iconview, if `0`, then the scenario is represented as a treeview.

Valid keywords for the `mmi` nested section:

path the path of the `mmi` file

required
the required version of the file

caption the caption of the corresponding tab page Valid keywords for the `ic` nested section:

path the path of the initial condition file

required
the required version of the initial condition file

active if `1`, then the initial condition is active, otherwise it is inactive

Valid keywords for the `message_tab` nested section:

name name of the message tab

message_types
list of message type names whose messages are logged in this tab

Syntax

```
SIM
 /* Simulation Definition file */
 : keyvals
 | tEOF
 ;
keyvals
 : keyval
 | keyvals keyval
 ;
keyval
 : server string ;
 | version numeric ;
 | model { file_keyvals }
 | schedule { file_keyvals }
 | export { file_keyvals }
 | alias { file_keyvals }
 | usr { file_keyvals }
 | ic { ic_keyvals }
 | mdl { mdl_keyvals }
 | mmi { mmi_keyvals }
 | message_tab { message_tab keyvals }
 ;
file_keyvals
 : file_keyval
 | file_keyvals file_keyval
 ;
file_keyval
 : path string ;
 | required string ;
 ;
ic_keyvals
 : ic_keyval
 | ic_keyvals ic_keyval
 ;
ic_keyval
 : path string ;
 | required string ;
 | active numeric ;
 ;
mdl_keyvals
 : mdl_keyval
 | mdl_keyvals mdl_keyval
 ;
mdl_keyval
```



```
 : path string ;
 | caption string ;
 | required string ;
 | active numeric ;
 | iconView numeric ;
 ;
mmi_keyvals
 : mmi_keyval
 | mmi_keyvals mmi_keyval
 ;
mmi_keyval
 : path string ;
 | required string ;
 | caption string ;
 ;
 message_tab_keyvals
 : message_tab_keyval
 | message_tab_keyvals message_tab_keyval
 ;
 message_tab_keyval
 : name string ;
 | message_types string ;
 ;
```

A.10 MMI file format

The format is identical to the simulation definition. The purpose of an MMI file is to define monitors and action buttons on a tab page. The following keywords are valid for the MMI format:

version the version number of the file format (should be `2`)

monitor start a nested section for a monitor definition. See below for valid keywords. This keyword can be used more than once.

Valid keywords for the `monitor` nested section:

name the caption of the monitor or action button

mdl the scenario file containing the action used by the action button. Use an empty string if not relevant.

action the action executed or disabled/enabled by the action button. Use an empty string if not relevant.

path The path to the shared object this monitor uses. Can be left out if the monitor is not a plugin.

monitorType
the type of the monitor:

Type	Description
0	Alpha numerical monitor
1	Plot against the simulation time
2	Plot against the wall clock time
3	Plot against another variable
4	Action button
5	Plugin Monitor

Table A.2: Monitor Types

history the maximum number of data points that are used for the plot. Use 0 if not relevant.

left the position of the left edge of the monitor in pixels

top the position of the top edge of the monitor in pixels

width the width of the monitor in pixels

height the height of the monitor in pixels

manualScalingX
if `1`, then the X-axis has a fixed range, otherwise the X-axis scales automatically.

xMin the minimum value of the X-axis

xMax the maximum value of the X-axis

manualScalingY
if `1`, then the Y-axis has a fixed range, otherwise the Y-axis scales automatically.

yMin the minimum value of the Y-axis

yMax the maximum value of the Y-axis

var start a nested section for a variable definition. See below for valid keywords. This keyword can be used more than once.

Valid keywords for the `var` nested section:

name the variable to monitor. This is the only keyword if the var belongs to a plugin.

showLine
if `1`, then draw the line connecting two data points.

lineColor
the color of the line. It is the decimal representation of the hexadecimal RGB value 0xRRGGBB.

symbol the symbol to use for a datapoint.

Value	Description
0	No symbol
1	Ellipse
2	Rectangle
3	Diamond
5	Down triangle
6	Up triangle
7	Left triangle
8	Right triangle
9	Cross
10	X-Cross

Table A.3: Available Symbols

Note that value 4 is not used.

symbolColor
: the color of the symbol. It is the decimal representation of the hexadecimal RGB value 0xRRGGBB.

readOnly
: if `1`, then this variable is read only.

Valid keywords for the `custom` nested section:

name The key that identifies this custom property.

value The value associated with the custom property.

Syntax

```
MMI
 /* Man-Machine Interface file */
 : keyvals
 | tEOF
 ;
keyvals
 : keyval
 | keyvals keyval
 ;
keyval
 : monitor { monitor_keyvals }
 | version numeric ;
 ;
monitor_keyvals
 : monitor_keyval
 | monitor_keyvals monitor_keyval
 ;
monitor_keyval
 : var { var_keyvals }
| name string ;
| mdl string ;
| action string ;
| path string;
| propertiesPath string;
| monitorType numeric ;
| history numeric ;
| left numeric ;
| top numeric ;
| width numeric ;
| height numeric ;
| manualScalingX numeric ;
| xMin numeric ;
| xMax numeric ;
| manualScalingY numeric ;
| yMin numeric ;
| yMax numeric ;
;
var_keyvals
 : var_keyval
 | var_keyvals var_keyval
 ;
```

```
var_keyval
 : name string ;
| showLine numeric ;
| lineColor numeric ;
| symbol numeric ;
| symbolColor numeric ;
| readOnly numeric ;
;
```

A.11 User Program Definition file format

The format is identical to the simulation definition. The purpose of a `.usr` file is to specify a program that can be used to connect to a running simulator. The following keyword is valid for the `.usr` format:

def the specification of the program and its arguments. Note that the sequence `%h` is replaced with the hostname of the running simulator and the sequence `%c` is replaced with the preferred connection number.

Syntax

```
USR
 /* User Program Definition file */
 : keyvals
 | tEOF
 ;
keyvals
 : keyval
 | keyvals keyval
 ;
keyval
 : def string ;
 ;
```


Appendix B

XML Schemas

The XML files used in EuroSim are officially described by XML schemas. These schema files are located in the `lib/schemas` subdirectory of the EuroSim installation directory.

Appendix C

Simulator launch options

The following are the command line options that can be passed to the `main()` function of the simulator:

`-h`	Show on-line help and exit.
`-v`	Enable verbose printing of currently running simulator.
`-u` *uid*	(Numeric) uid for file ownership of recordings etc.
`-g` *gid*	(Numeric) gid for file ownership of recordings etc.
`-c` *number*	Connection number offset for the simulator process. Needed if more simulators are to be run on one host.
`-x` *simfile.sim*	Simulation definition to initially load.
`-m` *scenario.mdl*	Scenario to initially load.
`-e` *exportsfile.export*	Exports file for ExtSimAccess.
`-i` *initialcond.init*	Initial condition file to load.
`-d` *datadict.dict*	Data dictionary to load.
`-s` *schedule.sched*	Schedule file to load the scheduler with.
`-f` *number*	Frequency to run the asynchronous processes with. The default for the asynchronous frequency is 2 Hz.
`-R` *directory*	Directory to write recording files to. Defaults to the directory where the *simfile.sim* file came from.
`-l` *number*	Period (with respect to asynchronous frequency) for datalogger. Every *number*'th cycle data values will be delivered to (interested) clients (e.g. a simulation controller with a datamonitor). Defaults to 1.
`-r` *number*	When *number* is 0, real-time mode is off, when it is 1 it is on.
`-D` *flags*	Debugging flags. Only available when EuroSim libraries were compiled with `DEBUG` defined.
`-M` *modelfile.model*	The name of the model file used to create the simulator.
`-E`	Don't use the daemon for services (CPU allocation).
`-I`	Do not go to initializing state automatically.
`-S`	Stand-alone mode (do not wait for client to connect). You may want to use this flag in combination with the `-E` flag. Useful for debugging from the command line with i.e. `gdb`.

Note that under normal circumstances the above options will be passed to the simulator by the EuroSim daemon.

Example of a debugging session, running the simulator from the command line using gdb. Note that you

must have root privileges.

```
$ gdb mysimulator.Linux/mysimulator.exe

(gdb) run -c 1 -x mysimulator.sim -s mysimulator.sched
        -d mysimulator.Linux/mysimulator.dict
        -M mysimulator.model -r 1 -user 18157 -g 100
        -R result_dir -v -f 10 -E -S
```


Appendix D

As Fast As Possible (AFAP) simulation

D.1 Introduction

The execution sequence of as fast as possible (AFAP) scheduling is a result of the same constraints as normal real-time scheduling and the overall behavior will thus be the same. However, one should be aware that AFAP scheduling exploits the parallelism of the schedule to a maximum. If a schedule is not well defined, this parallelism could lead to erroneous behavior. Below is an explanation of the operation of the scheduler, followed by some examples illustrating AFAP scheduling and some consequences regarding parallelism.

D.2 Deadlines and simulation time

A task in EuroSim has a deadline which is equal to the sum of its start time and its allowed execution time. A deadline is the point in time at which a task should be ready. In a non real-time simulation the deadline is not a real world time, but a (virtual) simulation time. In a normal speed non real-time simulation this simulation time runs as fast as the real world time. However when a task is not ready before its deadline, the simulation time is halted until the task gets ready. Thus, when a task misses a deadline no more tasks will be started until that task gets ready.

When the scheduler is running a simulation as fast as possible it increments the simulation time and starts tasks, until the simulation time reaches the deadline of one of the started tasks. The scheduler then waits until that task is ready and continues to increment the simulation time until the next deadline is reached.

D.3 Example 1: AFAP simulation with 2 independent tasks

Two tasks A and B are scheduled according to the schedule of Figure D.1. Both tasks have an allowed execution time of 15 ms. Task A has a real execution time of 4 ms and runs on processor 1. Task B has a real execution time of 6 ms and runs on processor 2. The real time execution sequence is shown in Figure D.2. Tasks B starts after task A is ready.

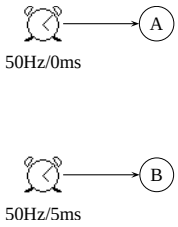


Figure D.1: Schedule of example 1

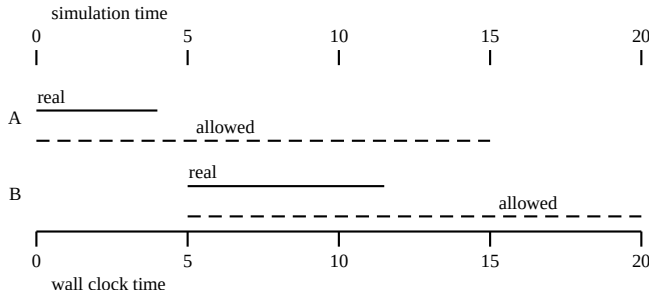


Figure D.2: Real time execution sequence

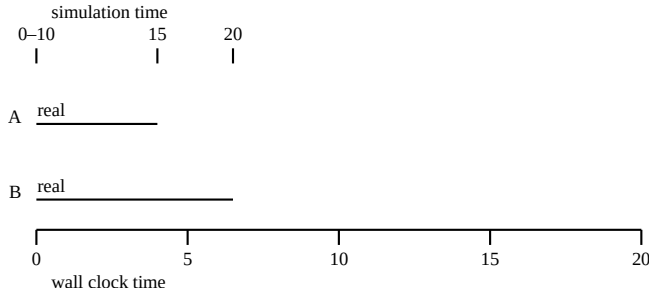


Figure D.3: AFAP execution sequence

Figure D.3 shows the execution sequence of the AFAP simulation. After task A is started, the simulation time may be increased immediately up to 5 ms, because there is no task with a deadline at 5 ms. Task B can thus be started and the simulation time can be increased up to 10 ms. The simulation time can be increased up to 15 ms only after the completion of task A and up to 20 ms after the completion of task B. The 20 ms of simulation time are executed in 6 ms real time, an acceleration factor of 3.3.

In the AFAP simulation task A and B run in parallel where they were running exclusive in the real time simulation.

D.4 Example 2: implicit mutual exclusion of two tasks

Tasks A and B are scheduled as in example 1. However, the allowed execution time for task A is set to 5 ms. The real time execution shown in Figure D.4 does not differ from Figure D.2. But, the parallelism in the AFAP simulation (Figure D.5) has disappeared. The simulation time cannot be incremented up to 5 ms until task A has completed.
Due to this implicit exclusion the acceleration factor is 2.

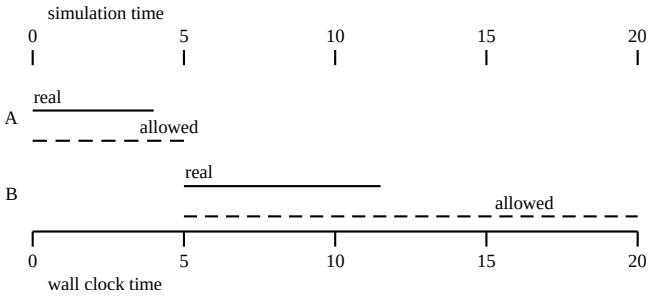


Figure D.4: Real time execution sequence with 5 ms allowed execution time for task A

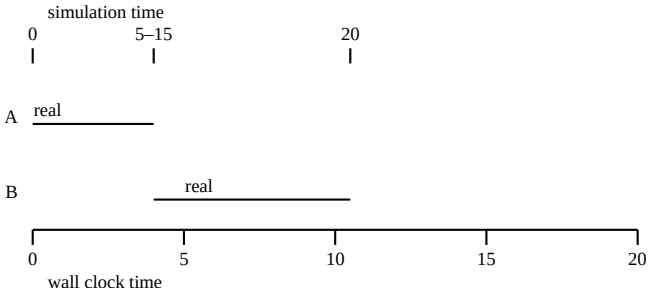


Figure D.5: AFAP execution sequence with 5 ms allowed execution time for task A

D.5 Example 3: A chain of tasks is a pipeline and has parallelism

A chain of tasks as shown in Figure D.6 is a pipeline and will be executed as such by the scheduler.

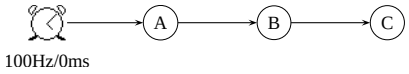


Figure D.6: A chain of tasks forming a pipeline

The schedule has a basic frequency of 1000 Hz and the tasks have the following properties:

- Processor: any (Schedule Editor default)
- Allowed execution time: 4 ms
- Real execution time: 3 ms

In a real time run these specifications result in the following task sequence:

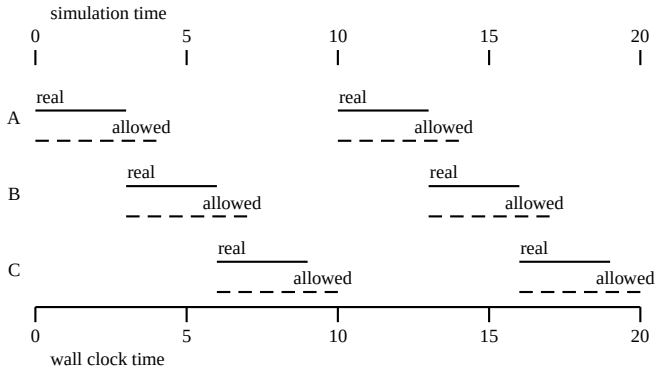


Figure D.7: Real time execution of the task chain

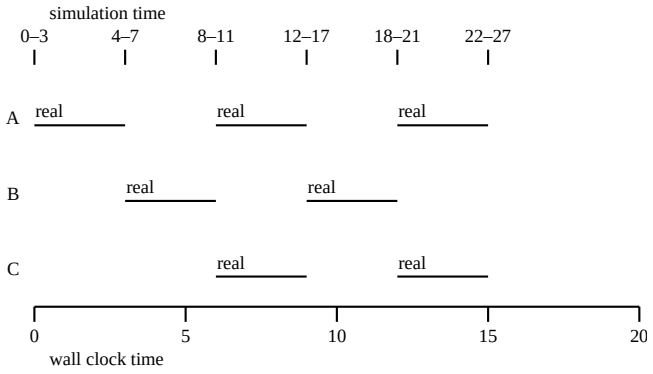


Figure D.8: AFAP execution of the task chain

After task B has completed simulation time can be incremented to 11 ms allowing task A to start again. According to the schedule this is allowed, since task C does not depend on A. The effect is that task A and C run in parallel.
If this is not the intended behavior then task C should be made dependent on task A (Figure D.9) or the sum of all allowed execution times should be made smaller then the task period.
In fact, with this schedule parallelism would also occur in the real time situation if every task had a real execution time of 4 ms.

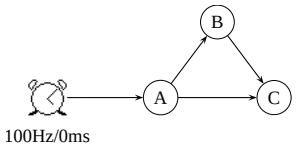


Figure D.9: A chain of dependent tasks

D.6 Other effects

Offset + allowed execution time >period

If the sum of the offset of a task and its allowed execution time is larger than the period it can happen that the task is started after a state transition.

Timed Events and Timed State Changes

.

In accelerated mode, Timed Events and Timed State Changes only work properly when they are expressed in simulation time. (Quite trivial.)

Non real time tasks (output connectors)

.

The execution delay of non real time tasks depends on the load of the system. They are not synchronized to real time tasks (by definition). It can thus happen that output connectors overflow because the accelerated periodic tasks are activating them with a too high frequency.

D.7 Performance

Estimates for the acceleration factor in AFAP scheduling can be made with the data form the timings file incremented with the scheduler overhead of Table D.1.

Activity	Time (μs)
Clock tick	8
Task activation	12
Empty actionMgr	17
Active Action/Recorder/Stimulus	11
Inactive Action/Recorder/Stimulus	1

Table D.1: Scheduler overhead measured on a SGI/Origin 200 R10000@225MHz with EuroSim Mk2rev2

Note that the ActionMgr has a default frequency equal to the basic frequency. This can become one of the major CPU consuming tasks in an accelerated simulation. Accelerated simulations will run faster if the ActionMgr is scheduled at a lower frequency.

D.8 Example of performance computation

	Frequency (Hz)	Task duration (μs)
Clock	1000	
Task A	500	100
Task B	20	500
ActionMgr	1000	
Recorder 1	100	
Recorder 2	10	

Table D.2: Example schedule on 1 CPU.

		Frequency (Hz)	Duration (μs)	Subtotal (μs)	Total contribution (μs)
Tasks	Task A	500	20	10000	
	Task B	20	500	10000	

Table D.3: Computation time of the not optimized schedule.

		Frequency (Hz)	Duration (μs)	Subtotal (μs)	Total contribution (μs)
	Total				10000
Scheduler	Clock	1000	8	8000	
	Task A	500	12	6000	
	Task B	20	12	240	
	Total				14240
ActionMgr	ActionMgr	1000	17+1+1	19000	
	Recorder 1	100	10	1000	
	Recorder 2	10	10	100	
	Total				20100
Total					44340

Table D.3: Computation time of the not optimized schedule.

Maximum acceleration of this schedule: 1000000/44340 = 23.

The actionMgr uses 20100/44340 = 45% of the computation time.

When the actionMgr is scheduled at 100 Hz it will only use 3000 μs.

The maximum acceleration will then be 1000000/27240 = 37.

This schedule could be optimized further if a basic frequency of 500 Hz is used, giving another 4000 μs reduction. The maximum acceleration will then be 1000000/23240 = 43.

Appendix E

Scheduler Errors

In this appendix, two categories of errors are described:

- Errors generated by the Schedule Editor when creating or modifying a schedule.
- Errors generated by the EuroSim scheduler during simulation runs.

E.1 Schedule Editor errors

The Schedule Editor helps the model developer by indicating where problems arise during schedule definition. When one of the items placed on the schedule view is red, then there is an error for that item. The error can be viewed in the item attributes window. Below the possible error messages are described.

`name_unique`
: The name entered is already in use by another task. Change the name.

`number_of_input_flows`
: The item needs (mandatory) input. Add an input.

`number_of_output_flows`
: The item needs (mandatory) output. Add an output.

`active_flows`
: There is no active flow. Active flows are flows from data generating items. Connect a data generating item.

`frequency_mismatch`
: A task has two input with different input frequencies, or a synchronous store has an input frequency which does not match the assigned input frequency. Remove one of the inputs, change the frequency of one of the inputs, or use a synchronous store in one of the flows.

`frequency_zero`
: The timer of the synchronous store has a frequency of zero. Change it.

`incorrect_ratio`
: The ratio of the input and output frequency of a synchronous store is not *1:n* or *n:1*. Adjust one or both of the frequencies.

`cycle` There is a cycle in the schedule (i.e. following the flows you can come back where you started). Break the cycle by removing a flow or task.

`critical`
: Timing problem. The scheduler can not guarantee that the task can be completed in the available time. Modify timing of item or items connected to item concerned.

E.2 Scheduler run-time messages

The errors in this section are generated by the EuroSim scheduler during a simulation run. Each error has in the margin one or two of the following symbols:

N This message is an informational message only. No action is required.

W This message is a warning. It indicates a potential problem, which does not yet prevent the system proceeding.

E This message is an error. The system cannot proceed.

S This message should not occur (it stems from a file generated by EuroSim itself). Submit an SPR for this message.

Each message is accompanied by a short description and recovery suggestions if recovery by the user is possible.

ES: `at line nnn, syntax error`
This error is flagged when the textual schedule definition file contains a syntax error.

ES: `cannot open scheduler description file sss`
The schedule definition file could not be opened at initialization of `RT_SCHD`, probably because it is not present in the current directory. Make sure that the schedule definition in a file named `SCHEDULE_FILE` is present in the current directory, and restart `RT_SCHD`.

E: `at line nnn, number of real time processors must be within the range [1...p]`
The schedule definition file requests a number of real time processors which is larger than physically available. Correct the definition file by choosing a processor in the reported range, or restart with real time privileges off (no super-user authorities). This latter will result in non real-time execution mode, in which any number of 'real time' processors may be emulated.

E: `at line nnn, basic frequency must be within the range (0...f]`
A scheduler clock frequency beyond the system-imposed limit has been requested in the schedule definition file. Choose a clock frequency which falls within the reported range.

ES: `at line nnn, task sss has not been defined in the current state`
In each EuroSim state, tasks must be declared before use in the schedule definition file; apparently this is not the case for the reported task. Add (or move) the declaration of the task.

ES: `at line nnn, store sss has not been defined in the current state`
In each EuroSim state, stores must be declared before use in the schedule definition file; apparently this is not the case for the reported store. Add (or move) the declaration of the store.

ES: `at line nnn, inputconnector sss has not been defined in the current state`
In each EuroSim state, input connectors must be declared before use in the schedule definition file; apparently this is not the case for the reported input connector. Add (or move) the declaration of the input connector.

ES: `at line nnn, outputconnector sss has not been defined in the current state`
In each EuroSim state, output connectors must be declared before use in the schedule definition file; apparently this is not the case for the reported output connector. Add (or move) the declaration of the output connector.

ES: `at line nnn, this processor number falls outside the defined range of real time processors`
In the schedule definition file, a task has been allocated to a processor which is not in the range of real time processors which has been requested in the same file. Lower the processor number of the indicated task such that it falls in the range requested at the `RT_PROCESSORS` request.

E: `executer process creation failed`

Creation of a real time task executor process failed. The most probable cause of this situation is insufficient memory.

W: `cannot run executor on processor` *p*

Allocation of one of the real time executor processes to the specified processor failed. This message will be the result of starting `RT_SCHD` with insufficient privileges. The system will proceed in non real-time mode. When this is not intended, stop the simulation, and restart with super user authorities.

W: `too many reschedule levels for executor`

One of the internal scheduler's stacks overflows. This situation almost always occurs in combination with real time errors. Resolve the cause of the real time errors.

W: `the task activation tick of the previous cycle was still active at a new tick; this resulted in the loss of one basic cycle`

This warning is an indication that the system cannot support the requested clock frequency: the periodic part of the scheduler overruns. Reduce the clock frequency.

WS: `a preemption of the task activation tick detected; this should not have occurred`

The scheduler detected a double invocation of its periodic part, a situation which definitely should not have occurred.

W: `too few processors for specified amount of executors`

The schedule definition file requests a number of real time processors which is larger than physically available. This message is reported in combination with message `at line nnn, number of real time processors must be within the range [1...p]`. Correct the definition file by choosing a processor in the reported range, or restart with real time privileges off (no super-user authorities). This latter will result in non real-time execution mode, in which any number of 'real time' processors may be emulated.

WS: `executor table overflow`

This message indicates an overflow of one of the scheduler's internal tables. It should never occur, since the size of this table has been chosen 'sufficiently' large.

N: `execution stopped before task` *sss*

In debugging mode, this message reports each task which has hit a breakpoint; this task is the one which will be resumed at the next 'step' command.

WS: `taskpool was too small (extended, but this should not have occurred)`

This situation indicates that some preallocated memory in unit `Sched_TaskPool.c` is insufficient. Although it is not expected, this situation might occur in simulations with a large number of different task frequencies or task execution time bounds. The system responds to this situation by dynamically enlarging its memory resources which might theoretically result in real time errors, although the probability of this is very low. Raise an SPR, requesting the size of preallocated memory (`FREELIST_POOLSIZE`) in `Sched_Taskpool.c` to be raised, and continue simulating.

W: `An input event raised to connector` *sss* `was lost due to insufficient buffer space. Raise the capacity of this input connector in this state (currently` *nnn*`) and rerun the simulation`

Self explanatory.

W: `An input event raised to connector` *sss* `was lost due to insufficient buffer space. Raise the total capacity of the input connectors in this state (currently` *nnn*`) and rerun the simulation`

Self explanatory.

W: `An output event raised by connector` *`sss`* `was lost due to insufficient buffer space. Raise the total capacity of this output connector in this state (currently` *`nnn`*`) and rerun the simulation`

Self explanatory.

W: `pending state buffer overflow; state transition request ignored`

A very rapid sequence of state transition requests has caused an overflow of an internal buffer. Slow down with changing states by modifying schedule.

W: `hard real time error at uptime=`*`nnn`* `msec: periodic tasks were still active when they should have completed; basic cycle has been extended`

An overload condition has been detected, in which execution of a periodic task took longer than its allowed execution time (unless otherwise specified, this allowed time is equal to its activation period). The system responds to this situation by slowing down the real time.

Increase number of real time processors used (if possible), or decide if the effective schedule is not optimal. A schedule is not optimal if processors are unused for longer time spans[1] where this could have been avoided by a 'smarter' activation order of previously executed tasks. In these cases, scheduling can be influenced by processor allocation, use of task offsets and -priorities, and by adding dependencies between tasks.

W: `illegal state transition from` *`sss`* `to` *`sss`* `(ignored)`

An unallowed EuroSim state transition has been requested. It is ignored. Check the state transition diagram for legal transitions.

W: `real time mode transition refused: this machine is non real-time`

A transition of `RT_SCHD`'s mode to mode 'real time' has been requested in a simulation which runs with insufficient authorities, or which runs on a machine without real- time capabilities. The mode transition is ignored. Re-run with super user authorities, and use a multiprocessor platform.

W: `frequency change refused: this simulation is in real time execution mode`

A request has been given to change the clock frequency to a rate different from the rate on which the current schedule is based (200 Hz default). This request is refused in real time simulation mode. Make a mode transition to mode 'non real-time'.

W: `frequency change refused: the requested frequency (`*`nn`* `Hz) is larger than the bound imposed by the system (`*`nn`* `Hz)`

A request has been given to change the clock frequency to a rate higher than a system-imposed bound. This has been ignored. Choose a lower rate.

W: *`itemname`* `hard real time error for` *`itemtype`* `(`*`itemdetails`*`): previous firing not completed; basic cycle has been extended`

The specified item has generated a hard real time error.

E.3 Low level errors

The errors from the previous section are scheduler run-time errors which are raised through the EuroSim message reporting mechanism. It is possible that errors occur that are not caught by this mechanism. This is usually because:

- They are raised at system initialization, when the message mechanism has not yet been initialized. These errors usually result in a text like '`error:` *description*'.
- They cannot be caught (e.g. bus errors, access violations). These errors usually result in a core dump.

[1] 'Longer' here is relative to the time granularity of the simulation, so it might apply to one or more milliseconds.

- They are on the level of code assertions, in libraries which do not 'know' the message mechanism. These errors usually result in a text like '`Assertion failed`'.

All errors of these kinds are reported through standard error, i.e. they are displayed on the console or the window in which EuroSim was started. In most cases, they indicate a problem in `RT_SCHD` and should be reported through an SPR. The second category of errors may also be caused by errors in the user code.

Appendix F

Introduction to CVS

F.1 Introduction

CVS, short for Concurrent Versions System, allows you to save versions of your files for later retrieval by yourself or other users (provided they have sufficient access rights). The files are stored in what is called a "repository". This chapter describes the basic commands that are required to start using CVS with EuroSim. See [CVS00] for more information on CVS.

F.2 Initializing the repository root

After deciding where to install the CVS repository root (usually a directory on a network drive that is backed-up at regular intervals), you must initialize it:

- Open a shell and change directory to the designated directory (create it first if it doesn't exist yet):

  `cd` *repository_root_directory*

- Set the `CVSROOT` environment variable:

  `export CVSROOT=`*repository_root_directory*

  Example for Linux:

  ```
  export CVSROOT=/projects/share/repository
  ```

  See Section F.4 for a description on how to use CVS under Windows.

- Initialize the CVS repository:

  ```
  cvs init
  ```

If all went well, a `CVSROOT` directory is created in the *repository_root_directory*. Note that you only have to perform the above steps once.

F.3 Setting up a CVS repository

Once the CVS repository root has been initialized, you can add "repositories" to it. When using CVS with EuroSim, you can create a repository for the directory where your project files are located:

- Go to the directory where the files of your EuroSim project are located (model files, schedule file, etc...).

  `cd` *project_directory*

- Create an empty CVS repository directory in the CVS repository root:

  `cvs import -I \* -m` *log_msg repository vendor_tag release_tag*

  The `-I` option with the escaped wildcard (`\*`) tells CVS to ignore all files in the project directory. This is done because at this point we do not want to import any files into the repository: we selectively add files to the repository later on by means of the menu commands in the EuroSim tools.

  The `-m` option allows you to enter a descriptive log message for the repository. Enclose the message in quotes or double quotes.

  The *vendor_tag* and *release_tag* can be any text, because we are not importing any files at this point.

  Example:

  ```
  cvs import -I \* -m 'Test' MyProject Foo Bar
  ```

- Go to the parent directory

  ```
  cd ..
  ```

- Initialize *project_directory* with the CVS files:

  `cvs checkout -d` *project_directory repository_name*

  The project directory should now contain a directory `CVS`.

  Example:

  ```
  cvs checkout -d MyProject MyProject
  ```

You can now start the EuroSim Project Manager, select your project and select the *Tools:Project Settings* menu command to set the project repository root to the *repository_root_directory* that you assigned to the `CVSROOT` environment variable.

When starting the EuroSim tools from the Project Manager, you can use the *Tools:Version* menu commands to add files to the repository.

F.4 Using CVS under Windows

When you are using Cygwin's native version of CVS, then specify the `CVSROOT` environment variable as follows:

`export CVSROOT=/cygdrive/`*drive_letter*`/`*repository_root_directory*

Example for Cygwin when your repository is on the `F:` drive

```
export CVSROOT=/cygdrive/f/repository
```

Other versions of CVS for Windows may require the addition of the *local* server specification like this:

`export CVSROOT=:local:`*drive_letter*`/`*repository_root_directory*

For example:

```
export CVSROOT=:local:F:/repository
```

Consult the README files of the version of CVS that you are using for more information on how to set up CVS.

F.5 More information

You can get more information by typing:

```
man cvs
```

on the command line. Of course the internet provides multiple sources of CVS manuals in multiple formats (.tex, .pdf, etc...). O'Reilly & Associates have a nice pocket reference, see [CVS00].

Appendix G

Support for Phar Lap ETS

G.1 Introduction

Phar Lap ETS is a dedicated real-time operating system that supports a subset of the Windows Application Programming Interface (win32 API). EuroSim supports this platform with some constraints, which are described in this chapter.

G.2 Stubbed Win32 API functions

The list of win32 API functions that are supported by Phar Lap ETS is described in their technical reference which is part of the Phar Lap ETS SDK. A copy of the list is provided by the file

```
$EFOROOT/lib/PharLapSupportedWin32API.txt
```

When building a simulator for the Phar Lap target, the tool *checkPharLapAPI* is used to check that the simulator is not using any unsupported Win32 API calls. In the log window of the Model Editor a warning is given for each unsupported function that is referenced by the simulator.

Following is a list of a selection of functions that are not supported by Phar Lap ETS, but which are reimplemented for EuroSim simulators with suitable default behaviour. The implementation for (most of) these functions is empty, unless indicated otherwise.

ADVAPI library	
AllocateAndInitializeSid	
DeregisterEventSource	
GetSidSubAuthorityCount	
GetTokenInformation	
GetUserName	
LookupAccountSid	
OpenProcessToken	
RegCloseKey	
RegCreateKey	
RegSetValueEx	
RegisterEventSource	
ReportEvent	

KERNEL library	
AddAtomA	
CreateProcess	
OpenProcess	
SetPriorityClass	
SetThreadIdealProcessor	
SleepEx	Implemented with `Sleep()`
TerminateProcess	
VirtualLock	
FormatMessage	
GetExitCodeProcess	
GetSystemInfo	dwNumberOfProcessors defaults to 1
GetTempPath	Defaults to `C:/temp`
WaitForSingleObjectEx	Reimplemented with `WaitForSingleObject()`
MPR library	
WNetGetUniversalNameA	
NETAPI library	
Netbios	
RPC library	
authunix_create_default	
clnt_create	
clnt_pcreateerror	
xdr_array	
xdr_int	
xdr_string	
xdr_void	
WINMM library	
timeSetEvent	
timeBeginPeriod	
timeEndPeriod	
timeGetDevCaps	
timeKillEvent	
WINSOCK library	
WSASetEvent	
WSACloseEvent	
WSAResetEvent	
WSACreateEvent	
WSAEventSelect	
WSAWaitForMultipleEvents	

The `exit()` call is supported by Phar Lap ETS, but is reimplemented to reset the system to wait for an incoming `run.cmd`, instead of a process exit. This was done because the simulator runs in the same process context as the dll loader, and an exit would thus cause the entire loader (including FTP server) to exit.

G.3 Building the simulator for a Phar Lap ETS target system

To build a simulator for the Phar Lap ETS platform, take the following steps:

1. Select the *Tools:Set Build Options* menu item in the EuroSim Model Editor.
2. Go to the Support tab page and place a check mark on the Phar Lap ETS support item.
3. Follow the usual steps for building a simulator: **Make clean** and **Build**.

The other build options may or may not work in combination with the Phar Lap ETS support option. Some options require additional dynamic link libraries to be available at runtime on the Phar Lap ETS target, e.g. `qt-mt.dll`. This is not supported at this moment.

It is important that the simulator project (on the localhost) and the simulator (running on the Phar Lap system) reside on a file system with the same drive letter. If the Phar Lap ETS file system is mounted on `C:`, then the simulator project must also reside on `C:`. This is required because various simulator files use absolute paths to refer to other files. The drive on the Phar Lap ETS platform can be changed by rebuilding the kernel.

G.4 Running the simulator on the Phar Lap ETS target system

The mechanism for launching a simulator on a target system with the Phar Lap ETS kernel is different from the mechanism used on other platforms (Linux, Windows) that are supported by EuroSim. Because the `CreateProcess()` function is not supported by the Phar Lap kernel, it is not possible to create more processes, and therefor to run more than one simulator. Neither is there support for RPC, so the `esimd` daemon used on other platforms had to be replaced.

See Figure G.1 for a representation of the sequence of events when launching a simulator on the Phar Lap ETS target system. After startup of the system, the Phar Lap ETS boot loader loads the kernel into memory and activates it. The kernel that is provided by EuroSim is configured in such a way that it will automatically load the Phar Lap version of the EuroSim daemon. Once the daemon is started, it will start an FTP server that is part of the kernel. After that, the daemon simply waits for incoming files.

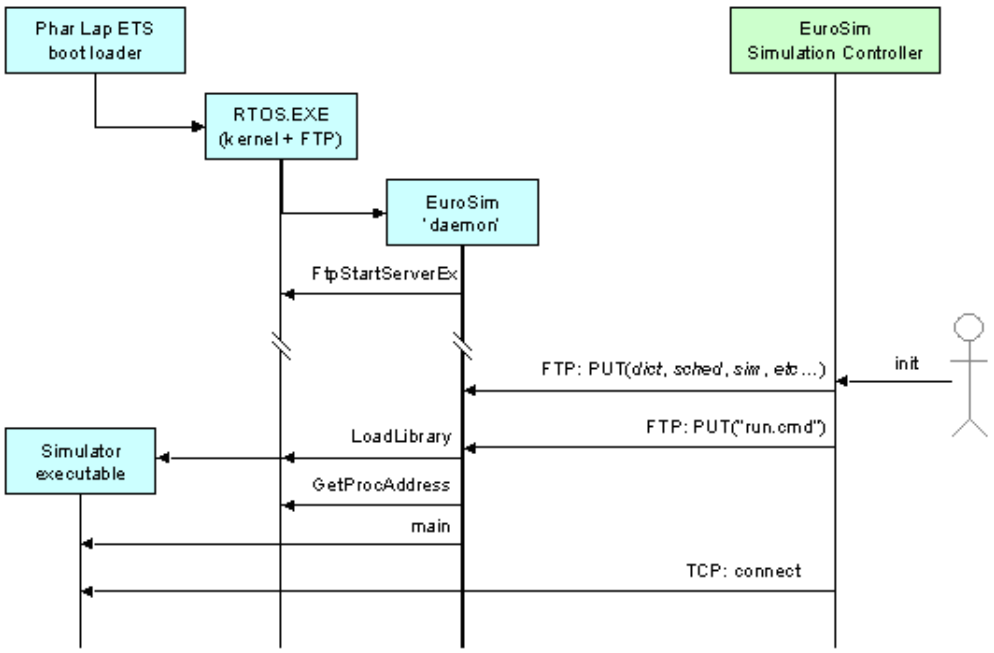


Figure G.1: Message Sequence Diagram for starting the simulator on a Phar Lap ETS system.

When you press the **Init** button on the toolbar of the EuroSim Simulation Controller, it will check which files make up the simulator mission and send them to the target system using FTP[1]. These files consist of the EuroSim simulator files, the simulator executable, and the stubbed win32 API DLLs. Once all files are stored, a file called `run.cmd` is sent. This file contains the name of the simulator executable and its command line. The simulator executable is built as a DLL by the Model Editor. As mentioned before, Phar Lap does not support the `CreateProcess()` system call, so the `LoadLibrary()` system call is used instead to load the executable. After the call to LoadLibrary returns successfully, the daemon retrieves the main entrypoint of the simulator and passes control to it. Once the simulator is running, the Simulation Controller connects to it by means of TCP/IP, similar to simulations running on other platforms.

When the Simulation Controller disconnects from the simulation or the simulator is stopped, the (intermediate) results are retrieved from the Phar Lap ETS target by FTP. The results are stored in the usual date/-time directory structure in the simulator project directory (unless specified otherwise, see Figure 12.13). The simulator output on stdout and stderr are redirected to the files `stdout.txt` and `stderr.txt`, respectively. These files are also retrieved and stored in the date/time directory structure.

G.5 Supported network adapters

The Phar Lap ETS kernel supports the following Ethernet adapters:

- 3com 3c509
- ADMtek pegasus II (usb)
- AMD Pcnet (ISA and PCI)
- Crystal CS89x0
- Digital 2114x
- Intel 8254x

[1]Files that are uploaded to the Phar Lap ETS target systems are placed in a RAM-disk that is created by the boot loader. Make sure the ramdisk is large enough to hold all the necessary files. To change the size of the ramdisk the Phar Lap ETS kernel needs to be rebuild (see Section G.6).

- Intel 8255x
- NE 2000 Compatible
- RealTek 81x9
- SMC 8003/8216/8416
- SMC 91C92/91C94
- VIA VT610x

A kernel must be built to specifically support a netwerk adapter. Every kernel only supports a single type of network adapter.

G.6 Building your own kernel

The Phar Lap ETS kernel is built with Microsoft Visual Studio 6. It is necessary to obtain a license from Phar Lap in order to use their Software Development Kit (SDK).
To built a Phar Lap ETS kernel follow the instructions in the documentation of the Phar Lap ETS Software Development Kit (SDK) and take the following notes into account:

- All symbols that are linked to the `WSOCK32.DLL` at run-time, must be resolved by Phar Lap ETS's `KERNEL32.DLL` by means of the `-dllredirect` option at link time of the Phar Lap ETS kernel.
- The `winsock32.dll` functionality is contained in the Phar Lap ETS kernel. There is no mapping from the internal symbols to the symbols that an application expects. This mapping has to be given by the user as an export file. The export file can be linked in the kernel with the linkloc linker. The dllload project contains the export file `wsock.xpo` that provides this mapping.

Under `$EFOROOT/src/PharlapETS/dllload/` the source for the dllload project is found. With `build.bat` the Phar Lap ETS kernel is built. The following command links the kernel with support for Intel Gigabit network cards.

```
linkloc.exe @vc.emb @vcmt.emb @log.emb @rtwinapi.emb @winsock.emb
@eth-rtl.emb @pcat_sc.emb @PCAT_TM.EMB @pcat_kb.emb @lfs.emb
@ftpserve.emb @ldr.emb @crtdll.emb @msvcrt.xpo @winsock.emb
@win32.xpo -dllredirect wsock32 dllload -stack 32786
```

Use Microsoft Visual Studio 6 with the Phar Lap ETS integration suite to tweak the kernel parameters such as the ramdisk size (project file is `dllload.dsw`). After that, build the kernel image and a boot floppydisk with the `build.bat` script.

Appendix H

Software Problem Reports

In case a problem or error with EuroSim occurs, please contact the EuroSim helpdesk, preferably by email to esim-support @eurosim.nl.

Document the problem or error with as much detail as possible. Things of interest are:

- Software version numbers
- Hardware specifications
- Sequence of actions (such as selecting files, clicking buttons, changing state of the simulator)
- Contents of files used

Preferably the problem or error should be reproducible. If possible try to create a minimal environment in which the error occurs, to facilitate finding the source of the problem.

Please also describe the criticality of the error, which can be one of:

Critical A major problem that hinders the completion of the user's job. This category includes a time aspect (solution is needed as soon as possible) for the user to be able to finish the job.

Major A serious problem, but the user can still continue with the job.

Minor A problem was noted, but it is not seriously affecting the use of EuroSim.

Suggestion
A suggestion for the improvement of EuroSim.

Question
A question on EuroSim details.

When the helpdesk receives your error report and it is not a user error, a Software Problem Report will be logged in the EuroSim problem tracking system. An SPR number is generated and can be provided to you if required. Generally Customer maintain a problem report in their own tracking system, and correlate that report to the EuroSim SPR by included the EuroSim SPR number in their problem report description.

Depending on the criticality and your maintenance status the problem may be immediately worked on or delayed untill the next Software Review Board. When the problem report is accepted, it is assigned to a developer and the status changes to Approved for Implementation (A4I). The developer changes the status to Started, investigates and solves the problem, and subsequently changes the status to Implemented. The Software Review Board accepts the answer, plans its release, and switches the status to Approved for Release (A4R). For each release the ResolvedSPRList text file included with the distribution documents which SPRs have been solved.

Appendix I

Abbreviations

AFAP	As Fast As Possibe
API	Application Programmers Interface
ASCII	American Standards Code for Information Interchange
COTS	Commercial Off The Shelf
CPAN	Comprehensive Perl Archive Network
Dict	Dictionary
DS	Airbus Defence and Space
EFO	EuroSim Follow-On
EI	External Interrupt
ERA	European Robotic Arm
ESA	European Space Agency
Esim	EuroSim
ESTEC	European Space Research and Technology Centre
EuroSim	European Real-time Operations Simulator
F77	Fortran 77
FFT	Fast Fourier Transform
FIFO	First In, First Out
GNAT	GNU ADA Translator
GUI	Graphical User Interface
HIL	Hardware In the Loop
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
Hz	hertz
ID	Identification
IGS	Image Generation System
I/O	Input/Output
LCM	Least Common Multiple
MDK	Model Development Kit
MDL	Mission Definition Language
MIF	Maker Interchange Format

Mk	Mark
MMI	Man-Machine Interface
NIVR	Netherlands Agency for Aerospace Programs
NLR	National Aerospace Laboratory NLR
org	Organization
OSF	Open Software Foundation
PCI	Peripheral Component Interconnect
POSIX	Portable Operating System Interface
RCS	Revision Control System
RPC	Remote Procedure Call
SGI	Silicon Graphics Incorporated
SMDL	Simulation Model Definition Language
SMI	Simulation Model Interface
SMP	Simulation Model Portability
SMP2	Simulation Model Portability 2
SPR	Software Problem Report
SUM	Software User Manual
TSP	Transport Sample Protocol
URL	Uniform Resource Locator
UTC	Coordinated Universal Time
WINNT	Windows NT
VME	VERSAmodule Eurocard
XML	Extensible Markup Language

Appendix J

Definitions

Action From a user's perspective, an action is part of his scenario, and defines both the required response to be taken when an *event* occurs, plus the required event. An action can be one of stimulus, recorder, monitor, intervention, and event. EuroSim provides specific editors for default recorders and stimuli, and a generic action editor for all other actions and customized recorders, stimuli and monitors. Monitor actions are obsolescent and are replaced with MMI definitions.

Application definition file
Format of files created by LynX; contain initialization and run-time information for a Vega application. Files have a .adf extension.

Data dictionary
A list of public data variables and parameters extracted from *model* code, i.e. those which are accessible to the user for (optionally) updating, monitoring and recording. The list is augmented with descriptive information (such as units, default values, ranges).

Data View
A subset of the data items in the EuroSim *data dictionary*. Used to define data items which are to be read/written by an *external simulator* at run time, and therefore provides a mechanism for sharing data between two independent *simulators*.

Entry point
A function or procedure in the model code (for which some restrictions apply) which can be used to create *tasks* in the Schedule Editor.

Event A discrete occurrence during a *simulation run*, which (can) cause a change in the behavior of the system being simulated, for example a component failure.

Execution state
The state of a *simulator*. Certain user requests are only valid in certain states.

External simulator
A simulator which is not running under EuroSim.

Facility management
The means of providing maintenance support and project and user management during the simulation life cycle.

Flight format
Binary format used for input and output by the MultiGen and ModelGen database modelling tools. It is a comprehensive format that can represent nearly all imaging concepts. Files in Flight format are structured as a linear sequence of records and have a .flt extension.

Hardware-in-the-loop
A piece of equipment which forms part of the real-world system, which is given a real-time interface to the simulation loop.

Initial condition
: Consistent set of model state values, to put the *model* into a particular state at the beginning of a *simulation run*. In EuroSim, the initial condition can be created with the Initial Condition Editor, or it can be a snapshot of values from previous simulation run.

Journal Information resulting from a particular *simulation run*(excluding sampled data values), e.g. log of executed *event* s, error/warning messages, and *marks*.

Man-in-the-loop
: A person taking on the role of an operator within the real-world application, who is provided with a real-time interface to the simulation loop.

Mark A pointer or reference mark made by a user during a *simulation run*, to provide an easy means of returning to a point of interest during *test analysis*.

Simulation Definition
: Complete definition of a particular test for a particular *model* and *schedule*, specifying the *initial conditions*, *stimuli* and variables which are to be recorded. For on-line evaluation, variables can also be viewed on screen by specifying monitors.

MMI *Definition*
: Defines the contents of a tab page in the Simulation Controller used for interacting with the simulator. Normally this tab page contains one or more monitors.

Model A set of components (*sub-models* and data files) which together define the data and behavioral characteristics of a specific real-world system, or part thereof. See *Simulator*.

Observer
: The user who (optionally) attends a*simulation run* and who may select variables for viewing, and *mark* interesting observations, but who is not able to affect the execution outcome in any way.

Operational modes
: EuroSim provides different modes of use which are available to one or more users; for example, the Model Developer uses EuroSim for *simulator* development, the Test Analyst uses it for analysis of *test results*. Particular user activities are only available during particular modes, for example *application model* s can only be updated during *simulator development*. EuroSim is able to support two or more modes simultaneously. See *simulator development*, *test preparation*, *test execution*, and *test analysis*.

Phase A time offset between completion of one *task* and activation of another task which is dependent on that completion, defined as a quantity of wall-clock time.

Real-time
: During real-time execution or interfacing, the time-lining of the activities appears to be that which would be seen in an equivalent situation in the real-world. This is achieved through guaranteed periodicity of processing and response time within fixed deadlines.

Schedule
: A set of attributed tasks, timers, scheduling events and their respective dependencies. The overall behavior of a schedule is deterministic, whereas that of a single task need not be. A schedule is executed by the scheduler. The scheduler has four states: Initializing, Standby, Executing and Exiting. Every state has its own schedule. The same task may appear in one or more state schedules.

Simulation
: The process of using *models* that behave or operate like a given system when provided a set of controlled inputs.

Simulation program
: The computer program, built out of *simulator software*, used for the simulation.

Simulation run
: Execution of a *simulator* according to specified *simulation definition*.

Simulator
: A hardware device or *simulation program* or combination of both with which *simulation* can be performed. A simulator together with a *simulation definition* can be used to start a *simulation run*.

Simulator development
: Mode of operation, where the Model Developer can create and/or update *model*s and *simulator* definitions, and generate simulators. See *Operational Modes*.

Simulator software
: Model-dependent software combined with model-independent software for the performance and control of real time and non-real time *simulation*.

State
: The current phase in the execution of the simulation. EuroSim states are: initialization, standby, executing and exit.

Stimuli
: A set of data which are input to the *model* during a *simulation run*, which represent data from an interfacing system or sub-system which would normally be present in the real-world; they can be used during replays of simulation runs, to provide copies of the original operator inputs.

Sub-model
: A component of a *model*, which defines (in source code) an element or set of elements within the real-world application. The parts of a sub-model visible to other "users" are the set of accessible state data items (which are listed as part of the model *data dictionary*) and a set of operations which can be called by other sub-models or listed within a *task* within the schedule.

System services
: A set of services offered by EuroSim which can be called directly from *model* code, for example in order to request information on the current simulation (e.g. simulated time, *execution state*), or to communicate with HIL devices.

Task
: A unit within a model schedule consisting of an ordered list of one or more *entry points*. Task execution starts with the first entry point listed, and suspends (always) after the last entry point listed has been executed. It is possible for tasks to be executed in parallel in a multi-processor environment.

Test analysis
: Mode of operation, where the Test Analyst can mathematically analyze *test results,* replay visual images and export data for external use. See *Operational modes*.

Test Conductor
: The user who operates the *simulator* as a tool to perform a *simulation run*.

Test execution
: Mode of operation, where the *Test Conductor* has interactive control of a *simulation run*, and may initiate on-line events. The Test Conductor and (optionally) an *Observer* may also monitor *data dictionary* item values and create *marks*. See *Operational modes*.

Test preparation
: Mode of operation, where the *Test Conductor* can create and/or update *simulation definitions*, and an *Observer* can identify *data dictionary* items for monitoring. See *Operational modes*.

Test results
: All information resulting from a particular *simulation run*, i.e. the *journal* and the recorded *data dictionary* item values.

Revision Record

Iss	Rev	Date	Reason for change	Changes
0	1	11-Mar-1994	Internal review	Document creation
0	2	10-Apr-1994	Internal review	Expanded contents and internal comments resolved
0	3	15-Dec-1994	Mk0.1 release	All document
0	4	7-Feb-1995	Continued updating of issue 0 revision 3	All pages
0	5	25-Apr-1995	Issued for DD/R EuroSim Mk0.1	SR/R-1-RID-SRD-74, SR/R-2-RID-SRD-5, AD/R-2-RID-Model_ICD-2, AD/R-2-RID-Model_ICD-3, AD/R-2-RID-SRD-3, AD/R-2-RID-SUM-2.
1	0	18-May-1995	Internal comments	All pages.
1	1	26-Jun-1995	Updated after DDR.	
2	0	15-Jul-1996	New document for EuroSim Mk0.2	Reference number of document changed to NLR-EFO-SUM-2
2	1	16-Dec-1996	Issued for DD/R EuroSim Mk0.2	Internal review comments processed. SPRs implemented: 166, 364, 370, 380, 397, 406, 462, 475, 484, 571, 574, 578, 603, 612, 629, 633, 652, 657, 712, 814, 840, 960, 961, 1010, 1011, 1045, 1205, 1216, 1273, 1293, 1326, 1483
2	2	17-Feb-1997	Updated after DD/R	The following RIDs have been implemented: 53..67, 69..76, 78..102, 104, 106..123, 125..164, 166..187, 202..209, 211..214, 216..224, 226..251, 255..257, 260, 263, 266..269. Note that not-implemented RIDs from the 200 range have been re-issued for the delta DD/R
2	3	25-Apr-1997	Updated after delta DD/R	The following RIDs have been implemented: 42..44, 47..51, 53..68, 72..83, 85..88, 90, 91, 93..102, 104..106, 107 (partly), 108..116, 119..123
2	4	1-May-1997	EuroSim Mk1 SUM	Inclusion of IGS information/references: reference to IGSSUM, inclusion of IGS overview, definition of IGS interfaces within EuroSim (action IGS-PM7-3). Approved RIDs from DD/R: 68, 77, 103, 105, 124, 125
2	5	24-Jun-1997	Added RID numbers for revisions 2 and 3 above	Approved SPRs implemented: 1557, 1549, 1592. Update Test Analyzer section in accordance with SPR-1505, 1651. Updated appendix on MDL following DD/R RID 177 and DD/R RID 103. Also some knock-on changes in Mission Tool Reference.

Iss	Rev	Date	Reason for change	Changes
3	0	2-Mar-2000	Mk2 release	SPR 1633 ,Section 3.2.
3	1	2-May-2000	Mk2rev1 release	Event counter functions added to EuroSim Services. High resolution and max number processors changes added. Recorder file switching and Stimuli cycling changes documented. *HLA extension: EsimRTI* usage as appendix added.
3	2	6-Oct-2000	Mk2rev2 release	Added appendix describing the run-time interface as used by the test controller. Added appendix explaining AFAP scheduling pitfalls.
4	0	14-May-2002	Mk3 release	Updated the manual to conform to the new Graphical User Interface
4	1	12-Sep-2003	Mk3rev1 release	Converted to LaTeX. Updated screenshots. Update descriptions of publish functions (API headers), Added description on new 'diff with' functionality (GUI), Added action button support (Simulation Controller), Added description for timebar (Schedule Editor), Added section on user defined EuroSim compatible devices (HW), Updated MDL syntax description, Added chapter for Windows COM interface
4	2	2-Sep-2004	Mk3rev2 release	Added new chapters for Model Description Editor and Parameter Exchange Editor. Simulation Controller: added description for exports file, removed sections on IGS. Schedule Editor: added description on how to add Parameter Exchange file(s) to the schedule. Model Editor: Added the Model Description file node. EuroSim files and formats: Added Model Description and Parameter Exchange files. Updated screen shots
5	0	18-Apr-2006	Mk4rev0 release	Added new chapters for Calibration Editor, SMP2 Editor and the Web Interface. Model Editor: Added the SMP2 Catalogue file node. Updated various screen shots
5	1	28-Jan-2008	Mk4rev1 release	Added new chapters for Batch utilities (python, java, tcl), Java interface, Error Injection and the Transfer Sample Protocol. Updated various screen shots
5	2	19-Mar-2011	Mk4rev2 release	Added chapters for the new C++ API and Embedded EuroSim, Updated Scheduler chapter on timing and metrics, Updated various screen shots

Iss	Rev	Date	Reason for change	Changes
5	3	15-Jun-2011	Mk4rev3 release	Work in progress.... Added new interface function esimEventTime, Updated various screen shots
5	4	7-Nov-2011	Mk4rev4 release	Work in progress.... Added new interface SMP2, Updated various screen shots
6	0	01-Oct-2012	Mk5rev0 release	Updated C++ interface, Updated SMP2 interface, Moved Embedded EuroSim to addon document, Modified the licensing scheme, Removed Irix, SGI, RTI, Updated various screen shots
6	1	22-Jun-2013	Mk5rev1 release	Windows7 support, Including UML Transformer via Satellite++ example, Cleaned up Moonlander example, Documented frontsheet version repaired, Appended Revision History,
6	2	05-Mar-2014	Mk5rev2 release	Expanding CPP interface Update of Schedule Editor Reference on Timebar addition of esimTrace functions
6	3	20-Mar-2015	Mk5rev3 release	Further expanding CPP interface Rewrite of External Hardware Chapter Addition of section on file assocations in ME Addition of section on Trouble Shooting Removale of SMP1 reference Restructure of Reference chapters

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