Project Deliverable D6.1 Annex

Guidelines and Tool Manuals

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Abstract

This document describes the use of the different tools composing the Q-ImPrESS platform.

Keywords:
Modelling, Abstraction, Tools, Manuals, Working Method, Q-ImPrESS IDE, Tool Usage

Revision history

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1.1	10/12/2010	M. Masetti	Reverse engineering and Performance Analysis manual updated
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1 Introduction

This deliverable extends D6.1, providing practical details on the use of the Q-ImPrESS IDE and related tools and represents a reference manual for software engineers.
This deliverable specifically addresses recommendation R7 of the First Project Review.

The structure of the deliverable is as follows:
Chapter 2 provides a short summary of the Q-ImPrESS method as detailed in D6.1.
Chapter 3 provides in-depth hints on SAM and how a system is modelled.
Chapter 4 contains a reference manual for each of the mentioned tools.
Appendix A contains a "Getting started" guide for beginners.
Appendix B provides a tutorial on how to modify SAM using tree editors.
Appendix C contains the SAMM grammar.
Appendix D provides a glossary.

1.1 Q-ImPrESS overall workflow

Q-ImPrESS provides a platform for software engineers for the quality evaluation of multiple evolution alternatives of a system. Different quality attributes can be predicted before implementation takes place. This leads to a shorter time to production while assuring a better quality of the target system.

Figure 1 shows an overview of the Q-ImPrESS workflow as applied at ABB/Ericsson:

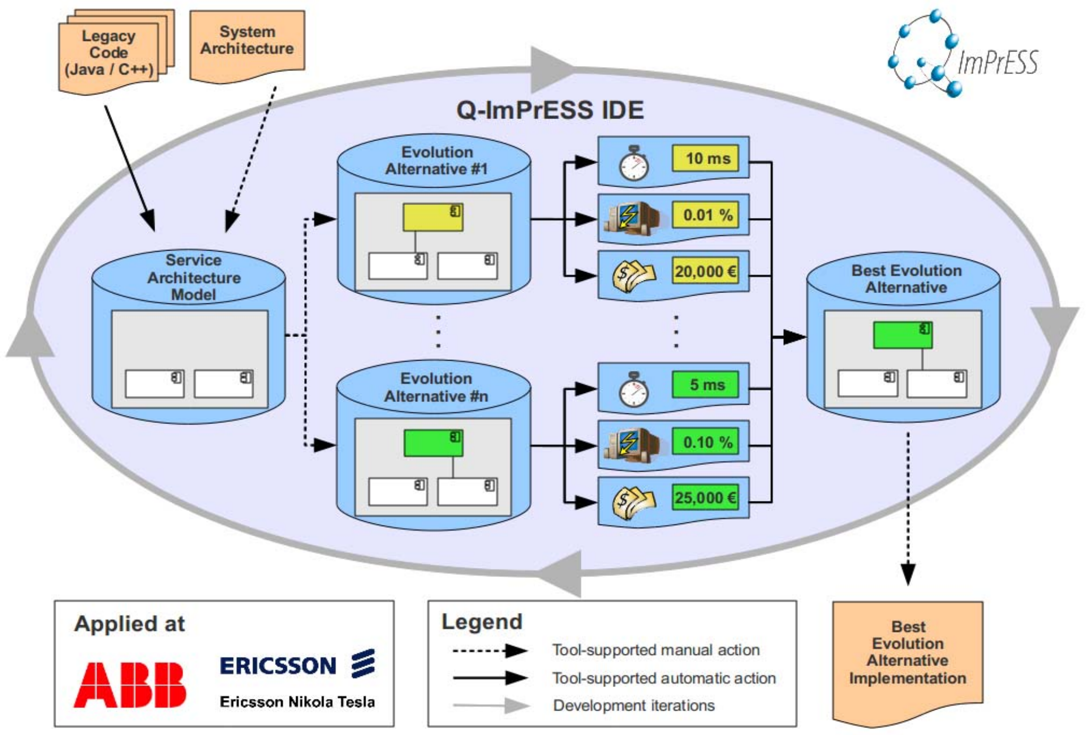


Figure 1: Q-ImPrESS workflow overview

Several evolution alternatives of a system can be designed, derived quality attributes are computed, and a final trade-off analysis is used to choose the best alternative.

1.2 Workflow and tools

Figure 2 depicts in details all the activities supported by the Q-ImPrESS platform:

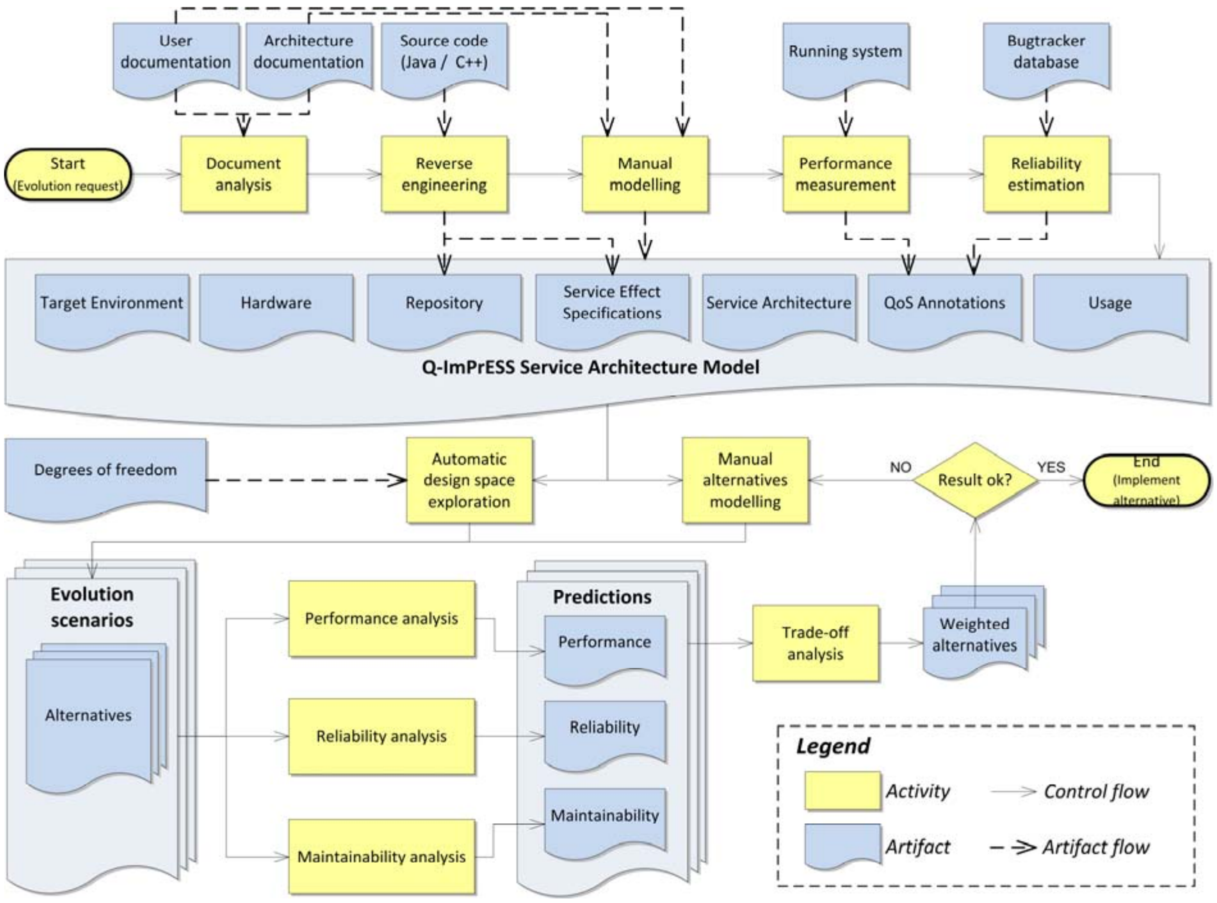


Figure 2: Activities supported by the Q-ImPrESS platform

The process starts with an evolution request. Requirements for the evolution request are collected and formalised. The first activity aims at building the Service Architecture Model of the system (if not already available). Automatic (or semi-automatic) activities, like reverse engineering or performance measurements are performed in order to derive the SAM representation of the system, or manual editors can be used instead. The requirements of the evolution request are used for manual modelling of alternatives representing different solutions for the evolution scenario. Model alternatives can also be derived automatically, e.g. by using evolutionary algorithms.

Various quality assessments are performed for each alternative and quality prediction results are obtained. The trade-off analysis can be performed in order to estimate the effectiveness of the alternatives with respect to the evolution scenario requirements. The entire process loops until a suitable alternative is found.

1.3 Advantages of using Q-ImPrESS during system design and software development

Q-ImPrESS is based on the Eclipse and Eclipse EMF frameworks and therefore can be easily adopted and integrated in the development environment.

With the use of the Q-ImPrESS IDE the model of a large component-based system can be handled efficiently. Moreover several different evolving alternatives can be modelled and evaluated thus avoiding the implementation/testing/deployment phases of the traditional production cycle for several alternatives.

A key feature of the Q-ImPrESS platform is the notion of modelling abstraction level; Q-ImPrESS allows a software engineer to describe a component either as a grey or black box in terms of quality attributes (stopping at a high abstraction level), while fully modelling main components using the analysis tools provided by the platform.

1.4 Advantages of using Q-ImPrESS during software evolution and maintenance

Especially in domains where software solutions have a long life cycle (Telecom, Industry) and are characterised by high quality standards, the product evolution and maintenance phase is crucial. This phase accompanies the product until its commercial end and may last years (and often decades), therefore very seldom it is performed by the team involved in the initial product design and implementation. Moreover, shifting maintenance to a different location than production is becoming a normal procedure for medium/large companies in an effort to cut down costs.
In this phase, using a development tool that conveys design information and decisions is of utmost importance. The Q-ImPrESS platform lets perform a reverse engineering of existing code and can be used to ease maintenance of old software code while allowing testing alternative solutions without actually coding them.

2 The Q-ImPrESS method

This chapter briefly introduces the Q-ImPrESS method.

2.1 Overview of the Q-ImPrESS method

The process of assessing the quality of large, distributed component-based software systems is quite complex. The Q-ImPrESS method, outlined in D6.1 and depicted in Figure 3, splits the process in a sequence of phases, making the overall procedure easy:

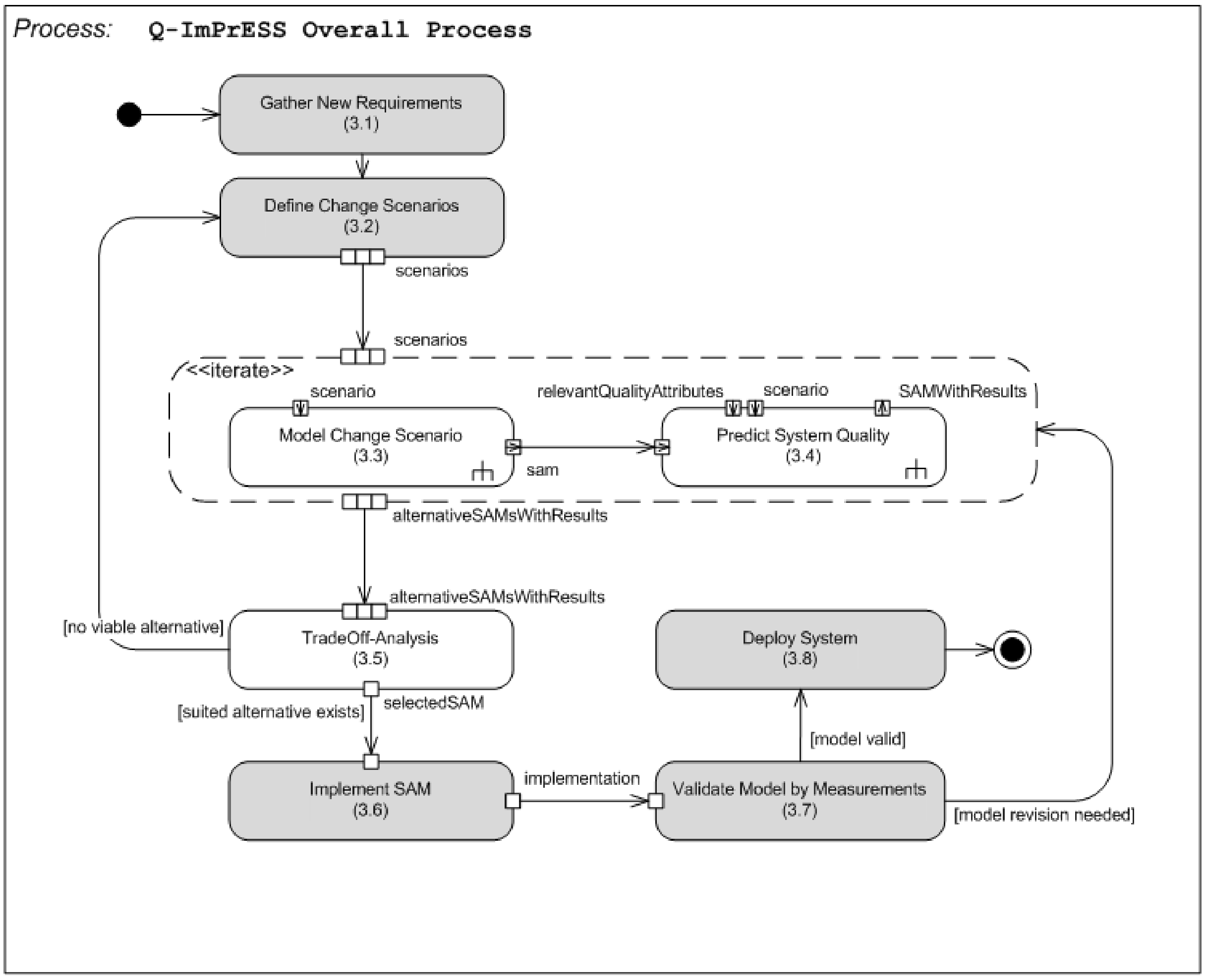

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
relevantQualityAttributes
scenario
SAMWithResults
Model Change Scenario (3.3)
sam
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
Deploy System (3.8)
[suited alternative exists]
selectedSAM
[model valid]
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]

Figure 3: The Q-ImPrESS method

The number reported in each process box is the chapter number in D6.1 describing the process.
The overall workflow starts with the definition of different change scenarios (alternatives) each potentially suited to solve new requirements.
Each (assembly) change scenario has to be modelled, prediction analysis is performed for each model, and results are then confronted pair wise unless a suitable scenario is elected as the best solution.

The following sections contain a short description of each method phase, starting from phase 3.3 (Model a change scenario).

2.2 Model a change scenario

Model creation (detailed as process 3.3 in D6.1) is a recursive process, where the main steps in the cycle are the ones as follows.

2.2.1 Components selection

Depending on the change scenario, only some components of the system are affected. Moreover, the level of model details (abstraction level) can differ for different components. The components involved in the change scenario should be thoroughly modelled, as the more fine grained the model is the more accurate the quality prediction on the alternative can be.

The abstraction level measures the level of details and accuracy of a model with respect to the system modelled.
At a high abstraction level, a system is described by few composite components or sub-systems. As an example, if the system under analysis is a plant PCS (Process Control System), the legacy ERP system at level 3 could be modelled as a single component, providing daily production schedules (maybe updated several times a day) and requesting control data back, without affecting the accuracy of the analysis method on the PCS system.
At a medium abstraction level the number of components increases, but they still lack an adherent description of their internals (as obtained reverse engineering components code) and quality annotations are still manually input. Composite components reveal details of their structure, interfaces and connectors are fully described.
At a low abstraction level the model precisely adheres and describes the components under analysis.

There is a trade-off to consider while choosing the right abstraction level. As time spent on modelling decreases shifting toward a higher abstraction level, the deviation between predicted and measured quality attributes increases. Moreover complexity and size of models increase at lower abstraction levels. This implies considering another inner loop: a component model could not be yet at the right abstraction level and another cycle may be needed before passing to the next component to model. The software engineer should choose this based on his/her experience.

2.2.2 Model components as grey/black boxes

Components and services not touched by the change scenario do not need to be modelled in details. The requirement is anyhow that quality annotations for these components meet requirements. As only component external behaviour has to be defined (we do not need any detail on the component's structure), the quickest way to model it is to instrument it at its connectors, deploy and run it on a reference suite test and monitor it.

2.2.3 Reverse engineering of selected components

We can obtain a model (a complete component structure) for the selected components from component code using reverse engineering techniques.
Software may need some adaptations before being ready to be analysed by the reverse engineering tools provided by the Q-ImPrESS IDE. The time consumption of this phase is unpredictable, as it is proportional to the LOC size but also depends on the technology used and the subtle language nuances of that technology (example: VisualC 6 with respect to C++).
The level of details of the component structure can increase recursively applying reverse engineering. This phase again needs manual input and cannot be fully automated.

As explained in D6.1 (3.3.3.4) the reverse engineering process is basically divided into three steps: first, code is analysed to obtain an abstract structure, then information regarding components and interfaces is extracted and finally the user can add behaviour annotations (in the form of Petri Nets or in other ways as the Q-ImPrESS platform can be extended to include different plugins to work with).

As explained, the software engineer iterates the previous phases until all of the system components have been modelled.

2.2.4 Model system assembly

At this point models for all individual components are available. Now they need to be assembled to represent a Service Architecture Model.
Hence the system architect takes components from repository and plugs them together using connectors.
The graphical editor can be used for this phase; this makes connection creation and handling much an easier task with respect to using the text editor.

2.2.5 Model system deployment

The deployment model needs to be updated if the assembly change scenario involves the creation of new components (that need to be allocated), or in case the HW resources are changed. For each alternative model the corresponding deployment scheme has to be modelled.

2.2.6 Model system usage

The workload intensity caused by the users of the service oriented system can be potentially extracted during the runtime monitoring process, however the need for a manual update of this model is foreseen and therefore included in the workflow. Moreover, modelling alternatives for different usage schemes, system quality attributes at different system usage settings can be investigated.

2.2.7 Add quality annotations

The software engineer has to provide quality annotations for the modelled components in order to predict the impact of a change requests on the selected components.
Quality annotations can be derived in different ways depending on their nature.
Regarding performance quality annotation, they can be expressed defining a formula that relates the performance of a component (or a part of it) with other parameters (the input throughput, the quantity of RAM or the number of CPU used). To derive it, code has to be instrumented and executed against a reference scenario. The Q-ImPrESS tool-set provides basic instrumentation suites, but there are several more sophisticated tools available to perform fine resolution performance measurements. The software engineer has then to analyse the performance data (timestamps) and derive (linear) functions of the execution times with respect to the identified parameters.
Regarding reliability quality annotations, a linear distribution representing the component reliability can be estimated analysing the data regarding bugs reported for the components covering a consistent time frame. Other formula can be found in literature regarding this topic.

The Q-ImPrESS IDE provides editors for editing quality annotations.

2.2.8 System Model validation

For a consistent and valid prediction analysis, the model used to assess quality prediction has to adhere to the real system under investigation. Model has to be verified and validated before being used to evaluate change scenarios (design alternatives).
Model validation is not performed as a single step, but usually model gets refined along a modelling loop, where model comes closer to the system modelled at each loop cycle.
The already mentioned model abstraction is refined as well during these loops. Usually the software engineer starts modelling the system at a high abstraction level and checks model consistency before refining the model and scale down to a lower abstraction level.
If the Q-ImPrESS tool is used for prediction analysis, checking model consistency means instrumenting the code and checking that system performance, for a known use case, closely match model performance prediction running the same use case.
There is a relationship between the model abstraction level and the 'granularity' of code instrumentation too: at a high abstraction level, code instrumentation can be rather sparse, determining performance at component level. As the level of details in the model increases, instrumentation has to be performed at a finer resolution to check model consistency. Each time the system has to perform a known execution and the same execution has to be predicted. If prediction does not match system execution times, the software engineer has to adjust the model before advancing to a new loop cycle.

To run the model we have first to complete it by providing information regarding the component deployment scheme and user input. The time spent configuring the model for a reference scenario depends on the complexity of the system, but usually it should be easier then running the entire system (at least the model can run on one machine). We collect quality prediction analysis results from model execution and we check how closely they match with real quality data we collected for the same reference model. If differences exceed defined thresholds (say system model performance differs for more than 20% the system performance

measurements), the software engineer has to go back to phase 2.2.4 checking again the quality annotations defined for each component.
If the model is coherent, the software engineer, based on the required change scenario, has to judge if the model abstraction level is enough or some components should be modelled at a finer resolution. This depends on the system and the change scenario examined. If the abstraction level is too high the user has to start again at phase 2.2.2 either modelling black box components as composite components or cycling more on the reverse engineering phase.

2.2.9 System quality prediction

A system model reflecting a change scenario is performed and results are collected back in the model. Currently prediction analysis is composed by: Performance prediction, Reliability Prediction, Maintainability prediction. For a prediction analysis to take place, the alternative model (SAM) has to be converted in the specific prediction tool format (PCM for performance prediction, KLAPER + PRISM for the reliability analysis). The time consumption of this phase depends on the complexity of the models.

2.2.10 Results trade-off analysis

Alternatives can then be selected for the trade-off analysis in order to select the most viable solution. The Q-ImPrESS IDE provides a tool that performs Pareto analysis and derives the best alternative that meets change quality requirements.
If no alternatives meet quality requirements, the system engineer has to identify new change scenarios and restart modelling them.

2.2.11 Implement viable alternative and validate model.

The alternative that is judged as the best match is implemented. The JPFChecker tool can be used in this phase to verify the consistency of a behaviour model with the actual implementation of a service.
After deployment, the quality of the system is assessed and compared to the predicted. If analysis results offset exceeds a threshold, the alternative modelled should be checked again and validated (implementation may be checked as well for compliance with the model.

To effectively apply the Q-ImPrESS method a user has still to comprehend how a system is modelled and which tools come into play in each of the method processes.

3 The Q-ImPrESS SAMM: how a system is modelled

The Q-ImPrESS Service Architecture Meta-Model (SAMM) provides the meta-model for modelling a Service Architecture Model (SAM).

A Service Architecture Model consists of different parts that are split up into several model files. Figure 4 shows how the different EMF model files are connected with each other.

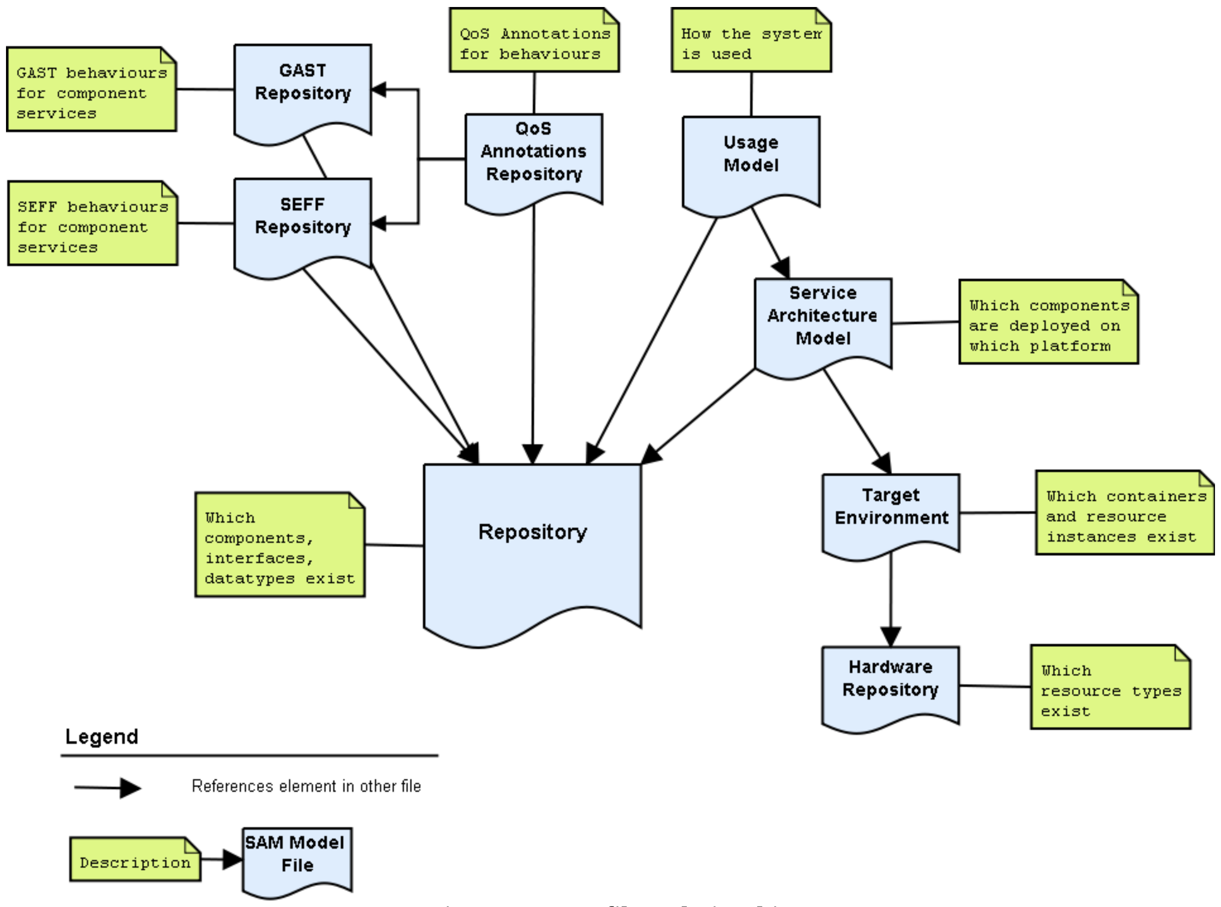

GAST behaviours for component services
GAST Repository
QoS Annotations for behaviours
How the system is used
QoS Annotations Repository
Usage Model
SEFF behaviours for component services
SEFF Repository
Service Architecture Model
Which components are deployed on which platform
Which components, interfaces, datatypes exist
Repository
Target Environment
Which containers and resource instances exist
Hardware Repository
Which resource types exist
Legend
References element in other file
Description
SAM Model File

Figure 4: SAM files relationship

Appendix B depicts in details all the practical steps for the creation and editing of different service models.

4 Tool Manuals

This chapter provides the documentation for all the tools of the Q-ImPrESS platform.
The order tools are presented should reflect a typical usage scenario of the Q-ImPrESS platform, also described in D6.1, and summarised in chapter 1.2.
Tools can be grouped by the activities they fulfil:
Service Architecture Model Handling: these tools act as a foundation for the rest of the platform tools. The Backbone tools extend the Eclipse platform and are responsible for handling new project types, perspectives and other Eclipse elements. From the user-perspective, the aim of the Backbone tools is to support the user in the usage of the platform and the management of SAM models.
Section 4.1 (IDE basics), 4.3 (the Repository Editor), 4.4 (the Composite Editor), 4.5 (the SEFF Editor), 4.6 (the QoS Editor), 4.7 (the Text Editors) describe the Backbone tools in detail.
Reverse Engineering: This process phase is covered by section 4.8.
Quality Prediction Analysis: The usage of each analysis tool is provided in section 4.9 (Performance prediction), 4.10 (Reliability prediction), 4.11 (Maintainability prediction).
Trade-Off Analysis: Practical details on how to perform a trade-off analysis based on the prediction results are given in section 4.12.
Alternative implementation check: Although the implementation phase of the chosen alternative model is not covered by the Q-ImPrESS platform, a tool to check the adherence of the Java implementation with the selected alternative behavioural model is provided in section 4.13.
Off-line tools: External tools are not included in the Q-ImPrESS IDE, but have proved to be useful during the development of the platform are described in sections 4.14 and 4.15.

4.1 Q-ImPrESS IDE installation

The Q-ImPrESS IDE can be installed on top of an Eclipse Galileo development environment. This way, the Q-ImPrESS IDE can be installed on any platform that supports the required Eclipse platform.

This section describes in detail how to install the Q-ImPrESS IDE.

4.1.1 Downloading Eclipse

In order to install the Q-ImPrESS IDE, please download the "Eclipse Modeling Tools" distribution from the Eclipse download website: http://www.eclipse.org/downloads/
To install the "Eclipse Modeling Tools" distribution, simply unzip the downloaded ZIP file. Note: There may be issues when using the built-in ZIP functionality of Windows OS. We recommend the use of alternative ZIP decompression tools, such as 7-zip (http://www.7-zip.org/).

4.1.2 Installing the Q-ImPrESS tools in Eclipse

Once you have installed Java 1.6 and the Eclipse Galileo Modeling Tools distribution, please execute the following steps to get started with the Q-ImPrESS IDE:

- Start Eclipse. Select "Help" → "Install New Software…" from the menu.
- Make sure the Galileo update site is available. It should be available with a fresh Eclipse Galileo Modeling Tools distribution. Otherwise, add the Galileo update site "http://download.eclipse.org/releases/galileo".
- Add the following update site by clicking on "Add…"
  - Name: "Q-ImPrESS Update Site"
  - Location: http://q-impress.ow2.org/release
- You can now select the newly created update site "Q-ImPrESS Update Site" using the "Work with" dropdown list.
- Select the following items listed in the install window: "Palladio Component Model", "Q-ImPrESS Tools (EU FP7 Project)", and "SISSy". Then click "Next".
- The following window shows all features that are to be installed. Confirm the selection with "Finish".
  During the installation process, a security warning might pop up, notifying you that some of the software contains unsigned content. Continue the installation process by press "OK".
- After the installation is finished, a window will pop up asking you to restart the Eclipse workbench. Select "No" and shutdown Eclipse manually.
- Locate the eclipse installation folder, and locate the file "config.ini" in the "configuration" folder

- Open the file and append the following line:
  “osgi.framework.extensions=eu.qimpress.ide.editors.text.xtextfix”
  If a line starting with “osgi.framework.extensions=” already exists, just append “,eu.qimpress.ide.editors.text.xtextfix” to the line.
- Save and close the file, start Eclipse.

The Q-ImPrESS IDE is now installed.

For more information, refer to the Download section at the Q-ImPrESS website at http://www.q-impress.eu/wordpress/software/ .

4.2 IDE Basics: Working with alternatives

4.2.1 Tool Description

The set of Backbone plug-ins constitutes a core part of the Q-ImPrESS IDE. Backbone plugins integrate all the other tools by providing a uniform infrastructure for the modelling, visualization and manipulation of models and their alternatives. Leveraging the Q-ImPrESS toolset over a backbone layer ensures a high IDE consistency and quality standards.

4.2.2 Purpose of the tool

The purpose of the Backbone infrastructure is to provide a layer for simplified access to various operations over Q-ImPrESS projects, repositories, alternatives, and models and to support the functionality of the other Q-ImPrESS tools. Backbone is also responsible for visualization of Q-ImPrESS project artefacts within the Eclipse IDE.

4.2.3 Tool relationship with the Q-ImPrESS workflow

Backbone plugins, being the foundation, participate in all the other parts of Q-ImPrESS workflow by providing a uniform infrastructure.

4.2.4 Tool Usage

Q-ImPrESS Backbone is an inherent part of Q-ImPrESS IDE and its functionality is integrated and shown in various parts of the IDE. Conceptually, it manages five core Q-ImPrESS IDE artifacts:

- ***Q-ImPrESS project*** – encapsulates source code as well as models stored in alternatives repository, analysis settings and launch configurations
- ***Alternatives repository*** – is a repository containing a hierarchical structure of model alternatives.
- ***Model alternative*** – represents one particular version of an application architecture. The alternative includes various models describing the architecture.
- ***Default alternative*** – only one alternative in the tree of alternatives is selected as a working alternative. The other alternatives are not accessible (their models cannot be accessed).
- ***Model*** – model included in an alternative.

4.2.5 Tool prerequisites

The Backbone has no special prerequisites.

4.2.6 Tool activation

The Backbone is activated during the startup sequence of the Eclipse platform. It publishes the Q-ImPrESS perspective configuring the Eclipse environment in order to show Q-ImPrESS related GUI elements (views, buttons, projects' content).

Q-ImPrESS perspective activation

The Q-ImPrESS perspective can be activated by selecting it from the Eclipse perspective menu (see Figure 5). The perspective activation causes reconfiguration of Eclipse platform layout to show Q-ImPrESS related tools.

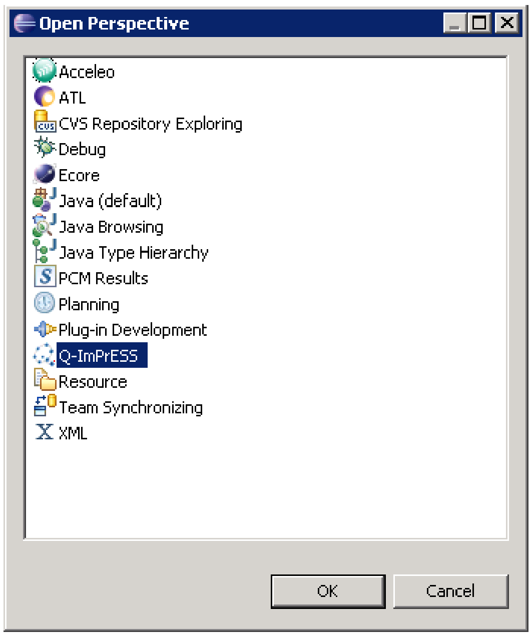


Figure 5: Perspective selection dialog

Q-ImPrESS project activation

Every Q-ImPrESS project is marked by a dedicated Eclipse nature. When applied to a project, the Q-ImPrESS nature enables the use of Q-ImPrESS tools. This is indicated by a small icon of the "*Q*" letter shown in the bottom-right (moved to upper-right in latest releases) corner of the project icon ( ).

There are two ways of associating the Q-ImPrESS nature with a project: (i) by creating a new Q-ImPrESS project, with the nature enabled by default, or (ii) by associating the Q-ImPrESS nature with an existing project explicitly using the pop-up menu.

Create new Q-ImPrESS project

A new Q-ImPrESS project can be created from the main menu “File” → “New” → “Project…”.

Selecting a Q-ImPrESS project item from the list opens the Q-ImPrESS project creation wizard (see Figure 6). The wizard allows users to create a new Q-ImPrESS project with a given name.

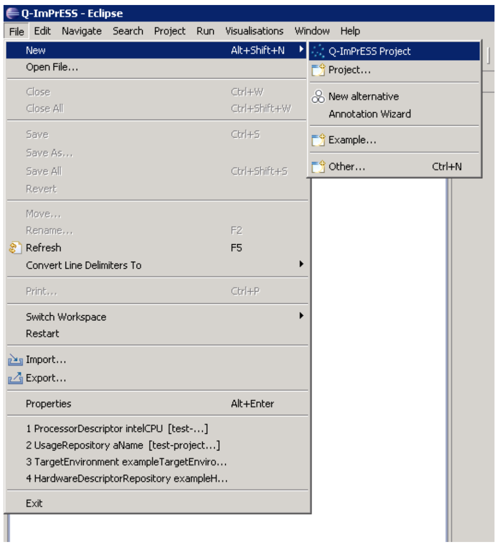


Figure 6: Create Q-ImPrESS project

If activated, the Q-ImPrESS perspective contains a dedicated menu action “File” → “New” → “Q-ImPrESS Project” which also leads to the project creation wizard.

Associating the Q-ImPrESS nature with an existing project

To activate the Backbone infrastructure user has to associate the Q-ImPrESS nature with a given project. This can be done in the project pop-up menu using menu item "Add/Remove Q-ImPrESS nature" (see Figure 7). Similarly, the same procedure is used to remove an existing Q-ImPrESS nature from a project.

An activated Q-ImPrESS nature is indicated by a small icon of "*Q*" letter shown in the bottom-left corner of the project icon ( ) within the Project Explorer view.

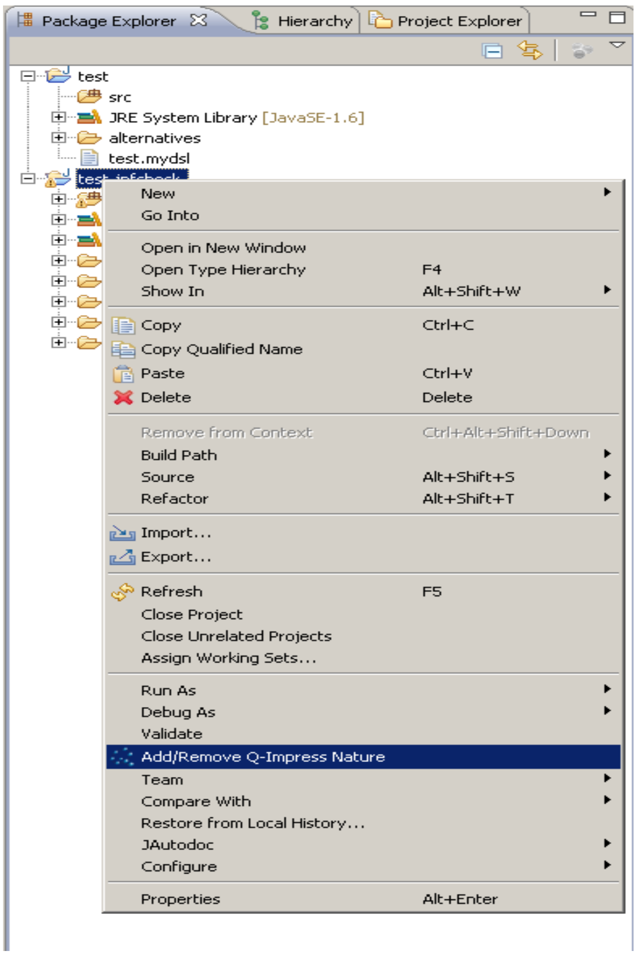
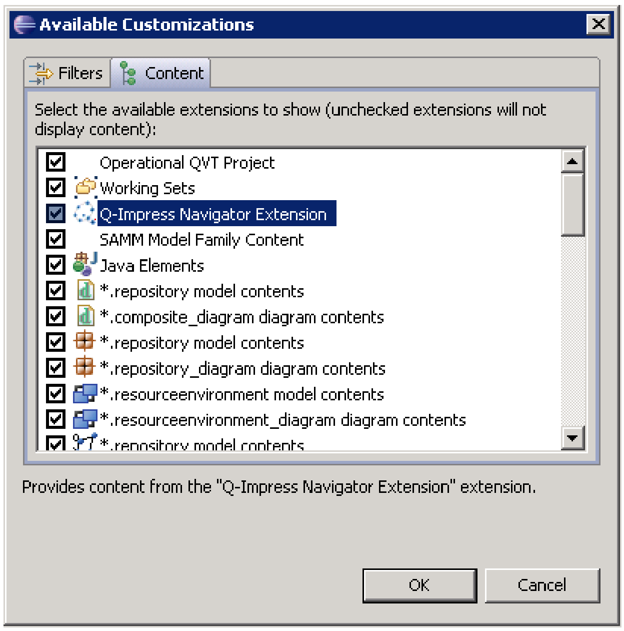


Figure 7 Enabling project Q-ImPrESS nature

Q-ImPrESS project content activation

By default the Project Explorer view shows the content of a Q-ImPrESS project. It is possible to customise the list of visible items by using the "Customize View…" item from the view's menu. The "Q-ImPrESS navigator extension" content provider is responsible for rendering the Q-ImPrESS related information (see Figure 8).



Select the available extensions to show (unchecked extensions will not display content):

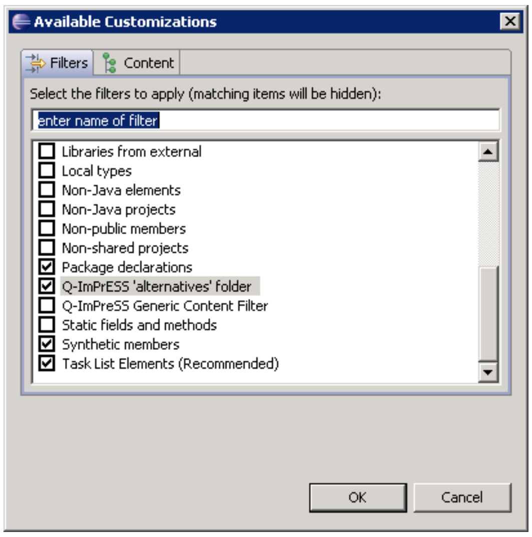
- [✓] Operational QVT Project
- [✓] Working Sets
- [✓] Q-Impress Navigator Extension
- [✓] SAMM Model Family Content
- [✓] Java Elements
- [✓] *.repository model contents
- [✓] *.composite_diagram diagram contents
- [✓] *.repository model contents
- [✓] *.repository_diagram diagram contents
- [✓] *.resourceenvironment model contents
- [✓] *.resourceenvironment_diagram diagram contents
- [✓] *.repository model contents

Provides content from the "Q-Impress Navigator Extension" extension.

Figure 8: List of Project Explorer content extensions

Q-ImPrESS project filters activation

Each Q-ImPrESS project includes a set of files and folders that can easily be managed by applying view filters within the Project Explorer. To activate or deactivate filters select the "Customize View…" item *in the Project Explorer* menu. A window containing the list of available filters is depicted in the Figure 9. In particular, there are two Q-ImPrESS related items: (i) "Q-ImPrESS alternatives folder" which manages the rendering of a system folder containing storage of alternatives; *and (ii) "Q-ImPrESS Generic Content Filter" which* provides a group filter for Q-ImPrESS-related tools.


Available Customizations

Filters | Content

Select the filters to apply (matching items will be hidden):

enter name of filter

- [ ] Libraries from external
- [ ] Local types
- [ ] Non-Java elements
- [ ] Non-Java projects
- [ ] Non-public members
- [ ] Non-shared projects
- [x] Package declarations
- [x] Q-ImPrESS 'alternatives' folder
- [ ] Q-ImPreSS Generic Content Filter
- [ ] Static fields and methods
- [x] Synthetic members
- [x] Task List Elements (Recommended)

Figure 9: List of content filters

Q-ImPrESS annotation properties activation

Q-ImPrESS annotation properties view is part of the Properties View. This view can be activated for each model entity through the option "Show properties view" in the entity pop-up menu.

Q-ImPrESS annotation wizard activation

The Backbone provides an implementation of an advanced annotation wizard which allows for associating QoS annotations with selected model entities. The wizard can be activated via the Eclipse File menu: "File" → "New" → "Annotation Wizard" (see Figure 10), or by selecting "File" → "New" → "Other…" and choosing the item "Q-ImPrESS Annotation Wizard" in a list of wizards.

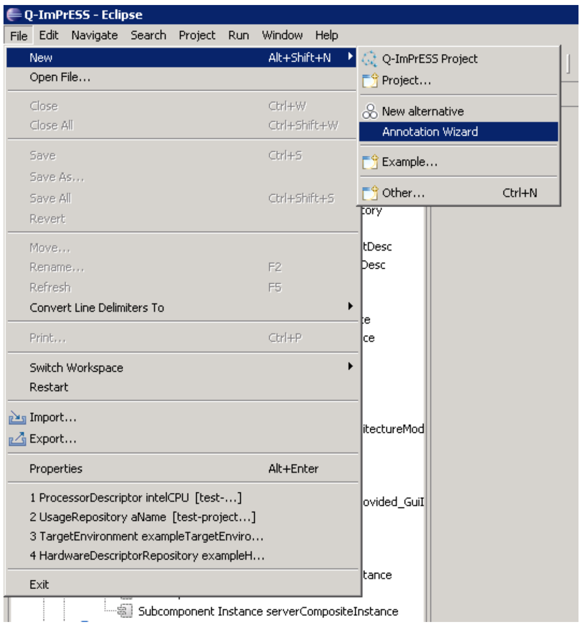


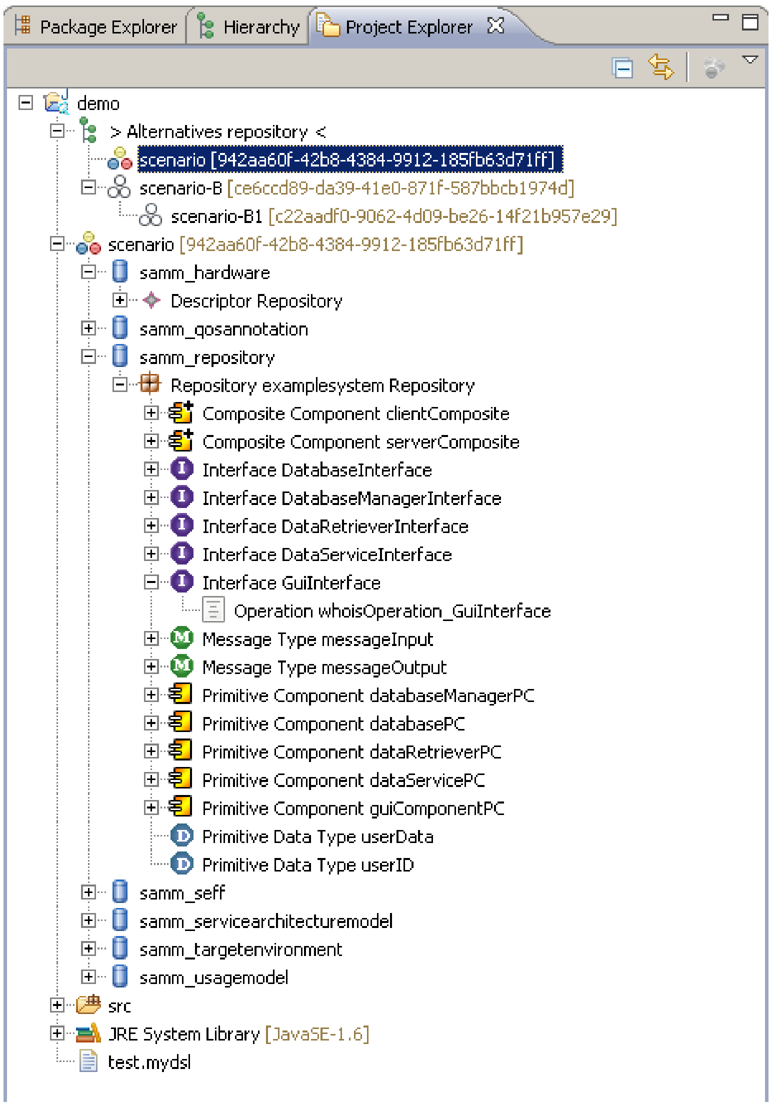
Figure 10: Activation of the QoS annotations wizard

4.2.7 Usage instructions and expected outputs

Q-ImPrESS project view

When Q-ImPrESS nature view is associated with a project, two additional nodes are shown. The first node called "Alternatives repository" (see Figure 11) contains a repository of alternatives. Alternatives are organised into a tree. Each alternative is marked with an icon. The alternative label shows the name and an internal identifier also used as a directory name where the alternative is persisted.
There is always one alternative from the repository selected as a "default" alternative. This is indicated by the icon.

The default alternative has a dedicated node in the *Project Explorer view* that also renders the associated models depicted by the icon. Each model comprises model artifacts that can be edited using a generic EMF tree editor, graphical editor or syntax-aware text editor with highlighting features.



```
demo
  > Alternatives repository <
    scenario [942aa60f-42b8-4384-9912-185fb63d71ff]
    scenario-B [ce6ccd89-da39-41e0-871f-587bbcb1974d]
      scenario-B1 [c22aadf0-9062-4d09-be26-14f21b957e29]
  scenario [942aa60f-42b8-4384-9912-185fb63d71ff]
    samm_hardware
      Descriptor Repository
    samm_qosannotation
    samm_repository
      Repository examplesystem Repository
        Composite Component clientComposite
        Composite Component serverComposite
        Interface DatabaseInterface
        Interface DatabaseManagerInterface
        Interface DataRetrieverInterface
        Interface DataServiceInterface
        Interface GuiInterface
          Operation whoisOperation_GuiInterface
        Message Type messageInput
        Message Type messageOutput
        Primitive Component databaseManagerPC
        Primitive Component databasePC
        Primitive Component dataRetrieverPC
        Primitive Component dataServicePC
        Primitive Component guiComponentPC
        Primitive Data Type userData
        Primitive Data Type userID
    samm_seff
    samm_servicearchitecturemodel
    samm_targetenvironment
    samm_usagemodel
  src
  JRE System Library [JavaSE-1.6]
  test.mydsl
```

Figure 11: The project view with enabled Q-ImPrESS nature

Creation of a new alternative

The “New Alternative” action is located in the pop-up menu of the alternatives repository node and in the pop-up menu of each alternative (see Figure 12).

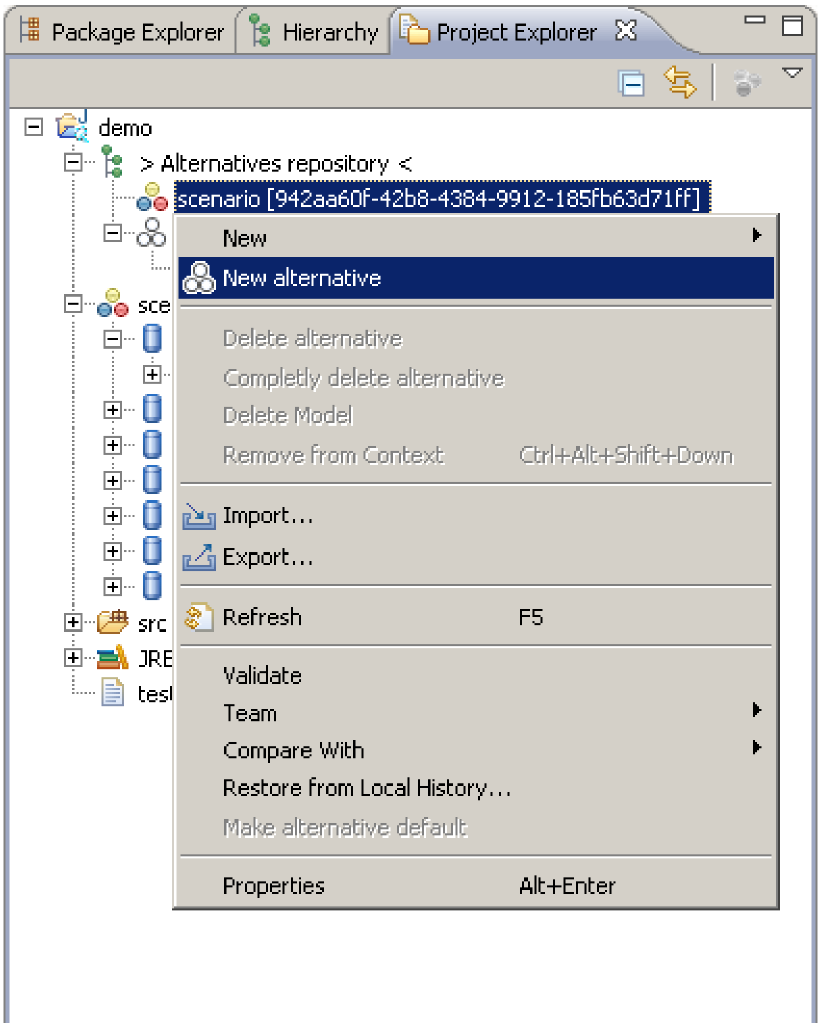
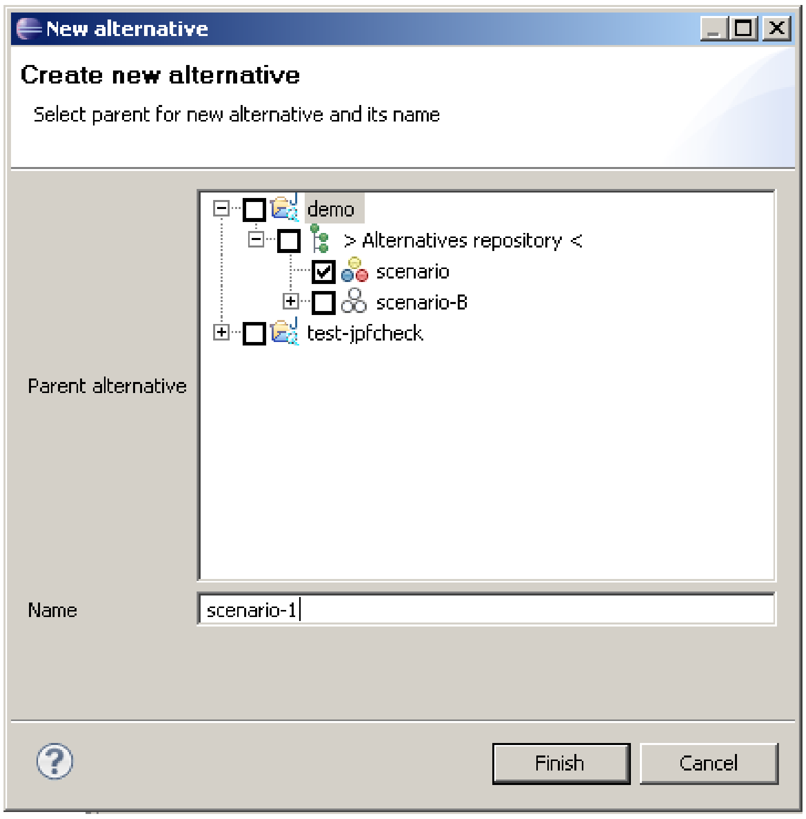


Figure 12: New alternative action

Selecting the "New Alternative" action, a wizard is shown (see Figure 13) and the user can pick a parent alternative. Provided no parent alternative is selected, a new alternative will be created as a top-level node in the alternative repository. Further, the user has to specify the name of a newly created alternative
.



Create new alternative

Select parent for new alternative and its name

Parent alternative

- [ ] demo
  - [ ] > Alternatives repository <
    - [✓] scenario
    - [ ] scenario-B
- [ ] test-jpfcheck

Name: scenario-1

Figure 13: New alternative wizard

Selecting default alternative

The action “Make alternative default” is shown in the pop-up menu for each non-default alternative (see Figure 14). Selecting the default alternative also updates the Project view.

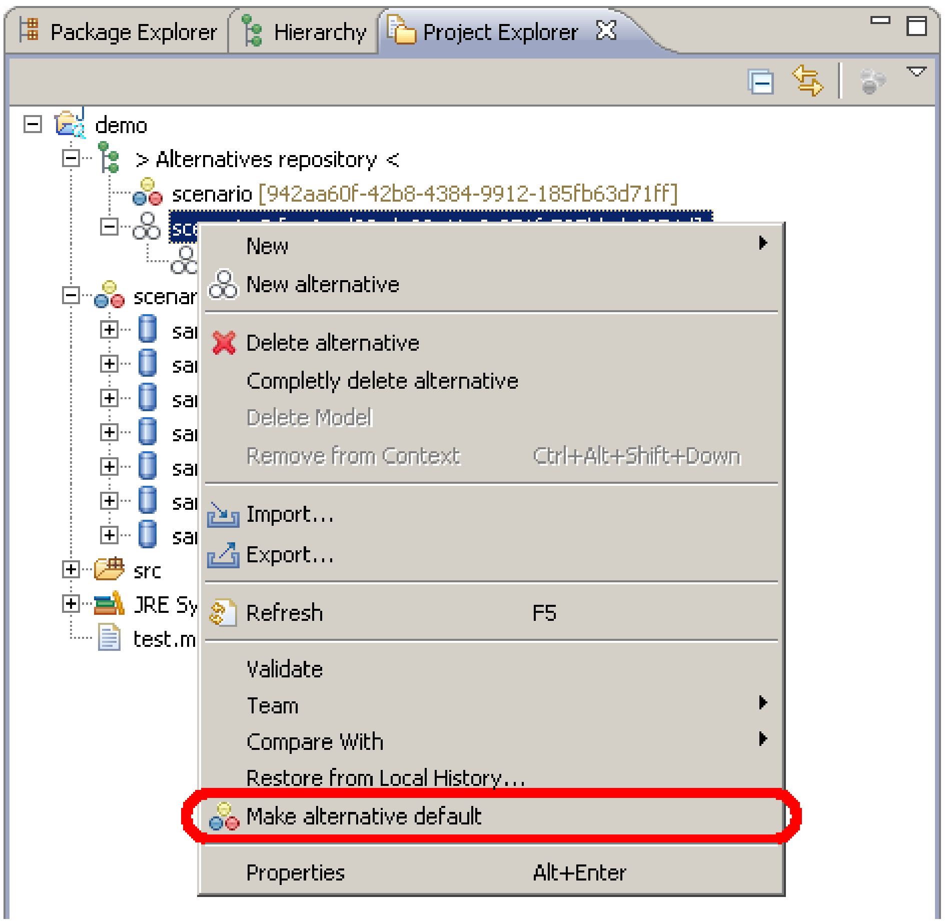


Figure 14: Make alternative default action

Adding a new model into an alternative

To add a new model into an alternative, the user has to select the default alternative and to choose the action “New” → “Other…” in the pop-up menu (see Figure 15).

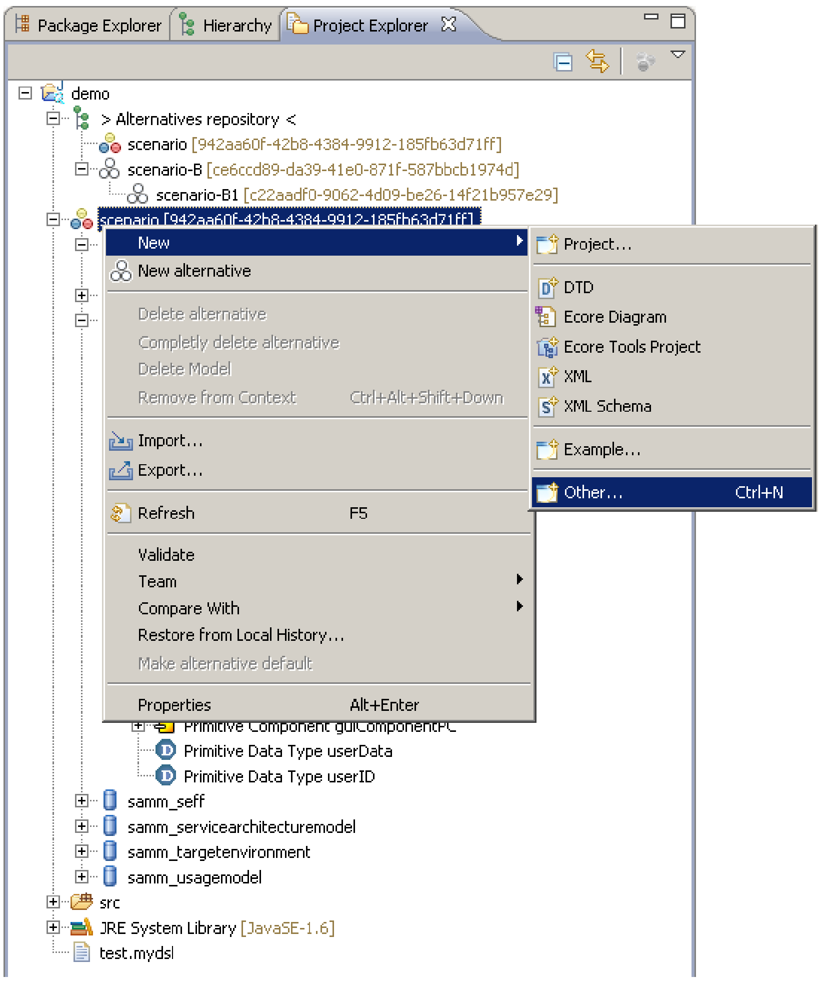
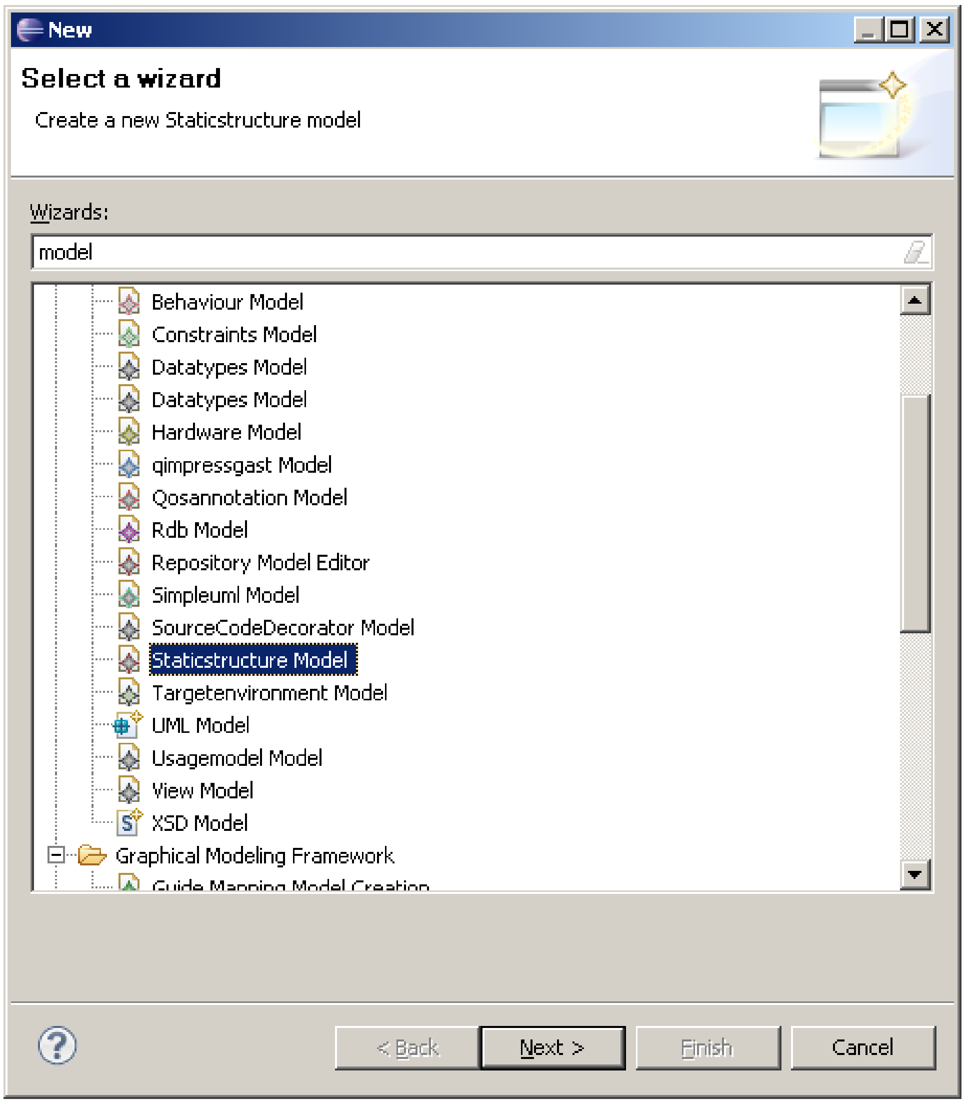

Package Explorer
Hierarchy
Project Explorer
demo
> Alternatives repository <
scenario [942aa60f-42b8-4384-9912-185fb63d71ff]
scenario-B [ce6ccd89-da39-41e0-871f-587bbcb1974d]
scenario-B1 [c22aadf0-9062-4d09-be26-14f21b957e29]
scenario [942aa60f-42b8-4384-9912-185fb63d71ff]
New
New alternative
Delete alternative
Completly delete alternative
Delete Model
Remove from Context Ctrl+Alt+Shift+Down
Import...
Export...
Refresh F5
Validate
Team
Compare With
Restore from Local History...
Make alternative default
Properties Alt+Enter
Project...
DTD
Ecore Diagram
Ecore Tools Project
XML
XML Schema
Example...
Other... Ctrl+N
Primitive Component guiComponentPC
Primitive Data Type userData
Primitive Data Type userID
samm_seff
samm_servicearchitecturemodel
samm_targetenvironment
samm_usagemodel
src
JRE System Library [JavaSE-1.6]
test.mydsl

Figure 15: Action for creating new model

Using a wizard, the user can create a new model by selecting the appropriate option from the provided types of models (see Figure 16).


New

Select a wizard

Create a new Staticstructure model

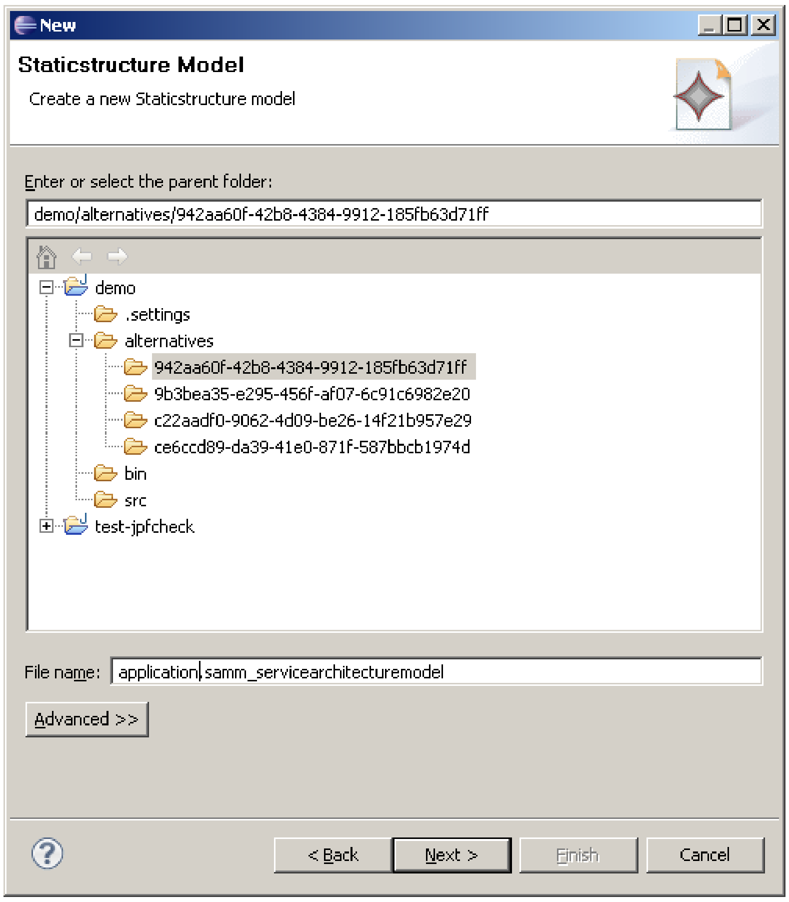
Wizards:

model

- Behaviour Model
- Constraints Model
- Datatypes Model
- Datatypes Model
- Hardware Model
- qimpressgast Model
- Qosannotation Model
- Rdb Model
- Repository Model Editor
- Simpleuml Model
- SourceCodeDecorator Model
- Staticstructure Model
- Targetenvironment Model
- UML Model
- Usagemodel Model
- View Model
- XSD Model
- Graphical Modeling Framework

Figure 16: Selecting the type of model

Before a new model is created it is necessary to specify the model name (see Figure 17).

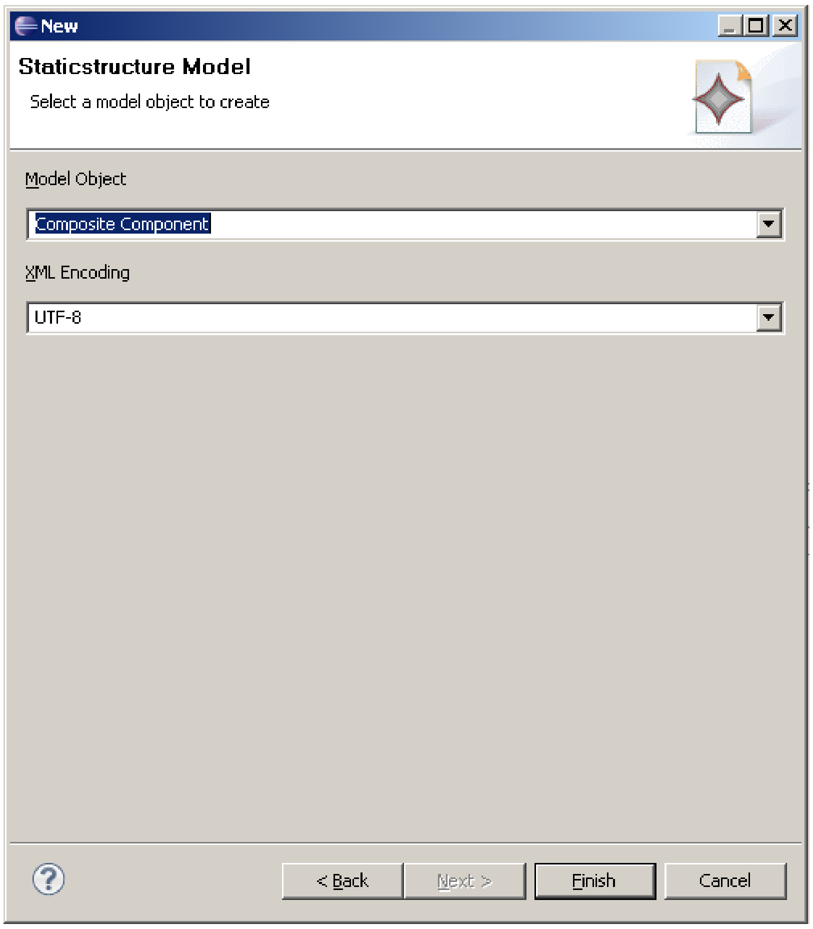

New
Staticstructure Model
Create a new Staticstructure model
Enter or select the parent folder:
demo
.settings
alternatives
942aa60f-42b8-4384-9912-185fb63d71ff
9b3bea35-e295-456f-af07-6c91c6982e20
c22aadf0-9062-4d09-be26-14f21b957e29
ce6ccd89-da39-41e0-871f-587bbcb1974d
bin
src
test-jpfcheck
Advanced >>
< Back
Next >
Finish
Cancel

Enter or select the parent folder: demo/alternatives/942aa60f-42b8-4384-9912-185fb63d71ff

File name: application.samm_servicearchitecturemodel

Figure 17: Associating a name with the model

Finally, a top-level modelling entity has to be selected (see Figure 18). After finishing the wizard, the new model is created within the selected alternative.



Model Object: Composite Component

XML Encoding: UTF-8

Figure 18: Selecting top-level modelling entity

Model editing

Each model can be edited either using a generated EMF tree editor or directly from the Project Explorer view using the context pop-up menu. In other words, each model artefact provides pop-up menu to create child- and sibling-artefacts, to delete an artefact and to show the property view (see Figure 19). Changes are directly stored into the corresponding model file.

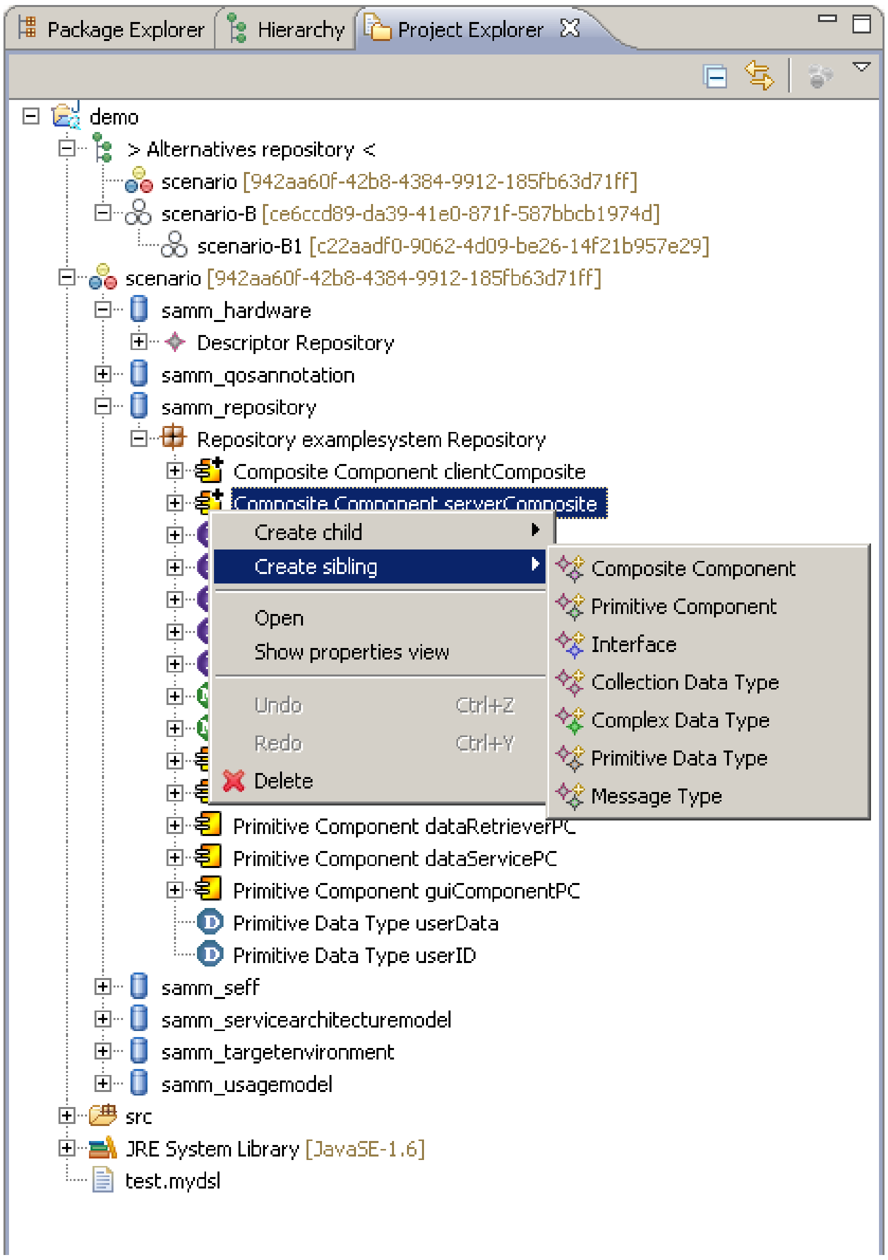
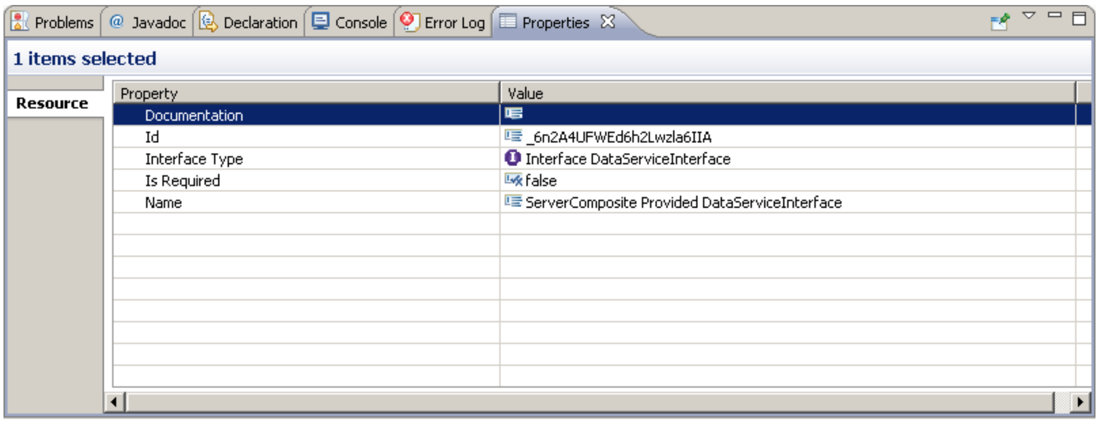

Package Explorer
Hierarchy
Project Explorer
demo
> Alternatives repository <
scenario [942aa60f-42b8-4384-9912-185fb63d71ff]
scenario-B [ce6ccd89-da39-41e0-871f-587bbcb1974d]
scenario-B1 [c22aadf0-9062-4d09-be26-14f21b957e29]
scenario [942aa60f-42b8-4384-9912-185fb63d71ff]
samm_hardware
Descriptor Repository
samm_qosannotation
samm_repository
Repository examplesystem Repository
Composite Component clientComposite
Composite Component serverComposite
Create child
Create sibling
Open
Show properties view
Undo Ctrl+Z
Redo Ctrl+Y
Delete
Composite Component
Primitive Component
Interface
Collection Data Type
Complex Data Type
Primitive Data Type
Message Type
Primitive Component dataRetrieverPC
Primitive Component dataServicePC
Primitive Component guiComponentPC
Primitive Data Type userData
Primitive Data Type userID
samm_seff
samm_servicearchitecturemodel
samm_targetenvironment
samm_usagemodel
src
JRE System Library [JavaSE-1.6]
test.mydsl

Figure 19 Editing model

Properties of a model can be edited via the Property view (see Figure 20). Also these changes are automatically saved into the corresponding model file.



Property	Value
Documentation	
Id	_6n2A4UFWEd6h2Lwzla6IIA
Interface Type	Interface DataServiceInterface
Is Required	false
Name	ServerComposite Provided DataServiceInterface

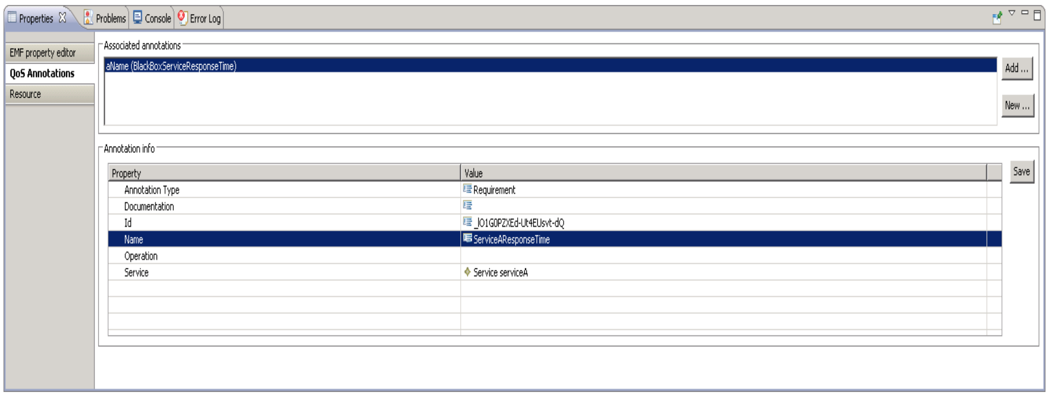
Figure 20: Property view for model entity

Opening model artefact editors

Each model artefact can be opened via a predefined set of editors. The possible open actions are shown in the pop-up menu of each model entity.

Annotation properties

Annotation properties can be shown for each model element. For a selected element, the annotation properties view shows a list of associated QoS annotations and the properties of the annotation (see Figure 21). It further allows users to re-associate existing annotations or create new annotations for a selected element.



aName (BlackBoxServiceResponseTime)

Property	Value
Annotation Type	Requirement
Documentation	
Id	_lO1G0PZXEd-Ut4EUsvt-dQ
Name	ServiceAResponseTime
Operation	
Service	Service serviceA

Figure 21: QoS annotation properties

Annotation wizard

The annotation wizard can be used to annotate repository elements with various kinds of annotations. The wizard can be activated via menu "File" → "New" → "Annotation Wizard" (see Figure 22).

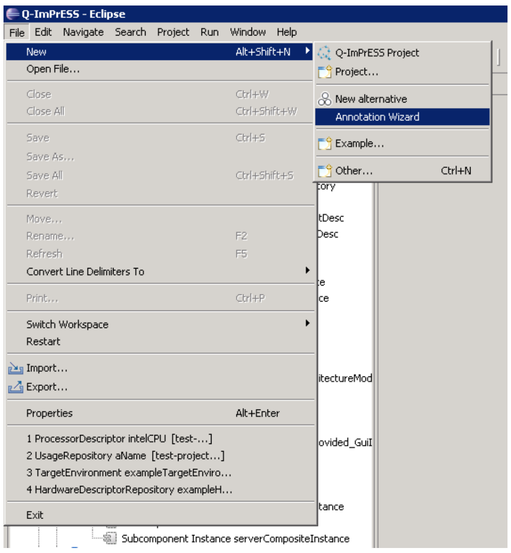
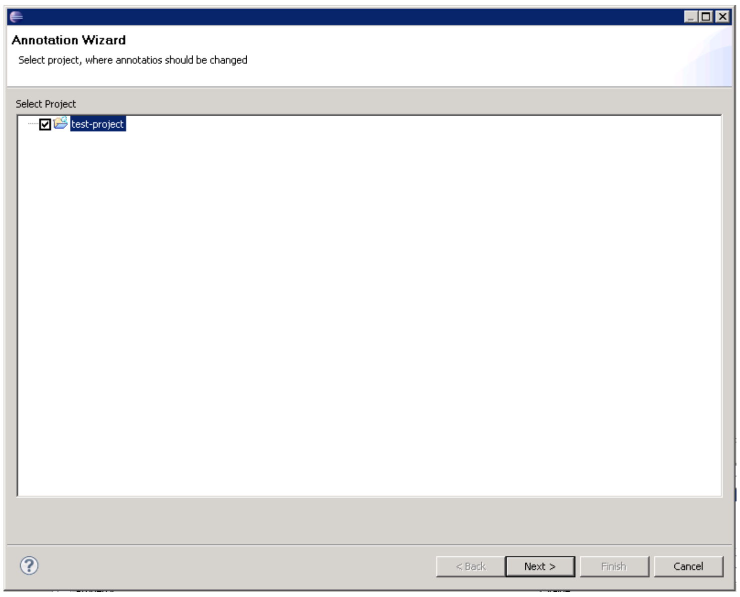


Figure 22: Annotation wizard activation

When activated, the wizard displays a dialog with a list of projects. User then selects the desired subset of projects where the elements will be annotated (see Figure 23).


Annotation Wizard

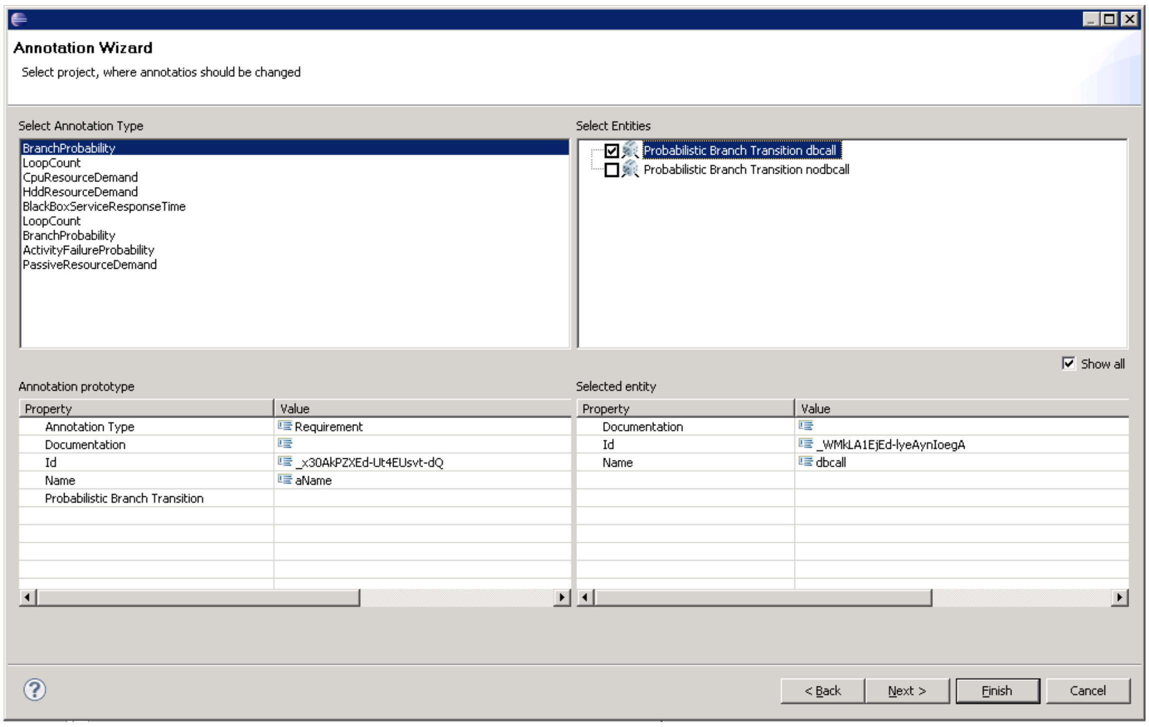
Select project, where annotatios should be changed

Select Project

☑ test-project

Figure 23: Annotation wizard – project selector

The next wizard dialog shows on the left side the list of provided annotation types. By selecting an annotation type the right menu shows repository elements which can be annotated (see Figure 24) by this annotation type. The dialog also shows properties of the annotation type and the selected repository element at the bottom.


Annotation Wizard

Select project, where annotatios should be changed

Select Annotation Type

BranchProbability
LoopCount
CpuResourceDemand
HddResourceDemand
BlackBoxServiceResponseTime
LoopCount
BranchProbability
ActivityFailureProbability
PassiveResourceDemand

Select Entities

[✓] Probabilistic Branch Transition dbcall
[ ] Probabilistic Branch Transition nodbcall

[✓] Show all

Annotation prototype

Property	Value
Annotation Type	Requirement
Documentation	
Id	_x30AkPZXEd-Ut4EUsvt-dQ
Name	aName
Probabilistic Branch Transition	

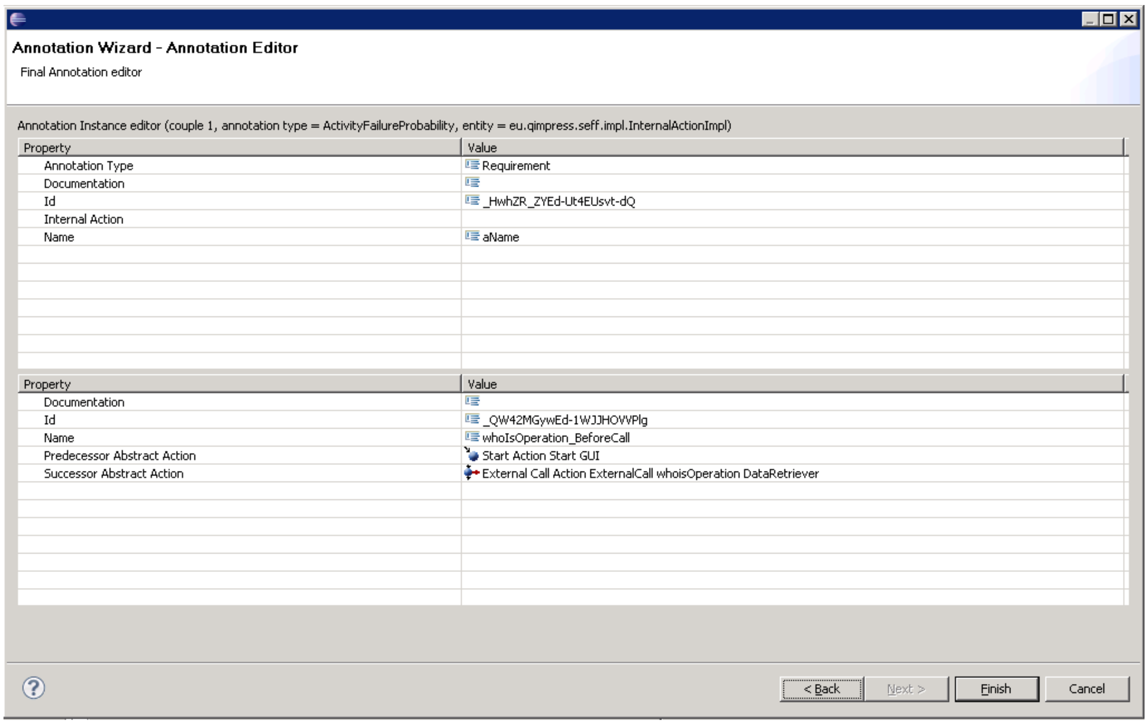
Selected entity

Property	Value
Documentation	
Id	_WMkLA1EjEd-lyeAynIoegA
Name	dbcall

Figure 24: Annotation wizard – annotating repository elements

When the “Finish” button is clicked, each selected element is associated with a “default” instance of the selected annotation type. However, when clicking the “Next” button, the annotation properties can be fine-tuned for every selected repository entity (see

Figure 25).



Annotation Instance editor (couple 1, annotation type = ActivityFailureProbability, entity = eu.qimpress.seff.impl.InternalActionImpl)

Property	Value
Annotation Type	Requirement
Documentation	
Id	_HwhZR_ZYEd-Ut4EUsvt-dQ
Internal Action	
Name	aName

Property	Value
Documentation	
Id	_QW42MGywEd-1WJJHOVVPlg
Name	whoIsOperation_BeforeCall
Predecessor Abstract Action	Start Action Start GUI
Successor Abstract Action	External Call Action ExternalCall whoisOperation DataRetriever

Figure 25: Annotation wizard – specification of annotation properties for a selected element

4.2.8 Caveats

Problems with the Q-ImPrESS project

In some cases (e.g., due to an obsolete workspace structure), the Q-ImPrESS project can be shown in a wrong way. This problem can be fixed by re-opening the affected projects and by restarting the Eclipse platform.

4.3 Repository Editor Manual

4.3.1 Purpose of the tool

The Repository Editor tool described here is a graphical editor for components of a Service Architecture Model (SAM) that ought to be maintained subsequently in a repository. It is intended as a complementary tool for the textual editor of repository components, primarily for the users who are more familiar with the graphical editing environments. Last but not least, such an editor enables users to reorganise the graphical representation of their models mostly resulting in a cleaner visualization of the model comparing to the automatically generated visual representations.
The tool is completely integrated into the Eclipse development environment and is available in an initial version covering a wide range of useful features.

4.3.2 Tool relationship with the Q-ImPrESS workflow

The Repository Editor can be used to create, edit or display repository elements such as components, interfaces, interface operations, or data types. It can be used anytime during the Q-ImPrESS workflow. However the most relevant workflow step for using the editor is the "Model Change Scenario" step (see Figure 26).

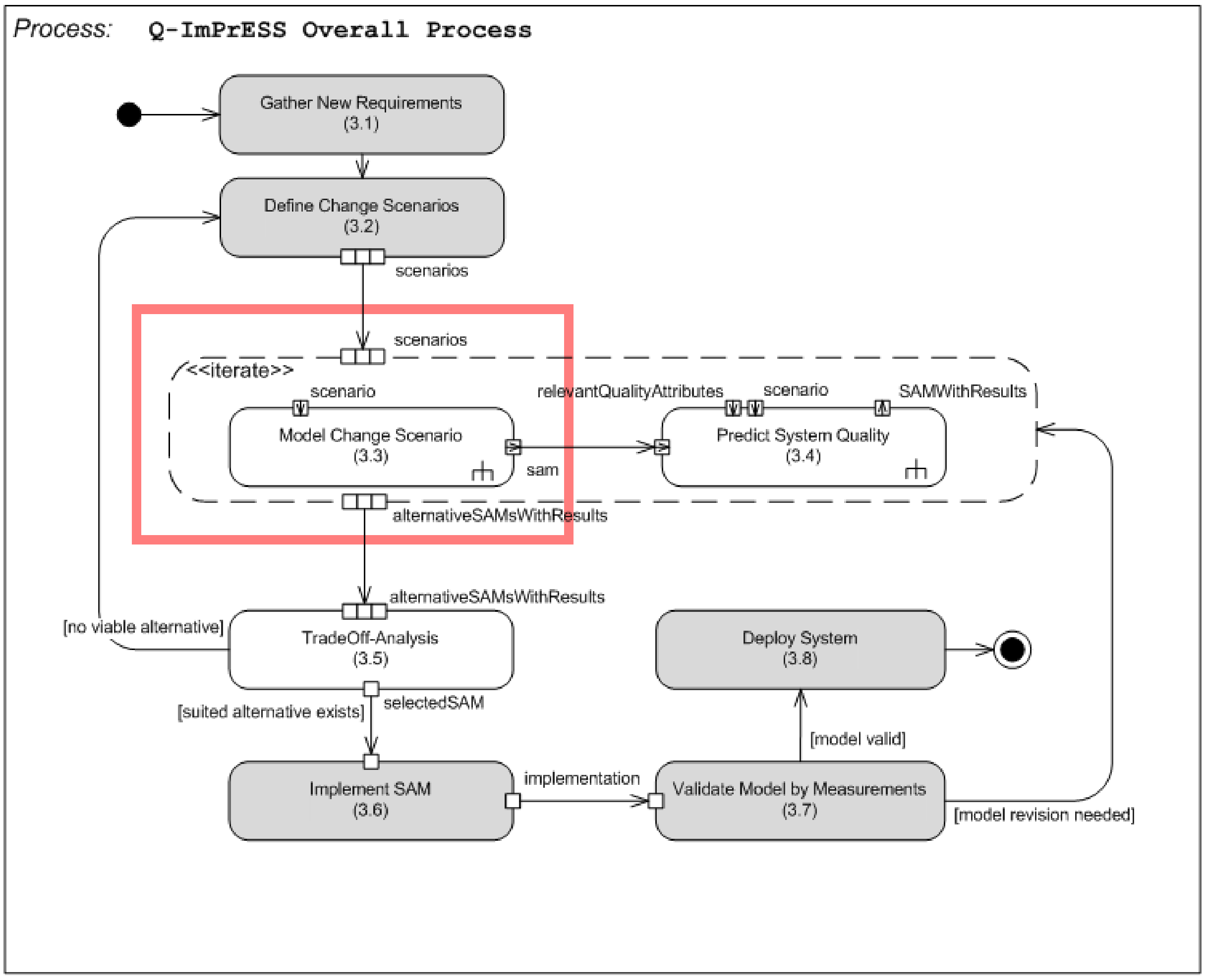

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
Model Change Scenario (3.3)
sam
relevantQualityAttributes
scenario
SAMWithResults
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
[suited alternative exists]
selectedSAM
Deploy System (3.8)
[model valid]
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]

Figure 26: Modelling change scenario workflow (copied from D6.1)

4.3.3 Tool prerequisites

The Repository Editor has no special prerequisites.

4.3.4 Tool activation

The tool needs a SAMM repository diagram file to work. If such a file already exists, it is sufficient to Double-Click on it to open it and start the editor.
In case such a file doesn't exist, it is possible to automatically generate such a file from an existing SAMM repository. Information about how to create a repository model file can be found in Section 4.1.
The following paragraphs will explain how to generate a diagram file from an existing repository model. A repository model is stored in a file with the file ending ".samm_repository". First it is necessary to select the existing repository in the Eclipse Project Explorer. Right-Clicking on the entry shows a context menu similar to the one displayed in Figure 27.

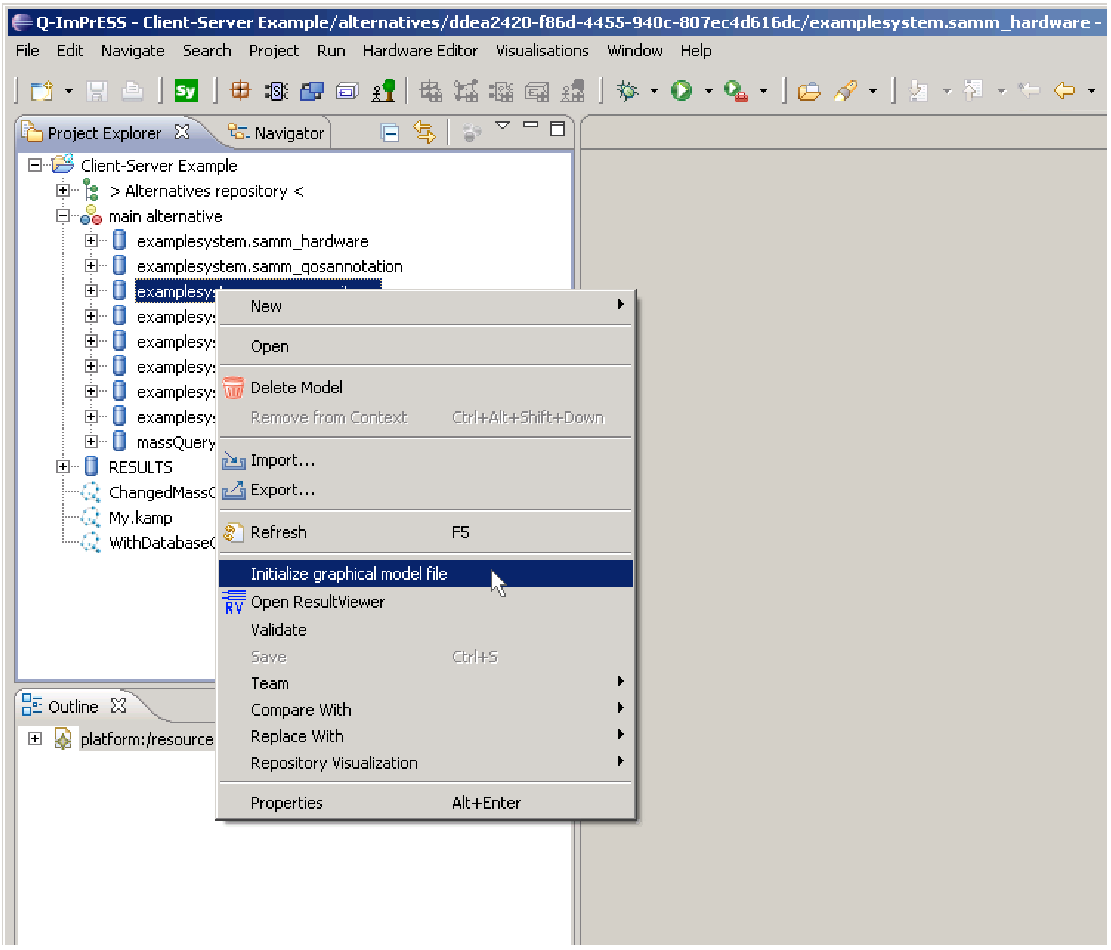
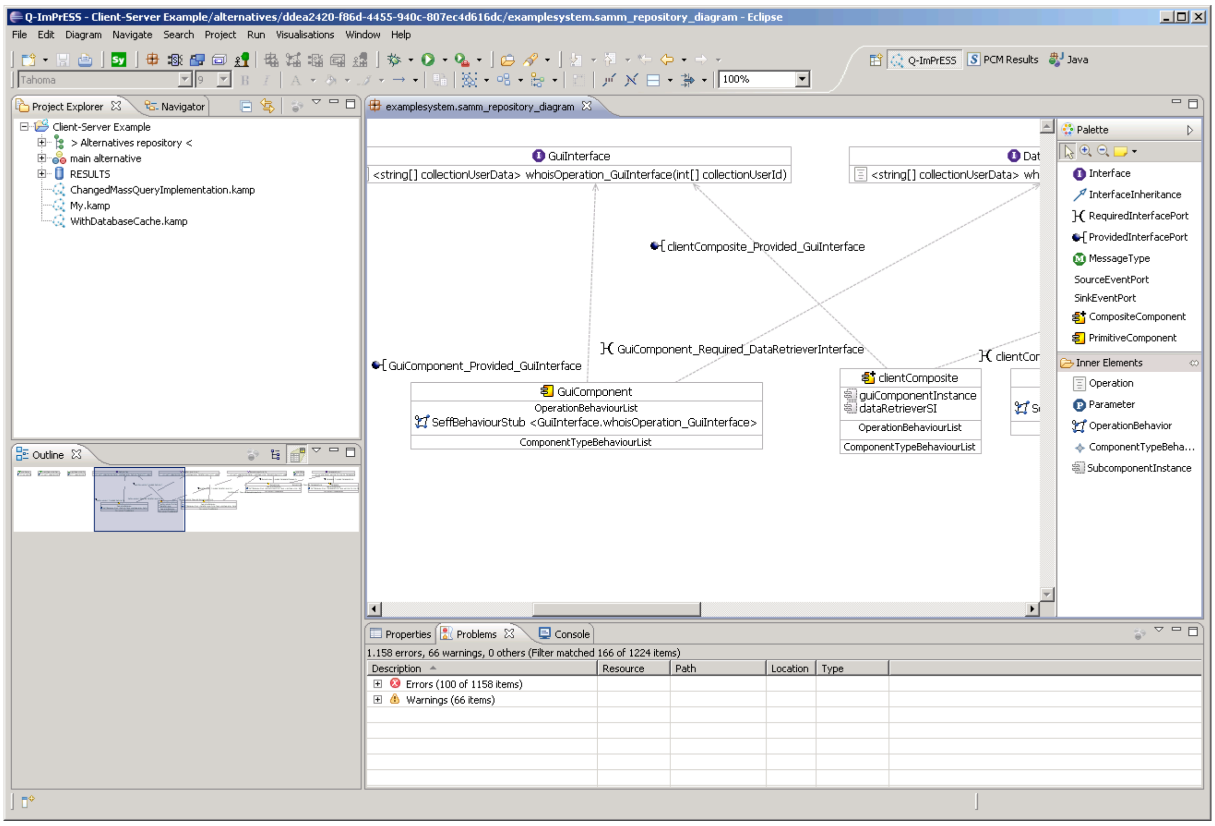

Q-ImPrESS - Client-Server Example/alternatives/ddea2420-f86d-4455-940c-807ec4d616dc/examplesystem.samm_hardware -
File Edit Navigate Search Project Run Hardware Editor Visualisations Window Help
Project Explorer
Navigator
Client-Server Example
> Alternatives repository <
main alternative
examplesystem.samm_hardware
examplesystem.samm_qosannotation
examplesy
massQuery
RESULTS
ChangedMass
My.kamp
WithDatabase
Outline
platform:/resource
New
Open
Delete Model
Remove From Context Ctrl+Alt+Shift+Down
Import...
Export...
Refresh F5
Initialize graphical model file
Open ResultViewer
Validate
Save Ctrl+S
Team
Compare With
Replace With
Repository Visualization
Properties Alt+Enter

Figure 27: Generating a diagram file for a repository

Selecting the menu entry highlighted in Figure 27 will result in a dialog opening. Here it is sufficient to simply select "Finish" to confirm all default settings and create a diagram entry

with them. The Project Explorer will show a new entry (the diagram has the file ending ".samm_repository_diagram") and the editor for the diagram file automatically opens.
The Repository Editor can also be opened by double-clicking on the repository diagram file. The screenshot in Figure 28 shows the diagram for an example repository.


Q-ImPrESS - Client-Server Example/alternatives/ddea2420-f86d-4455-945c-807ec4d616dc/examplesystem.samm_repository_diagram - Eclipse
File Edit Diagram Navigate Search Project Run Visualisations Window Help
Q-ImPrESS PCM Results Java
Project Explorer Navigator
Client-Server Example
> Alternatives repository <
main alternative
RESULTS
ChangedMassQueryImplementation.kamp
My.kamp
WithDatabaseCache.kamp
examplesystem.samm_repository_diagram
GuiInterface
<string[] collectionUserData> whoisOperation_GuiInterface(int[] collectionUserId)
clientComposite_Provided_GuiInterface
GuiComponent_Required_DataRetrieverInterface
GuiComponent_Provided_GuiInterface
GuiComponent
OperationBehaviourList
SeffBehaviourStub <GuiInterface.whoisOperation_GuiInterface>
ComponentTypeBehaviourList
clientComposite
guiComponentInstance
dataRetrieverSI
OperationBehaviourList
ComponentTypeBehaviourList
Palette
Interface
InterfaceInheritance
RequiredInterfacePort
ProvidedInterfacePort
MessageType
SourceEventPort
SinkEventPort
CompositeComponent
PrimitiveComponent
Inner Elements
Operation
Parameter
OperationBehavior
ComponentTypeBeha...
SubcomponentInstance
Outline
Properties Problems Console

1.158 errors, 66 warnings, 0 others (Filter matched 166 of 1224 items)

Description	Resource	Path	Location	Type
Errors (100 of 1158 items)				
Warnings (66 items)				

Figure 28: Editor showing the repository example diagram

4.3.5 Usage instructions and expected outputs

The current section will explain how a user is expected to work with the Repository Editor. It is assumed that the user already knows how to use a graphical editor, i.e. how to select elements, drag and drop elements or icons and the like. It is assumed out-of-scope for the given document to explain such basic knowledge.

When a diagram file is opened, it shows the typical interface for every editor working in an Eclipse environment. The following explanations make use of the Client/Server Example project that is shipped with the Q-ImPrESS IDE.

If the diagram has been automatically generated, the automatic placement of graphical elements may be not suited to allow viewing all elements in their entirety and the connections between them may be not clearly visible. Section 4.4.4 gives more information about how to improve the layout of model elements in a diagram file.

Working with editor tools for repository elements

The editor allows using the same elements as the textual editor for the repository. The editor allows the user to create elements simply by selecting the appropriate tool from the tool palette to the right of the editor window. The palette and the available tools are shown in Figure 29.

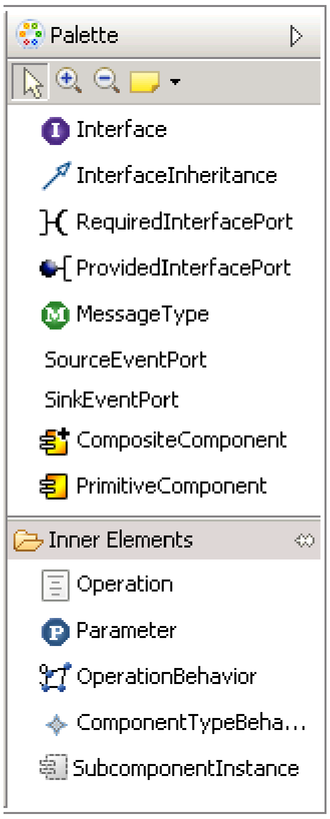


Figure 29: Editor tools palette

In order to create such an element a user has to perform the same action independently from the tool. At first the appropriate entry in the palette must be selected (from the upper section) and will be shown highlighted. Then the mouse cursor must be moved into the editor canvas. The mouse cursor shape changes according to the tool selected to show the user that an element of a given type is going to be created. The action needs to be finished by clicking at an appropriate location in the editor canvas resulting in the creation of a new element and its placement at that location.

Working with Inner Elements

The second section in the palette contains tools for the creation of inner elements. Such elements can only be created within other elements already placed on the editor canvas.
The use of these tools is in no way different from the tools of the upper section. To use such a tool, its icon must be selected and will be shown highlighted. Moving the mouse cursor into the canvas of the editor results in different cursor shapes depending whether the chosen tool can be applied to the given context or element or not.
As an example let's assume that we want to create a new Operation. We select the tool and move the mouse cursor over the component "clientComposite". As it is not possible to create an Operation for an element of that type, the cursor still shows a crosshair shape. This changes when we move it over the element "GuiInterface". It is possible to add an element of type Operation to this element (an Interface), so the cursor changes into a hollow arrow with a plus sign to indicate that the operation can be performed.

The same behaviour is implemented for the other inner elements shown in that section of the palette. Depending on the type of tool selected and type of element the cursor is pointing to, the cursor shape indicates the applicability of the chosen tool.

Working with OperationBehaviour

In the Inner Elements section of the palette, Operation Behaviours can be added to Primitive Components. Adding an element of type OperationBehavior opens a dialog box requiring the user to choose whether a SEFF behaviour stub or a GAST behaviour stub shall be created. After specifying the type of behaviour, a dialog box opens that allows the user to select the operation interface for which the behaviour is to be specified. By double-clicking on a SEFF behaviour, the graphical SEFF Editor opens which allows displaying and editing the SEFF behaviour. This editor is explained in detail in chapter 4.5.

Deleting elements

Deleting elements works as can be expected from such graphical editors. After selecting one or more elements, the mouse context menu (right-click) opens up showing an entry "Delete from Model" (see Figure 30).

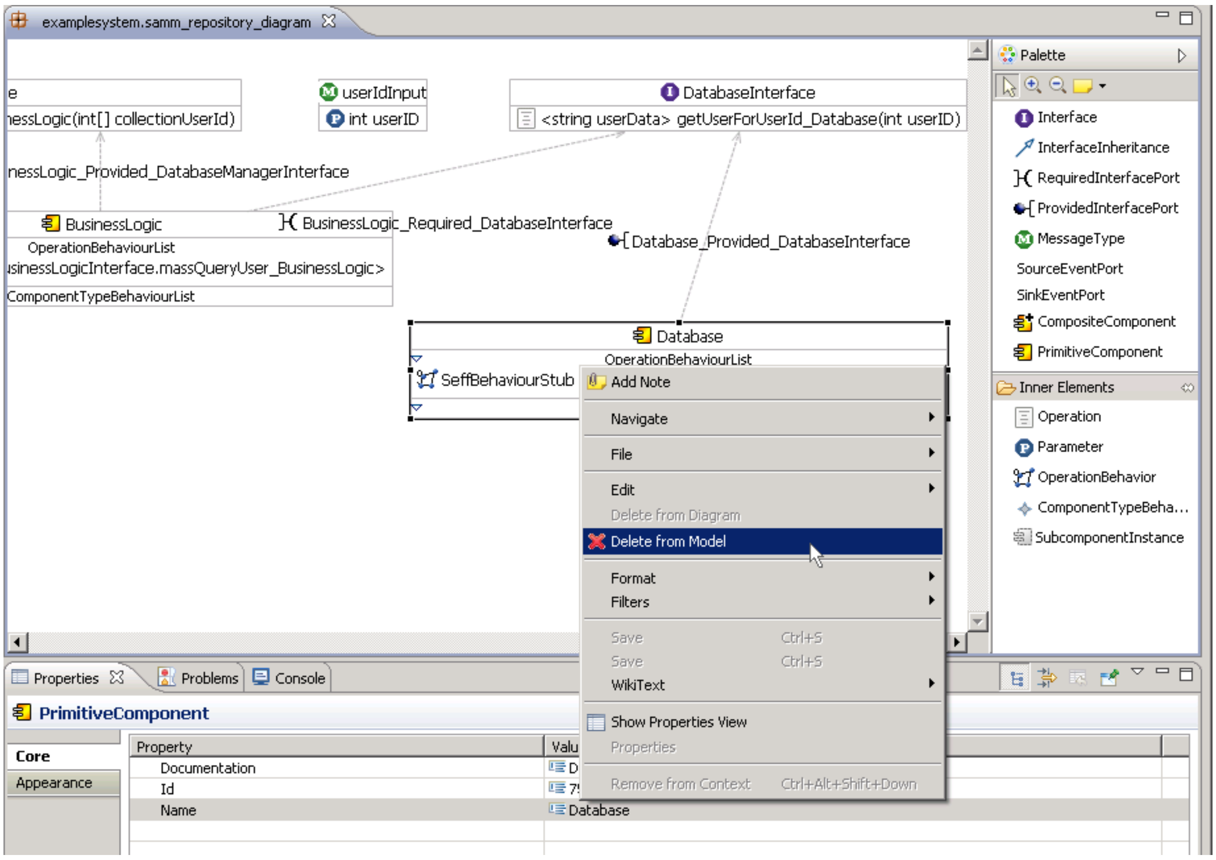


Figure 30: Deletion of elements

The delete operation deletes the selected element. It may also delete some of the elements associated to the element to be deleted in case those elements cannot exist apart from the element to delete.

Moving elements

Elements in the editor can be moved as expected. Simply select them and move them using the mouse cursor.

Sizing elements

When an element is selected that allows resizing, appropriate handles are shown. Selecting one of those handles and dragging it with the mouse will change the size of the element accordingly. In rare cases resizing is not possible and the element will retain its size even after an attempt to resize it.

Working with Composite Components

Working with composite components is special in that they feature a separate editor of their own. Double-clicking on a composite component opens the Composite Editor that displays the contents of the composite component. The editor can be used independently from the Repository Editor and it is described in a Section 4.4.
However, subcomponent instances for composite components can also be created in the Repository Editor. To add a subcomponent instance to a composite component, select the tool SubcomponentInstance from the palette and click inside a composite component on the canvas. A dialog opens which enables the user to select the subcomponent type for the subcomponent instance.

4.3.6 Caveats

In its current version, the tool doesn't extensively check the semantics of models created by the user. So it may be possible to draw models according to the rules set forth in the meta model (SAMM) which will not have any practical meaning, as they show situations which cannot be reasonably expected to occur. It may be necessary to enhance the editor after setting up rules, e.g. governing the possible combinations of elements in the model. A future version of the editor may check the model for validity at least when the user saves the model he created.

4.4 Composite Editor Manual: Modelling service architecture models and composite components

4.4.1 Purpose of the tool

The Q-ImPrESS IDE provides a graphical editor for a Service Architecture Model (SAM) and composite components. As both structures share the same concepts, the editor can be used for both. It is intended as a complement for the standard Eclipse editor for EMF based models. Users being more familiar with graphical editing environments will prefer this to the standard editor. Last but not least such an editor enables users to adapt the graphical representation of their models mostly resulting in a better visualization than what can be obtained from automatic visualization tools using the SAM. The editor is opened automatically whenever a user edits a composite component from the Repository Editor as well. It is also possible to save diagrams of composite components and Service Architecture Models as diagram files.

4.4.2 Tool relationship with the Q-ImPrESS workflow

The Composite Editor can be used to create, edit or display Service Architecture Models (SAM) or composite components. It can be used anytime during the Q-ImPrESS workflow, however the most relevant workflow step for using the editor is the step "Model Change Scenario" (see Figure 31).

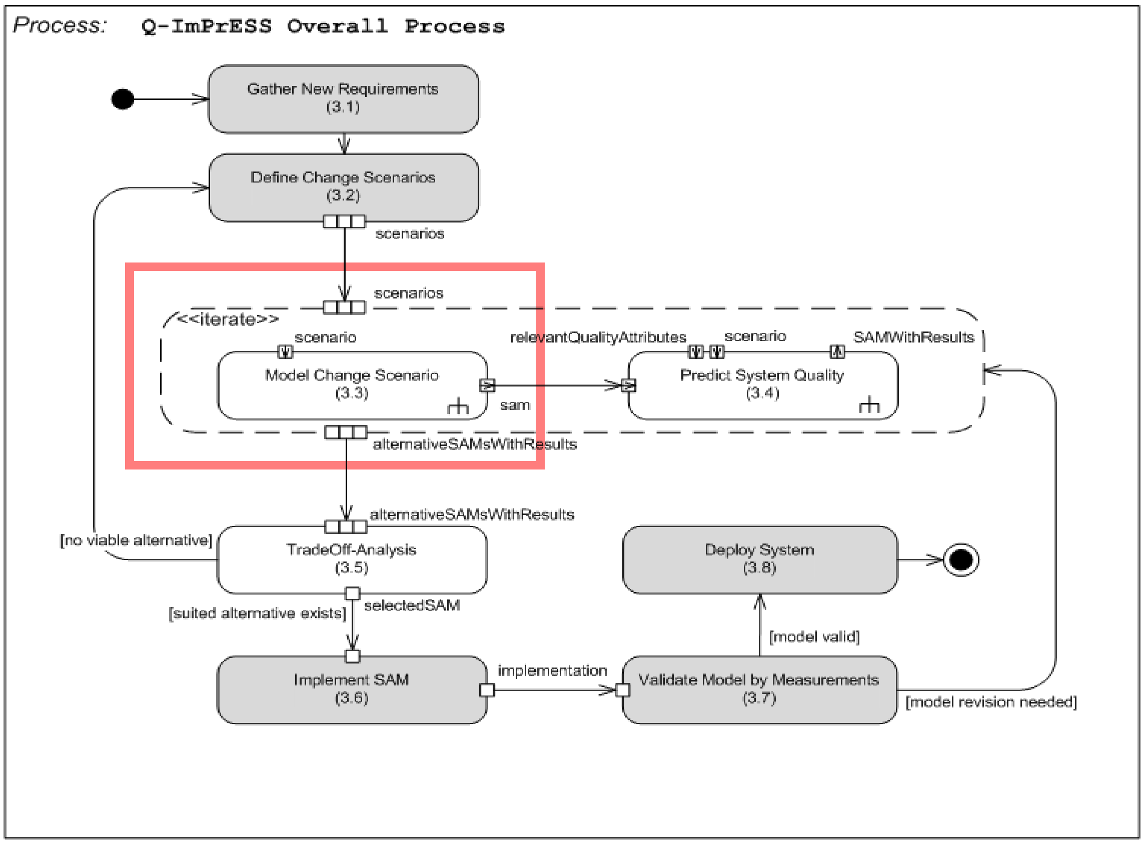
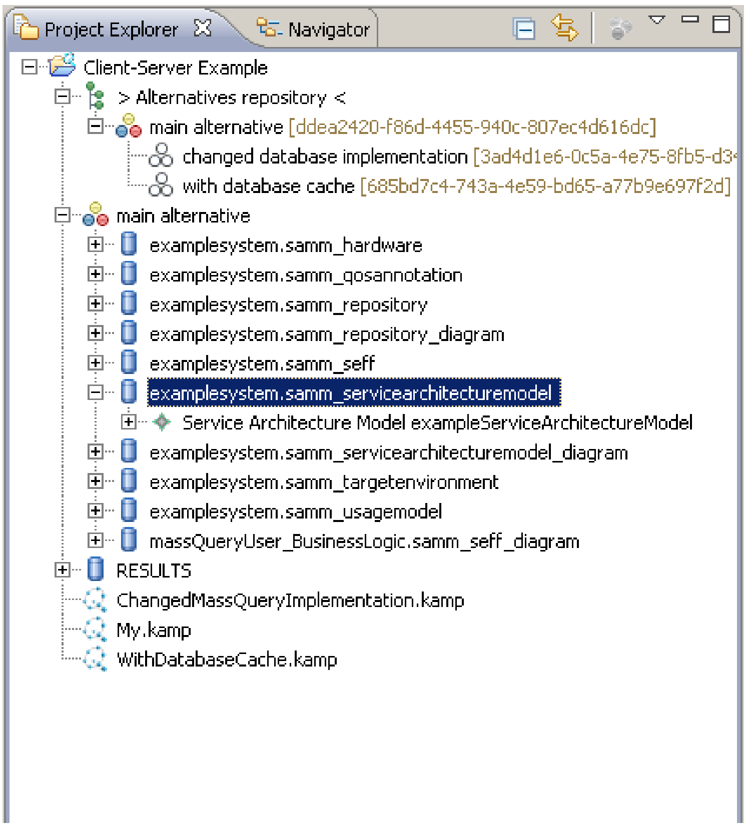

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
relevantQualityAttributes
scenario
SAMWithResults
Model Change Scenario (3.3)
sam
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
Deploy System (3.8)
[suited alternative exists]
selectedSAM
[model valid]
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]

Figure 31: Modelling change scenario workflow (copied from D6.1)

4.4.3 Tool activation

The Composite Editor can work on Service Architecture Model diagram files. If such a file already exists, double-clicking on it will automatically open the editor. The editor can also be opened from within the Repository Editor when a user wants to edit one of the composite components within the Repository Editor. Please refer to the previous chapter for more information about it and the integration with the Composite editor.
The screenshot in Figure 32 shows the Project Explorer with an example Q-ImPrESS project where a suitable Service Architecture Model file and its diagram file are available.



```
Client-Server Example
  > Alternatives repository <
    main alternative [ddea2420-f86d-4455-940c-807ec4d616dc]
      changed database implementation [3ad4d1e6-0c5a-4e75-8fb5-d3
      with database cache [685bd7c4-743a-4e59-bd65-a77b9e697f2d]
  main alternative
    examplesystem.samm_hardware
    examplesystem.samm_qosannotation
    examplesystem.samm_repository
    examplesystem.samm_repository_diagram
    examplesystem.samm_seff
    examplesystem.samm_servicearchitecturemodel
      Service Architecture Model exampleServiceArchitectureModel
    examplesystem.samm_servicearchitecturemodel_diagram
    examplesystem.samm_targetenvironment
    examplesystem.samm_usagemodel
    massQueryUser_BusinessLogic.samm_seff_diagram
  RESULTS
  ChangedMassQueryImplementation.kamp
  My.kamp
  WithDatabaseCache.kamp
```

Figure 32: A Service Architecture Model file and the corresponding diagram file in the Project Explorer

In the case shown, a Service Architecture Model diagram file already exists and could be opened and edited. If no such file exists (in cases where the models have not been edited using the graphical editor before), it can be automatically generated from an existing Service Architecture model.
To generate a diagram file, right-click on a Service Architecture Model file (such files have the file ending ".samm_servicearchitecturemodel") in the Project Explorer and select "Initialize graphical model file" (see Figure 33). A dialog opens in which the file location of the diagram file has to be specified.

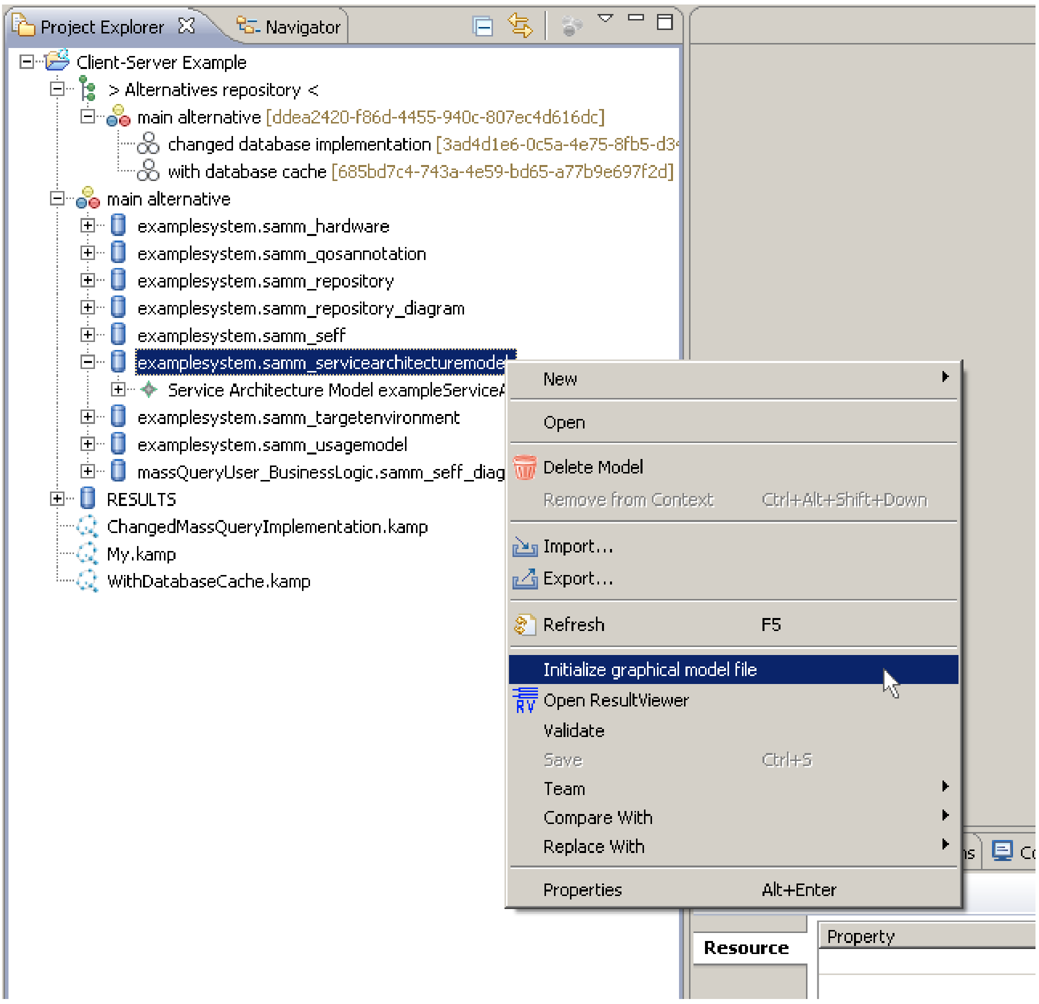

Project Explorer
Navigator
Client-Server Example
> Alternatives repository <
main alternative [ddea2420-f86d-4455-940c-807ec4d616dc]
changed database implementation [3ad4d1e6-0c5a-4e75-8fb5-d3
with database cache [685bd7c4-743a-4e59-bd65-a77b9e697f2d]
main alternative
examplesystem.samm_hardware
examplesystem.samm_qosannotation
examplesystem.samm_repository
examplesystem.samm_repository_diagram
examplesystem.samm_seff
examplesystem.samm_servicearchitecturemode
Service Architecture Model exampleService
examplesystem.samm_targetenvironment
examplesystem.samm_usagemodel
massQueryUser_BusinessLogic.samm_seff_diag
RESULTS
ChangedMassQueryImplementation.kamp
My.kamp
WithDatabaseCache.kamp
New
Open
Delete Model
Remove from Context Ctrl+Alt+Shift+Down
Import...
Export...
Refresh F5
Initialize graphical model file
Open ResultViewer
Validate
Save Ctrl+S
Team
Compare With
Replace With
Properties Alt+Enter
Resource
Property

Figure 33: Generate a diagram file for a Service Architecture Model

Using a right-Click on the selected entry shows the menu displayed in Figure 33. Selecting the highlighted entry will create a new entry in the workspace where the required model diagram file can be found.

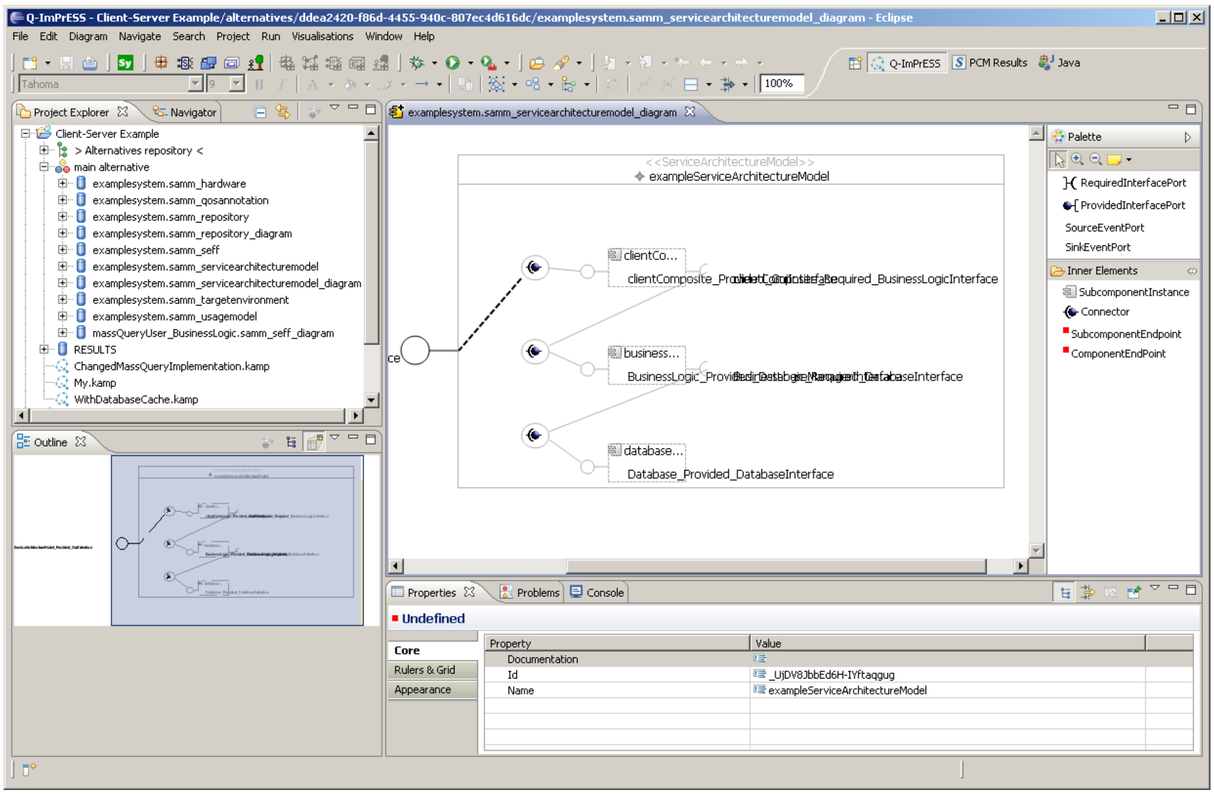
The Composite Editor can be opened for a Service Architecture diagram file by double-clicking on the file. For a composite component, it can be opened by double-clicking on the composite component in the graphical Repository Editor.

4.4.4 Usage instructions and expected outputs

The current section will explain how a user is expected to work with the Composite Editor. It is assumed that this user already knows how to use a graphical editor, i.e. knows how to select elements drag and drop elements or icons and the like. It is assumed out-of-scope for the given document to explain such basic knowledge.
When a diagram file is opened, it shows the typical interface for every editor working in an Eclipse environment. The following explanations are based on the Service Architecture Model of the Q-ImPrESS Client/Server Example project.

Opening the editor

The user starts an editing session by double-clicking on the Service Architecture Model diagram file as shown in Figure 32.
The editor opens in the usual location in the Eclipse environment as shown in Figure 34.


Q-ImPrESS - Client-Server Example/alternatives/ddea2420-f86d-4455-940c-807ec4d616dc/examplesystem.samm_servicearchitecturemodel_diagram - Eclipse
File Edit Diagram Navigate Search Project Run Visualisations Window Help
Q-ImPrESS
PCM Results
Java
Tahoma
100%
Project Explorer
Navigator
Client-Server Example
> Alternatives repository <
main alternative
examplesystem.samm_hardware
examplesystem.samm_qosannotation
examplesystem.samm_repository
examplesystem.samm_repository_diagram
examplesystem.samm_seff
examplesystem.samm_servicearchitecturemodel
examplesystem.samm_servicearchitecturemodel_diagram
examplesystem.samm_targetenvironment
examplesystem.samm_usagemodel
massQueryUser_BusinessLogic.samm_seff_diagram
RESULTS
ChangedMassQueryImplementation.kamp
My.kamp
WithDatabaseCache.kamp
Outline
examplesystem.samm_servicearchitecturemodel_diagram
<<ServiceArchitectureModel>>
exampleServiceArchitectureModel
clientCo...
business...
database...
Database_Provided_DatabaseInterface
Palette
RequiredInterfacePort
ProvidedInterfacePort
SourceEventPort
SinkEventPort
Inner Elements
SubcomponentInstance
Connector
SubcomponentEndpoint
ComponentEndPoint
Properties
Problems
Console
Undefined
Core
Rulers & Grid
Appearance

Property	Value
Documentation	
Id	_UjDV8JbbEd6H-IYftaqgug
Name	exampleServiceArchitectureModel

Figure 34: Composite Editor running in the Q-ImPrESS IDE

It should be noted that if the diagram has been automatically generated, not all graphical elements might be placed in a suitable way.

Working with components

After the automatic generation of the diagram, the main element, the ServiceArchitectureModel or composite component, might require just enough space in the editor to show all the contained elements and their labels (see Figure 35). To allow changing the placement of components, we have to increase the area for this component.
When we click into an otherwise empty area inside the component or its header, the whole component is selected. The editor indicates this by showing handles around the exterior of the component (see Figure 36).
When the user moves the mouse cursor over one of these handles, the pointer changes to another form indicating the action possible when selecting and holding the handle. For the handles on the sides of the component, this allows moving the selected side thus enlarging the area taken by the component. For the handles on either edge, it allows moving that edge, thus enlarging the component by moving two sides simultaneously.
This is compatible with analogous behaviour of other graphical editors and will allow users to become familiar with the editor in a short period of time.
In our example the component needs to be enlarged in order to allow changing the placement

of the contained components and connections. This will be achieved by selecting the lower right corner of our component and drag it to an appropriate location.

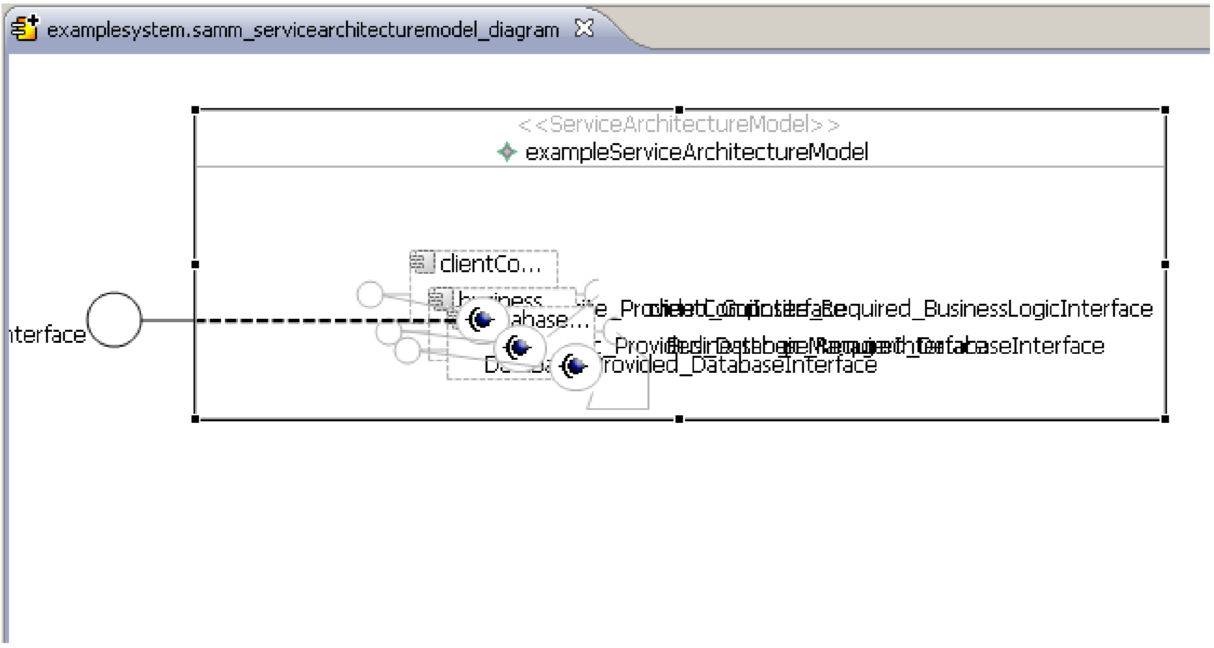

examplesystem.samm_servicearchitecturemodel_diagram
<<ServiceArchitectureModel>>
exampleServiceArchitectureModel
clientCo...
nterface

Figure 35: Editor with main element selected

After that we need to select one of the inner components to change its placement. Currently the components are overlapping making it hard to distinguish them from one another. The best way to select a component is by clicking once on its name. It is possible as well to click into an otherwise empty area within the component, although this proves difficult in our case with the overlapping components.

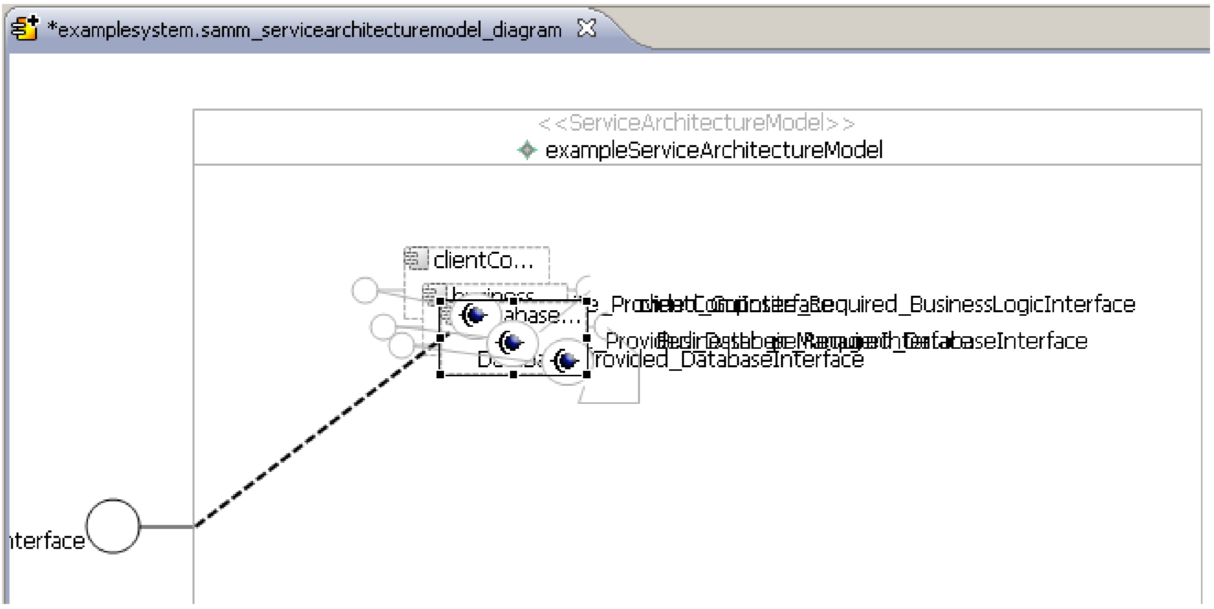

*examplesystem.samm_servicearchitecturemodel_diagram
<<ServiceArchitectureModel>>
exampleServiceArchitectureModel
clientCo...
nterface

Figure 36: Selecting inner components

After selecting the component, we can move it to another location. We repeat this with the two other components as well in order to see them without overlapping each other or any other element in the editor. Figure 37 shows how this may look.
The next thing to notice is that some of the labels are overlapping as well preventing the user to read them.

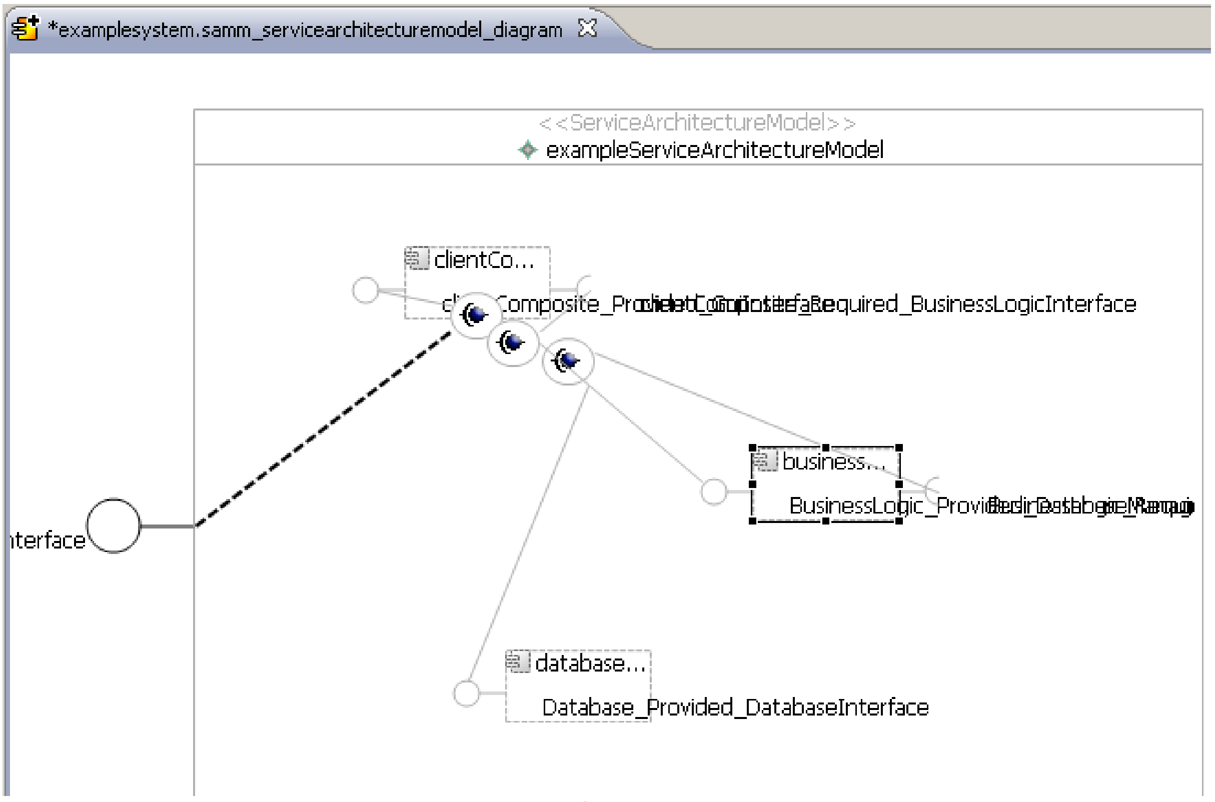

*examplesystem.samm_servicearchitecturemodel_diagram
<<ServiceArchitectureModel>>
exampleServiceArchitectureModel
clientCo...
business...
database...
Database_Provided_DatabaseInterface
nterface

Figure 37: Editor after moving components

To overcome this, we need to enlarge the components or move a label to another location.
Enlarging a component can be achieved by selecting it and dragging one of the handles until the components area is large enough to accommodate the label text.

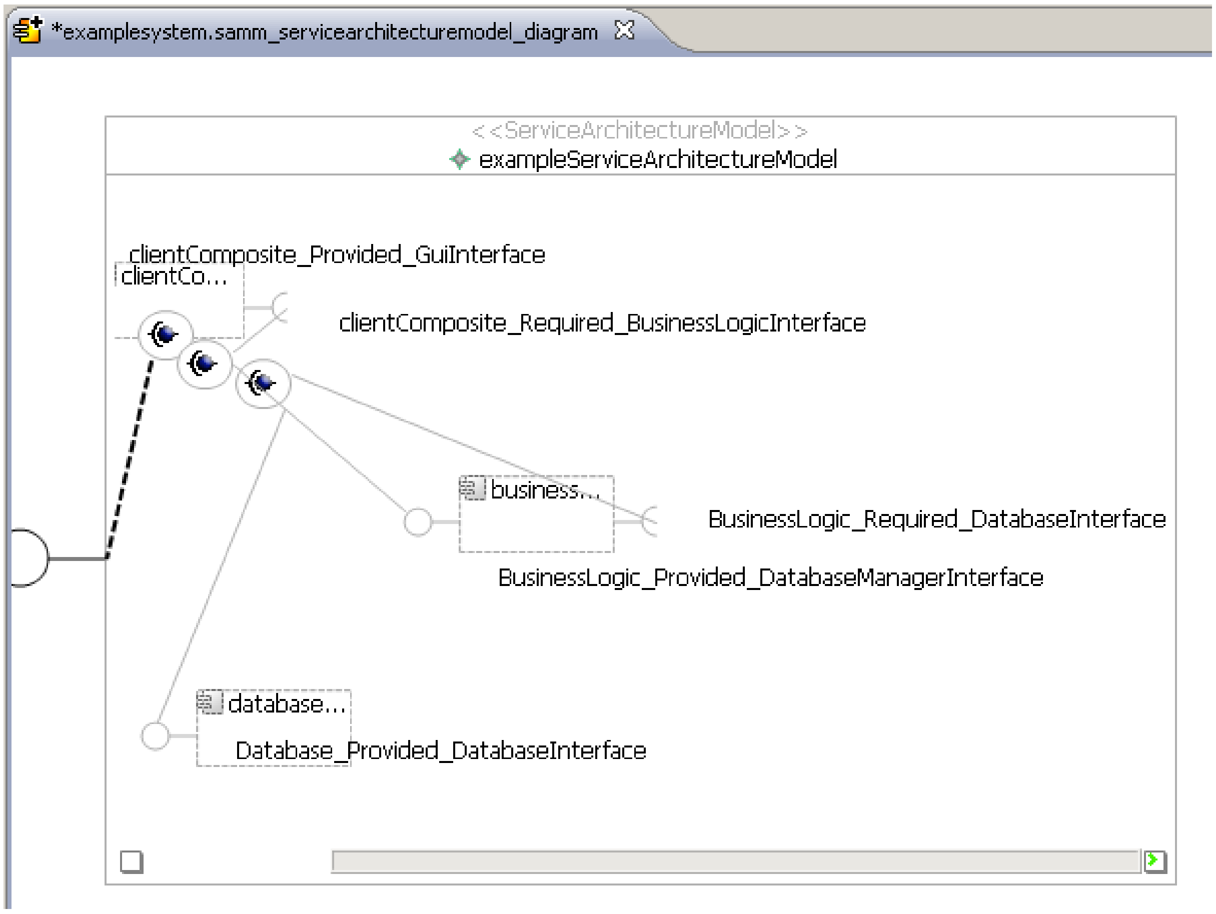

*examplesystem.samm_servicearchitecturemodel_diagram
<<ServiceArchitectureModel>>
exampleServiceArchitectureModel
clientComposite_Provided_GuiInterface
clientCo...
clientComposite_Required_BusinessLogicInterface
business...
BusinessLogic_Required_DatabaseInterface
BusinessLogic_Provided_DatabaseManagerInterface
database...
Database_Provided_DatabaseInterface

Figure 38: Editor after fixing overlapping labels

We can move labels the same way as we move components, by selecting them and then dragging them to their new location. The screenshot in Figure 38 shows the editor after both actions have been performed.

The next thing to do is to improve the layout of the connectors. This can be achieved by dragging the connector. Note that also the position of the component ports can be changed. Figure 39 shows the resulting representation of the Service Architecture Model after adapting the connector layout.

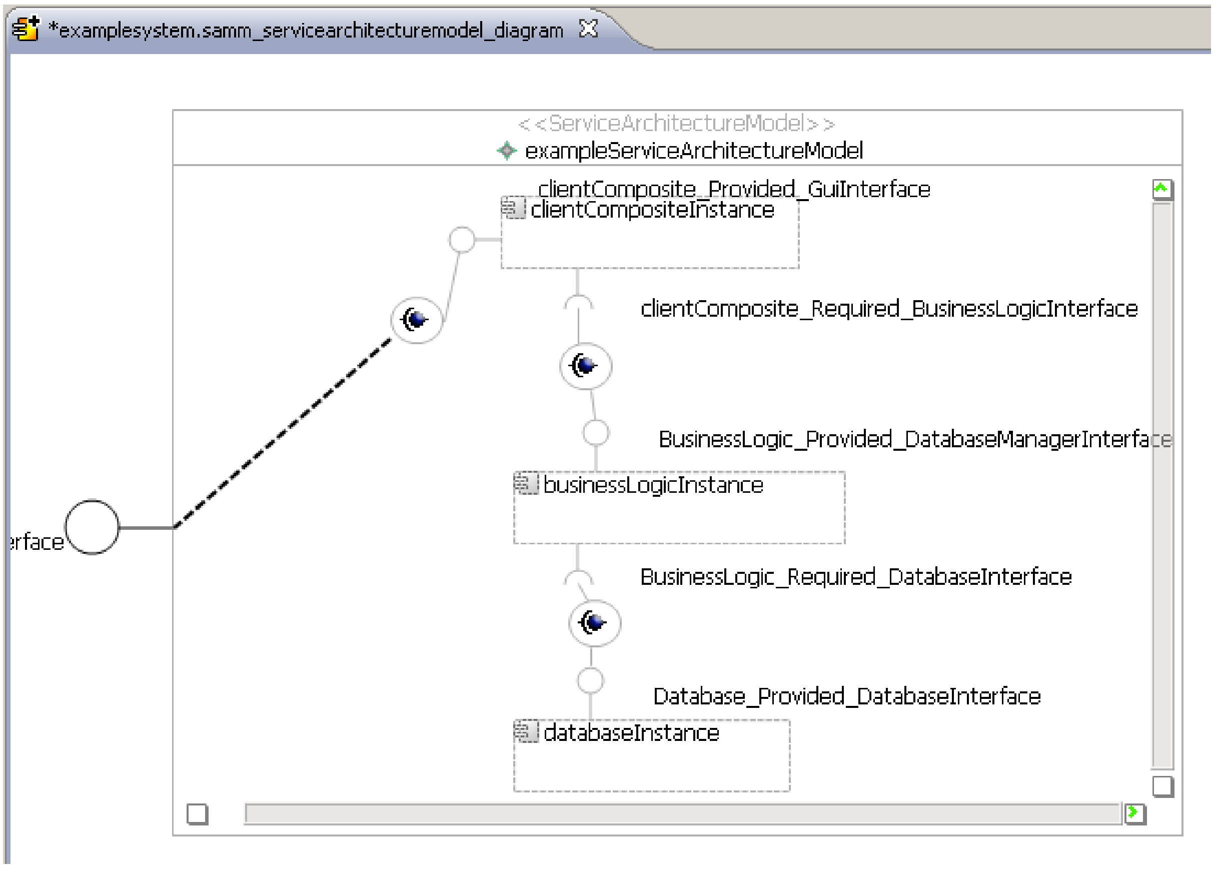

*examplesystem.samm_servicearchitecturemodel_diagram
<<ServiceArchitectureModel>>
exampleServiceArchitectureModel
clientComposite_Provided_GuiInterface
clientCompositeInstance
clientComposite_Required_BusinessLogicInterface
BusinessLogic_Provided_DatabaseManagerInterface
businessLogicInstance
BusinessLogic_Required_DatabaseInterface
Database_Provided_DatabaseInterface
databaseInstance
rface

Figure 39: Editor after improving graphical representation

Deleting elements

In order to demonstrate a special feature of the editor, we will re-create a connector contained in the model. To be able to do that, we need to delete it first.
Deleting elements works as can be expected from such graphical editors. After selecting one or more elements, the mouse context menu (right-click) opens up showing an entry "Delete from Model" (see Figure 40).

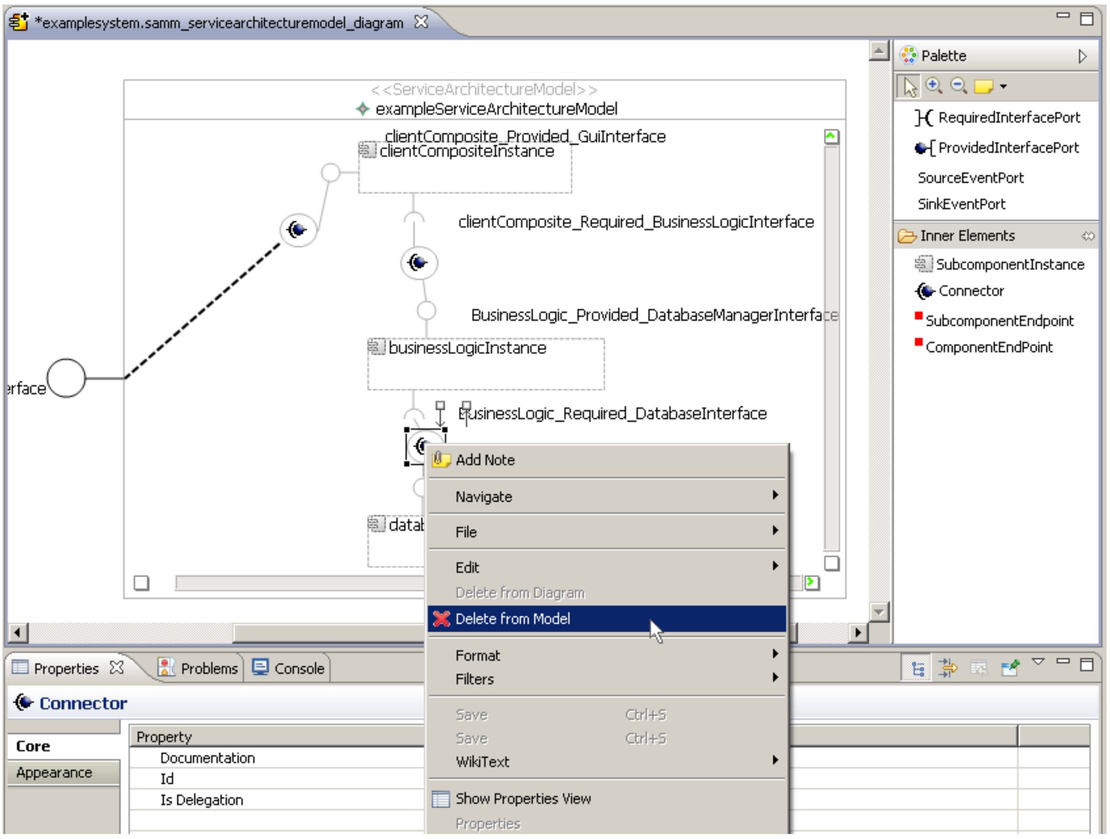


Figure 40: Deletion of connectors

The delete operation deletes the connector together with its associated endpoints.
Other elements are deleted the same way if necessary.

Adding elements

Now we can add a new connector to show the special feature of the editor. Adding elements is generally possible using the tool palette shown to the right of the editor window (see Figure 34). We need to click on one of the elements shown to select it. The selected element will be shown highlighted. After that we can move the mouse cursor to the editor pane and it will change its shape indicating that a new element will be inserted. We need to click in the location where we want to insert the element and the editor creates a new instance according to the tool we selected from the palette.
For our example we select the Connector tool and click in the editor somewhere between the businessLogicInstance component and the databaseInstance component. A new Connector is being created. We now need to specify its endpoints. Endpoints are used to connect the Connector elements with component ports (or provided ports of a Service Architecture Model). We select the SubcomponentEndPoint tool from the palette and move the mouse into the editor pane. The cursor shape changes to indicate that we are about to create an endpoint, which for the graphical representation implies connecting the Connector shape with a Port shape by a line.
We move the mouse cursor over the Connector and click and drag from there to the port with the label “BusinessLogic_Required_DatabaseInterface”. Here we release the mouse and a new endpoint will be created. The screenshot in Figure 41 shows the editor after the first endpoint has been created. To complete the connector, we have to create another endpoint that

connects the connector with the database component port "Database_Provided_DatabaseInterface".

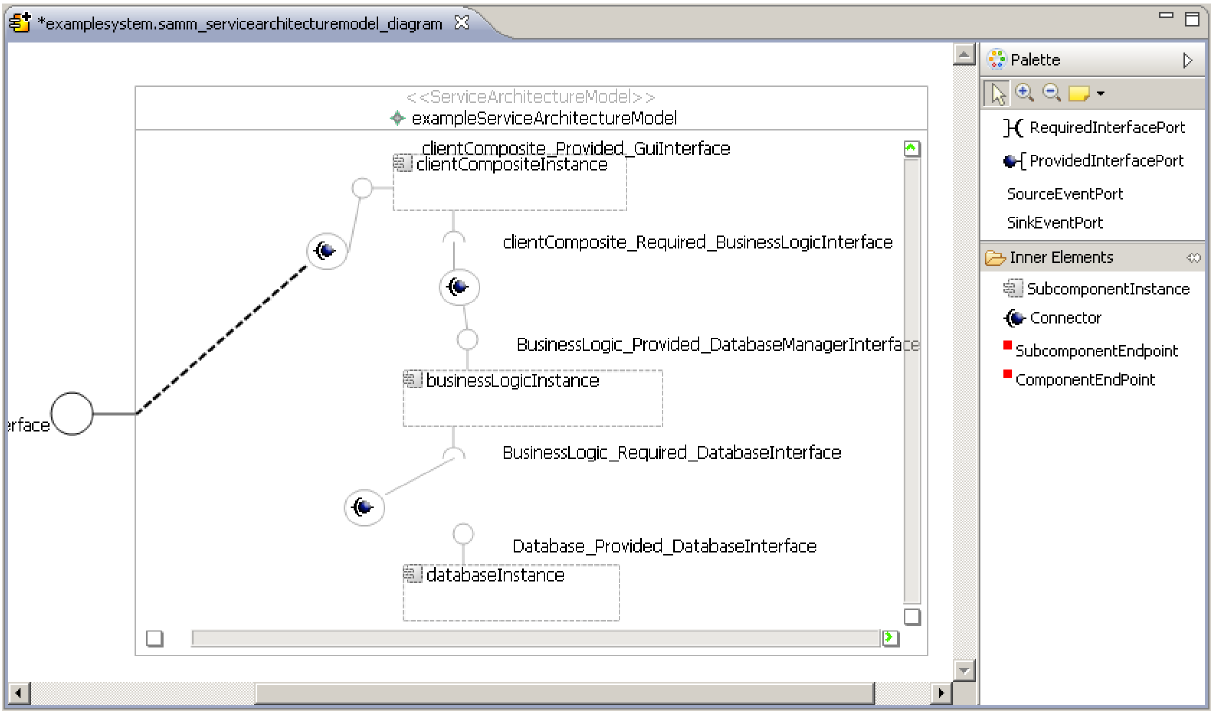

*examplesystem.samm_servicearchitecturemodel_diagram
<<ServiceArchitectureModel>>
exampleServiceArchitectureModel
clientComposite_Provided_GuiInterface
clientCompositeInstance
clientComposite_Required_BusinessLogicInterface
BusinessLogic_Provided_DatabaseManagerInterface
businessLogicInstance
BusinessLogic_Required_DatabaseInterface
Database_Provided_DatabaseInterface
databaseInstance
rface
Palette
RequiredInterfacePort
ProvidedInterfacePort
SourceEventPort
SinkEventPort
Inner Elements
SubcomponentInstance
Connector
SubcomponentEndpoint
ComponentEndPoint

Figure 41: Editor after creating a SubcomponentEndPoint

SubcomponentEndPoints are used to connect components on the same level, e.g. two components nested in a composite component, or two components in the Service Architecture Model. To create a connection between a port of a component with a port of a nested component, the ComponentEndPoint is used to connect the connector with the port of the outside component. Such connectors are called delegation connectors and are drawn with a thick line in the Composite Editor.
Figure 42 shows a delegation connector in the Service Architecture Model of the example project. It connects the outside port "ServiceArchitectureModel_Provided_GuiInterface" of the Service Architecture Model with the port "clientComposite_Provided_GuiInterface" of the "clientCompositeInstance" composite component.

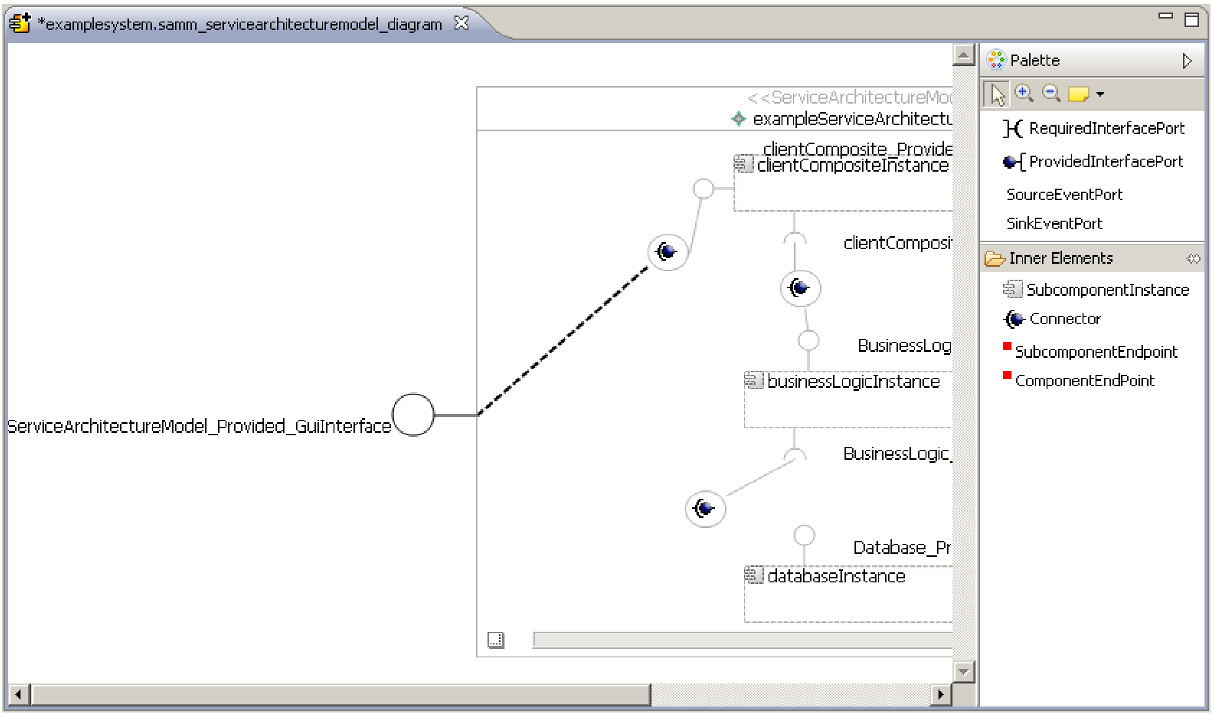
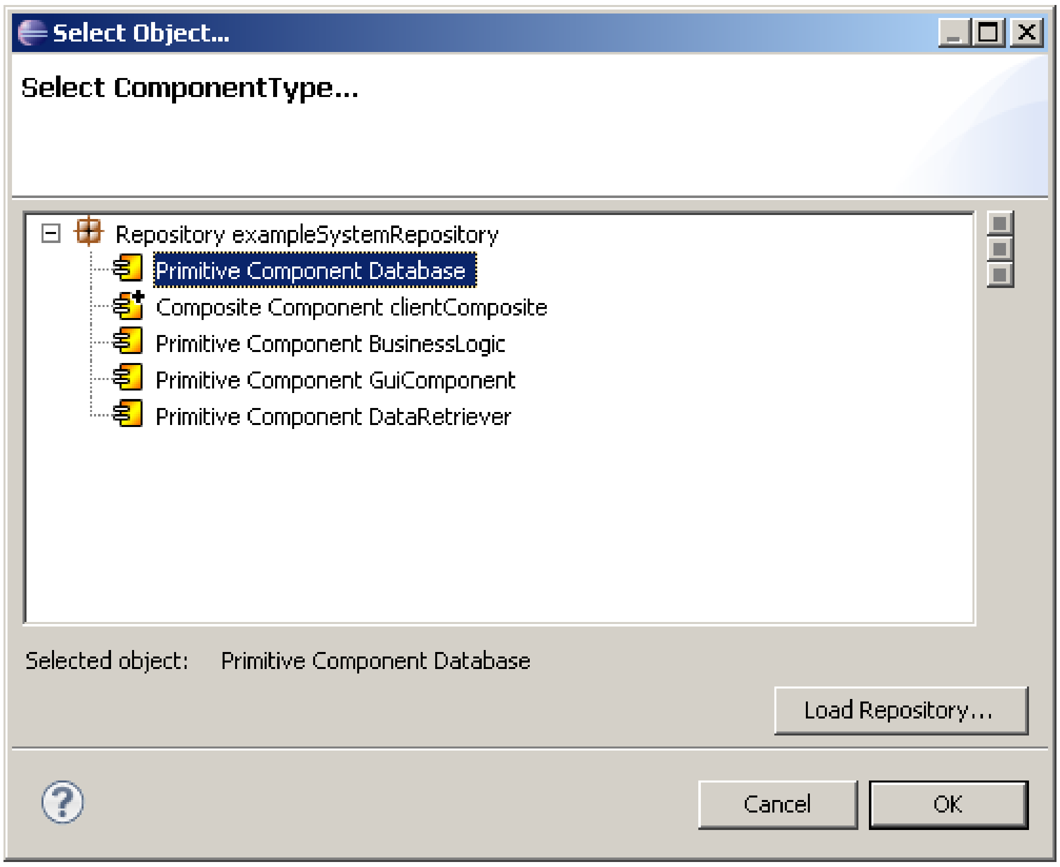


Figure 42: A delegation connector in the Service Architecture Model

Adding Subcomponent Instances

The editor allows the user to add new subcomponent instances. First the tool must be selected in the tool palette and the mouse must be clicked in the desired location where the new subcomponent instance shall be located. The editor so far only knows that a new instance shall be created, but has no information as to from what component the instance shall be derived. So the user has to choose this component from the available repositories. A selection dialog opens and displays the components available in the currently used repositories (see Figure 43).

In case the component to be instantiated should not be contained in the list shown, the user can load additional repositories that may contain the required component. After a selection is made the appropriate element is created in the editor.


Select Object...

Select ComponentType...

Repository exampleSystemRepository
- Primitive Component Database
- Composite Component clientComposite
- Primitive Component BusinessLogic
- Primitive Component GuiComponent
- Primitive Component DataRetriever

Selected object: Primitive Component Database

Figure 43: Selection of components to be instantiated

4.4.5 Caveats

In its current version, the tool doesn't extensively check the semantics of models created by the user. So it may be possible to draw models according to the rules set forth in the meta model (SAMM) which will not have any practical meaning, as they show situations which cannot be reasonably expected to occur. It may be needed to enhance the editor after setting up rules, e.g. governing the possible combinations of endpoints for a given connector. Currently it is possible to connect two provided ports with a connector without indicating a required port. We assume that a future version of the editor may check the model for validity at least when the user saves the created model.

4.5 SEFF Editor Manual

4.5.1 Purpose of the tool

The Q-ImPrESS IDE features a graphical editor that allows for modelling service-effect specification (SEFF) behaviours of primitive component operations (a primitive component is a component that does not contain other components, as opposed to composite components). Each provided service of a primitive components comprises such a SEFF behaviour description.
In the Q-ImPrESS toolchain, components can have different kinds of behaviours. The SEFF behaviour is an abstract behaviour of a component operation which includes relevant information for quality analysis offered by the Q-ImPrESS IDE.

4.5.2 Tool relationship with the Q-ImPrESS workflow

The Q-ImPrESS graphical SEFF editor can be used both in reverse-engineering and forward-engineering approaches. In a reverse-engineering approach, initial derived SEFF behaviours of component operations can be visualised and enhanced using the editor. In a forward-engineering approach, the editor can be used to create and behaviour models from scratch.

The tool described in the chapter belongs to the tool class “Model editing Tools to update system models” as described in section 2.1 in the document D6.1. This implies that it can be applied in any place in the tool chain where models of the appropriate type can be edited.
It can be used anytime during the Q-ImPrESS workflow. However the most relevant workflow step for using the editor is the “Model Change Scenario” (see Figure 44).

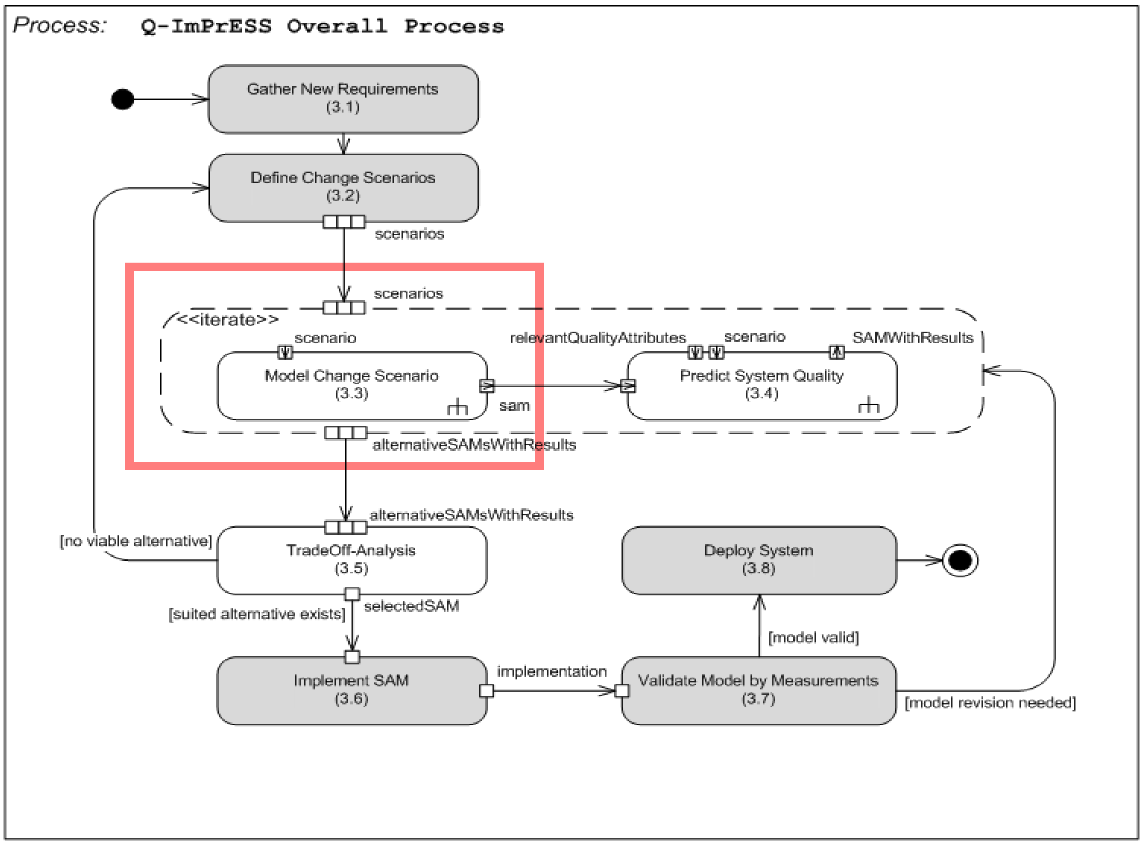

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
Model Change Scenario (3.3)
sam
relevantQualityAttributes
scenario
SAMWithResults
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
[suited alternative exists]
selectedSAM
Deploy System (3.8)
[model valid]
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]

Figure 44: Modelling change scenario workflow (copied from D6.1)

4.5.3 Tool prerequisites

The SEFF Editor has no special prerequisites except for the existence of at least one provided service of a primitive component for which a SEFF is going to be created.

4.5.4 Tool activation

The SEFF Editor works on SEFF diagram files which are stored in the corresponding SAM alternative folder. Diagram files have the file ending ".samm_seff_diagram", the editor can be launched by double-clicking the file.All SEFF behaviours for an alternative (i.e. the SEFF models, not the diagram files) are stored in a common SEFF Repository. This file has the file ending ".samm_seff" and is located in the alternative folder as well.
If no SEFF behaviour diagram file for a component exists, it can be created from within the graphical Repository Editor.
In the Repository Editor, all components are displayed, as well as behaviours that have been specified for a component. Figure 45 shows the Repository Editor with a component "Database" implementing the interface "DatabaseInterface". For the interface operation "getUserForUserId" a SEFF behaviour stub has been specified. The SEFF Editor can be opened by double-clicking a SEFF behaviour stub. For more information about the Repository Editor and behaviour stubs, refer to the Repository Editor Manual.

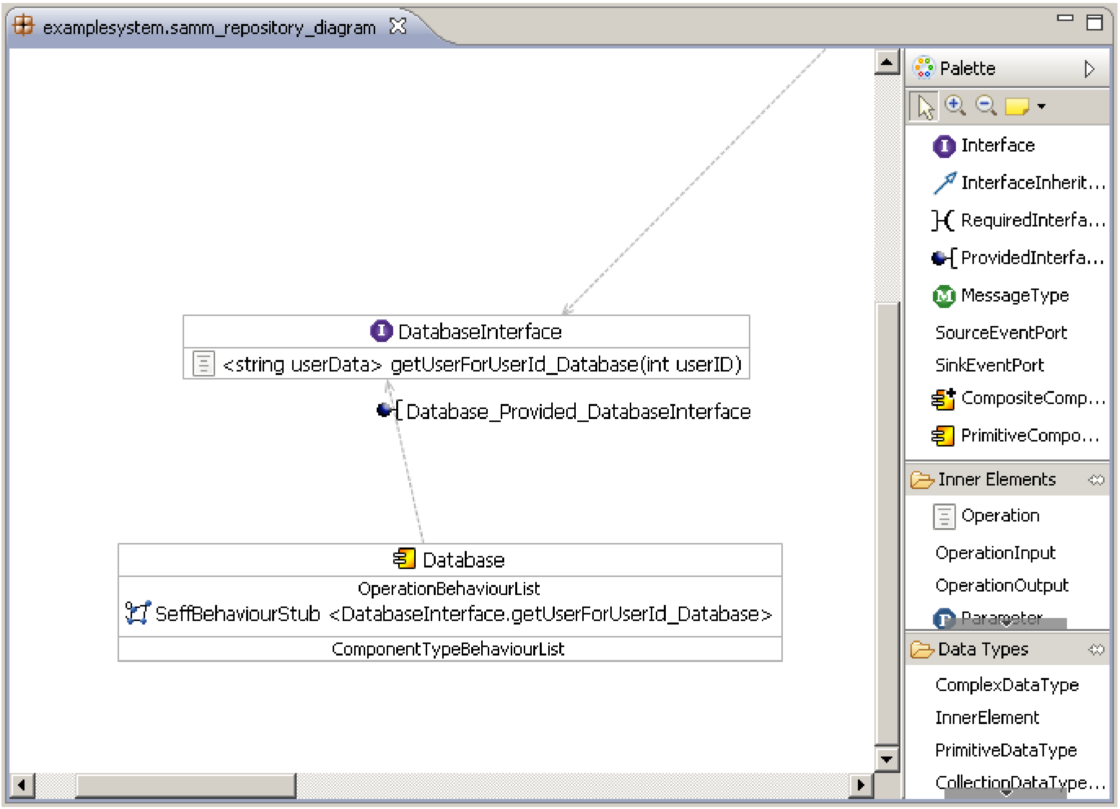


Figure 45: The Repository Editor showing a component with a SEFF behaviour stub

4.5.5 Usage instructions and expected outputs

The SEFF Editor is used in the same way as the other graphical editors. A SEFF behaviour contains of a series of actions, which are connected through control flow arrows. The first action in a behaviour must be a start action, the last action must be a stop action. All actions and the control flow link can be selected from the palette. Some actions, such as branch actions, loop actions and fork actions have nested behaviours, which may contain all kinds of SEFF action elements.

Figure 46 shows the SEFF Editor with an example SEFF, which contains of a start action, loop action and stop action. The loop action again contains a nested behaviour. The loop action loops the nested behaviour.

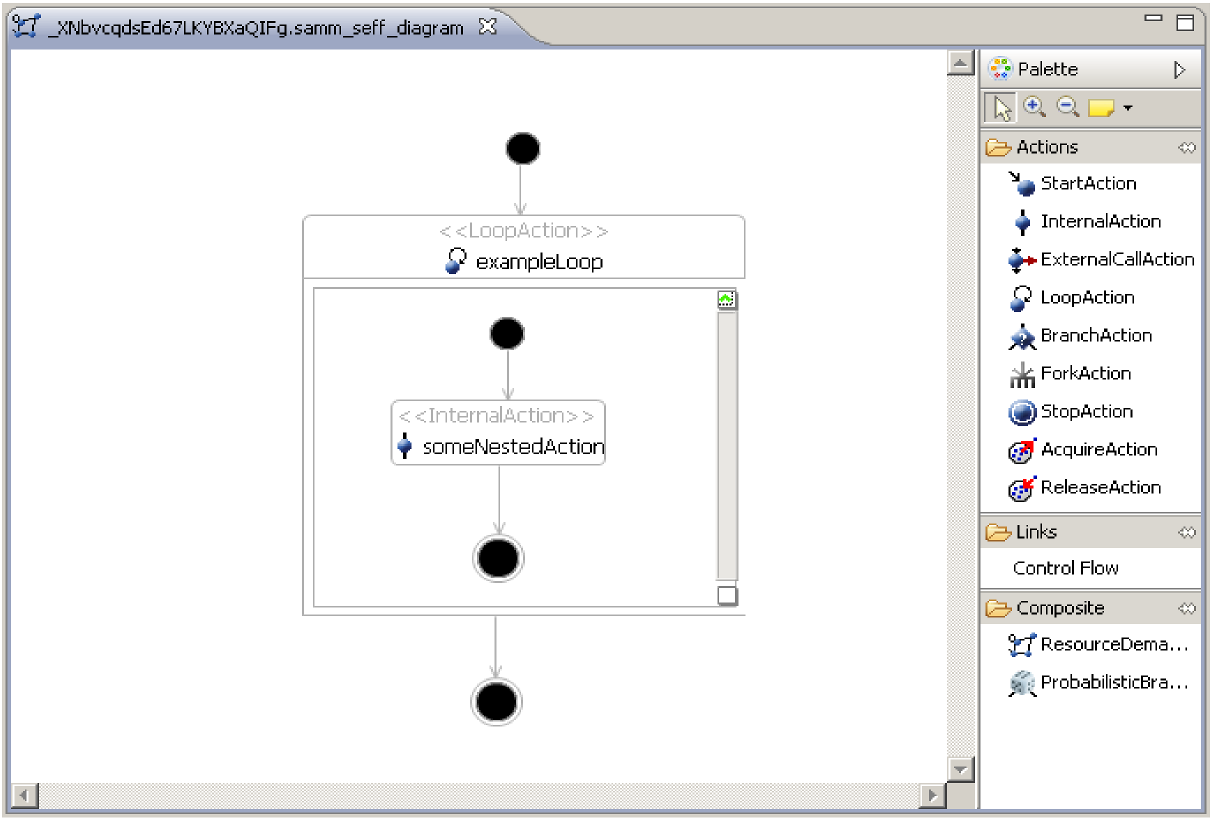


Figure 46: A SEFF Editor example

The editor allows the user to create the elements simply by selecting the appropriate tool from the tool palette to the right of the editor window. For all action elements, a name can be specified for better readability. To specify the control flow, actions can be connected by the Control Flow connector. The palette and the available tools are shown in Figure 47. The different actions are explained in the following.

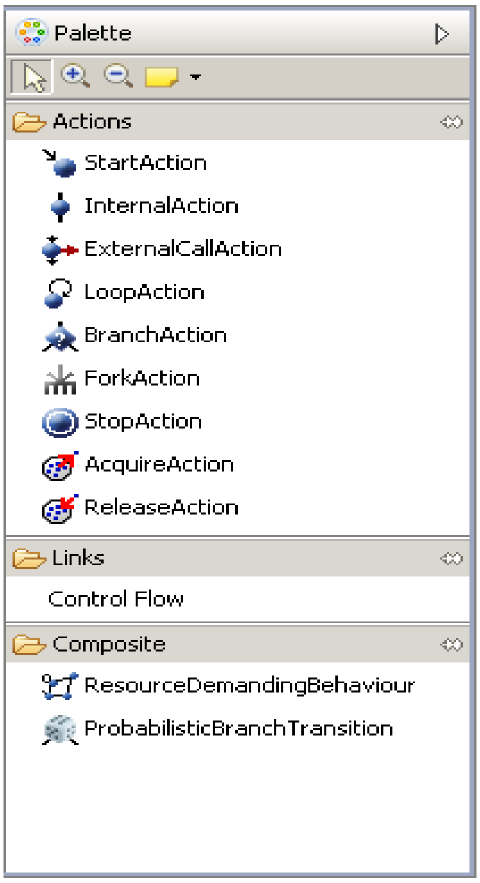


Figure 47: The SEFF Editor tools palette

StartAction
The first action of a behaviour.

InternalAction
Denotes some internal work during an operation for which the control flow is not specified in more detail. However, different quality annotations can be attached to an internal action, such as resource demands (for performance analyses) or failure probability (for reliability analyses). For more details, refer to the guide for QoS Annotations.

ExternalCallAction
Denotes a call to a required interface port of the component, which results in a call to a control flow outside of the component. When creating an external call action element, a dialog appears that allows selecting the required interface port of the component. If the dialog does not display any ports, select "Load Resource…" and then "Browse Workspace". In the following dialog, browse to the SAM repository file in which the component is located and select it. After closing the dialog, all required ports should appear. If still no ports appear, the component of the operation's behaviour does not contain any required ports, and a port has to be added in the component repository file. This can for example be done with the textual Repository Editor or the graphical Repository Editor.

LoopAction
Contains a nested behaviour that is repeated several times in a loop. To specify the nested

behaviour, after creating a loop action element, select “ResourceDemandingBehaviour” from the Composite editor palette and click inside the loop action element. A nested panel is being created inside the loop action element which allows specifying the nested behaviour. Here, at least a minimal behaviour has to be provided (i.e. a connected start action and stop action). The number of loop iterations is again specified as a QoS annotation.

BranchAction
Contains multiple nested behaviours where only one behaviour is executed when the control flow reaches the branch action. To add a branch behaviour after creating a branch action element, select “ProbabilisticBranchTransition” from the Composite editor palette and click inside the branch action element. A nested panel is being created. Then, select “ResourceDemandingBehaviour” from the Composite editor palette and click inside the nested panel. Now, nested behaviour elements can be created inside the panel. Again, at least a minimal behaviour has to be provided (i.e. a connected start action and stop action). For each branch behaviour, a branch probability has to be provided as a QoS annotation.

ForkAction
Contains multiple nested behaviours where all behaviours are executed in parallel when the control flow reaches the fork action. To add a forked behaviour, after creating a fork action element, select “ResourceDemandingBehaviour” from the Composite editor palette and click inside the fork action element. A nested panel is being created inside the fork action element which allows specifying the nested behaviour. Again, at least a minimal behaviour has to be provided (i.e. a connected start action and stop action).

StopAction
The last action of a behaviour.

AcquireAction
Denotes an acquire access to a passive resource. A passive resource denotes some kind of limited resource, e.g. a thread pool, a semaphore, etc. It is specified for a component in the repository editor. The mapping between acquire action and passive resource is provided as a QoS annotation.

ReleaseAction
Denotes a release of a passive resource. The mapping between release action and passive resource is provided as a QoS annotation (see separate Chapter).

4.5.6 Caveats

In its current version, the tool doesn’t extensively check the semantics of models created by the user. So it may be possible to draw models according to the rules set in the meta model (SAMM) which will not have any practical meaning, as they show situations which cannot be reasonably expected to occur. It may be necessary to enhance the editor after setting up rules, e.g. governing the possible combinations of elements in the model. We assume that a future version of the editor may check the model for validity at least when the user saves the model she created.

4.6 QoS Editor Manual

4.6.1 Purpose of the tool

The Quality of Service (QoS) Annotations editor allows the specification of QoS attributes for single actions of a SAMM SEFF behaviour model. Such annotations include failure probabilities, CPU and HDD demands. The editor represents a convenient and integrated way to edit the QoS Annotations which are stored in a decorator model for the SAMM SEFF model.

4.6.2 Tool relationship with the Q-ImPrESS workflow

QoS Annotations are defined along with the behaviour of services. Hence, they are modelled during the definition of the change scenario (see Figure 48).

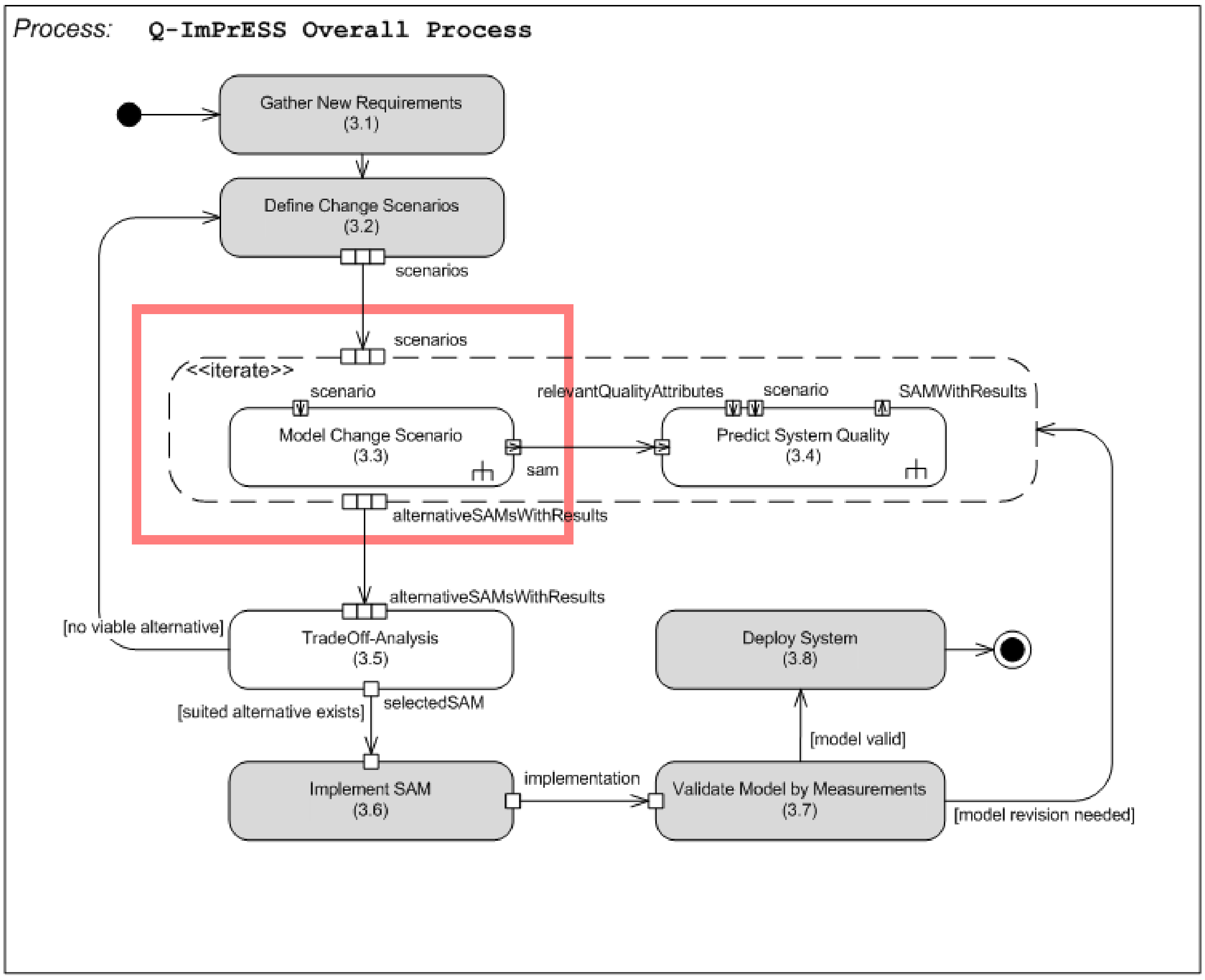

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
Model Change Scenario (3.3)
sam
relevantQualityAttributes
scenario
SAMWithResults
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
[suited alternative exists]
selectedSAM
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]
[model valid]
Deploy System (3.8)

Figure 48: Modelling change scenario workflow (copied from D6.1)

4.6.3 Tool prerequisites

The QoS Annotations Editor requires existing SEFFs to be annotated. These SEFFs must be part of a Q-ImPrESS design alternative in the Q-ImPrESS IDE, which is the case when following the tooling documentation.

4.6.4 Tool activation

The QoS Annotations Editor can be activated in from the context menu of graphical editors and is part of the “properties view”. Right-click on a model element, and select “Show Properties View” on order to open the view (see Figure 49). In the view, the tab “QoS Annotations” shows the editor.

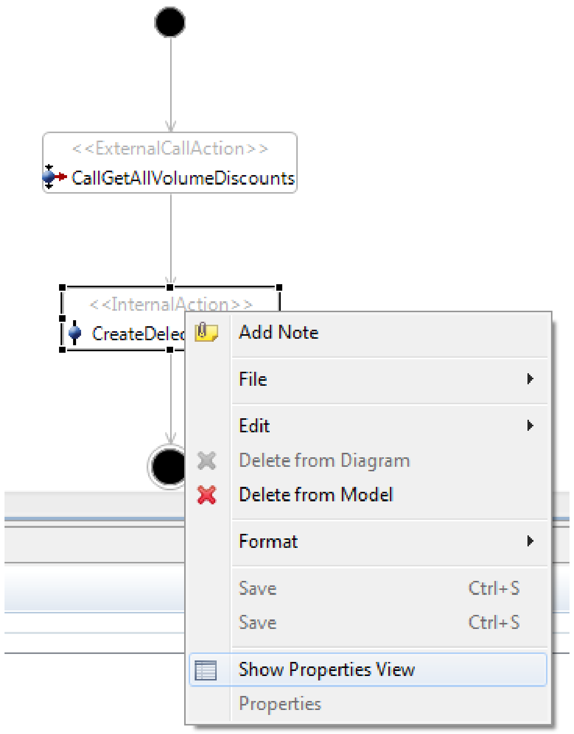


Figure 49: Opening the properties view from the context menu

4.6.5 Usage instructions and expected outputs

The QoS Annotations Editor can be accessed from the “properties view” if elements (typically InternalActions, Loops or Branches of a SAMM SEFF) are selected.

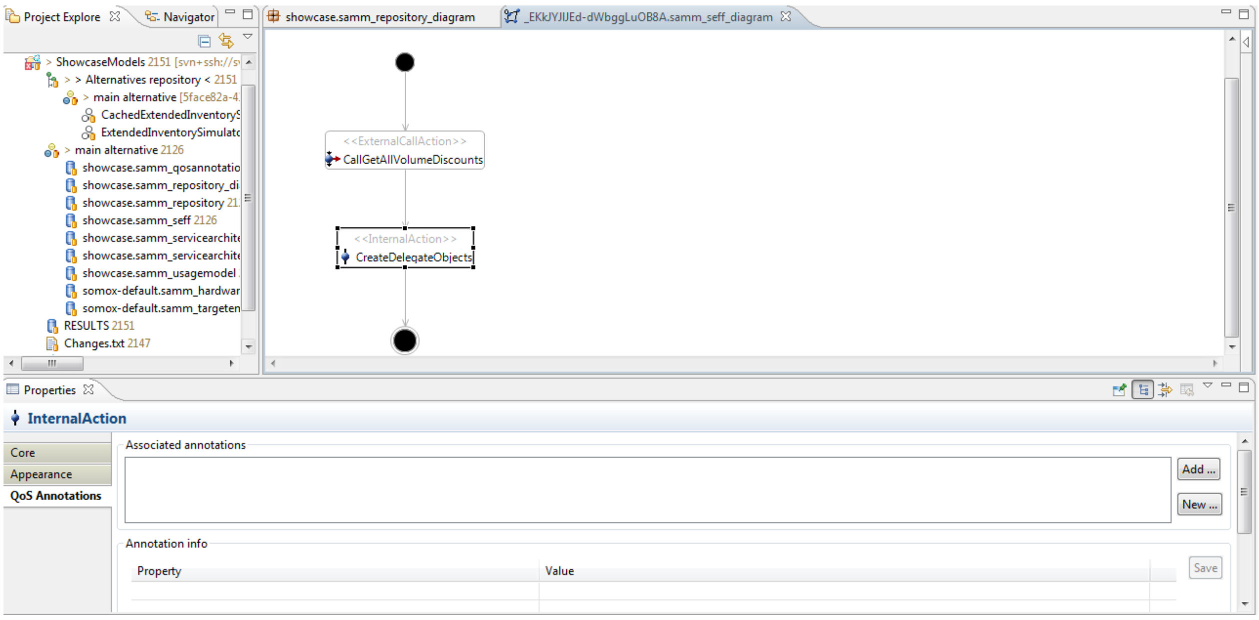
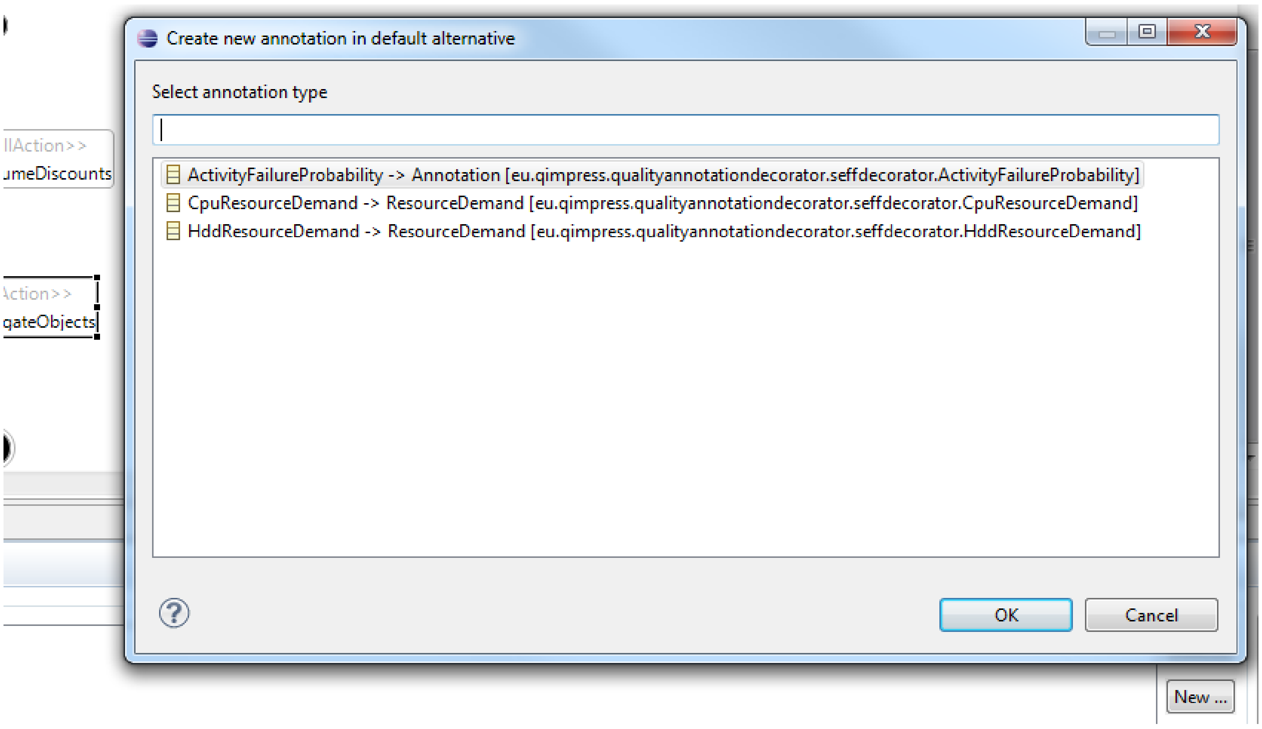

Project Explore
Navigator
showcase.samm_repository_diagram
_EKkJYJIJEd-dWbggLuOB8A.samm_seff_diagram
> ShowcaseModels 2151 [svn+ssh://s
> > Alternatives repository < 2151
> main alternative [5face82a-4
CachedExtendedInventoryS
ExtendedInventorySimulatc
> main alternative 2126
showcase.samm_qosannotatio
showcase.samm_repository_di
showcase.samm_repository 21
showcase.samm_seff 2126
showcase.samm_servicearchite
showcase.samm_servicearchite
showcase.samm_usagemodel
somox-default.samm_hardwar
somox-default.samm_targeten
RESULTS 2151
Changes.txt 2147
<<ExternalCallAction>>
CallGetAllVolumeDiscounts
<<InternalAction>>
CreateDelegateObjects
Properties
InternalAction
Core
Appearance
QoS Annotations
Associated annotations
Add ...
New ...
Annotation info
Property
Value
Save

Figure 50: The QoS annotations editor

When starting with the editor, no annotations are present in the model (see Figure 50). Using the “New…” button, new QoS Annotations can be added to the SEFF model.

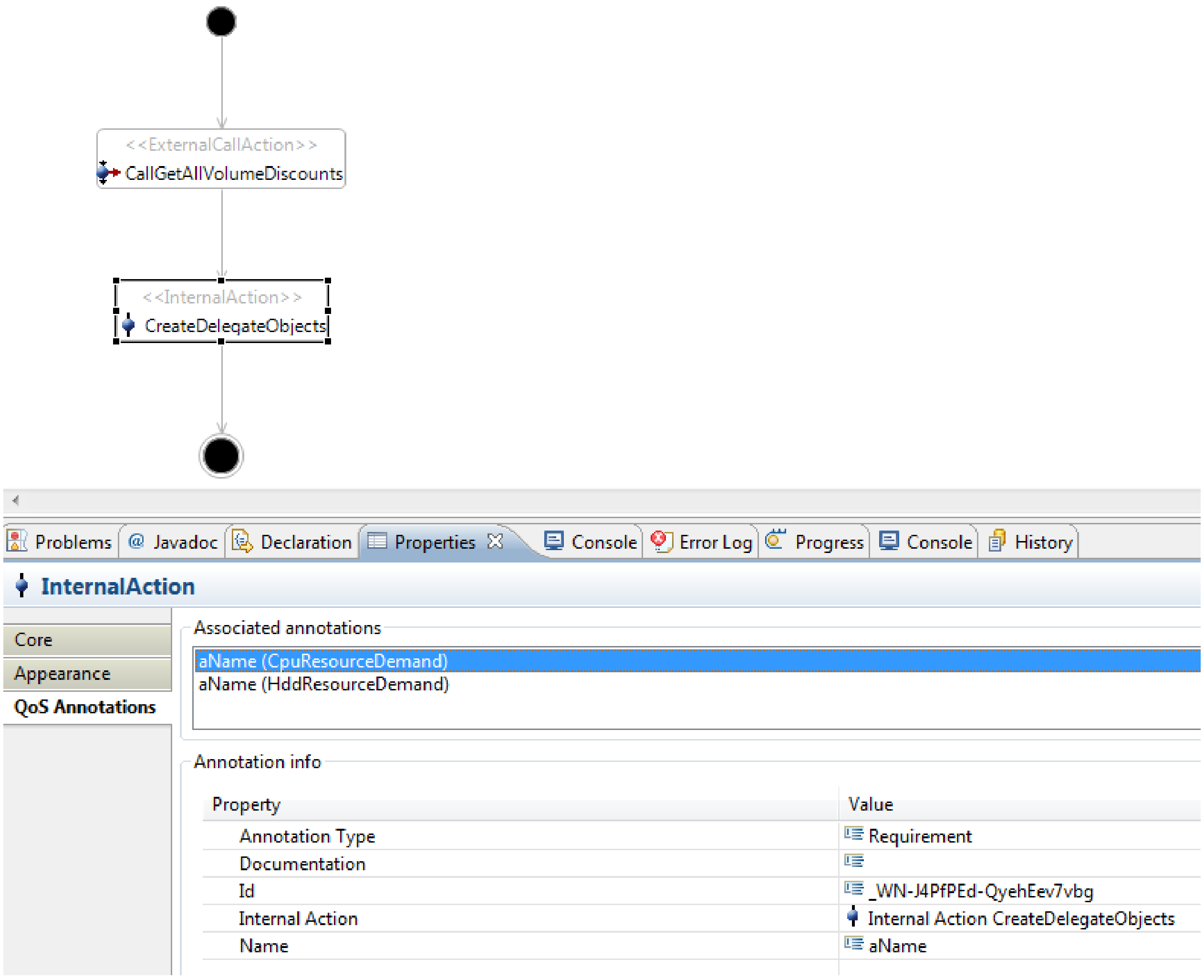


ActivityFailureProbability -> Annotation [eu.qimpress.qualityannotationdecorator.seffdecorator.ActivityFailureProbability]
CpuResourceDemand -> ResourceDemand [eu.qimpress.qualityannotationdecorator.seffdecorator.CpuResourceDemand]
HddResourceDemand -> ResourceDemand [eu.qimpress.qualityannotationdecorator.seffdecorator.HddResourceDemand]

Figure 51: Adding new QoS annotations

A pop-up menu then offers the different Quality of Service (QoS) annotations which are valid for a certain model element (see Figure 51). For InternalActions, Failure Probabilities, CPU Resource Demands, and HDD Resource Demands can be added, for Loops the number of loop iterations, and for Branches the branching probability (other valid annotations are listed per model element). Multiple QoS Annotations of different types can be added to a single

element of a model.
All annotations related to a certain model element are afterwards listed in the QoS Annotations property editor fields.



Associated annotations

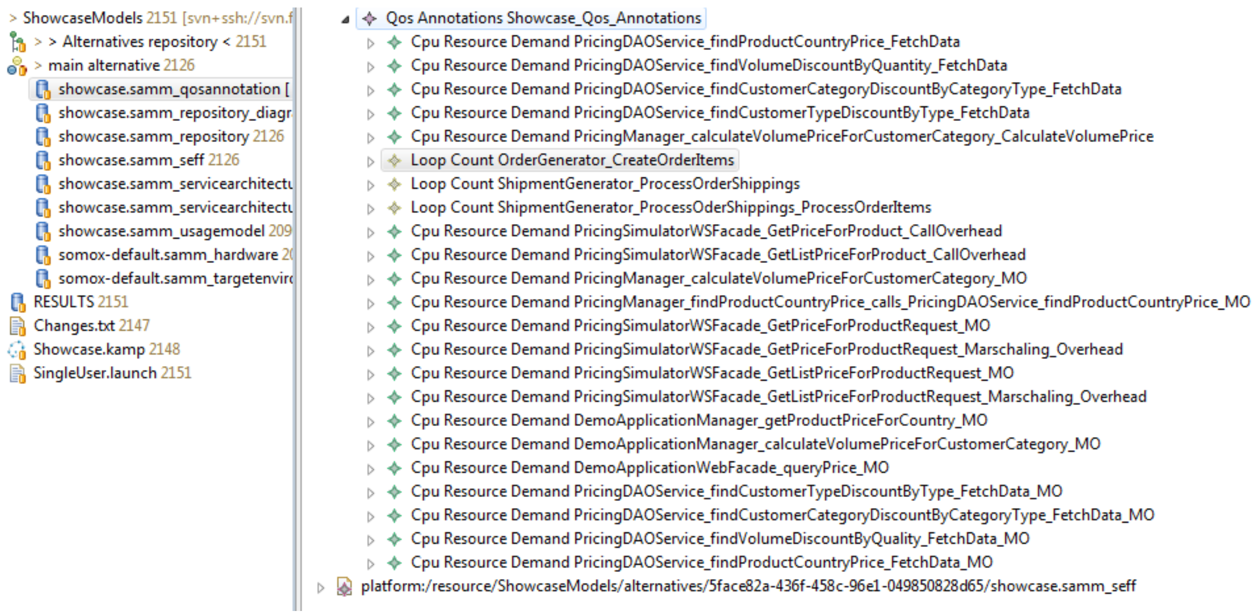
aName (CpuResourceDemand)
aName (HddResourceDemand)

Annotation info

Property	Value
Annotation Type	Requirement
Documentation	
Id	_WN-J4PfPEd-QyehEev7vbg
Internal Action	Internal Action CreateDelegateObjects
Name	aName

Figure 52: The QoS annotations editor containing annotations

In order to re-identify QoS Annotations in the next step, use expressive names in the "Name" field (instead of "aName" as indicated in the screenshot shown in Figure 52). Each QoS Annotation is stored in the ".samm_qosannotation" file of the selected Q-ImPrESS alternative. The file contains a decorator model for the other SAMM models (see Figure 53).



```
> ShowcaseModels 2151 [svn+ssh://svn.f
  > > Alternatives repository < 2151
  > main alternative 2126
      showcase.samm_qosannotation [
      showcase.samm_repository_diagr
      showcase.samm_repository 2126
      showcase.samm_seff 2126
      showcase.samm_servicearchitectu
      showcase.samm_servicearchitectu
      showcase.samm_usagemodel 209
      somox-default.samm_hardware 2
      somox-default.samm_targetenvir
  RESULTS 2151
  Changes.txt 2147
  Showcase.kamp 2148
  SingleUser.launch 2151
```

```
Qos Annotations Showcase_Qos_Annotations
  Cpu Resource Demand PricingDAOService_findProductCountryPrice_FetchData
  Cpu Resource Demand PricingDAOService_findVolumeDiscountByQuantity_FetchData
  Cpu Resource Demand PricingDAOService_findCustomerCategoryDiscountByCategoryType_FetchData
  Cpu Resource Demand PricingDAOService_findCustomerTypeDiscountByType_FetchData
  Cpu Resource Demand PricingManager_calculateVolumePriceForCustomerCategory_CalculateVolumePrice
  Loop Count OrderGenerator_CreateOrderItems
  Loop Count ShipmentGenerator_ProcessOrderShippings
  Loop Count ShipmentGenerator_ProcessOderShippings_ProcessOrderItems
  Cpu Resource Demand PricingSimulatorWSFacade_GetPriceForProduct_CallOverhead
  Cpu Resource Demand PricingSimulatorWSFacade_GetListPriceForProduct_CallOverhead
  Cpu Resource Demand PricingManager_calculateVolumePriceForCustomerCategory_MO
  Cpu Resource Demand PricingManager_findProductCountryPrice_calls_PricingDAOService_findProductCountryPrice_MO
  Cpu Resource Demand PricingSimulatorWSFacade_GetPriceForProductRequest_MO
  Cpu Resource Demand PricingSimulatorWSFacade_GetPriceForProductRequest_Marschaling_Overhead
  Cpu Resource Demand PricingSimulatorWSFacade_GetListPriceForProductRequest_MO
  Cpu Resource Demand PricingSimulatorWSFacade_GetListPriceForProductRequest_Marschaling_Overhead
  Cpu Resource Demand DemoApplicationManager_getProductPriceForCountry_MO
  Cpu Resource Demand DemoApplicationManager_calculateVolumePriceForCustomerCategory_MO
  Cpu Resource Demand DemoApplicationWebFacade_queryPrice_MO
  Cpu Resource Demand PricingDAOService_findCustomerTypeDiscountByType_FetchData_MO
  Cpu Resource Demand PricingDAOService_findCustomerCategoryDiscountByCategoryType_FetchData_MO
  Cpu Resource Demand PricingDAOService_findVolumeDiscountByQuality_FetchData_MO
  Cpu Resource Demand PricingDAOService_findProductCountryPrice_FetchData_MO
platform:/resource/ShowcaseModels/alternatives/5face82a-436f-458c-96e1-049850828d65/showcase.samm_seff
```

Figure 53: The QoS annotations decorator file

In the ".samm_qosannotation" file, the values for the QoS Annotations can be edited. QoS Annotations can be identified by their name.

To quantify the QoS Annotations, each QoS Annotation can contain a number of specifications which can refine each other. Constant numbers are the easiest case with the lowest expressive power, parametric formula are the most complex and powerful specification. In typical cases, for rough models, constant numbers are sufficient. To add a specification, right click on a QoS Annotation in the tree editor of the ".samm_qosannotation" file, and select the specification from the "New Child" submenu (see Figure 54).

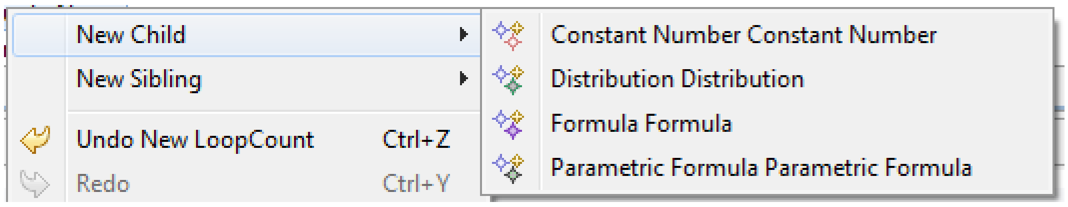
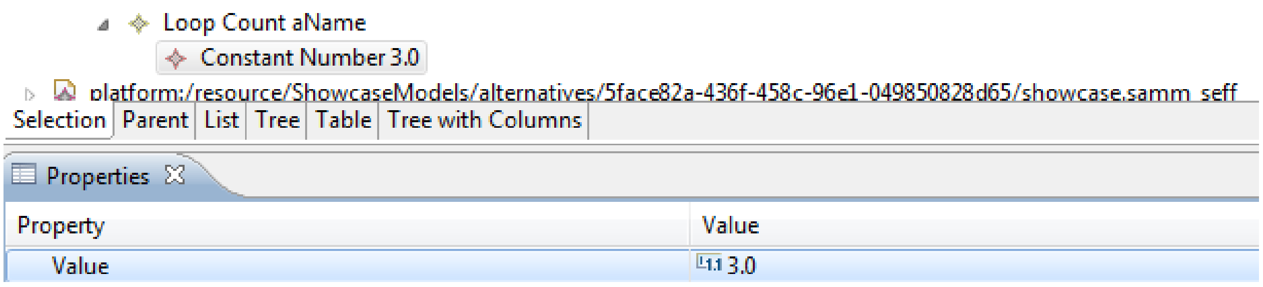

New Child
New Sibling
Undo New LoopCount Ctrl+Z
Redo Ctrl+Y
Constant Number Constant Number
Distribution Distribution
Formula Formula
Parametric Formula Parametric Formula

Figure 54: Adding a specification to a QoS annotation

The values are again editable from the properties view. In the following example shown in Figure 55, a loop is specified as being executed 3 times each time the control flow reaches it.



```
Loop Count aName
  Constant Number 3.0
platform:/resource/ShowcaseModels/alternatives/5face82a-436f-458c-96e1-049850828d65/showcase.samm_seff
```

Selection | Parent | List | Tree | Table | Tree with Columns
Properties

Property	Value
Value	3.0

Figure 55: Specifying specifications for a Qos annotation

Valid QoS Annotations include the ones listed in Figure 56:

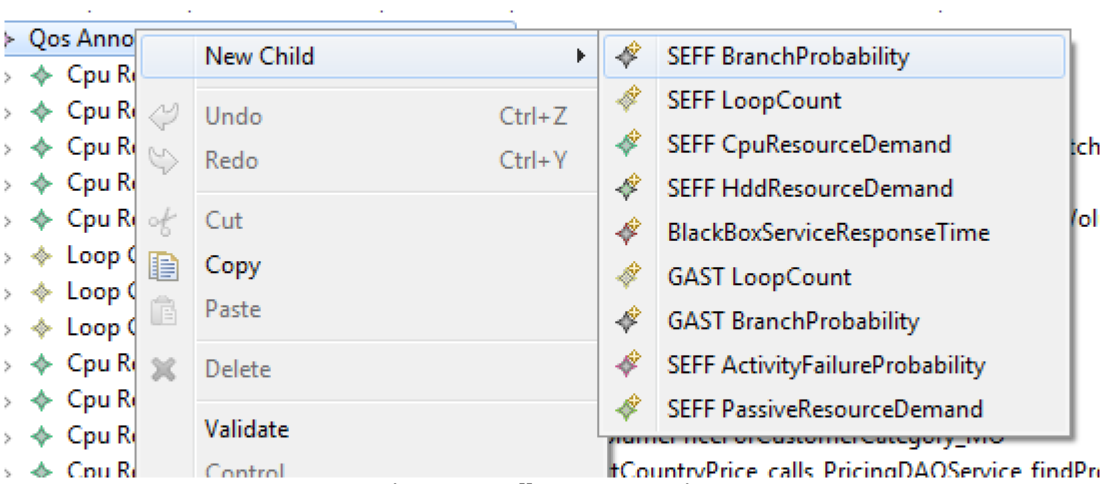


Figure 56: All QoS annotations

All loops, branches, and passive resources **must** carry QoS Annotations. Otherwise, the model is invalid and the analyses will fail. For internal actions, QoS Annotations are optional.

4.6.6 Caveats

Currently, no integrated editing of the values of QoS Annotations is possible. The extension of the editor is subject to future version of the tool. Depending on the analysis, not all QoS Annotations are supported. For example, currently, black box service response times are not yet supported by any analysis.

4.7 Text Editors Manual

4.7.1 Purpose of the tool

SAMM model text editor is used for manipulation of SAMM models using text editors.

4.7.2 Tool relationship with the Q-ImPrESS workflow

SAMM model text editor participates in the process of modelling an architecture scenario (see Figure 57). It is used as an alternative to other modelling tools like graphical editors or specialised editors (QoS Annotation editor).

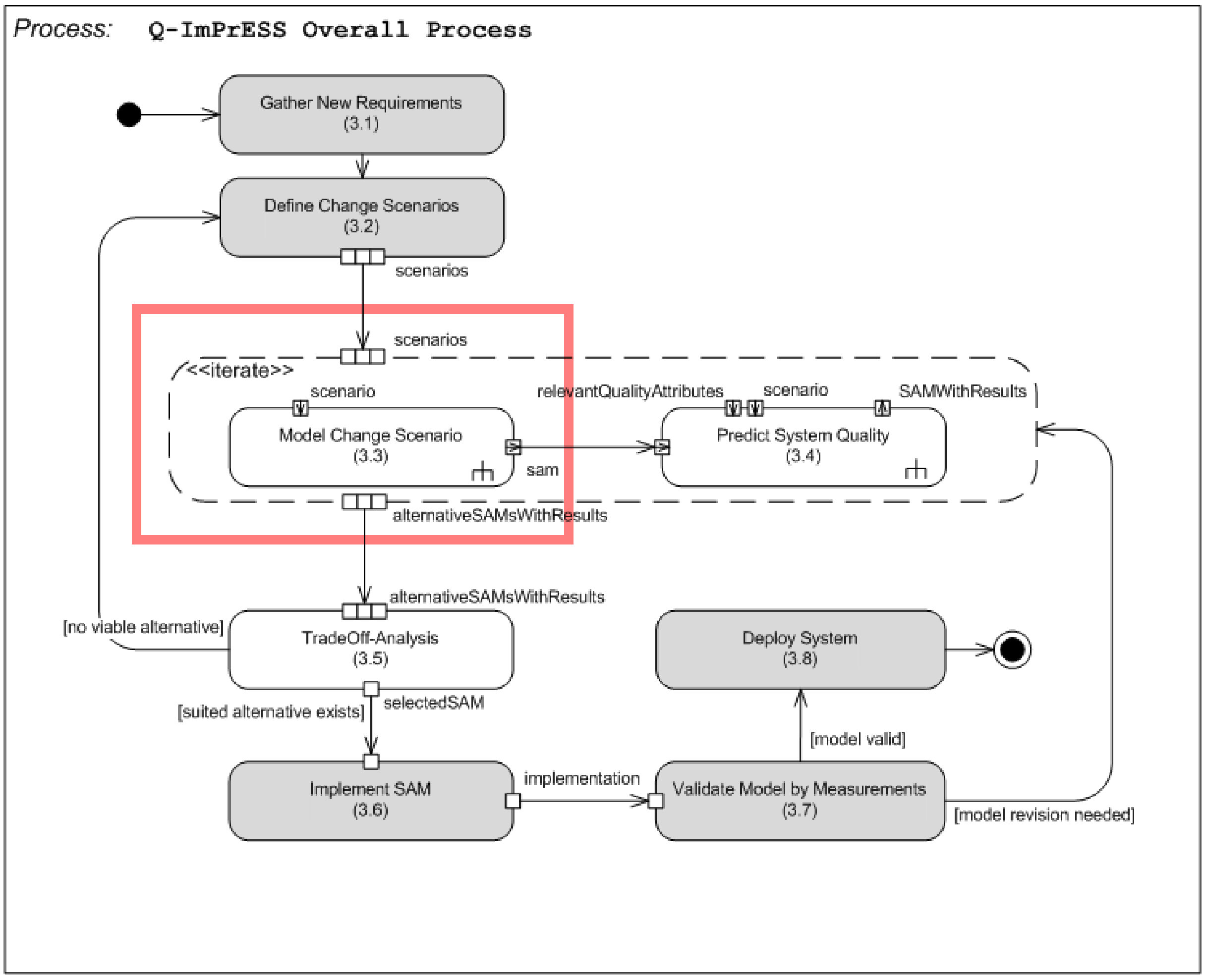

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
Model Change Scenario (3.3)
sam
relevantQualityAttributes
scenario
SAMWithResults
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
[suited alternative exists]
selectedSAM
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]
[model valid]
Deploy System (3.8)

Figure 57: Modelling change scenario workflow (copied from D6.1)

4.7.3 Tool prerequisites

The tool can be used only in projects having Q-ImPrESS nature.

4.7.4 Tool activation

The tool is available in projects once they acquire the Q-ImPrESS nature. Each entity of SAMM model has action "Open in text editor" in its pop-up menu. If the user select the action editor for the selected entity is automatically opened.

4.7.5 Usage instructions and expected outputs

The tool is used for creating and modifying SAMM models using text editors. These two use cases are described in the next two sections. The last section gives instructions how to edit particular SAMM model elements.

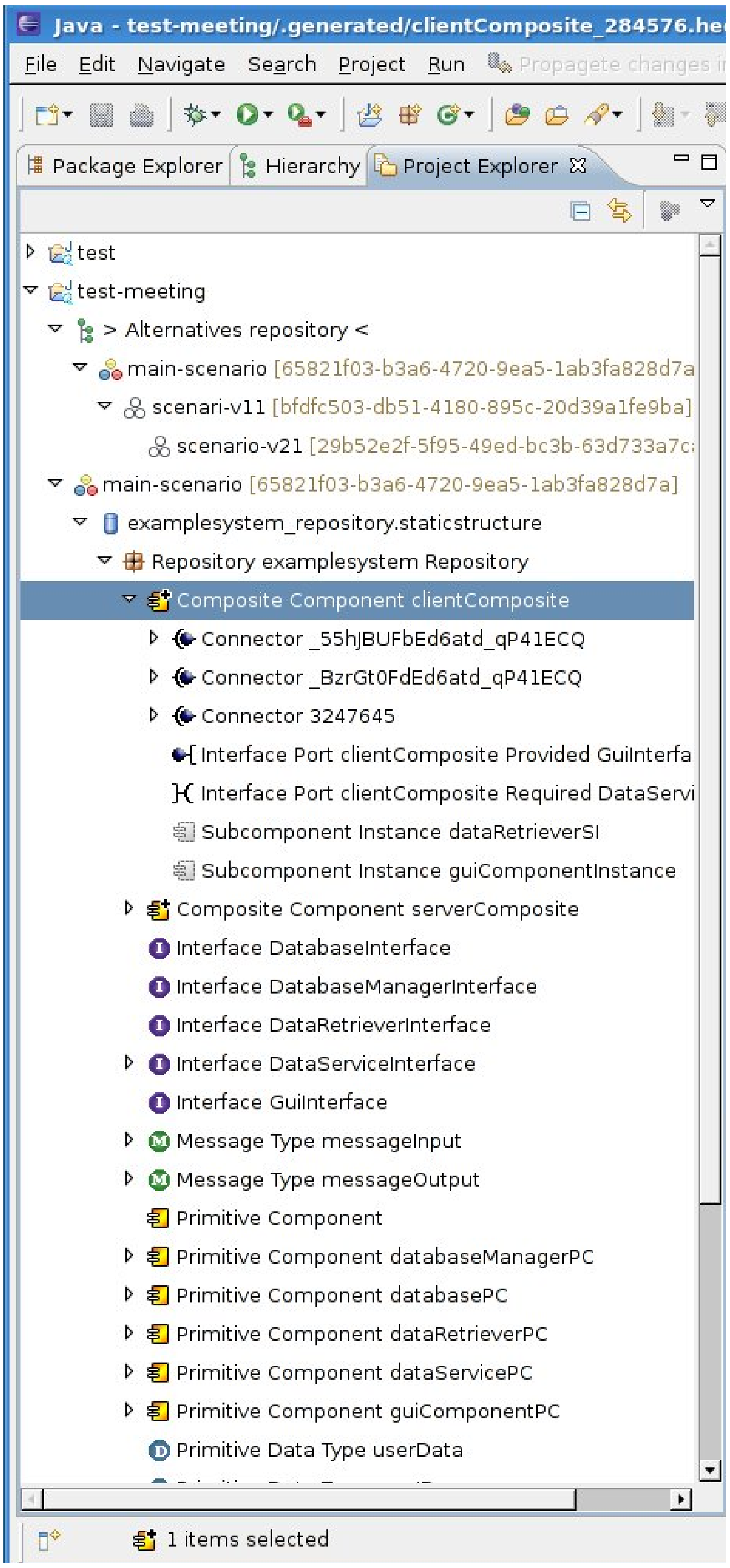
4.7.6 Creating new SAMM model

Right-click the project folder in the Project Explorer view and select the "New" → "File" item. Enter the file name where you intend to store new SAMM model. The file name has to end with the ".edifice" extension. Click the finish button. The wizard creates file having the entered file name and opens the SAMM model editor (blank window).

4.7.7 Modifying existing SAMM models

In the package explorer right-click the SAMM model you want to modify and select the "Open with" → "xtext editor" item. The eclipse opens a text editor containing definitions of SAMM model elements of the selected SAMM model.

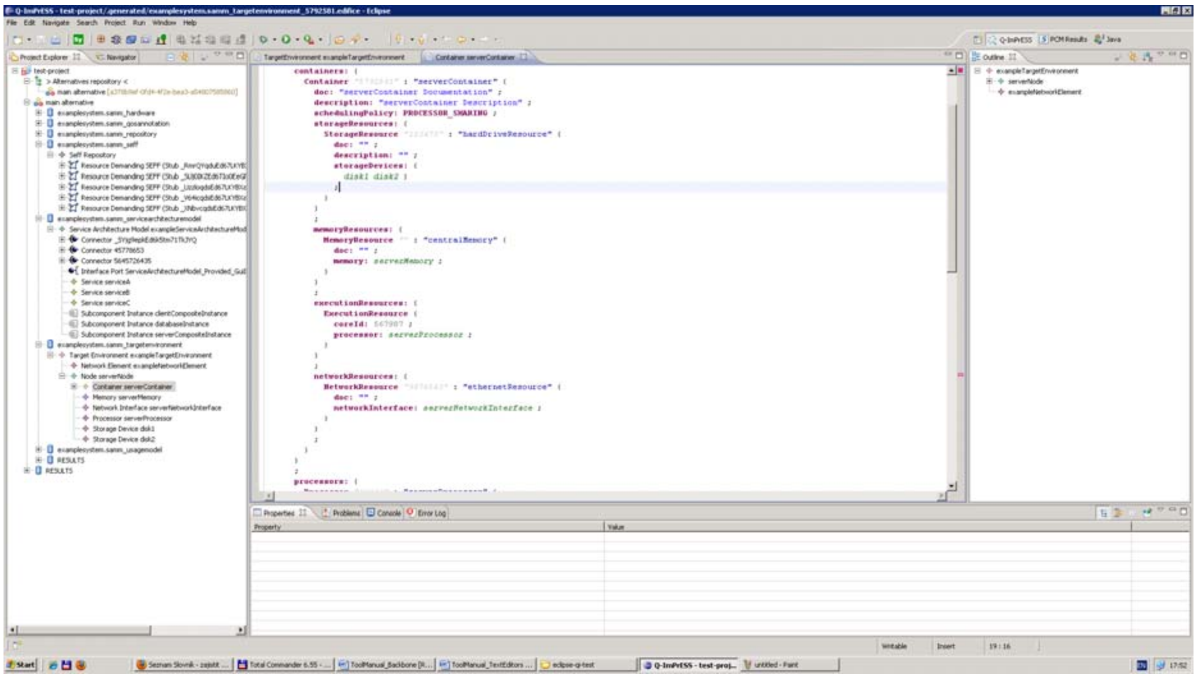
The following two figures show the use case. Figure 58 shows the Project Explorer containing the list of models, Figure 59 shows the editor containing definitions of SAMM model elements.


Java - test-meeting/.generated/clientComposite_284576.he
File Edit Navigate Search Project Run Propagete changes i
Package Explorer
Hierarchy
Project Explorer

```
test
test-meeting
  > Alternatives repository <
    main-scenario [65821f03-b3a6-4720-9ea5-1ab3fa828d7a
      scenari-v11 [bfdfc503-db51-4180-895c-20d39a1fe9ba]
        scenario-v21 [29b52e2f-5f95-49ed-bc3b-63d733a7c
  main-scenario [65821f03-b3a6-4720-9ea5-1ab3fa828d7a]
    examplesystem_repository.staticstructure
      Repository examplesystem Repository
        Composite Component clientComposite
          Connector _55hJBUFbEd6atd_qP41ECQ
          Connector _BzrGt0FdEd6atd_qP41ECQ
          Connector 3247645
          Interface Port clientComposite Provided GuiInterfa
          Interface Port clientComposite Required DataServi
          Subcomponent Instance dataRetrieverSI
          Subcomponent Instance guiComponentInstance
        Composite Component serverComposite
        Interface DatabaseInterface
        Interface DatabaseManagerInterface
        Interface DataRetrieverInterface
        Interface DataServiceInterface
        Interface GuiInterface
        Message Type messageInput
        Message Type messageOutput
        Primitive Component
        Primitive Component databaseManagerPC
        Primitive Component databasePC
        Primitive Component dataRetrieverPC
        Primitive Component dataServicePC
        Primitive Component guiComponentPC
        Primitive Data Type userData
```

```
1 items selected
```

Figure 58: Project Explorer view with an instance of SAMM meta-model



```
containers: {
  Container "5792581" : "serverContainer" {
    doc: "serverContainer Documentation" ;
    description: "serverContainer Description" ;
    schedulingPolicy: PROCESSOR_SHARING ;
    storageResources: {
      StorageResource "[illegible]" : "hardDriveResource" {
        doc: "" ;
        description: "" ;
        storageDevices: {
          disk1 disk2 }
        ;
      }
    }
    ;
    memoryResources: {
      MemoryResource "" : "centralMemory" {
        doc: "" ;
        memory: serverMemory ;
      }
    }
    ;
    executionResources: {
      ExecutionResource {
        coreId: 567987 ;
        processor: serverProcessor ;
      }
    }
    ;
    networkResources: {
      NetworkResource "[illegible]" : "ethernetResource" {
        doc: "" ;
        networkInterface: serverNetworkInterface ;
      }
    }
    ;
  }
}
;
processors: {
```

Figure 59: Text editor for a composite component

Refer to Appendix C for the SAMM model elements grammar.

4.8 Reverse Engineering Manual

4.8.1 Purpose of the tool

The Q-ImPrESS reverse engineering toolchain consists of two integrated tools: SISSy and SoMoX.
SISSy is a tool that can be used to reverse-engineer source code. Based on source code, a GAST representation is being created.
SoMoX is a tool that can be used to detect components of software systems. It takes a GAST representation as input and creates a SAM model containing the detected components.
Besides components, SoMoX reverse engineers a full instance of the SAM model which includes interfaces, ports, connectors, component instances, and composite component structures. The reverse engineered model represents a complete component-based software architecture.
Components are detected by various heuristics, which can be configured and weighted. Each heuristic represents a detection strategy which reacts to structures in software artefacts such as the structure in the code, naming, and communication styles.

4.8.2 Tool relationship with the Q-ImPrESS workflow

Describe how the tool fits into the Q-ImPrESS workflow. Use a diagram to highlight its position in the overall process.
The reverse engineering toolchain can be used in the process of modelling an architecture scenario (see Figure 60). In addition to the manual creation of models based on the editors described in Section 4.3 – Section 4.7, the reverse engineering toolchain can be used to automatically create models based on existing software systems for which source code is available.

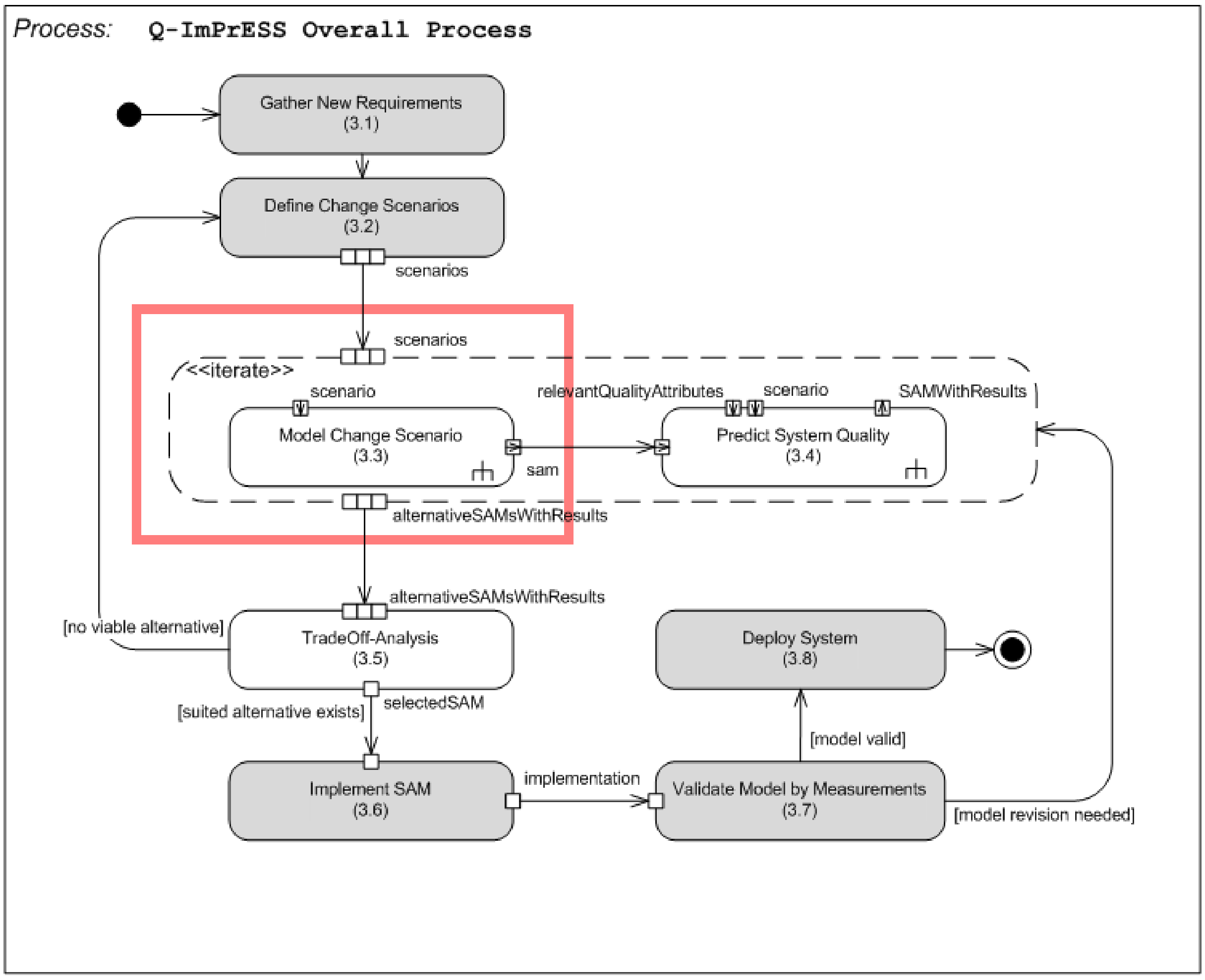

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
Model Change Scenario (3.3)
sam
relevantQualityAttributes
scenario
SAMWithResults
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
[suited alternative exists]
selectedSAM
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]
[model valid]
Deploy System (3.8)

Figure 60: Modelling change scenario workflow (copied from D6.1)

4.8.3 Tool prerequisites

In order to detect components of a software system, the source code should be available as Eclipse workspace project to allow a smooth and straight reverse engineering run. The source code project should compile without errors and all depending libraries need to be specified in the project settings.
The reverse engineering run of Q-ImPrESS creates a SISSy GAST model from source code which then serves as input for SoMoX. A valid Q-ImPrESS project with the design alternative which is going to be reverse engineered needs to exist in the workspace.
For better performance regarding database speed we recommend using an installed database system like PostgreSQL. Otherwise a Derby database can be used out of the box.

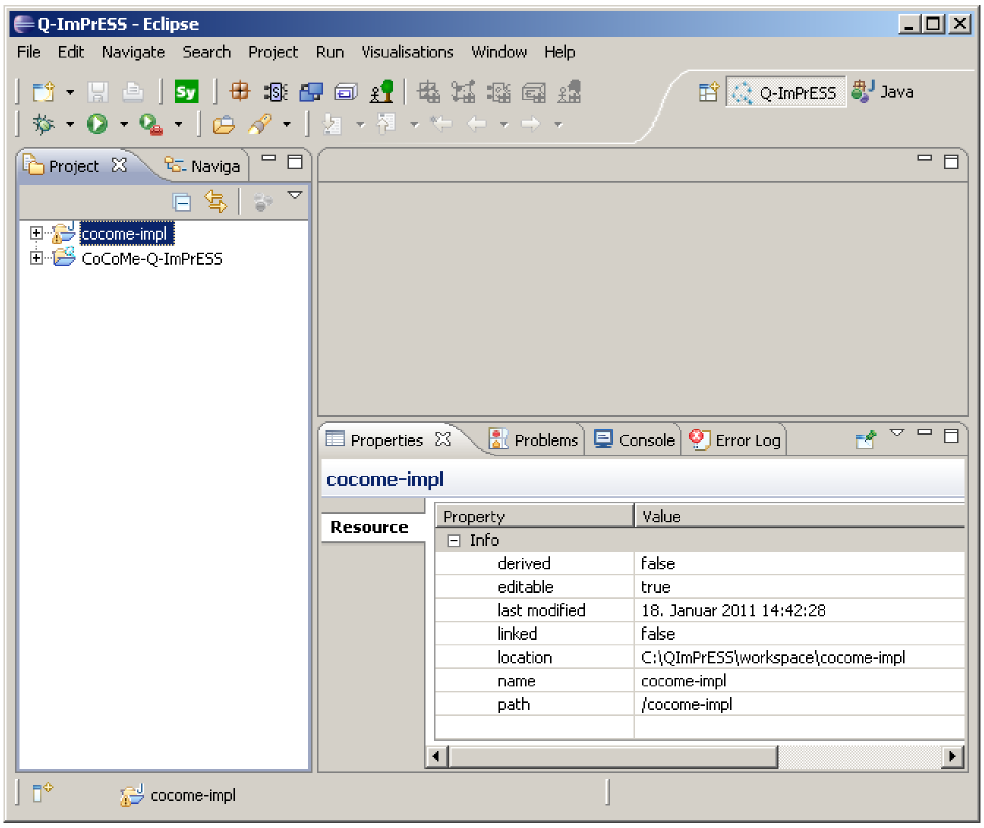
4.8.4 Tool activation

The tool doesn't need any activation. After installation of the Q-ImPrESS IDE, reverse engineering functionality is directly available in the eclipse environment.

4.8.5 Usage instructions and expected outputs

In order to perform a reverse engineering run to derive a Q-ImPrESS model from source code, the source code has to be available on the machine, e.g. as an eclipse workspace project. In the following, we describe how to apply the reverse engineering toolchain on a Java project. We use the CoCoMe java implementation for this. The CoCoMe implementation can be downloaded at http://agrausch.informatik.uni-kl.de/CoCoME.

The most convenient way to apply reverse engineering is to provide the source code as a workspace project first. We switch to the Q-ImPrESS perspective, import the CoCoMe project into the workspace, and create a Q-ImPrESS project called "Cocome-Q-ImPrESS" in the workspace (see Figure 61).



Property	Value
Info	
derived	false
editable	true
last modified	18. Januar 2011 14:42:28
linked	false
location	C:\QImPrESS\workspace\cocome-impl
name	cocome-impl
path	/cocome-impl

Figure 61: Importing the Java project into the workspace

If the Project Explorer view is not displayed, switch to the view ("Window" → "Show View" → "Project Explorer). Now, right-click on the imported Java project (in the running example, the CoCoMe project cocome-impl) and select "Create Q-ImPreSS Reverse Engineering Launch" (see Figure 62).

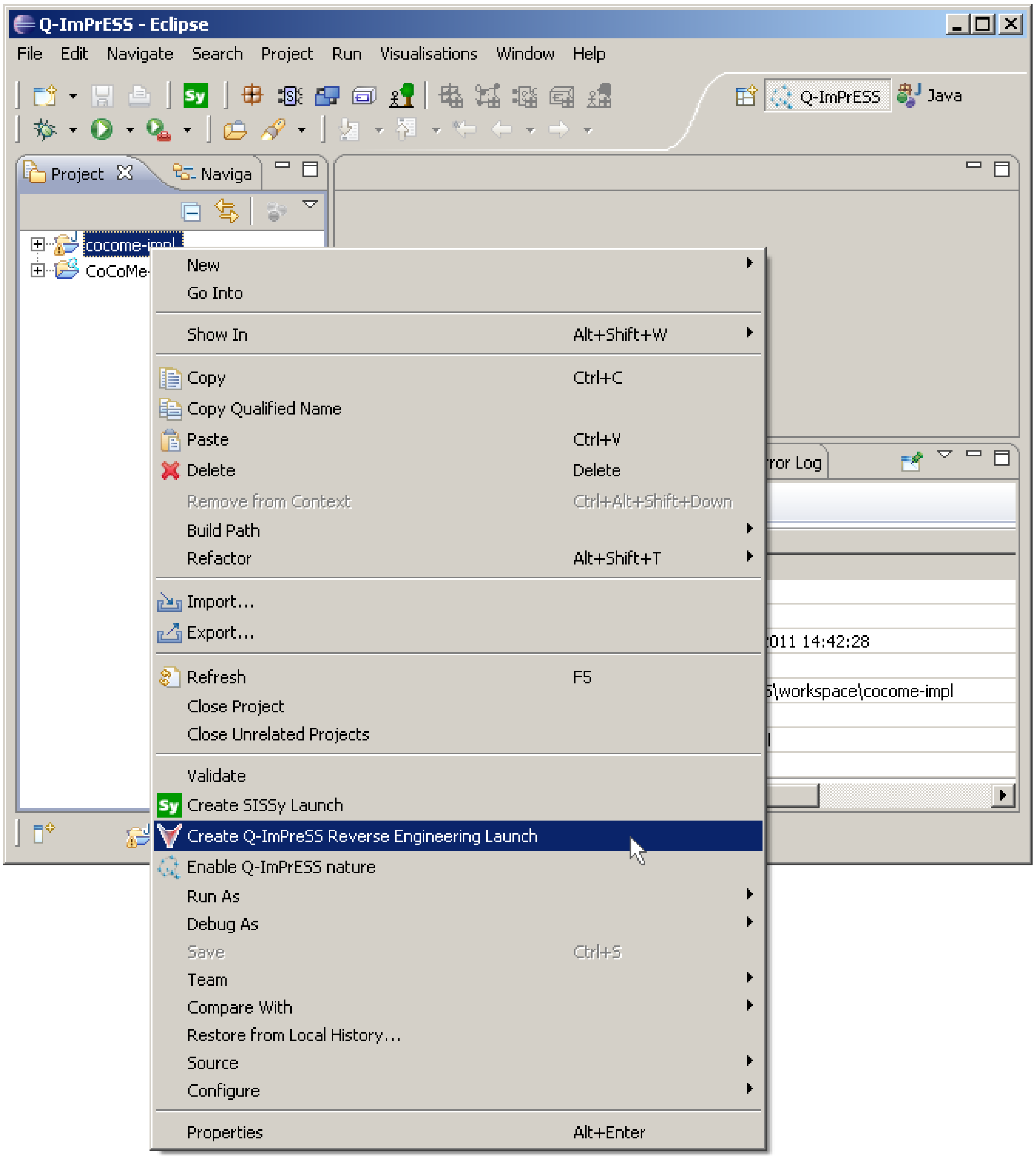
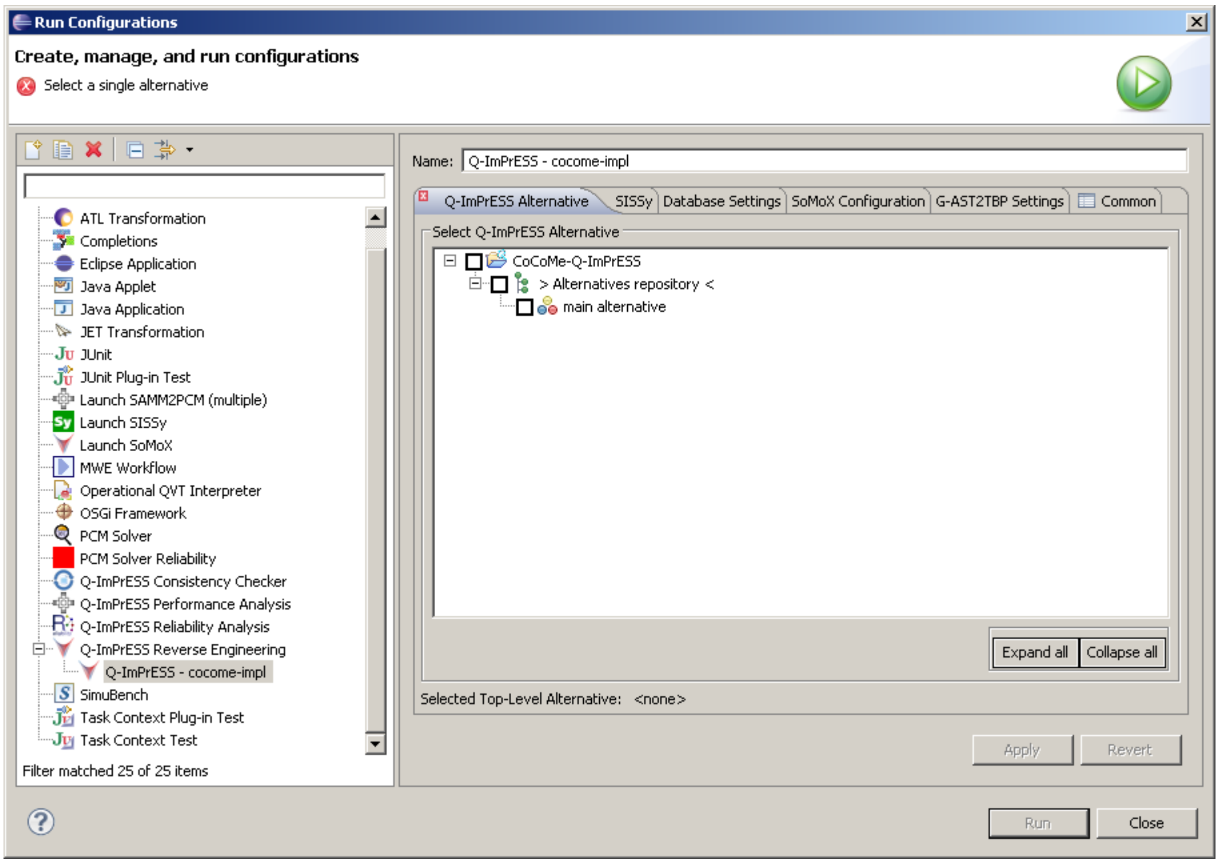


Figure 62: Creating a Reverse Engineering launch

A reverse engineering launch configuration is being created which already contains some necessary settings, for example the input paths of the source code project and its referenced libraries. Figure 63 shows the initial tab of the launch configuration, in which the user has to select the Q-ImPrESS project for reverse engineering.


Run Configurations

Create, manage, and run configurations

Select a single alternative

- ATL Transformation
- Completions
- Eclipse Application
- Java Applet
- Java Application
- JET Transformation
- JUnit
- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- PCM Solver Reliability
- Q-ImPrESS Consistency Checker
- Q-ImPrESS Performance Analysis
- Q-ImPrESS Reliability Analysis
- Q-ImPrESS Reverse Engineering
  - Q-ImPrESS - cocome-impl
- SimuBench
- Task Context Plug-in Test
- Task Context Test

Filter matched 25 of 25 items

Name: Q-ImPrESS - cocome-impl

Q-ImPrESS Alternative | SISSy | Database Settings | SoMoX Configuration | G-AST2TBP Settings | Common

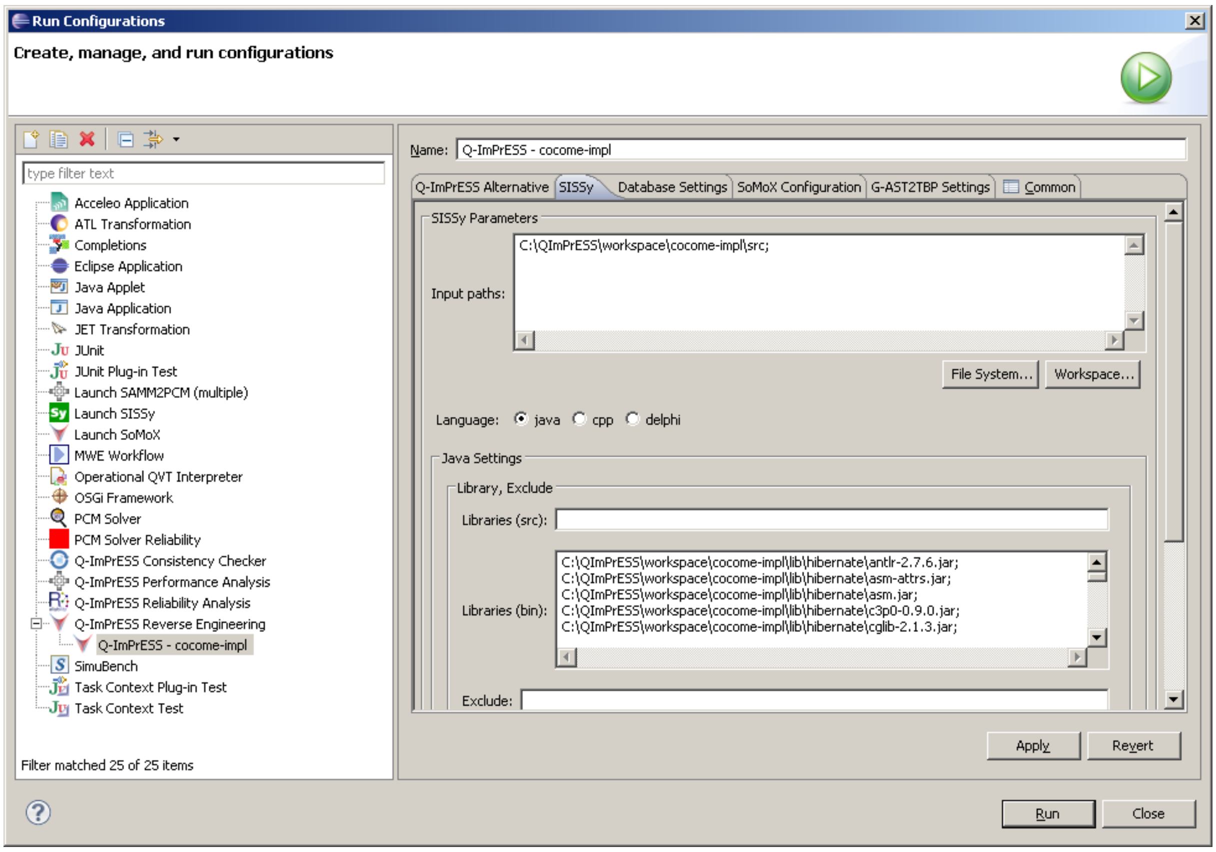
Select Q-ImPrESS Alternative

- CoCoMe-Q-ImPrESS
  - > Alternatives repository <
    - main alternative

Selected Top-Level Alternative: <none>

Figure 63: Reverse Engineering launch configuration: Selecting the Q-ImPrESS alternative

The second tab of the launch configuration contains SISSy configuration parameters (see Figure 64). Some parameters have already been derived by the source code project, for example the path to the source code files that is used for SISSy, or paths to libraries that the source code requires. If needed, these parameters can be adapted for the reverse engineering run.


Run Configurations

Create, manage, and run configurations

type filter text

- Acceleo Application
- ATL Transformation
- Completions
- Eclipse Application
- Java Applet
- Java Application
- JET Transformation
- JUnit
- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- PCM Solver Reliability
- Q-ImPrESS Consistency Checker
- Q-ImPrESS Performance Analysis
- Q-ImPrESS Reliability Analysis
- Q-ImPrESS Reverse Engineering
  - Q-ImPrESS - cocome-impl
- SimuBench
- Task Context Plug-in Test
- Task Context Test

Filter matched 25 of 25 items

Name: Q-ImPrESS - cocome-impl

Q-ImPrESS Alternative | SISSy | Database Settings | SoMoX Configuration | G-AST2TBP Settings | Common

SISSy Parameters

Input paths: C:\QImPrESS\workspace\cocome-impl\src;

File System... Workspace...

Language: [✓ java] cpp delphi

Java Settings

Library, Exclude

Libraries (src):

Libraries (bin):
```
C:\QImPrESS\workspace\cocome-impl\lib\hibernate\antlr-2.7.6.jar;
C:\QImPrESS\workspace\cocome-impl\lib\hibernate\asm-attrs.jar;
C:\QImPrESS\workspace\cocome-impl\lib\hibernate\asm.jar;
C:\QImPrESS\workspace\cocome-impl\lib\hibernate\c3p0-0.9.0.jar;
C:\QImPrESS\workspace\cocome-impl\lib\hibernate\cglib-2.1.3.jar;
```

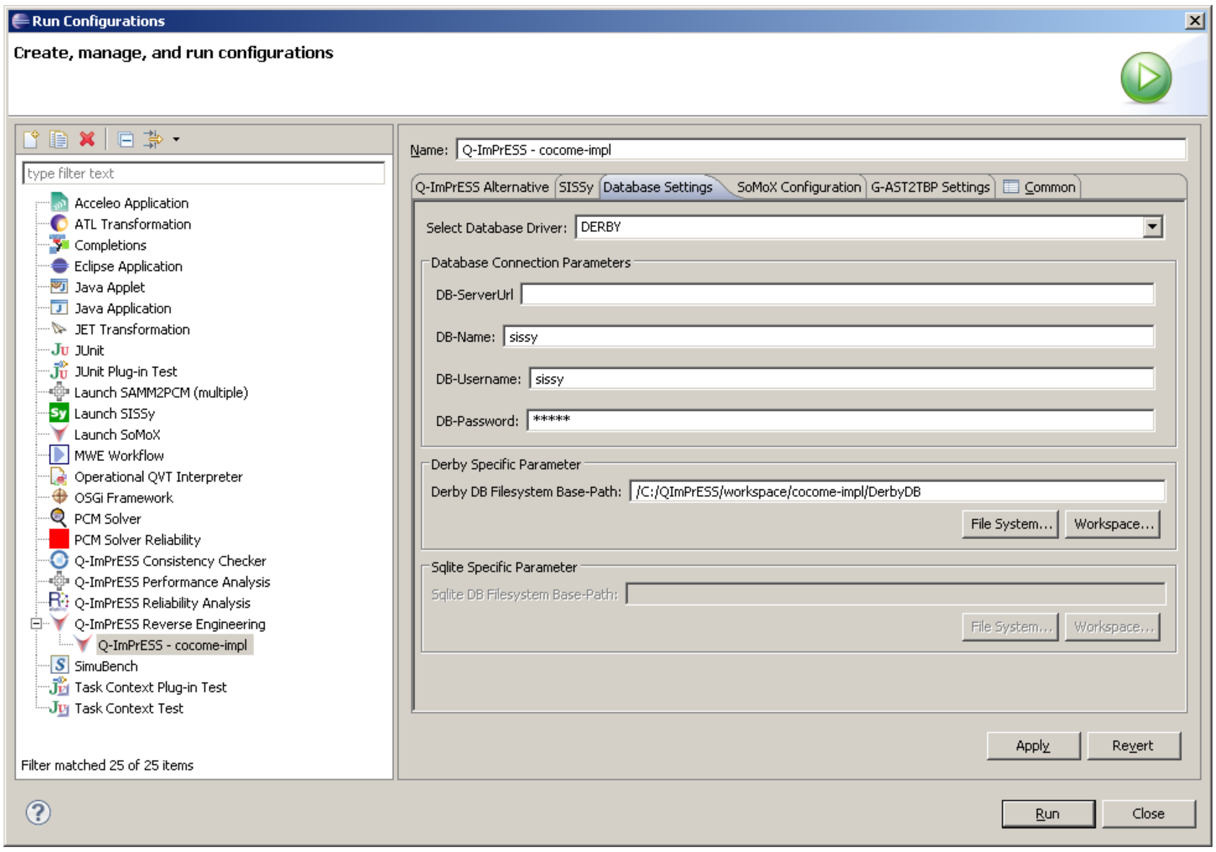
Exclude:

Apply Revert

Run Close

Figure 64: Reverse Engineering launch configuration: SISSy configuration parameters

In the third tab of the launch configuration, the SISSy database settings have to be adapted (see Figure 65). SISSy can use a PostgreSQL database or the Java-integrated Derby database. PostgreSQL can only be used if such a database is available on the machine. A Derby database can always be used, since it comes with the Java JRE. However, SISSy runs slower when using Derby.



Run Configurations

Create, manage, and run configurations

type filter text

- Acceleo Application
- ATL Transformation
- Completions
- Eclipse Application
- Java Applet
- Java Application
- JET Transformation
- JUnit
- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- PCM Solver Reliability
- Q-ImPrESS Consistency Checker
- Q-ImPrESS Performance Analysis
- Q-ImPrESS Reliability Analysis
- Q-ImPrESS Reverse Engineering
  - Q-ImPrESS - cocome-impl
- SimuBench
- Task Context Plug-in Test
- Task Context Test

Filter matched 25 of 25 items

Name: Q-ImPrESS - cocome-impl

Q-ImPrESS Alternative | SISSy | Database Settings | SoMoX Configuration | G-AST2TBP Settings | Common

Select Database Driver: DERBY

Database Connection Parameters
DB-ServerUrl:
DB-Name: sissy
DB-Username: sissy
DB-Password: *****

Derby Specific Parameter
Derby DB Filesystem Base-Path: /C:/QImPrESS/workspace/cocome-impl/DerbyDB
File System... Workspace...

Sqlite Specific Parameter
Sqlite DB Filesystem Base-Path:
File System... Workspace...

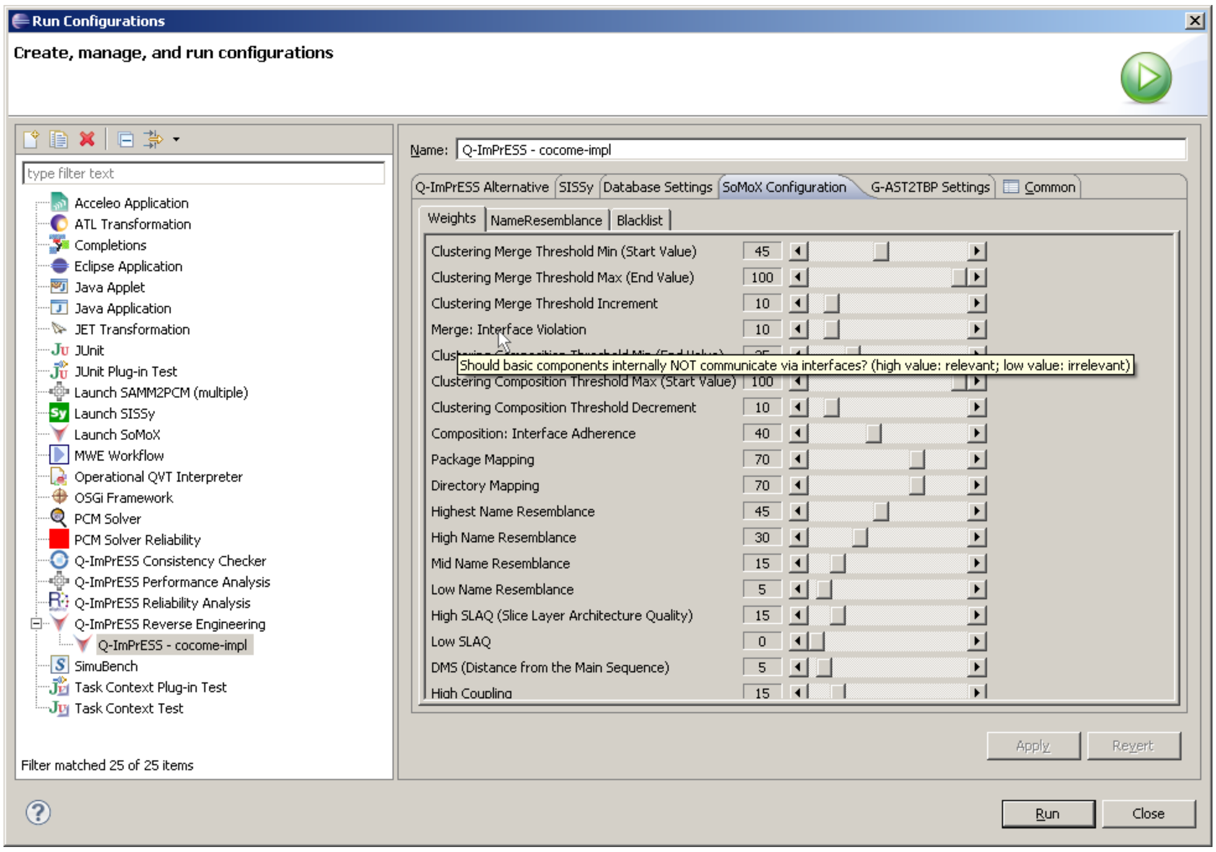
Apply Revert

Run Close

Figure 65: Reverse Engineering launch configuration: SISSy database settings

When selecting Derby, a database name, user name and password have to be provided. Insert “sissy” in all three fields.

The tab “SoMoX Configuration” provides three sub-tabs. In the first sub-tab “Weights”, select weights for those component detection strategies which best match your preferred reverse engineering results (see Figure 66).



Run Configurations

Create, manage, and run configurations

type filter text

- Acceleo Application
- ATL Transformation
- Completions
- Eclipse Application
- Java Applet
- Java Application
- JET Transformation
- JUnit
- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- PCM Solver Reliability
- Q-ImPrESS Consistency Checker
- Q-ImPrESS Performance Analysis
- Q-ImPrESS Reliability Analysis
- Q-ImPrESS Reverse Engineering
  - Q-ImPrESS - cocome-impl
- SimuBench
- Task Context Plug-in Test
- Task Context Test

Filter matched 25 of 25 items

Name: Q-ImPrESS - cocome-impl

Q-ImPrESS Alternative | SISSy | Database Settings | SoMoX Configuration | G-AST2TBP Settings | Common

Weights | NameResemblance | Blacklist

Clustering Merge Threshold Min (Start Value)	45
Clustering Merge Threshold Max (End Value)	100
Clustering Merge Threshold Increment	10
Merge: Interface Violation	10
Clus	
Clustering Composition Threshold Max (Start Value)	100
Clustering Composition Threshold Decrement	10
Composition: Interface Adherence	40
Package Mapping	70
Directory Mapping	70
Highest Name Resemblance	45
High Name Resemblance	30
Mid Name Resemblance	15
Low Name Resemblance	5
High SLAQ (Slice Layer Architecture Quality)	15
Low SLAQ	0
DMS (Distance from the Main Sequence)	5
High Coupling	15

Should basic components internally NOT communicate via interfaces? (high value: relevant; low value: irrelevant)

Apply | Revert

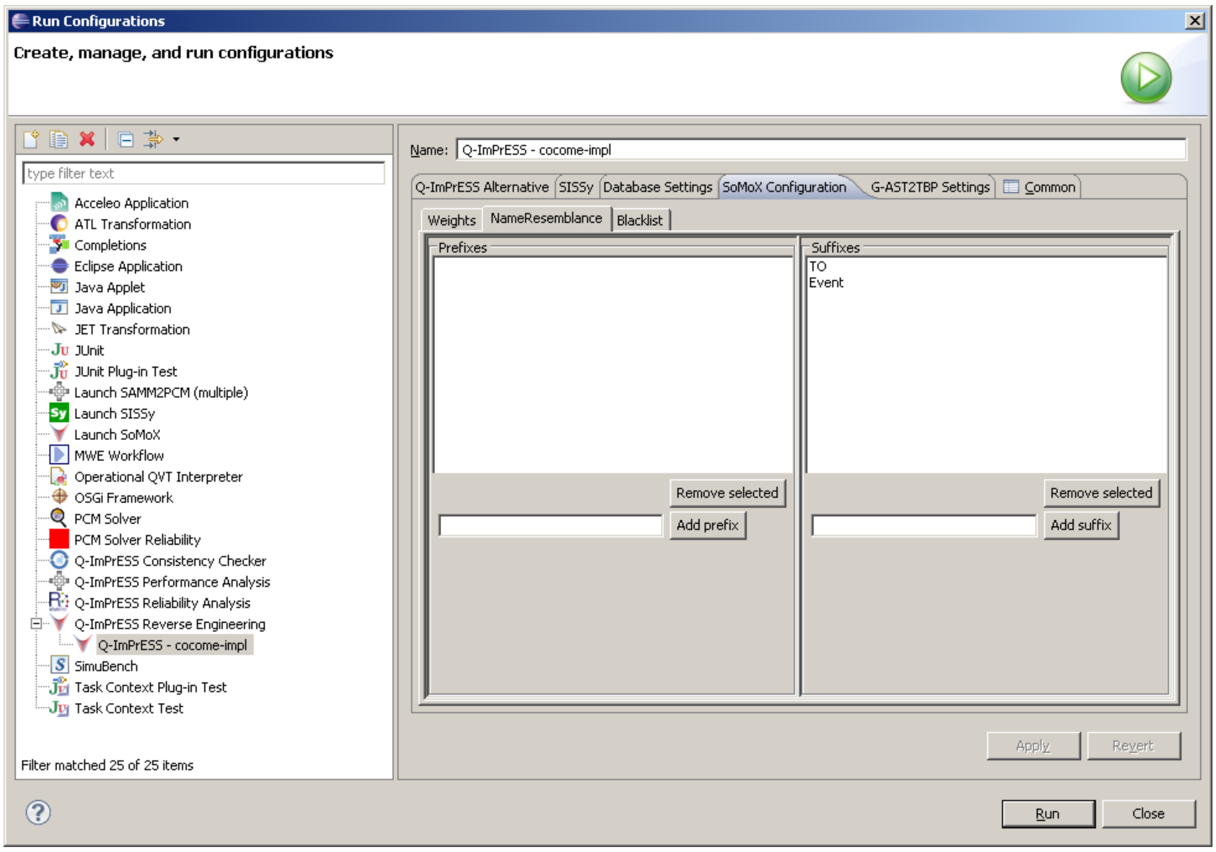
Run | Close

Figure 66: Reverse Engineering launch configuration: SoMoX weights specification

Each strategy has a single or multiple weights which need to be configured.

- The default weights provide reasonable components for most systems.
- 100 means: Use this strategy; 0 means: ignore this strategy. Any value between 100 and 0 is accepted.
- The most important weights are those for Clustering and Merge: Those define the minimal and maximal abstraction level of the reverse engineered system.
- Each weight is explained in more detail in the when hovering the slider text.

The "NameResemblance" sub-tab lets you specify pre and post fixes which should *not* be considered as indicators of similarity (see Figure 67). If for example "Event" is a typical postfix which does not indicate that classes belong to a single component, add "Event" as a postfix.


Run Configurations

Create, manage, and run configurations

type filter text

- Acceleo Application
- ATL Transformation
- Completions
- Eclipse Application
- Java Applet
- Java Application
- JET Transformation
- JUnit
- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- PCM Solver Reliability
- Q-ImPrESS Consistency Checker
- Q-ImPrESS Performance Analysis
- Q-ImPrESS Reliability Analysis
- Q-ImPrESS Reverse Engineering
  - Q-ImPrESS - cocome-impl
- SimuBench
- Task Context Plug-in Test
- Task Context Test

Filter matched 25 of 25 items

Name: Q-ImPrESS - cocome-impl

Tabs: Q-ImPrESS Alternative | SISSy | Database Settings | SoMoX Configuration | G-AST2TBP Settings | Common

Sub-tabs: Weights | NameResemblance | Blacklist

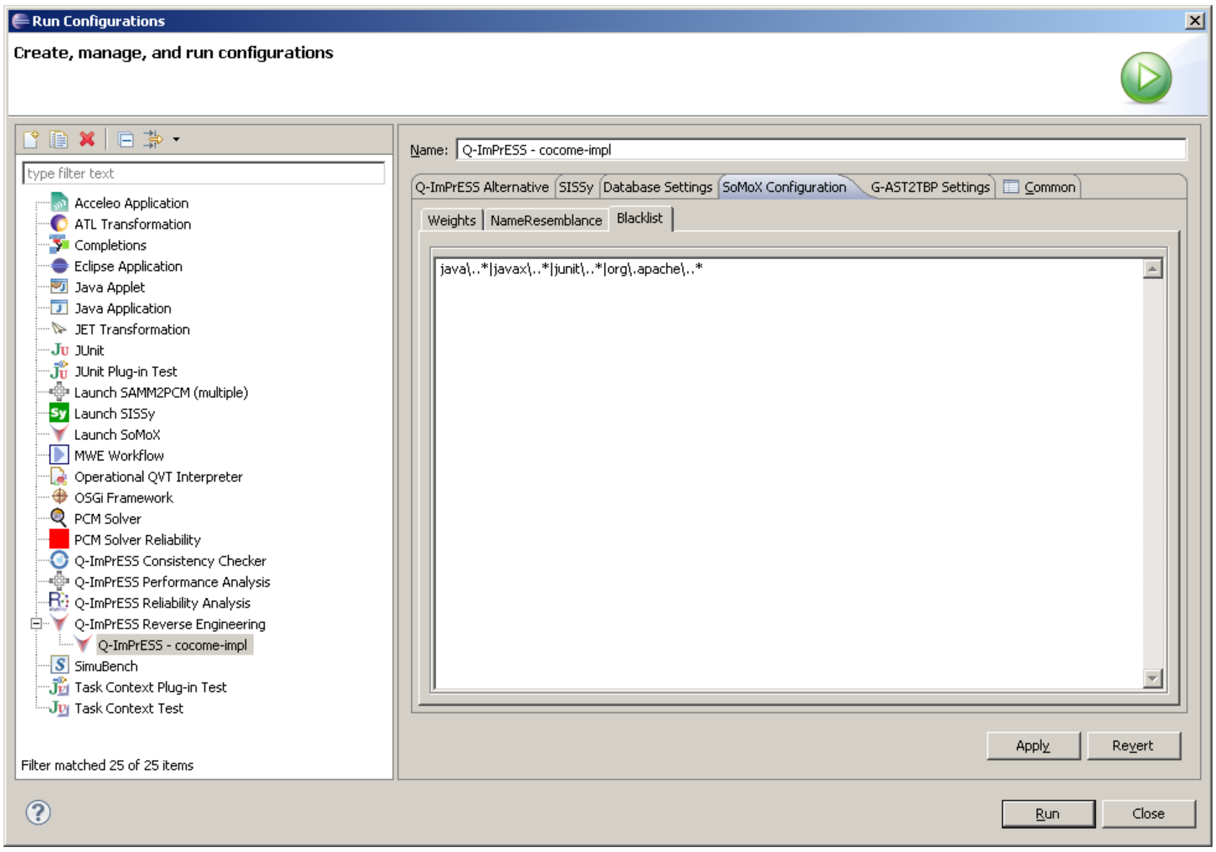
Prefixes

Suffixes
TO
Event

Figure 67: Reverse Engineering launch configuration: SoMoX name resemblance specification

In the "Blacklist" tab (see Figure 68), a blacklist can be specified that holds packages which should not be part of the metrics calculation. For example, a GAST may contain references to java API classes organised in the "java.*" packages. Hence, the blacklist contributes in scoping a reverse engineering project.

Blacklist entries are regular expressions. For example, to remove all API classes just enter `java\..*|javax\..*` (".*" is an infinite number of arbitrary characters; "\." is the escaped dot; "|" is the separator for multiple entries).

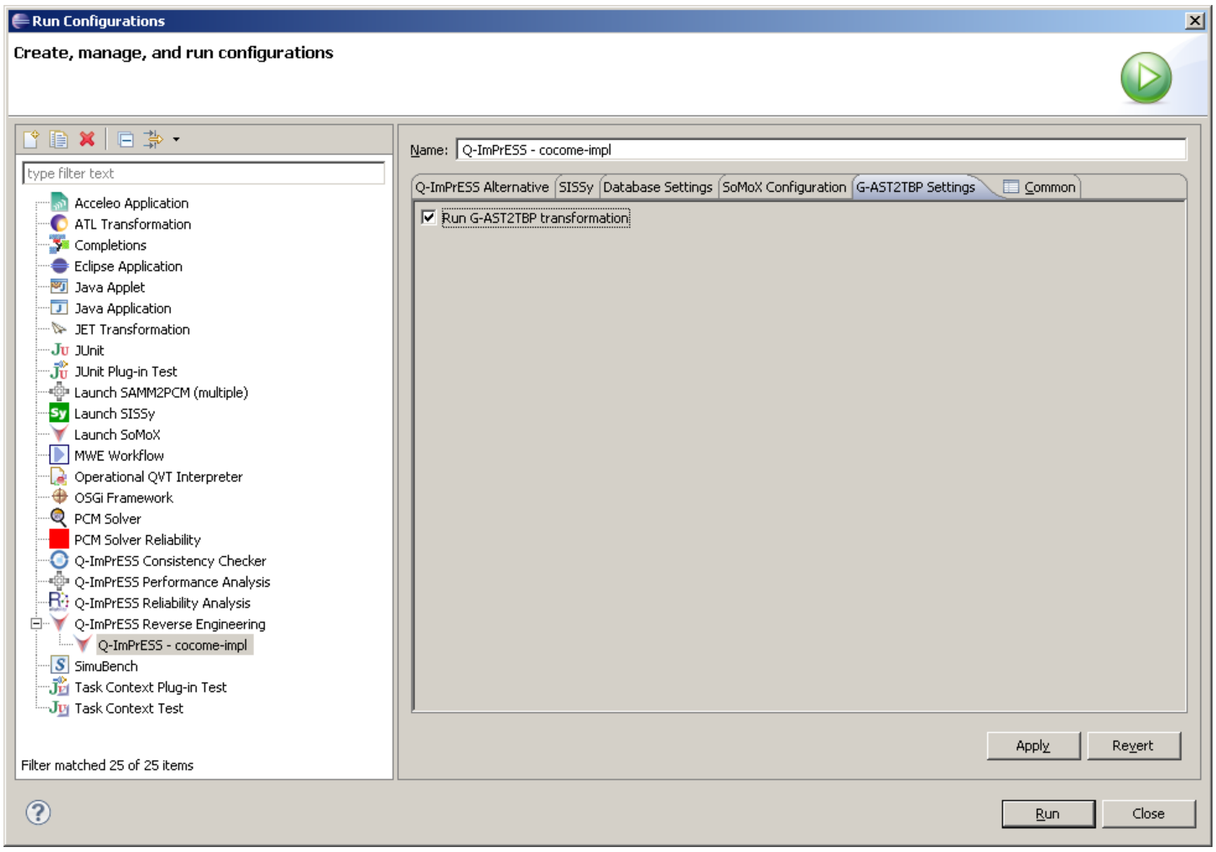


Name: Q-ImPrESS - cocome-impl

```
java\..*|javax\..*|junit\..*|org\.apache\..*
```

Figure 68: Reverse Engineering launch configuration: SoMoX blacklist specification

If you want the tool to create behaviour model in the form of Threaded Behaviour Protocols (TBP), check the checkbox at the “G-AST2TBP Settings” tab (see Figure 69).


Run Configurations

Create, manage, and run configurations

Name: Q-ImPrESS - cocome-impl

Q-ImPrESS Alternative | SISSy | Database Settings | SoMoX Configuration | G-AST2TBP Settings | Common

☑ Run G-AST2TBP transformation

- Acceleo Application
- ATL Transformation
- Completions
- Eclipse Application
- Java Applet
- Java Application
- JET Transformation
- JUnit
- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- PCM Solver Reliability
- Q-ImPrESS Consistency Checker
- Q-ImPrESS Performance Analysis
- Q-ImPrESS Reliability Analysis
- Q-ImPrESS Reverse Engineering
  - Q-ImPrESS - cocome-impl
- SimuBench
- Task Context Plug-in Test
- Task Context Test

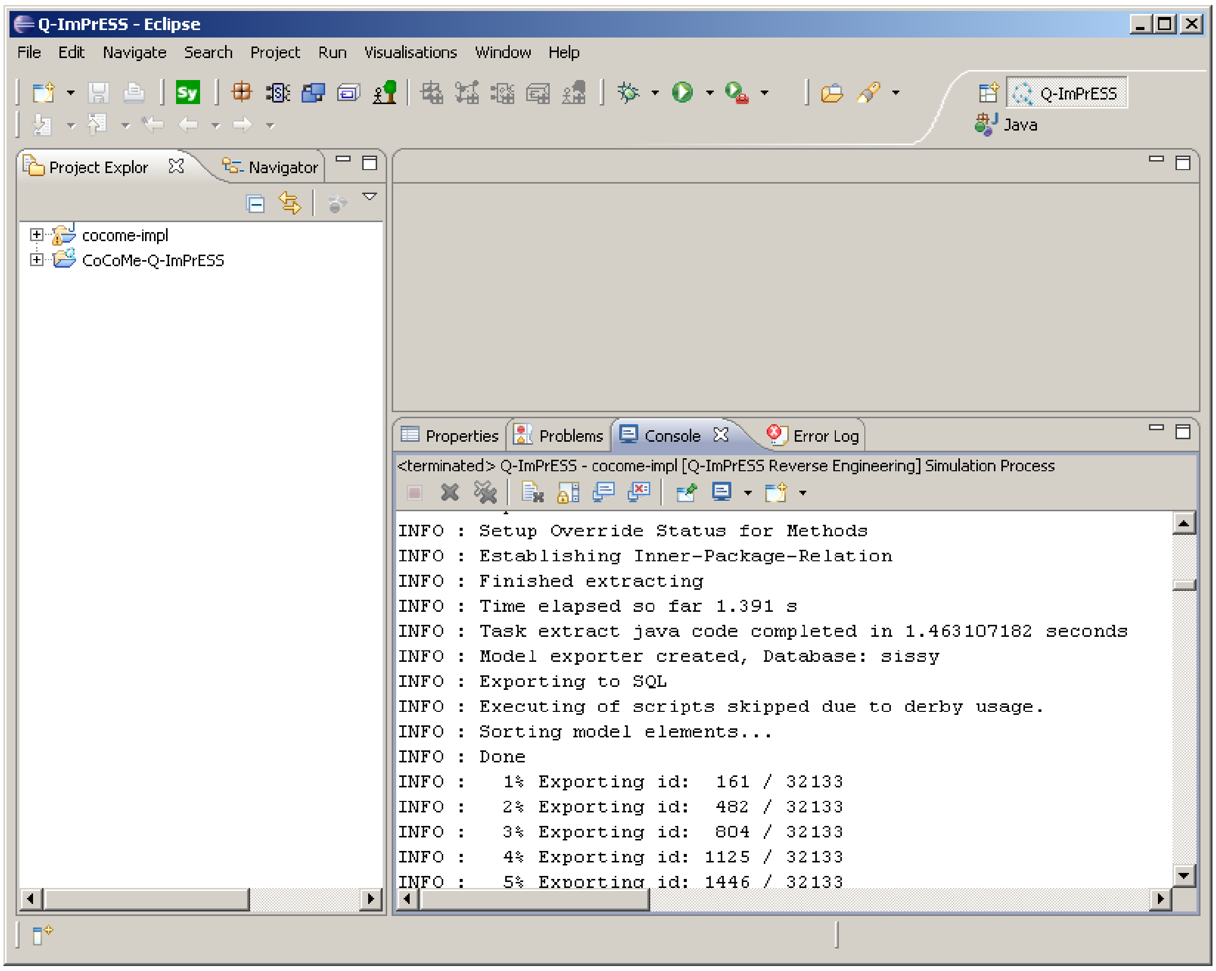
Filter matched 25 of 25 items

Figure 69: Reverse Engineering launch configuration: G-AST2TBP settings

After a successful run, a TBP file for each primitive component will be created in the alternative folder. You can modify the text inside the IDE if needed. The TBP models can be used for checking consistency between component implementation in Java and the TBP models.

Afterwards, the basic configuration for the reverse engineering run is complete.

Run the launch configuration to perform the reverse engineering run. Open the console view to get information about the run (see Figure 70).

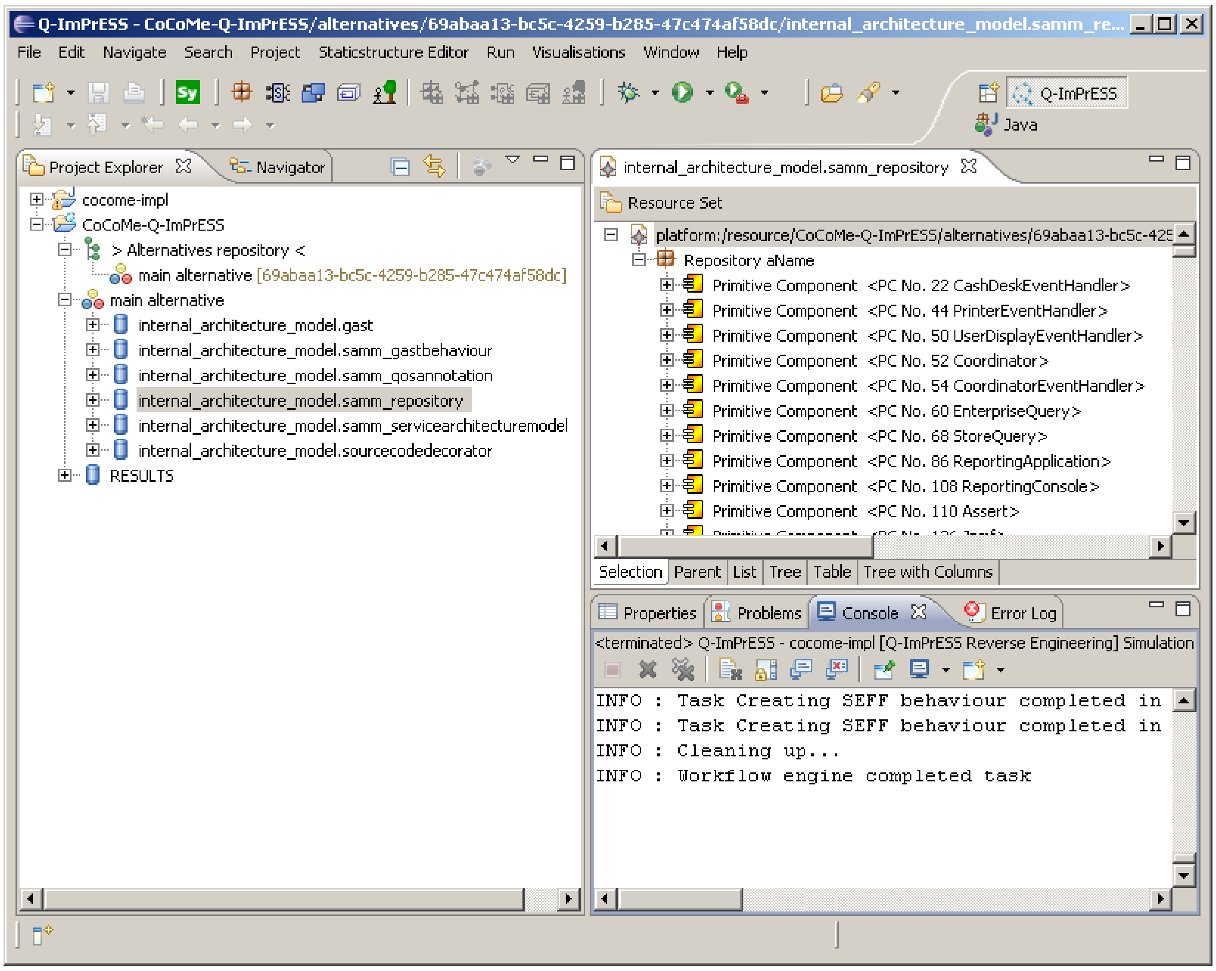


<terminated> Q-ImPrESS - cocome-impl [Q-ImPrESS Reverse Engineering] Simulation Process

```
INFO : Setup Override Status for Methods
INFO : Establishing Inner-Package-Relation
INFO : Finished extracting
INFO : Time elapsed so far 1.391 s
INFO : Task extract java code completed in 1.463107182 seconds
INFO : Model exporter created, Database: sissy
INFO : Exporting to SQL
INFO : Executing of scripts skipped due to derby usage.
INFO : Sorting model elements...
INFO : Done
INFO :   1% Exporting id:   161 / 32133
INFO :   2% Exporting id:   482 / 32133
INFO :   3% Exporting id:   804 / 32133
INFO :   4% Exporting id:  1125 / 32133
INFO :   5% Exporting id:  1446 / 32133
```

Figure 70: Console view during a Reverse Engineering run

Once the run completed successfully, the output model files has been created. The model files can be found in the folder of the alternative which had been selected for the run (see Figure 71).



Q-ImPrESS - CoCoMe-Q-ImPrESS/alternatives/69abaa13-bc5c-4259-b285-47c474af58dc/internal_architecture_model.samm_re...

Project Explorer / Navigator:

- cocome-impl
- CoCoMe-Q-ImPrESS
  - > Alternatives repository <
    - main alternative [69abaa13-bc5c-4259-b285-47c474af58dc]
  - main alternative
    - internal_architecture_model.gast
    - internal_architecture_model.samm_gastbehaviour
    - internal_architecture_model.samm_qosannotation
    - internal_architecture_model.samm_repository
    - internal_architecture_model.samm_servicearchitecturemodel
    - internal_architecture_model.sourcecodedecorator
  - RESULTS

internal_architecture_model.samm_repository

Resource Set

- platform:/resource/CoCoMe-Q-ImPrESS/alternatives/69abaa13-bc5c-425
  - Repository aName
    - Primitive Component <PC No. 22 CashDeskEventHandler>
    - Primitive Component <PC No. 44 PrinterEventHandler>
    - Primitive Component <PC No. 50 UserDisplayEventHandler>
    - Primitive Component <PC No. 52 Coordinator>
    - Primitive Component <PC No. 54 CoordinatorEventHandler>
    - Primitive Component <PC No. 60 EnterpriseQuery>
    - Primitive Component <PC No. 68 StoreQuery>
    - Primitive Component <PC No. 86 ReportingApplication>
    - Primitive Component <PC No. 108 ReportingConsole>
    - Primitive Component <PC No. 110 Assert>

Console:

<terminated> Q-ImPrESS - cocome-impl [Q-ImPrESS Reverse Engineering] Simulation

```
INFO : Task Creating SEFF behaviour completed in
INFO : Task Creating SEFF behaviour completed in
INFO : Cleaning up...
INFO : Workflow engine completed task
```

Figure 71: Reverse Engineering output model files

4.8.6 Caveats

Please note that SoMoX is only applicable to software systems which are component-based or at least constructed with components in mind. It will not be able to reverse engineer non-component-based software systems. Furthermore, the software architecture has to be somehow encoded into the software artifacts.

SoMoX is highly sensitive to merge and compose weights/thresholds. These values almost always influence the minimal and maximal abstraction level, the number of reverse engineered components, and the number of reverse engineered abstraction levels. Stepwise refine these weights for merge and compose until the abstraction level meets your expectations (SoMoX cannot guess the desired abstraction level).

In rare cases the TBP models might not be created for some components. This is due to patterns that cannot be processed; this includes most notably the recursion, since it cannot be captured in the language of TBP.

4.9 Performance Prediction Manual

4.9.1 Purpose of the tool

The Palladio Component Model (PCM) is a domain-specific language that allows for modelling the design of component-based software. This design model can be transformed into a performance analysis model.
The PCM can be included into the Q-ImPrESS platform for performance predictions on Q-ImPrESS SAM models. Therefore, a SAM model has to be transformed into a PCM model and the PCM performance analysis has to be performed for the PCM output model.
The Q-ImPrESS platform provides an automated workflow for this.

4.9.2 Tool relationship with the Q-ImPrESS workflow

The performance prediction participates in the process of predicting the system quality in the Q-ImPrESS workflow (see Figure 72).
After a Q-ImPrESS SAM model has been created either by reverse-engineering or forward-modelling, different QoS attributes can be analysed by the Q-ImPrESS platform.
For performance analysis the SAM model has to be transformed into a PCM instance. Then the performance analysis results can be inspected in the Result Viewer and used as input for the trade-off analysis. Detailed PCM performance analysis results are available in the integrated PCM Results view in the Q-ImPrESS UI.

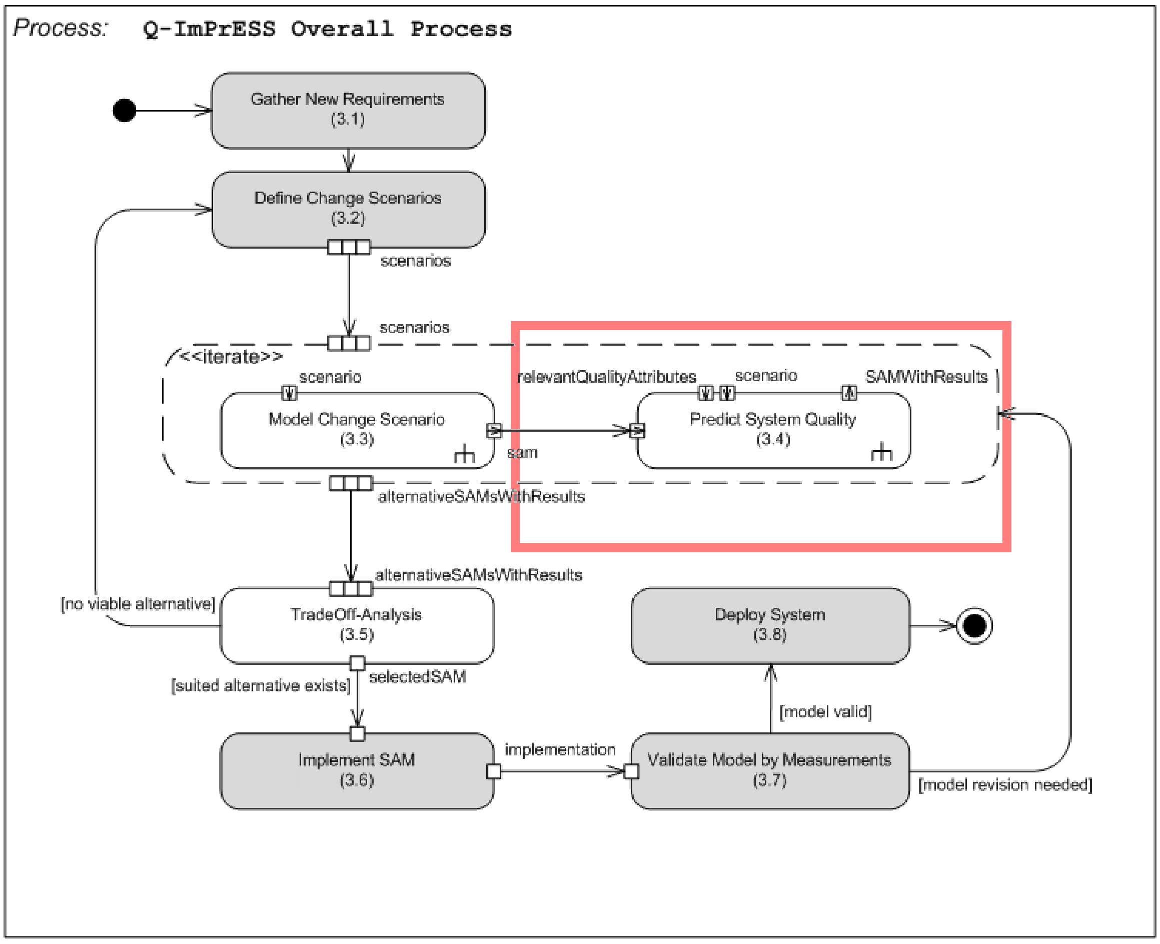

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
Model Change Scenario (3.3)
sam
relevantQualityAttributes
scenario
SAMWithResults
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
[suited alternative exists]
selectedSAM
Deploy System (3.8)
[model valid]
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]

Figure 72: Predicting system quality (copied from D6.1)

4.9.3 Tool prerequisites

The PCM simulation might need a lot RAM. Therefore, make sure the Q-ImPrESS Eclipse instance is started with useful memory parameters:
In the file eclipse.ini in the root directory of the Q-ImPrESS Eclipse installation, add the following lines:

```
-vmargs
-Xms512m
-Xmx768m
```

(note: the provided instructions could vary depending on the target operating system)

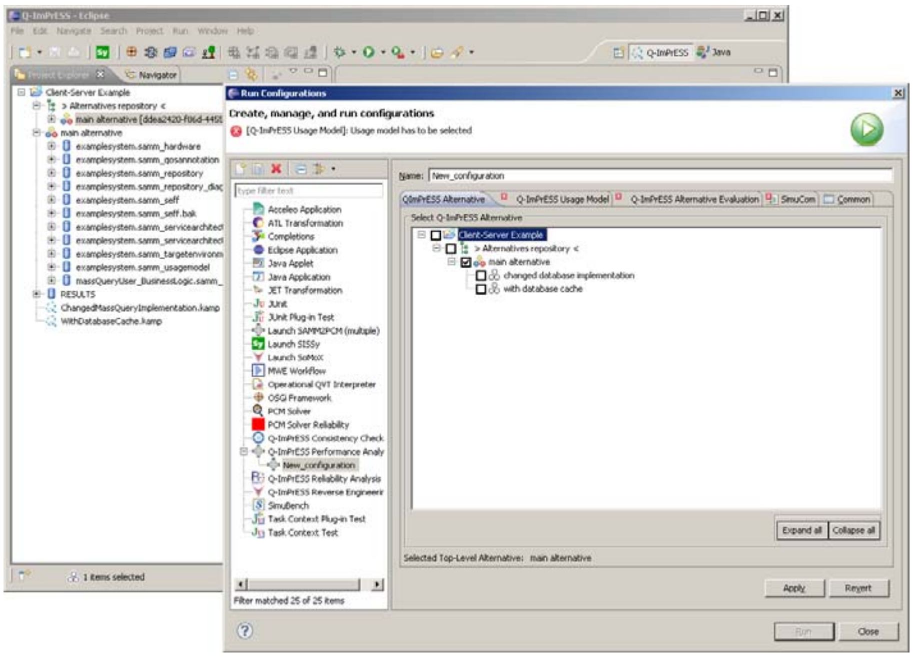
A PCM performance analysis needs a valid PCM input model for input. This model can be created automatically from a Q-ImPrESS SAM model.
Therefore, a Q-ImPrESS alternative has to be created which holds the SAM model files.

4.9.4 Tool activation

In the following, we assume that a Q-ImPrESS SAM model is already available. This SAM model has to be stored in a Q-ImPrESS alternative in the IDE workspace.

Click "Run" → "Run as…" to create a run configuration for the Q-ImPrESS performance prediction platform. On the left side view, right-click on "Q-ImPrESS Performance Analysis" and click "New". A new run configuration is being created and can now be specified.

On the first tab "Q-ImPrESS Alternative" of the configuration, select the Q-ImPrESS alternative for which a performance analysis should be performed (see Figure 73).



Run Configurations

Create, manage, and run configurations

[Q-ImPrESS Usage Model]: Usage model has to be selected

Name: New_configuration

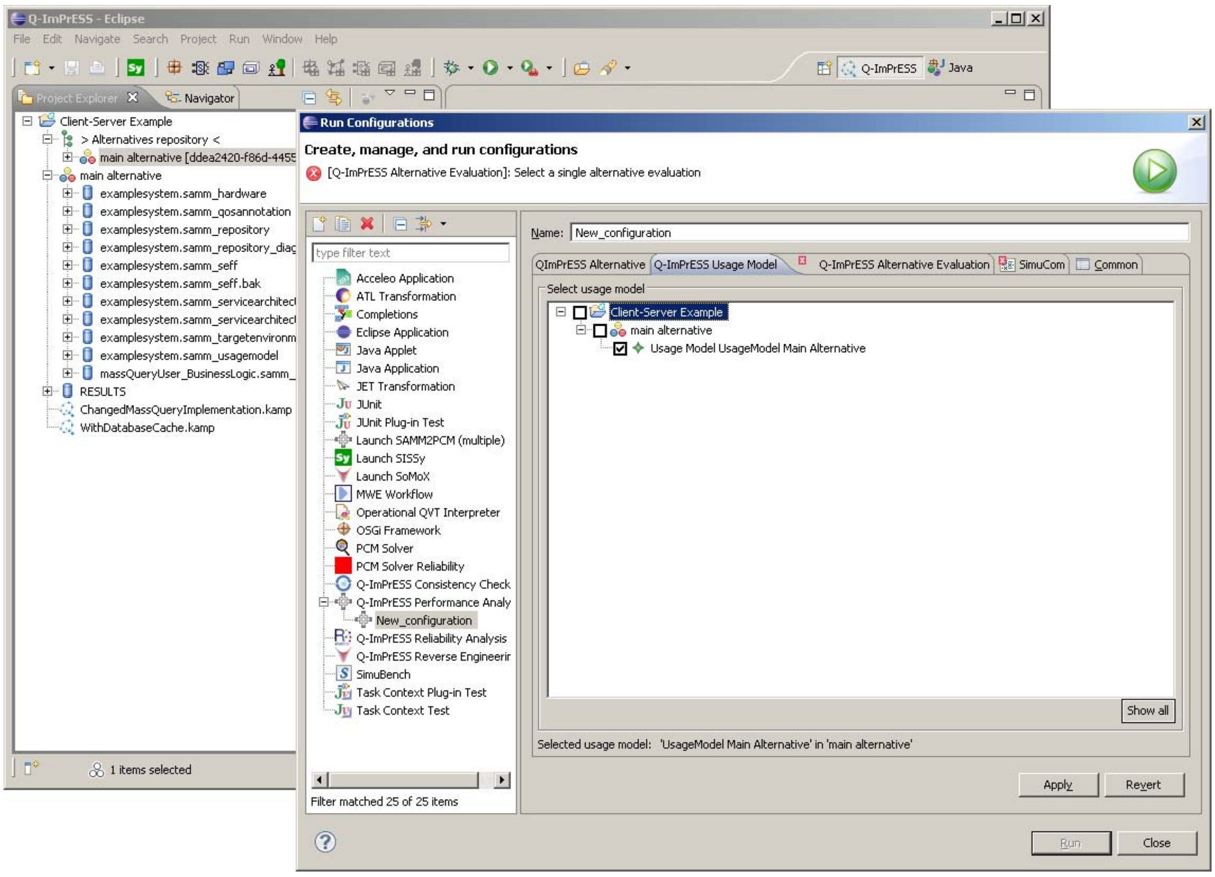
Select Q-ImPrESS Alternative

- Client-Server Example
  - > Alternatives repository <
    - [✓] main alternative
      - changed database implementation
      - with database cache

Selected Top-Level Alternative: main alternative

Figure 73: Selecting a Q-ImPrESS alternative for performance prediction

On the tab "Q-ImPrESS Usage Model", all defined usage models for the selected alternative are displayed. Select the usage model for which you want to analyse the SAM performance (see Figure 74).


Q-ImPrESS - Eclipse
File Edit Navigate Search Project Run Window Help
Q-ImPrESS
Java
Project Explorer
Navigator
Client-Server Example
> Alternatives repository <
main alternative [ddea2420-f86d-4455
main alternative
examplesystem.samm_hardware
examplesystem.samm_qosannotation
examplesystem.samm_repository
examplesystem.samm_repository_diag
examplesystem.samm_seff
examplesystem.samm_seff.bak
examplesystem.samm_servicearchitect
examplesystem.samm_servicearchitect
examplesystem.samm_targetenvironm
examplesystem.samm_usagemodel
massQueryUser_BusinessLogic.samm_
RESULTS
ChangedMassQueryImplementation.kamp
WithDatabaseCache.kamp
1 items selected
Run Configurations
type filter text
Acceleo Application
ATL Transformation
Completions
Eclipse Application
Java Applet
Java Application
JET Transformation
JUnit
JUnit Plug-in Test
Launch SAMM2PCM (multiple)
Launch SISSy
Launch SoMoX
MWE Workflow
Operational QVT Interpreter
OSGi Framework
PCM Solver
PCM Solver Reliability
Q-ImPrESS Consistency Check
Q-ImPrESS Performance Analy
New_configuration
Q-ImPrESS Reliability Analysis
Q-ImPrESS Reverse Engineerir
SimuBench
Task Context Plug-in Test
Task Context Test
Filter matched 25 of 25 items
QImPrESS Alternative
Q-ImPrESS Usage Model
Q-ImPrESS Alternative Evaluation
SimuCom
Common
Select usage model
Client-Server Example
main alternative
Usage Model UsageModel Main Alternative
Show all
Apply
Revert
Run
Close

Create, manage, and run configurations

[Q-ImPrESS Alternative Evaluation]: Select a single alternative evaluation

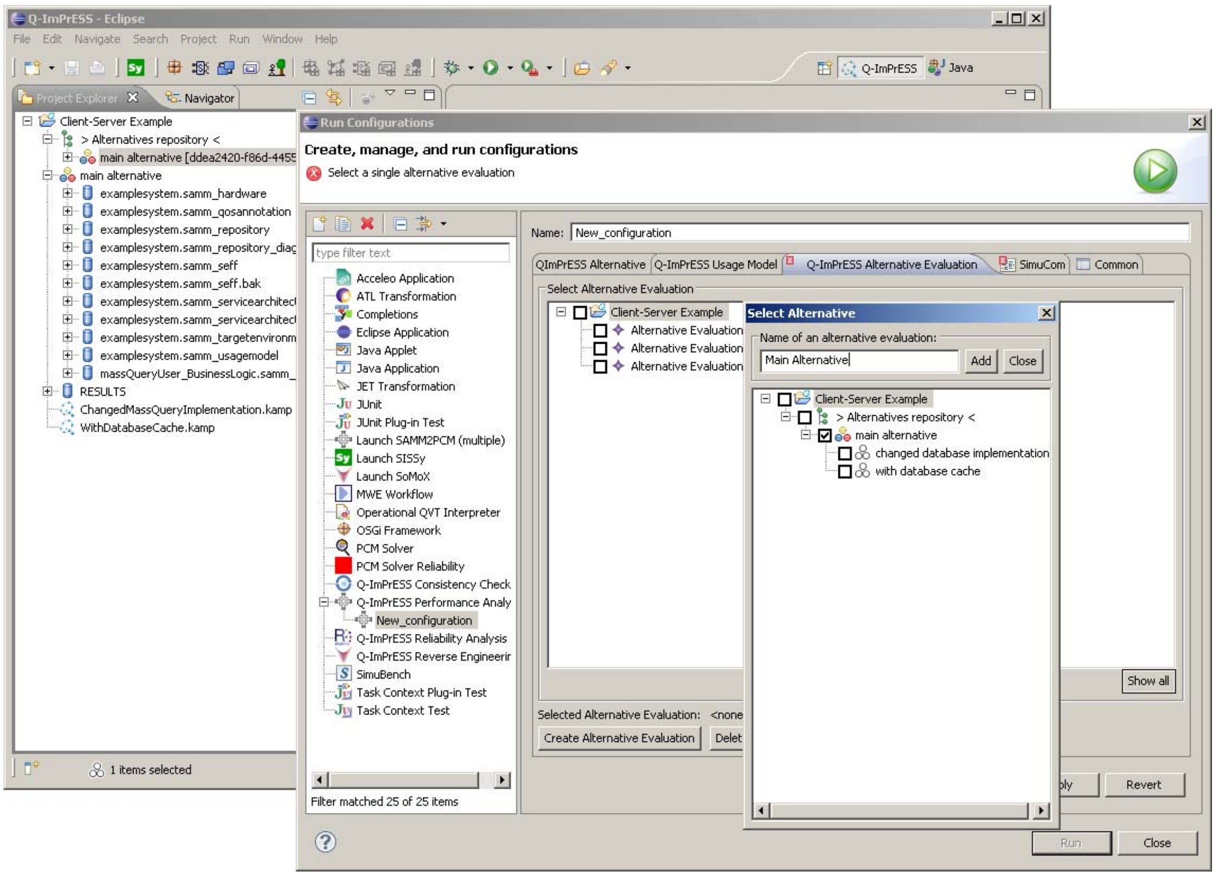
Name: New_configuration

☑ Usage Model UsageModel Main Alternative

Selected usage model: 'UsageModel Main Alternative' in 'main alternative'

Figure 74: Selecting the Usage Model for performance prediction

On the tab "Q-ImPrESS Alternative Evaluation", select the alternative evaluation in the Result Model in which the analysis results should be stored. By clicking on "Create Alternative Evaluation", you can specify new alternative evaluations in the subdialog (see Figure 75).



Run Configurations

Create, manage, and run configurations

Select a single alternative evaluation

Name: New_configuration

Select Alternative Evaluation

Client-Server Example
- Alternative Evaluation
- Alternative Evaluation
- Alternative Evaluation

Selected Alternative Evaluation: <none

Select Alternative

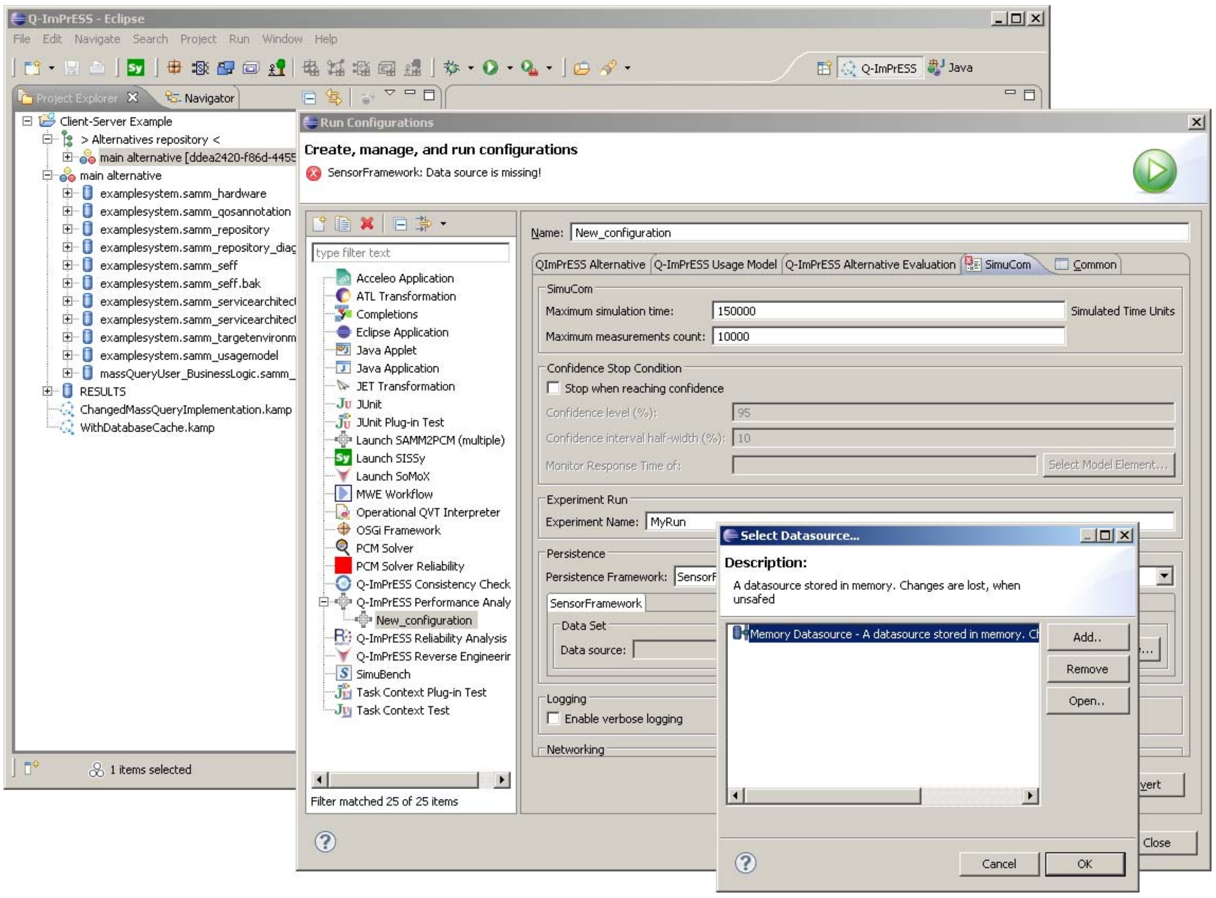
Name of an alternative evaluation: Main Alternative

Client-Server Example
- > Alternatives repository <
  - main alternative
    - changed database implementation
    - with database cache

Q-ImPrESS - Eclipse
File Edit Navigate Search Project Run Window Help
Project Explorer
Navigator
Q-ImPrESS
Java
Client-Server Example
> Alternatives repository <
main alternative [ddea2420-f86d-4455
main alternative
examplesystem.samm_hardware
examplesystem.samm_qosannotation
examplesystem.samm_repository
examplesystem.samm_repository_diag
examplesystem.samm_seff
examplesystem.samm_seff.bak
examplesystem.samm_servicearchitect
examplesystem.samm_servicearchitect
examplesystem.samm_targetenvironm
examplesystem.samm_usagemodel
massQueryUser_BusinessLogic.samm_
RESULTS
ChangedMassQueryImplementation.kamp
WithDatabaseCache.kamp
1 items selected
type filter text
Acceleo Application
ATL Transformation
Completions
Eclipse Application
Java Applet
Java Application
JET Transformation
JUnit
JUnit Plug-in Test
Launch SAMM2PCM (multiple)
Launch SISSy
Launch SoMoX
MWE Workflow
Operational QVT Interpreter
OSGi Framework
PCM Solver
PCM Solver Reliability
Q-ImPrESS Consistency Check
Q-ImPrESS Performance Analy
New_configuration
Q-ImPrESS Reliability Analysis
Q-ImPrESS Reverse Engineerir
SimuBench
Task Context Plug-in Test
Task Context Test
Filter matched 25 of 25 items
QImPrESS Alternative
Q-ImPrESS Usage Model
Q-ImPrESS Alternative Evaluation
SimuCom
Common
Add
Close
Show all
Create Alternative Evaluation
Delet
ply
Revert
Run
Close

Figure 75: Selecting the alternative evaluation for storing the performance prediction results

On the tab “SimuCom”, some necessary configuration for the PCM simulation engine has to be provided (see Figure 76). In the drop-down field “Persistence Framework”, select “SensorFramework”. To provide a valid run configuration, a data source has to be provided that stores the simulation results. This can be a file data source or a memory data source. New file data sources can be created in the subdialog.
If necessary, the maximum simulation time and number of measurements taken in the simulation can be adjusted. If the checkbox “Enable verbose logging” is checked, extensive logging output of the simulation engine is provided.
If you want to include detailed simulation of the networking resources, activate the check box “Simulate linking resources”.


Run Configurations

Create, manage, and run configurations

SensorFramework: Data source is missing!

Name: New_configuration

SimuCom
Maximum simulation time: 150000 Simulated Time Units
Maximum measurements count: 10000

Confidence Stop Condition
☐ Stop when reaching confidence
Confidence level (%): 95
Confidence interval half-width (%): 10
Monitor Response Time of:

Experiment Run
Experiment Name: MyRun

Persistence
Persistence Framework: SensorFramework

Data Set
Data source:

Logging
☐ Enable verbose logging

Networking

Select Datasource...
Description:
A datasource stored in memory. Changes are lost, when unsafed
Memory Datasource - A datasource stored in memory. C

Filter matched 25 of 25 items

1 items selected

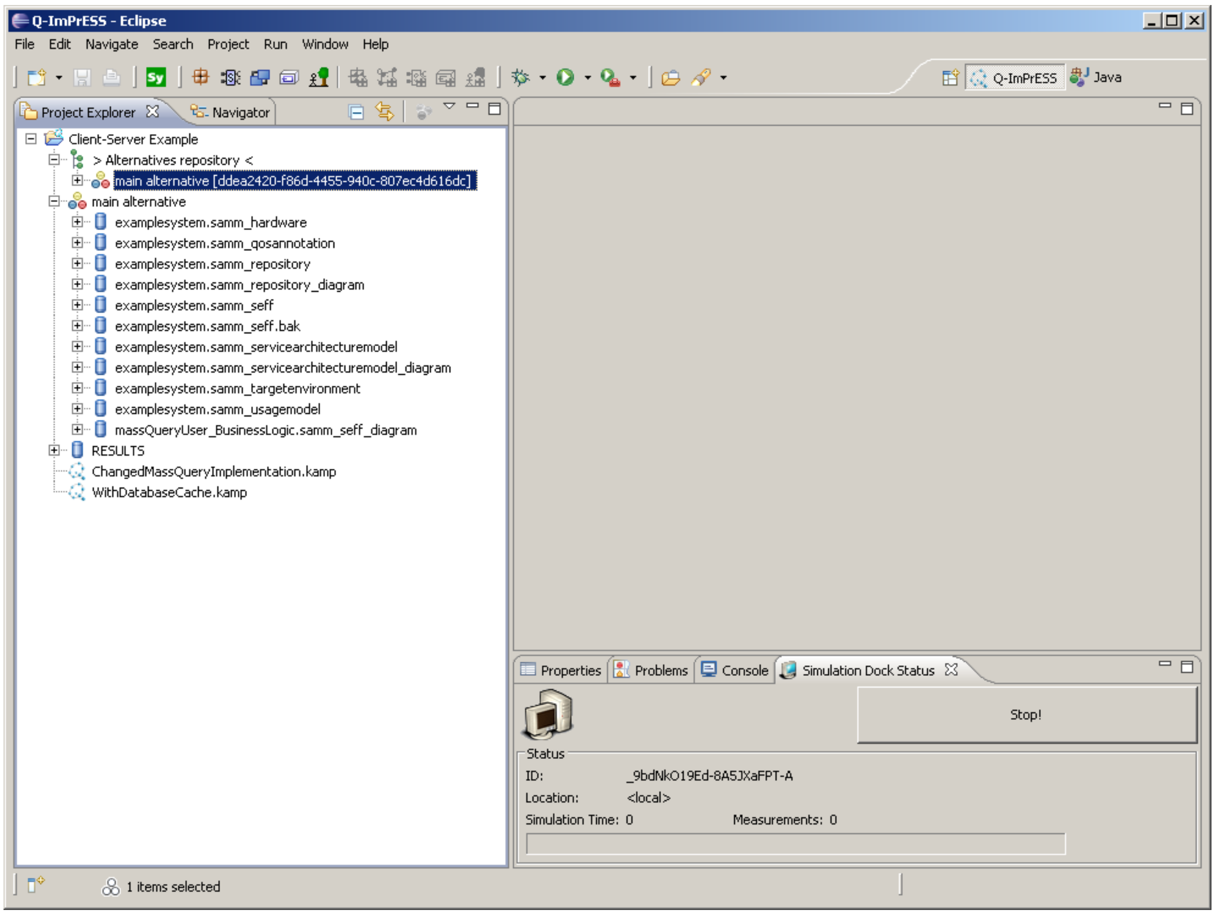
Q-ImPrESS - Eclipse
File Edit Navigate Search Project Run Window Help
Project Explorer
Navigator
Client-Server Example
> Alternatives repository <
main alternative [ddea2420-f86d-4455
main alternative
examplesystem.samm_hardware
examplesystem.samm_qosannotation
examplesystem.samm_repository
examplesystem.samm_repository_diag
examplesystem.samm_seff
examplesystem.samm_seff.bak
examplesystem.samm_servicearchitect
examplesystem.samm_servicearchitect
examplesystem.samm_targetenvironm
examplesystem.samm_usagemodel
massQueryUser_BusinessLogic.samm_
RESULTS
ChangedMassQueryImplementation.kamp
WithDatabaseCache.kamp
type filter text
Acceleo Application
ATL Transformation
Completions
Eclipse Application
Java Applet
Java Application
JET Transformation
JUnit
JUnit Plug-in Test
Launch SAMM2PCM (multiple)
Launch SISSy
Launch SoMoX
MWE Workflow
Operational QVT Interpreter
OSGi Framework
PCM Solver
PCM Solver Reliability
Q-ImPrESS Consistency Check
Q-ImPrESS Performance Analy
New_configuration
Q-ImPrESS Reliability Analysis
Q-ImPrESS Reverse Engineerir
SimuBench
Task Context Plug-in Test
Task Context Test
QImPrESS Alternative
Q-ImPrESS Usage Model
Q-ImPrESS Alternative Evaluation
SimuCom
Common
Select Model Element...
Add..
Remove
Open..
Cancel
OK
Close

Figure 76: Configuring the PCM simulation

4.9.5 Usage instructions and expected outputs

Running a created run configuration starts the performance prediction platform. The SAM model is being transformed into a PCM model. Once the PCM model has been created, the simulation starts immediately.

To see the simulation status, make sure the "Simulation Dock Status" is being displayed. This can be done by clicking "Window" → "Show View" → "Other…" and select the view "Simulation Dock Status" in the "Other" category. Figure 77 shows the simulation status view in the Q-ImPrESS IDE.

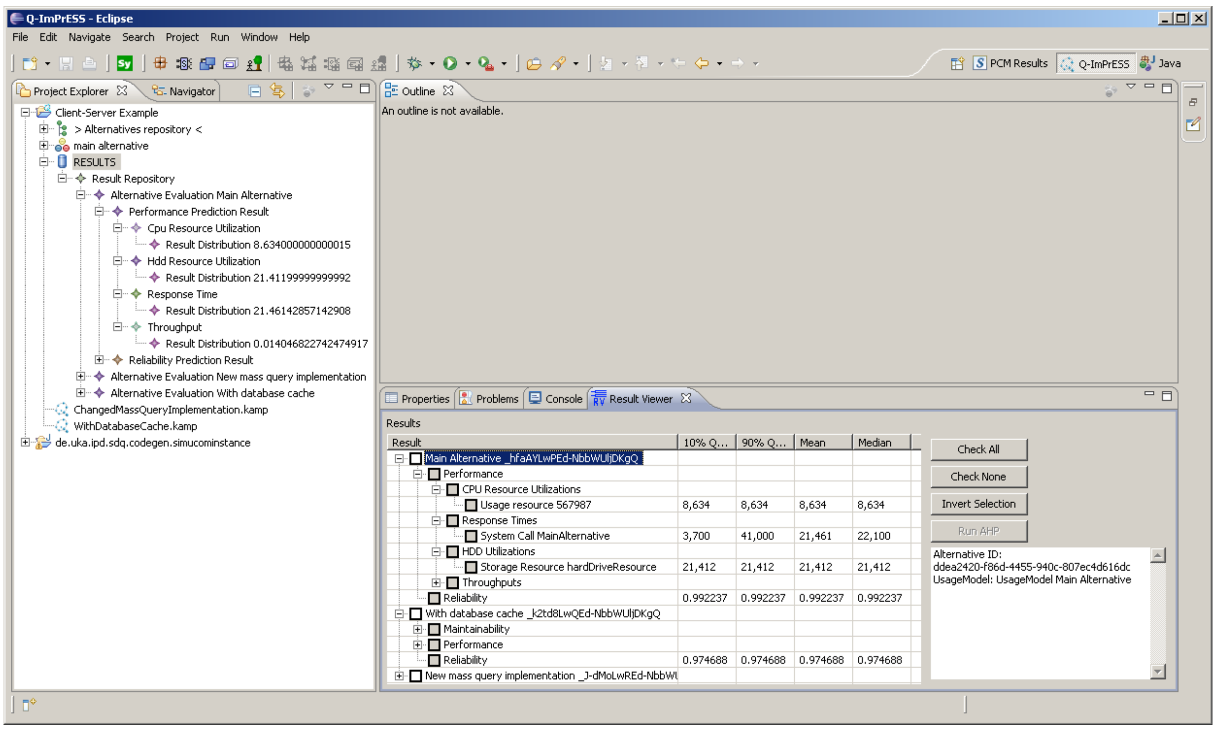


```
Client-Server Example
  > Alternatives repository <
    main alternative [ddea2420-f86d-4455-940c-807ec4d616dc]
  main alternative
    examplesystem.samm_hardware
    examplesystem.samm_qosannotation
    examplesystem.samm_repository
    examplesystem.samm_repository_diagram
    examplesystem.samm_seff
    examplesystem.samm_seff.bak
    examplesystem.samm_servicearchitecturemodel
    examplesystem.samm_servicearchitecturemodel_diagram
    examplesystem.samm_targetenvironment
    examplesystem.samm_usagemodel
    massQueryUser_BusinessLogic.samm_seff_diagram
  RESULTS
  ChangedMassQueryImplementation.kamp
  WithDatabaseCache.kamp
```

```
Status
ID:              _9bdNkO19Ed-8A5JXaFPT-A
Location:        <local>
Simulation Time: 0              Measurements: 0
```

Figure 77: The simulation status view for a performance prediction run

After the simulation run has completed, the results can be displayed. Open the results repository in the Q-ImPrESS project explorer by right-clicking on “RESULTS” and selecting “Open ResultViewer”. In the result viewer (see Figure 78), different performance analysis results are displayed, such as usage model response time and throughput, as well as resource utilizations. For every result, different statistical values are given (mean, median, 10% quantile and 90% quantile). A detailed description of the Q-ImPrESS results viewer can be found in Section 4.12.



```
Client-Server Example
  > Alternatives repository <
  main alternative
  RESULTS
    Result Repository
      Alternative Evaluation Main Alternative
        Performance Prediction Result
          Cpu Resource Utilization
            Result Distribution 8.634000000000015
          Hdd Resource Utilization
            Result Distribution 21.41199999999992
          Response Time
            Result Distribution 21.46142857142908
          Throughput
            Result Distribution 0.014046822742474917
        Reliability Prediction Result
      Alternative Evaluation New mass query implementation
      Alternative Evaluation With database cache
  ChangedMassQueryImplementation.kamp
  WithDatabaseCache.kamp
de.uka.ipd.sdq.codegen.simucominstance
```

An outline is not available.

Results

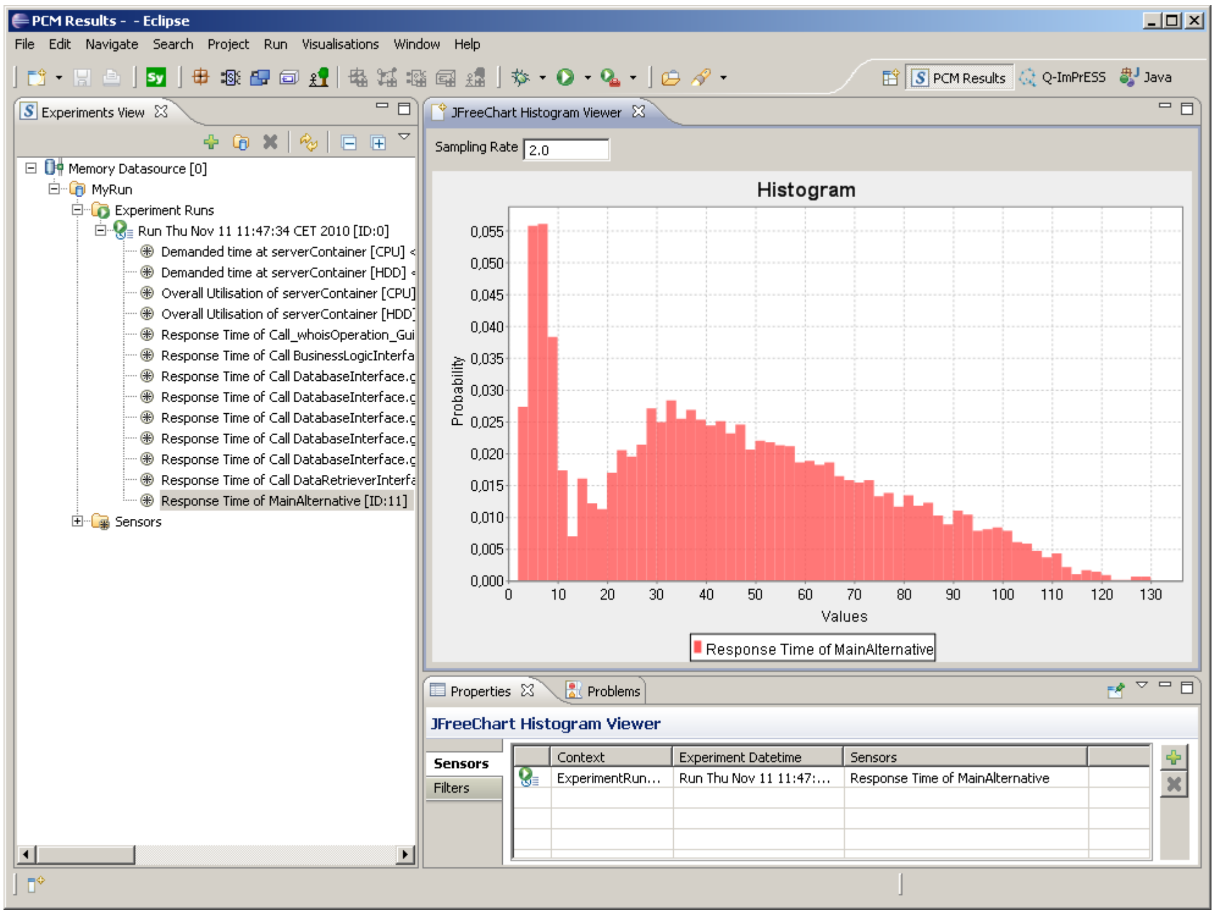
Result	10% Q...	90% Q...	Mean	Median
Main Alternative _hfaAYLwPEd-NbbWUljDKgQ				
Performance				
CPU Resource Utilizations				
Usage resource 567987	8,634	8,634	8,634	8,634
Response Times				
System Call MainAlternative	3,700	41,000	21,461	22,100
HDD Utilizations				
Storage Resource hardDriveResource	21,412	21,412	21,412	21,412
Throughputs				
Reliability	0.992237	0.992237	0.992237	0.992237
With database cache _k2td8LwQEd-NbbWUljDKgQ				
Maintainability				
Performance				
Reliability	0.974688	0.974688	0.974688	0.974688
New mass query implementation _J-dMoLwREd-NbbWU				

Alternative ID:
ddea2420-f86d-4455-940c-807ec4d616dc
UsageModel: UsageModel Main Alternative

Figure 78: Performance prediction results in the Q-ImPrESS Results Viewer

If you want to have a detailed look on the performance simulation results, you can open the PCM simulation results. Open the simulation results perspectives by clicking “Window” → “Open Perspective” → “Other…”. Select the “PCM Results” perspective.

In the “Experiments View”, the specified data sources are displayed. Select the specified data source of the simulation run. The data source contains the results of the simulation runs. For a performance simulation, these results are stored in sensors. For all operations and usage scenario, the response time is stored, for all resources, the utilization is stored.


PCM Results - - Eclipse
File Edit Navigate Search Project Run Visualisations Window Help
PCM Results
Q-ImPrESS
Java
Experiments View
JFreeChart Histogram Viewer
Sampling Rate 2.0
Histogram
Probability
Values
Response Time of MainAlternative
Properties
Problems
JFreeChart Histogram Viewer
Sensors
Filters

Memory Datasource [0]
MyRun
Experiment Runs
Run Thu Nov 11 11:47:34 CET 2010 [ID:0]
Demanded time at serverContainer [CPU] <
Demanded time at serverContainer [HDD] <
Overall Utilisation of serverContainer [CPU]
Overall Utilisation of serverContainer [HDD]
Response Time of Call_whoisOperation_Gui
Response Time of Call BusinessLogicInterfa
Response Time of Call DatabaseInterface.g
Response Time of Call DatabaseInterface.g
Response Time of Call DatabaseInterface.g
Response Time of Call DatabaseInterface.g
Response Time of Call DatabaseInterface.g
Response Time of Call DataRetrieverInterfa
Response Time of MainAlternative [ID:11]
Sensors

Context	Experiment Datetime	Sensors
ExperimentRun...	Run Thu Nov 11 11:47:...	Response Time of MainAlternative

Figure 79: Detailed performance prediction results in the PCM results visualisation

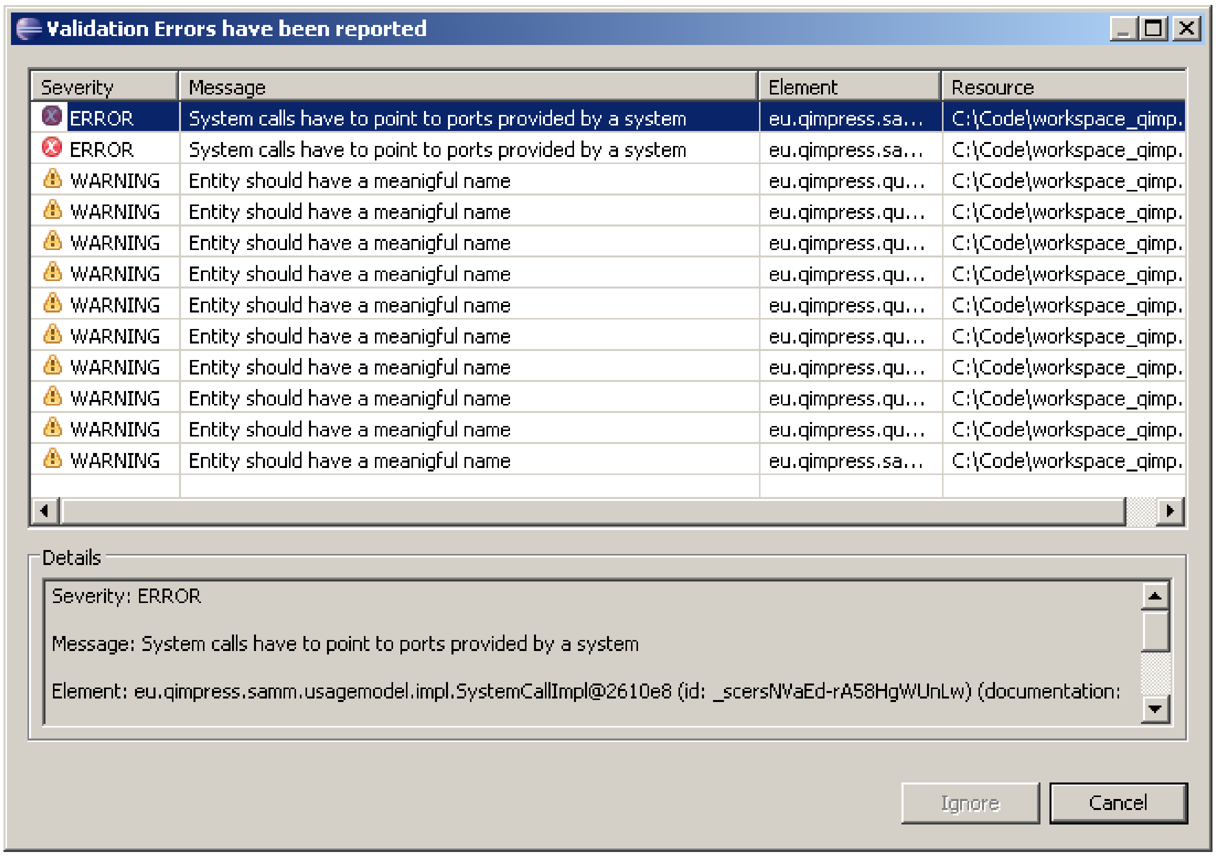
For a response time, different result presentations are possible. A meaningful display of results is the “Response Time Histogram” or the “Response Time Histogram-based CDF”. Double-click on the response time sensor in order to select the kind of display. Figure 79 shows the response time of a usage scenario as a histogram.

For a resource, the utilization can be displayed as a pie chart.

4.9.6 Caveats

The performance analysis cannot be performed if the model to analyse is not valid. In this case, a list of error messages is shown in a pop-up window when initiating performance prediction run (see Figure 80).

Displayed warnings can be ignored, but should be fixed in order to enhance the comprehensibility of the models. Errors cannot be ignored, but must be fixed.



Severity	Message	Element	Resource
ERROR	System calls have to point to ports provided by a system	eu.qimpress.sa...	C:\Code\workspace_qimp.
ERROR	System calls have to point to ports provided by a system	eu.qimpress.sa...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.qu...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.qu...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.qu...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.qu...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.qu...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.qu...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.qu...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.qu...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.qu...	C:\Code\workspace_qimp.
WARNING	Entity should have a meanigful name	eu.qimpress.sa...	C:\Code\workspace_qimp.

Details

```
Severity: ERROR

Message: System calls have to point to ports provided by a system

Element: eu.qimpress.samm.usagemodel.impl.SystemCallImpl@2610e8 (id: _scersNVaEd-rA58HgWUnLw) (documentation:
```

Figure 80: Detected warnings and errors for a Q-ImPrESS model during a performance prediction run

4.10 Reliability Prediction Manual

4.10.1 Purpose of the tool

The reliability analysis in Q-ImPrESS supports engineers to compute reliability information about complex systems. It enables engineers to extract the reliability of a service from the description of the system and a specific usage model.
The Q-ImPrESS platform provides an automated workflow for that purpose starting from a Service Architectural Model.

4.10.2 Tool relationship with the Q-ImPrESS workflow

The reliability prediction participates in the process of predicting the system quality in the Q-ImPrESS workflow (see Figure 81).

After a Service Architectural Model has been created either by reverse-engineering or forward-modelling, the reliability analysis can be performed by the Q-ImPrESS platform.
The analysis results can be inspected in the integrated Q-ImPrESS UI or be used as input for the trade-off analysis.

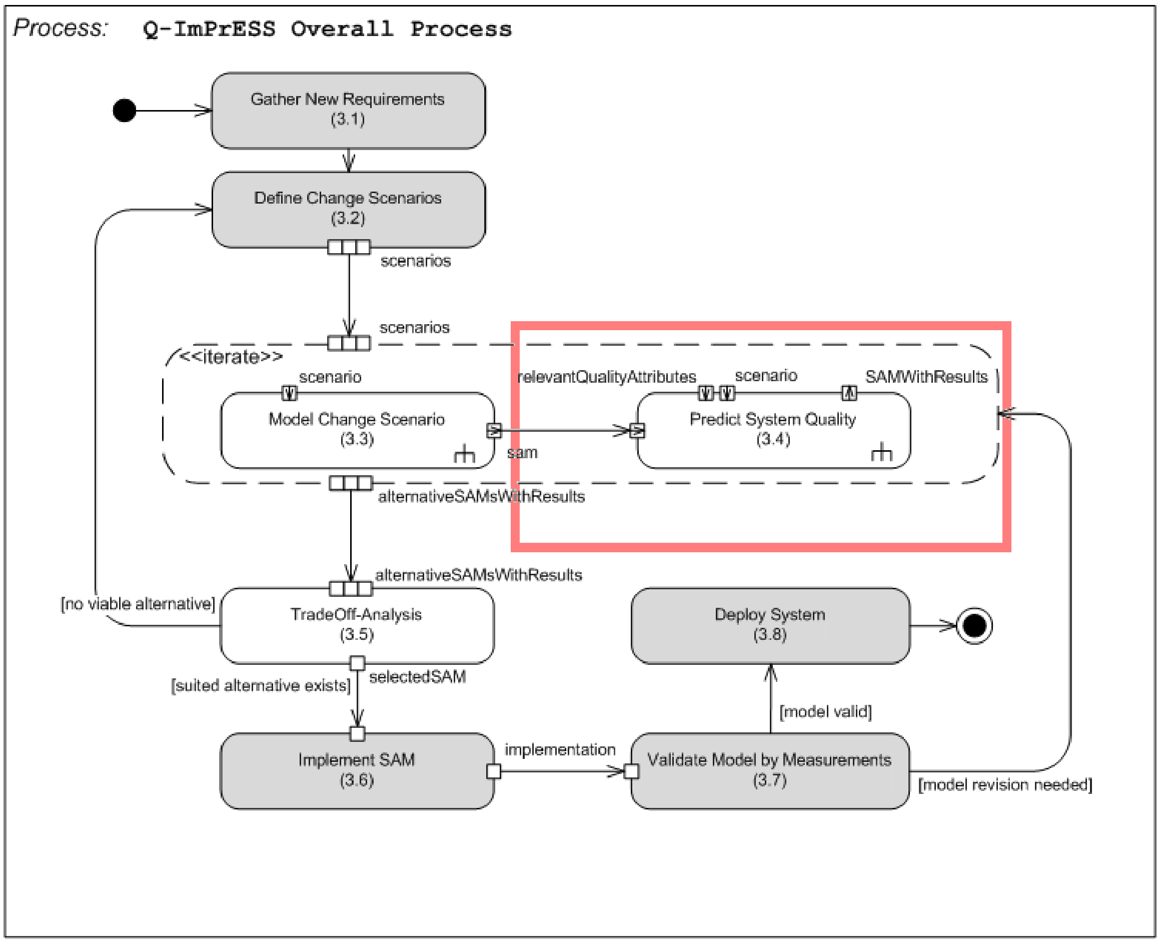

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
Model Change Scenario (3.3)
sam
relevantQualityAttributes
scenario
SAMWithResults
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
[suited alternative exists]
selectedSAM
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model valid]
[model revision needed]
Deploy System (3.8)

Figure 81: Predicting system quality (copied from D6.1)

4.10.3 Tool prerequisites

To run a reliability analysis, a model of the system must be first designed. In detail, the reliability analysis takes as input a specific Q-ImPrESS model.

4.10.4 Tool activation

To run the reliability analysis for a model alternative, the following steps have to be performed:

First, open the run configuration window of eclipse. From the menu, select “Run” → “Run Configurations...”.
Create a new “Q-ImPrESS Reliability Analysis” launch configuration.
In the launch configuration, select the alternative to analyse from the tree menu in the “QImPrESS Alternative” tab (see Figure 82).

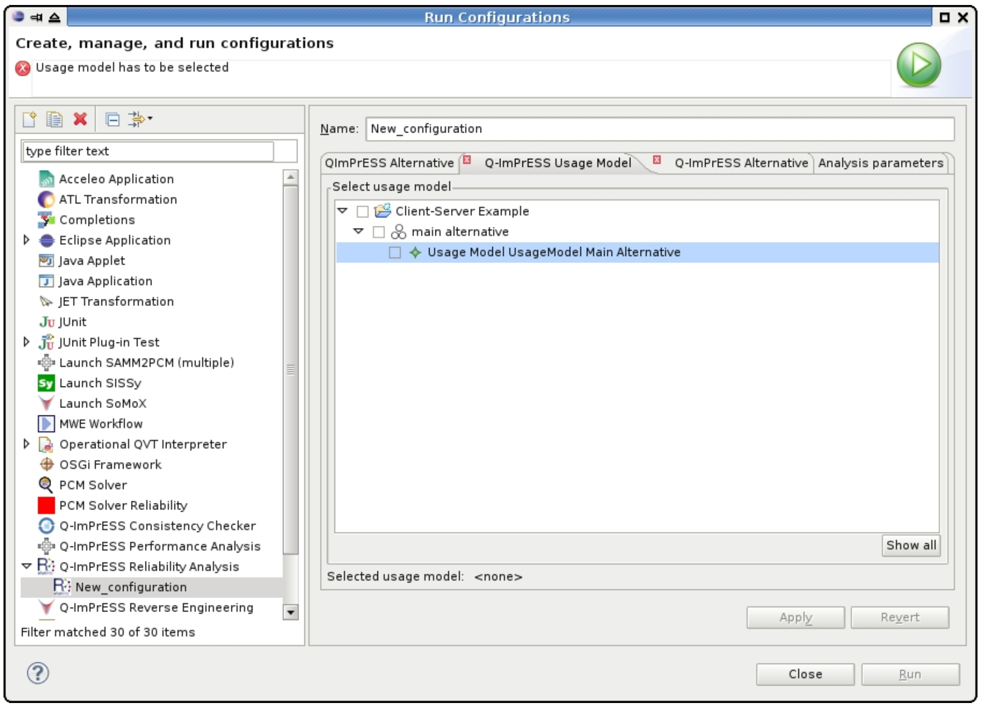
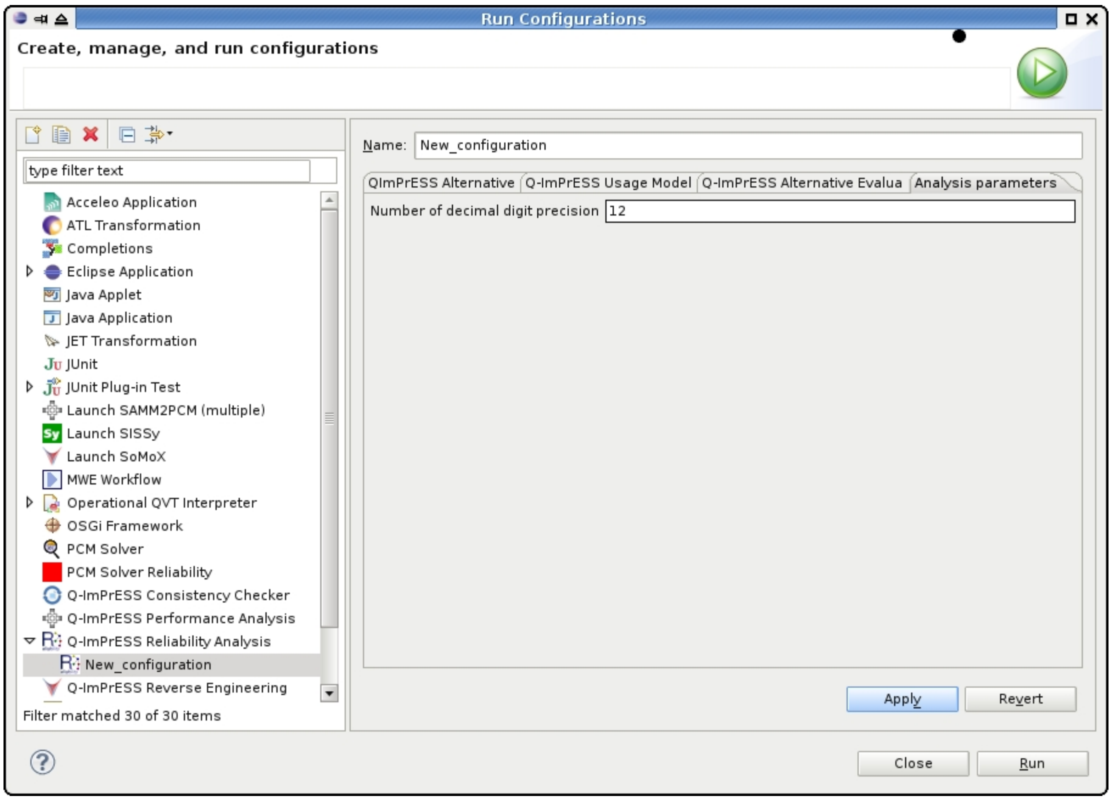


Figure 82: Selecting a Q-ImPrESS alternative for reliability prediction

Select the usage scenario to analyse from the tree menu in the "Q-ImPrESS Usage Model" tab (see Figure 83).


Run Configurations

Create, manage, and run configurations

type filter text

- Acceleo Application
- ATL Transformation
- Completions
- Eclipse Application
- Java Applet
- Java Application
- JET Transformation
- JUnit
- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- PCM Solver Reliability
- Q-ImPrESS Consistency Checker
- Q-ImPrESS Performance Analysis
- Q-ImPrESS Reliability Analysis
  - New_configuration
- Q-ImPrESS Reverse Engineering

Filter matched 30 of 30 items

Name: New_configuration

QImPrESS Alternative | Q-ImPrESS Usage Model | Q-ImPrESS Alternative Evalua | Analysis parameters

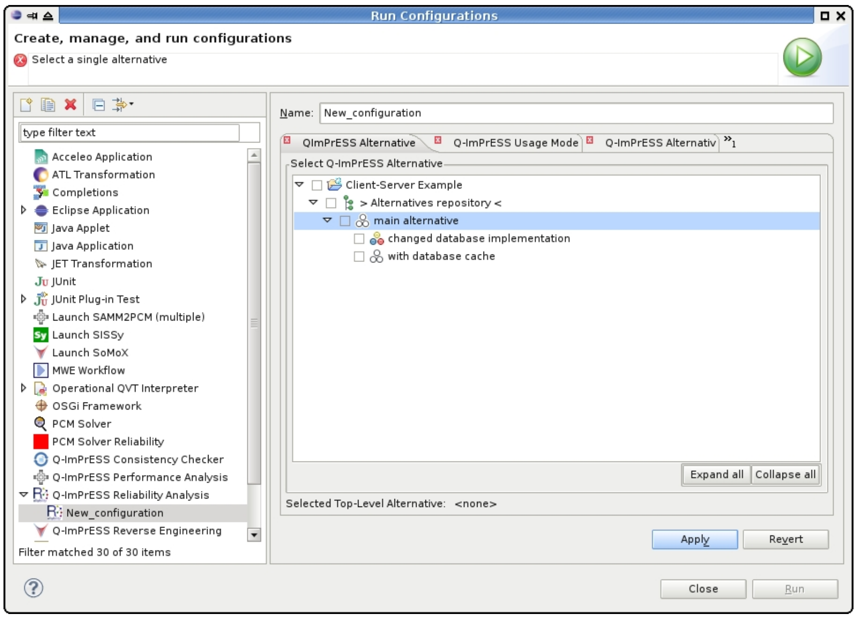
Number of decimal digit precision: 12

Apply | Revert

Close | Run

Figure 83: Selecting the Usage Model for reliability prediction

Select the alternative evaluation where the analysis result will be stored from the tree menu in the "QImPrESS Alternative Result" tab (see Figure 84).


Run Configurations

Create, manage, and run configurations

Select a single alternative

type filter text

- Acceleo Application
- ATL Transformation
- Completions
- Eclipse Application
- Java Applet
- Java Application
- JET Transformation
- JUnit
- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- PCM Solver Reliability
- Q-ImPrESS Consistency Checker
- Q-ImPrESS Performance Analysis
- Q-ImPrESS Reliability Analysis
  - New_configuration
- Q-ImPrESS Reverse Engineering

Filter matched 30 of 30 items

Name: New_configuration

QImPrESS Alternative | Q-ImPrESS Usage Mode | Q-ImPrESS Alternativ | »1

Select Q-ImPrESS Alternative

- Client-Server Example
  - > Alternatives repository <
    - main alternative
      - changed database implementation
      - with database cache

Expand all | Collapse all

Selected Top-Level Alternative: <none>

Apply | Revert

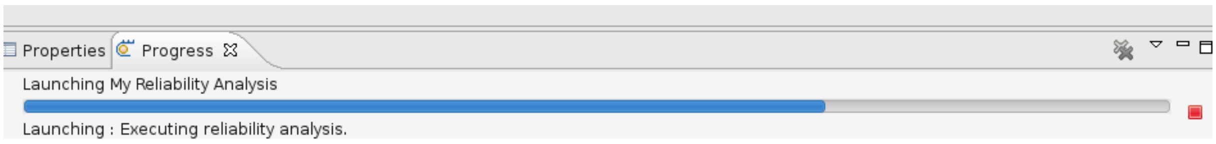
Close | Run

Figure 84: Selecting the alternative evaluation for storing the reliability prediction results

Set the precision of the reliability result value in the text field of the "Analysis parameters" tab. Save the configuration and launch it to run the reliability analysis.

4.10.5 Usage instructions and expected outputs

When the analysis is being run, you can see the progress in the Progress Window of Eclipse (see Figure 85).

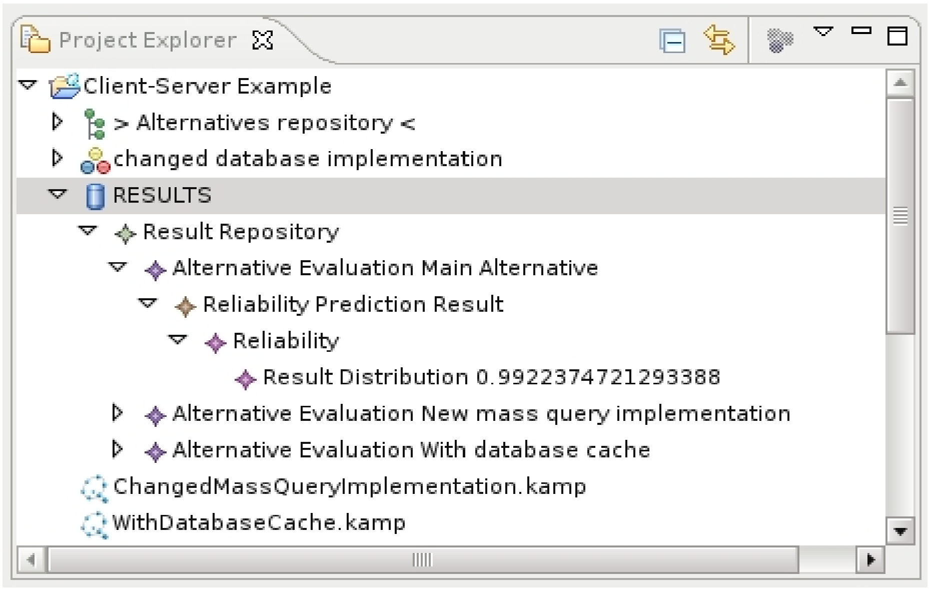


Launching My Reliability Analysis
Launching : Executing reliability analysis.

Figure 85: The analysis status view for a reliability prediction run

After the analysis has been executed, the result is saved into the result archive of the analysed Q-ImPrESS project. In particular, the result is available under the chosen alternative evaluation as shown in Figure 86.

The result value represents the predicted global reliability value for the system alternative under the specified usage scenario.



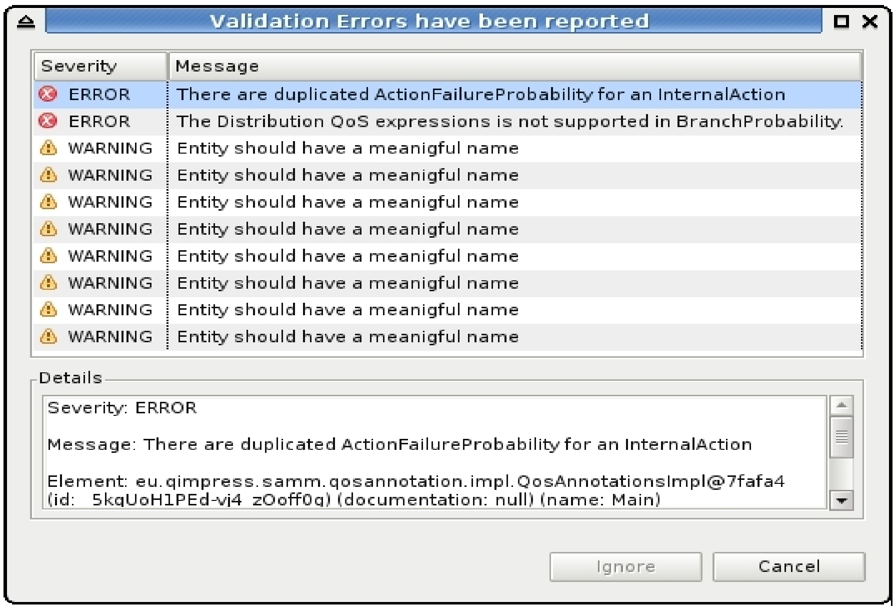
Client-Server Example
> Alternatives repository <
changed database implementation
RESULTS
Result Repository
Alternative Evaluation Main Alternative
Reliability Prediction Result
Reliability
Result Distribution 0.9922374721293388
Alternative Evaluation New mass query implementation
Alternative Evaluation With database cache
ChangedMassQueryImplementation.kamp
WithDatabaseCache.kamp

Figure 86: The reliability prediction results in the Q-ImPrESS project result model

4.10.6 Caveats

The reliability analysis cannot be performed if the model to analyse is not valid. In this case, a list of error messages is shown in a pop-up window when initiating a reliability prediction run (see Figure 87).

Displayed warnings can be ignored, but should be fixed in order to enhance the comprehensibility of the models. Errors cannot be ignored, but must be fixed.



Severity	Message
ERROR	There are duplicated ActionFailureProbability for an InternalAction
ERROR	The Distribution QoS expressions is not supported in BranchProbability.
WARNING	Entity should have a meanigful name
WARNING	Entity should have a meanigful name
WARNING	Entity should have a meanigful name
WARNING	Entity should have a meanigful name
WARNING	Entity should have a meanigful name
WARNING	Entity should have a meanigful name
WARNING	Entity should have a meanigful name
WARNING	Entity should have a meanigful name

Details

```
Severity: ERROR

Message: There are duplicated ActionFailureProbability for an InternalAction

Element: eu.qimpress.samm.qosannotation.impl.QosAnnotationsImpl@7fafa4
(id:  5kqUoH1PEd-vj4_zOoff0g) (documentation: null) (name: Main)
```

Figure 87: Detected warnings and errors for a Q-ImPrESS model during a reliability prediction run

4.11 Maintainability Prediction Manual

4.11.1 Purpose of the tool

The tool implements the KAMP method, i. e. Karlsruhe Architectural Maintainability Prediction. The purpose of the tool is to enable software architects to predict the maintainability of a software system using its architectural model. The core part is support for a guided estimation of change efforts. In order to predict maintainability the approach determines efforts estimates for implementing evolution scenarios.

4.11.2 Tool relationship with the Q-ImPrESS workflow

The maintainability prediction participates in the process of predicting the system quality in the Q-ImPrESS workflow (see Figure 88).
As inputs it uses the architecture alternatives that are located in Q-ImPrESS projects within the workspace of the Q-ImPrESS IDE. More exactly, it semi-automatically derives maintenance activities based on a created Service Architecture Model. As output it delivers a description of change in shape of a workplan and related effort estimates.

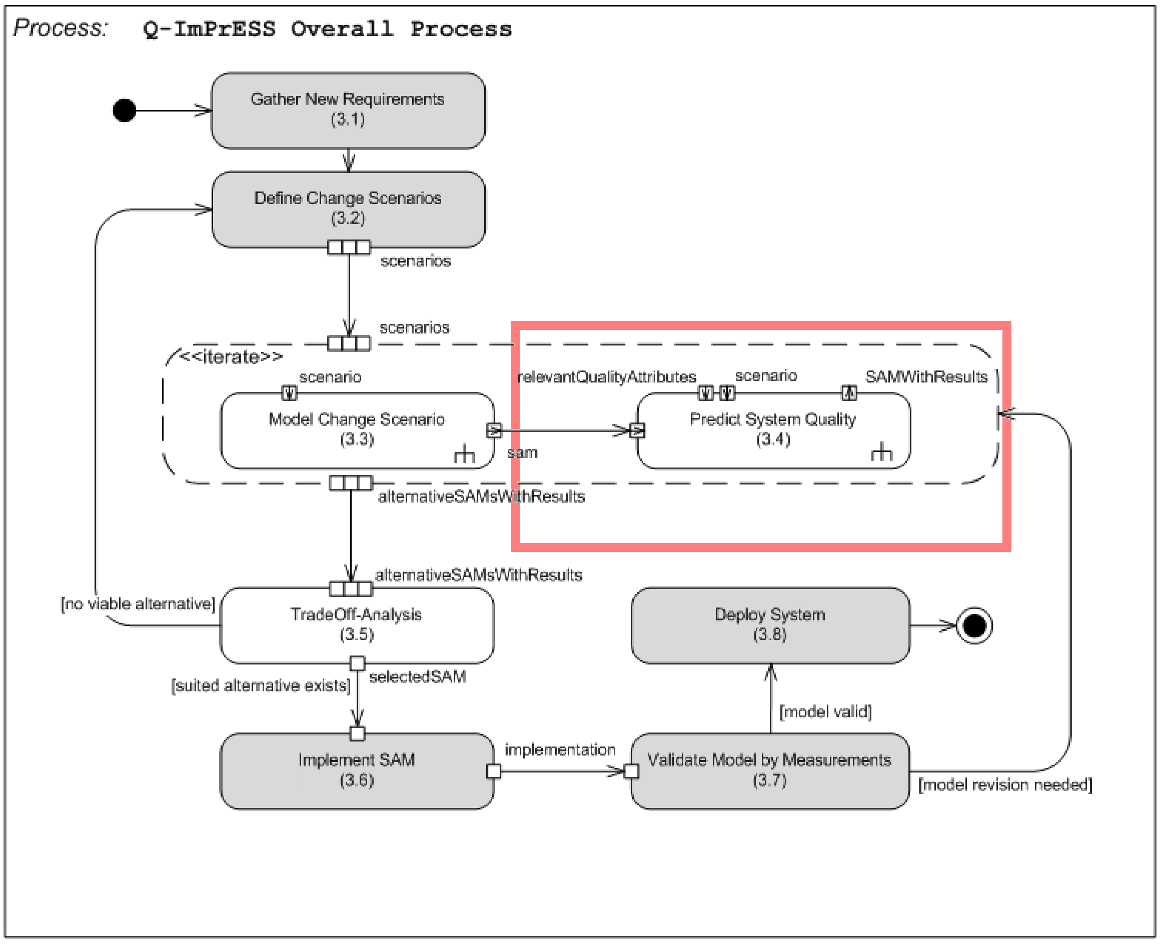

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
Model Change Scenario (3.3)
sam
relevantQualityAttributes
scenario
SAMWithResults
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
[suited alternative exists]
selectedSAM
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]
[model valid]
Deploy System (3.8)

Figure 88: Predicting system quality (copied from D6.1)

4.11.3 Tool usage

In the following, we use the Client-Server example project to illustrate how to use the KAMP tool for maintainability prediction.

Create new KAMP model file

In the beginning one needs to create a KAMP analysis model file by using a new file wizard.

Select “New” → Other...” in the context menu of a Q-ImPrESS project (see Figure 89).

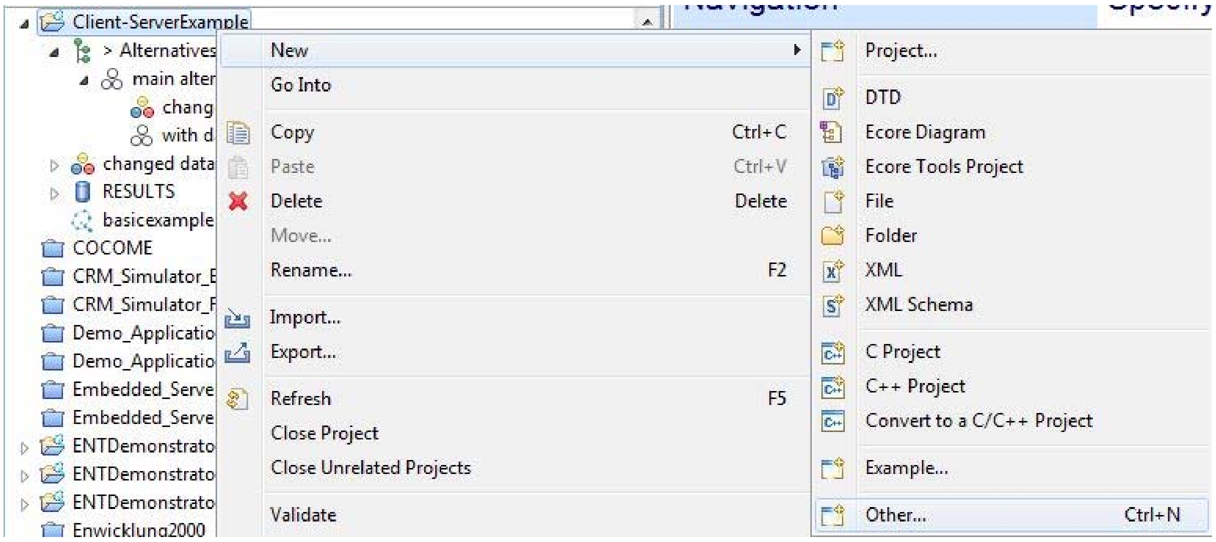


Figure 89: Creating a new KAMP model file: Open “New” dialog

Select the category “KAMP Models”, and the entry “KAMP Maintainability Analysis Model” (see Figure 90). The KAMP file contains everything which is necessary to manage maintainability analysis.

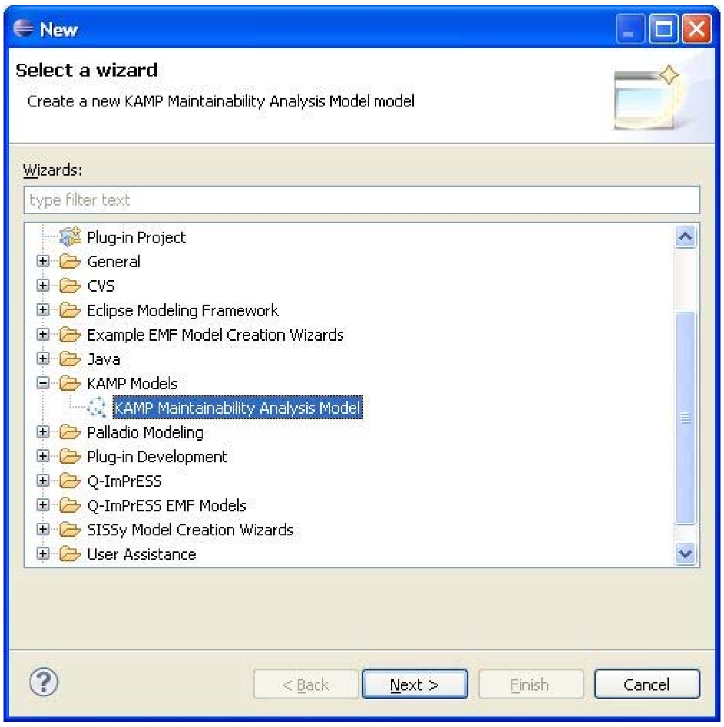


Figure 90: Creating a new KAMP model file: Select the KAMP Maintainability Analysis Model Wizard

On the next dialog page, select the Q-ImPrESS project for which a maintainability prediction should be performed, and enter a file name for the analysis model file (see Figure 91).

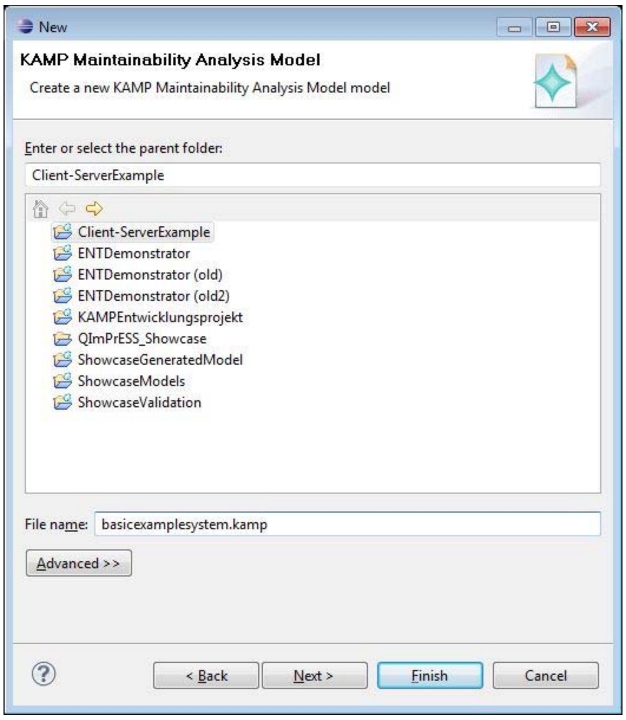


Figure 91: Creating a new KAMP model file: Specify a file name

Leave the next dialog page as it is. Click "Finish" to create the model file.

Navigation bar

The file is opened in a separate editor that has a navigation bar on the left side (see Figure 92). The navigation bar can be used to reach preparation and analysis steps of maintainability prediction.

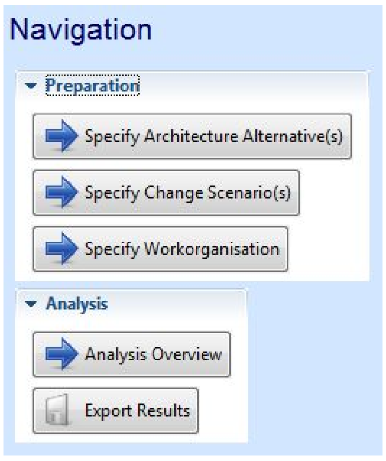
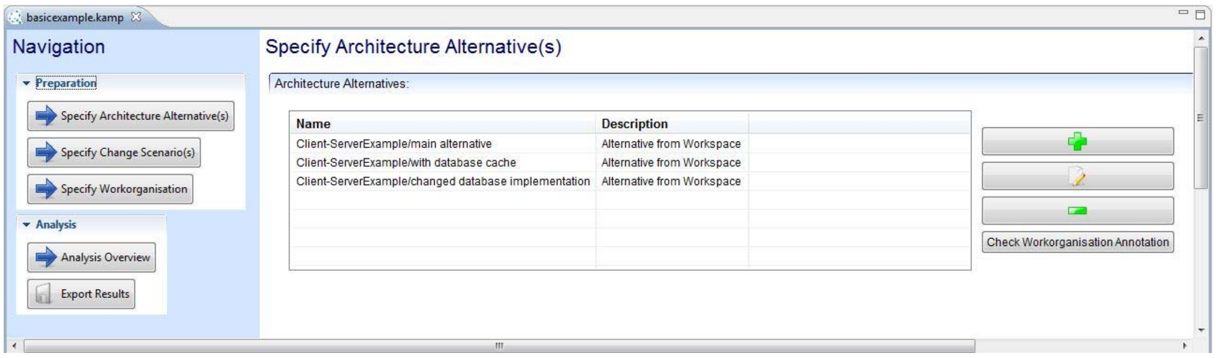


Figure 92: The navigation bar in the maintainability model editor

Specify architecture alternatives

The first button of the preparation section "Specify Architecture Alternative(s)" leads to a specification page for architecture alternatives (see Figure 93). This page is per default filled with the alternatives present in the current Q-ImPrESS project.


basicexample.kamp
Navigation
Preparation
Specify Architecture Alternative(s)
Specify Change Scenario(s)
Specify Workorganisation
Analysis
Analysis Overview
Export Results
Specify Architecture Alternative(s)
Architecture Alternatives:
Check Workorganisation Annotation

Name	Description
Client-ServerExample/main alternative	Alternative from Workspace
Client-ServerExample/with database cache	Alternative from Workspace
Client-ServerExample/changed database implementation	Alternative from Workspace

Figure 93: The editor page for specifying architecture alternatives

Architecture alternatives can also be manually added, edited or deleted via the corresponding button on the right side of the architecture alternative table.

As illustrated in the figure, for our basic example the alternatives are automatically listed.

Note: If architecture alternatives are not automatically listed, try to open the KAMP file from the "Project Explorer View".

Specify change scenarios

The second button in the preparation section "Specify Change Scenario(s)" shows a specification page for change scenarios (see Figure 94). Change scenario specifications are short descriptions of changes that occur in the system. The objective is to estimate the effort necessary for implementing change scenarios in architecture alternatives. A change scenario specification consists of a name and a textual description of the change.

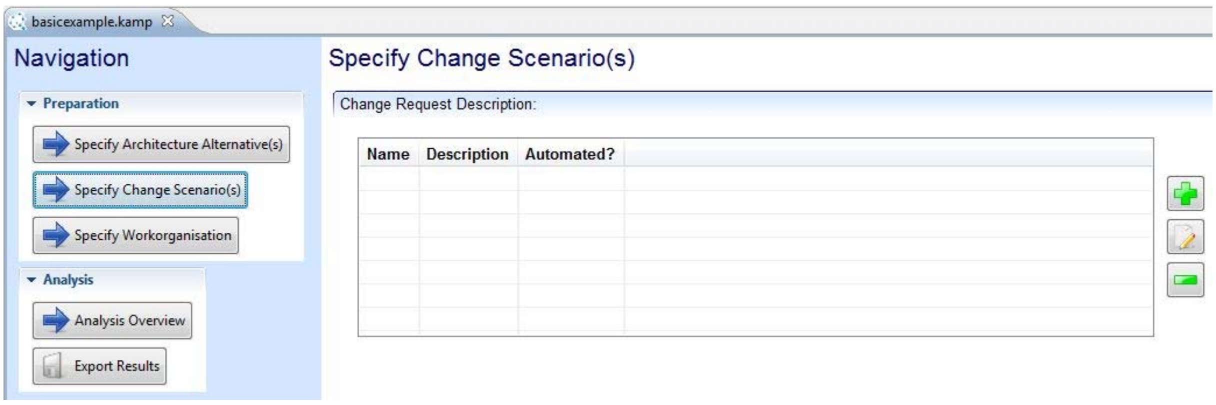


Figure 94: The editor page for specifying change scenarios

In order to add a change scenario specification press add button (+). Enter a name and a description of the change scenario (see Figure 95).

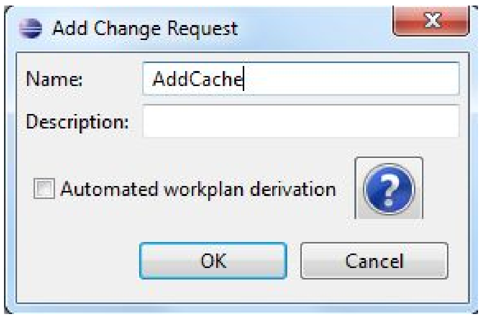
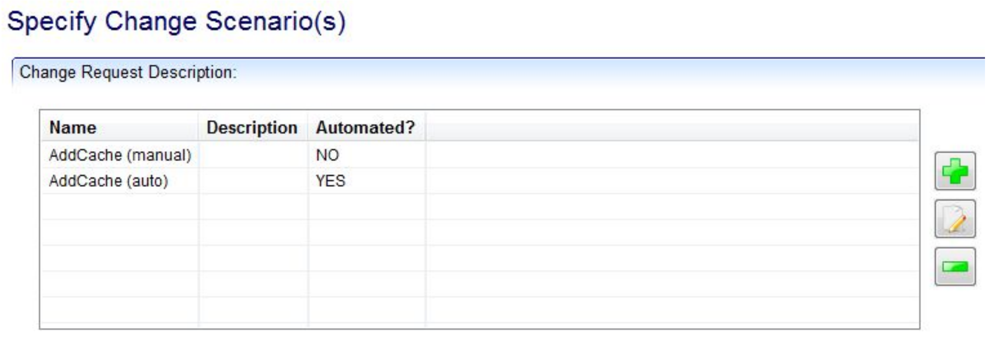


Figure 95: Adding a change request

KAMP derives a workplan which contains the activities for implementing the change scenario. This can be done in two different ways. 1) The first way is to run through a wizard dialog that asks what changes occur and helps to identify follow-up changes. 2) The second way is to model the changes in a sub-alternative in the Q-ImPrESS editor. KAMP then calculates the differences automatically and derives the workplan from the differences.

When adding a change scenario, a checkbox "Automated workplan derivation" is provided for selecting whether the workplan should be automatically derived from a sub-alternative or by running a wizard dialog.

For illustration purposes we added two change scenarios one with and one without automatic derivation (see Figure 96).


Specify Change Scenario(s)

Change Request Description:

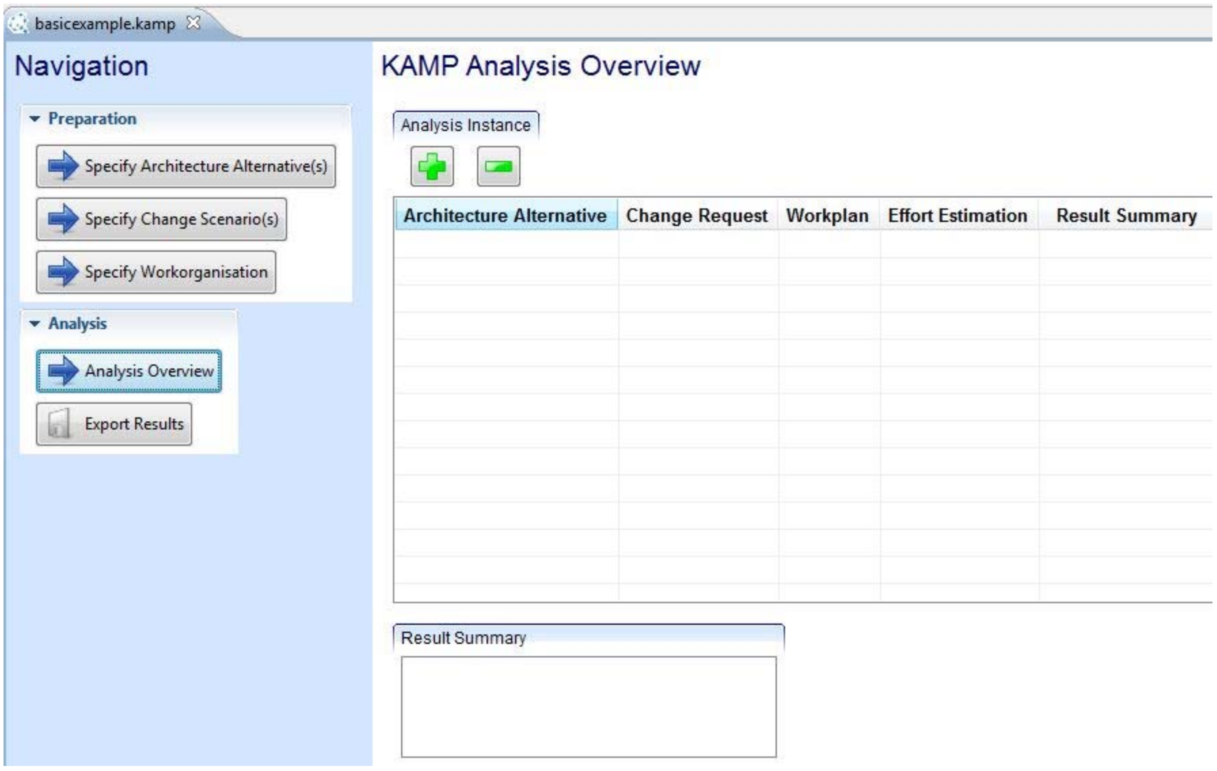
Name	Description	Automated?
AddCache (manual)		NO
AddCache (auto)		YES

Figure 96: Added change scenarios

Note: A this point there is no explicit mapping from change scenario to architecture alternative needed. This will be investigated in the first analysis step (i.e. workplan derivation).

Analysis overview

The first button in the analysis section ("Analysis Overview") of the navigation bar opens an overview of analysis instances (see Figure 97). Each analysis instance specifies a pair made of an architecture alternative and a change scenario for which the change effort should be determined. Each line in the overview table represents an analysis instance. Analysis instances can be added and removed by using the buttons (+, -) above the overview table, respectively.



Architecture Alternative	Change Request	Workplan	Effort Estimation	Result Summary

Figure 97: The analysis overview editor page

In order to add an analysis instance, press the add button (+) in order to open the dialog shown in Figure 98.

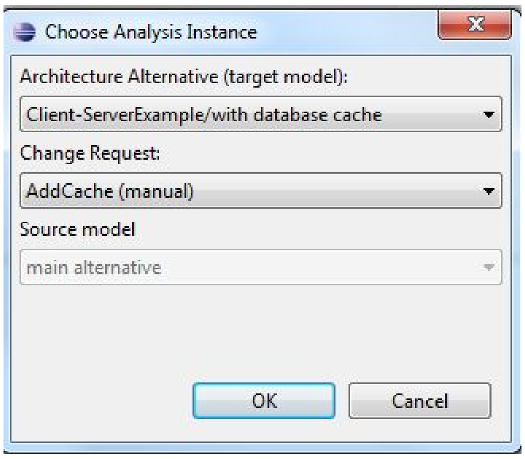
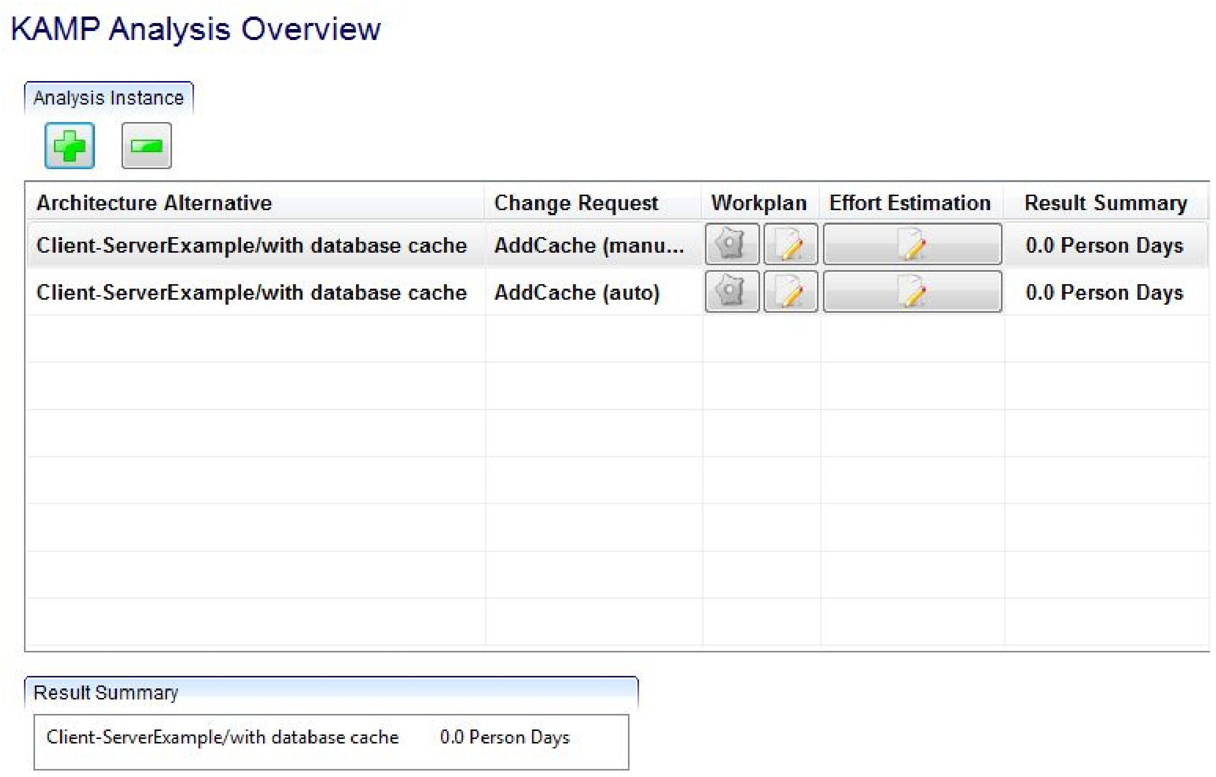


Figure 98: Adding an analysis instance to the analysis overview

In the first combo box, the target architecture model, for which the changes are described, has to be selected. In the second combo box, the change request that should be applied has to be selected.
In case of automatic derivation from sub-alternatives, KAMP calculates differences between source model and target model. In this case in the third combo-box the parent alternatives can be selected as source alternative. Differences are calculated between source and target.

In the Client-Server example visible in Figure 99, two analysis instances have been added. Both instances use the system with database cache as target alternative. The instance in the first line uses the manual change scenario, whereas the instance in the second line uses the automatic change scenario.


KAMP Analysis Overview

Analysis Instance

Architecture Alternative	Change Request	Workplan	Effort Estimation	Result Summary
Client-ServerExample/with database cache	AddCache (manu...			0.0 Person Days
Client-ServerExample/with database cache	AddCache (auto)			0.0 Person Days

Result Summary

Client-ServerExample/with database cache	0.0 Person Days

Figure 99: Analysis overview with added analysis instances

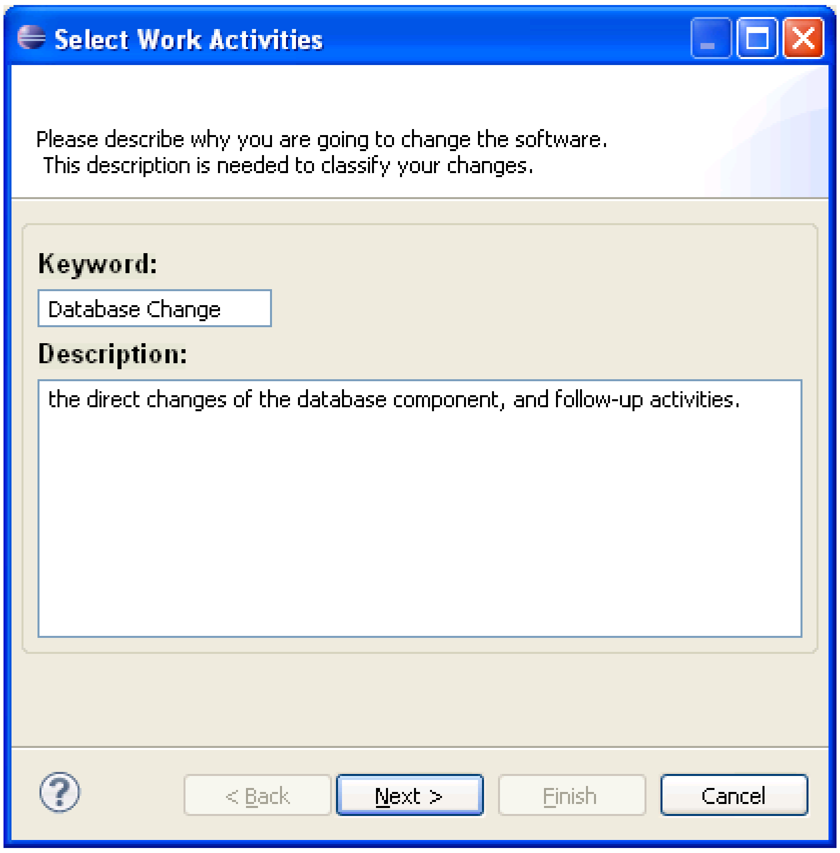
The analysis steps are enumerated in the columns. Each alternative has buttons for “Deriving Work Plan” (wheel symbol), “Editing Workplan” and (Bottom-Up-) “Effort Estimation”. In the last column a “Result Summary” in terms of “Person Days” is shown.

Workplan derivation by wizard dialog

At this point an analysis instance should be specified. Hence in the analysis overview a line should be present providing buttons for derivation and editing of workplans and effort estimation. The derivation itself is triggered by pressing the cogwheel button. In this section we look at the case when workplan derivation is done by running a wizard dialog. Automatic Workplan derivation is covered in the following section. Pressing the cogwheel button opens a wizard dialog.

Specify composite activity

In the first wizard page you have to specify a semantic rationale for the first composite task of the workplan, e.g. the first milestone of the change (see Figure 100). For small changes there might be only a single composite task necessary. For larger changes this provides a way to split up work into milestones. In “Keyword” enter a short rationale for the change. In “Description” enter a longer description of the change. By specifying more than one composite activity you can describe larger changes in a more structured and detailed way.



Please describe why you are going to change the software.
This description is needed to classify your changes.

Keyword:
Database Change

Description:
the direct changes of the database component, and follow-up activities.

Figure 100: Specifying activities

Select starting point
On the second wizard page you can select what kind of architecture model elements you can mark directly as affected by the change request (see Figure 101). You press "Select Components", if you know which components are affected. You can press "Select Interfaces", if you know interfaces (types) which are affected. You can press "Change Datatype Definition", if you know the directly affected data types.

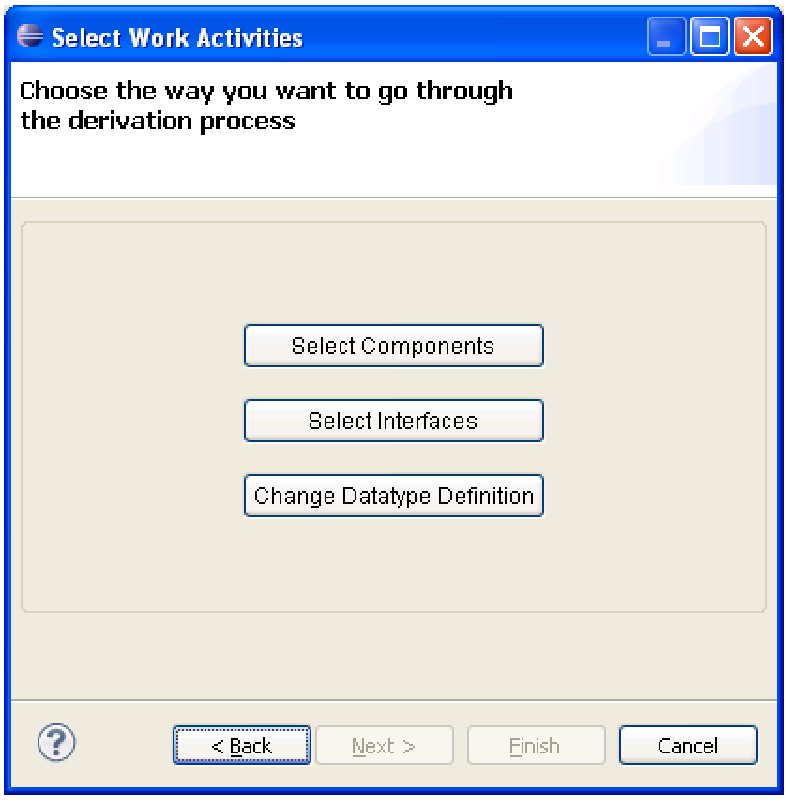
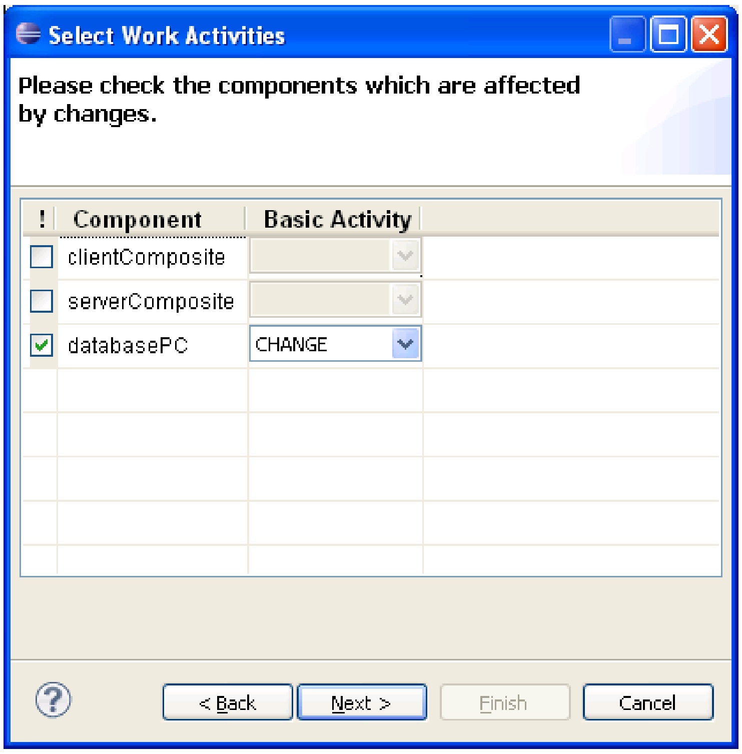

Select Work Activities
Choose the way you want to go through the derivation process
Select Components
Select Interfaces
Change Datatype Definition
< Back
Next >
Finish
Cancel

Figure 101: Selecting architecture model elements affected by a change request

Select "Component Activities"

After pressing "Select Components" you will get to another wizard page, where all components (from the architecture model) are listed (see Figure 102).



Please check the components which are affected by changes.

!	Component	Basic Activity
☐	clientComposite	
☐	serverComposite	
✓	databasePC	CHANGE

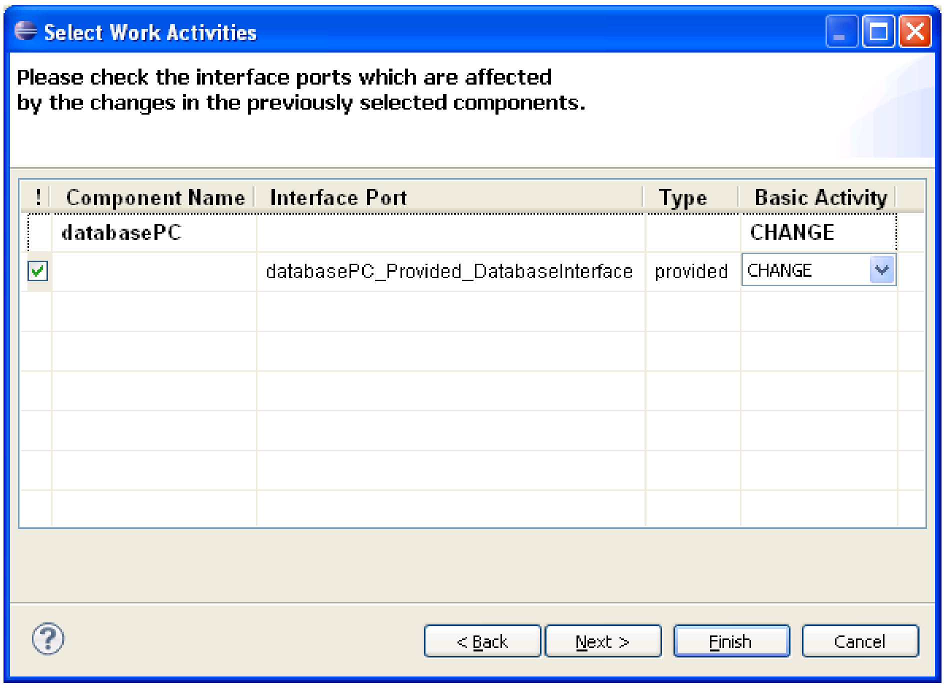
Figure 102: Selecting components affected by a change request

Mark those components which will be changed by implementing the change request. Additionally select what kind of basic activity (ADD, CHANGE, REMOVE) is done to the component. In the running example, component "databasePC" is directly affected, so we mark this component and specify the basic activity "CHANGE".

Select "Interface Port Activities" (First Refinement of Component Changes)

The next wizard page shows interface ports which are provided or required by selected components of the previous wizard page. Here the activity description can be refined by selecting the interface ports which are affected, and selecting the kind of basic activity.

In the running example, the port "Provided_DatabaseInterface" is affected. We mark it and select the basic activity "CHANGE".



Please check the interface ports which are affected by the changes in the previously selected components.

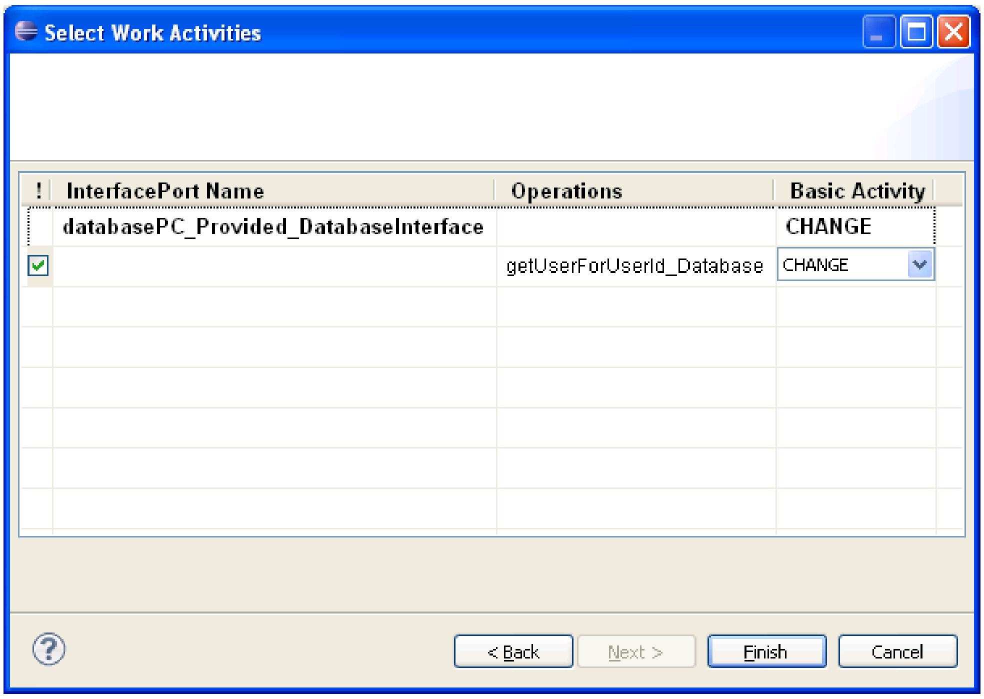
!	Component Name	Interface Port	Type	Basic Activity
	databasePC			CHANGE
✓		databasePC_Provided_DatabaseInterface	provided	CHANGE

Figure 103: Selecting interface ports affected by a change request

Select "Operation Activities"

The next wizard page asks for another refinement step (see Figure 104). Here, the operations (in the implementation of the previously selected components and interface ports) can be selected which are affected by the change request.

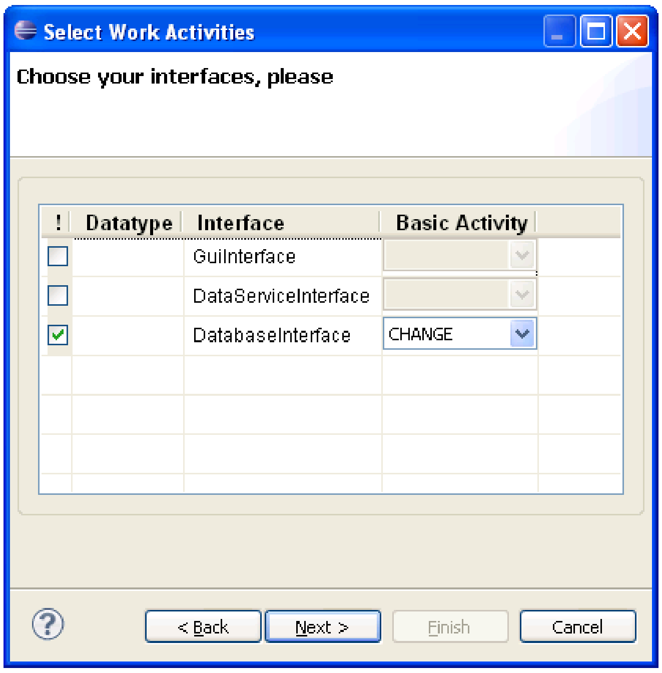
In the running example, the operation "getUserForUserID..." is marked with the basic activity "CHANGE".



!	InterfacePort Name	Operations	Basic Activity
	databasePC_Provided_DatabaseInterface		CHANGE
✓		getUserForUserId_Database	CHANGE

Figure 104: Selecting interface operations affected by a change request

Select "Interface Activities"
Instead of selecting components as described above, "Select Interfaces" can also be chosen as starting point if it is known that an interface definition has to be changed in order to accomplish the change request. Selecting interfaces directly gives KAMP tool the chance to derive proposals for follow-up activities automatically. In the running example, the interface "DatabaseInterface" is marked, and the basic activity "CHANGE" is selected (see Figure 105)



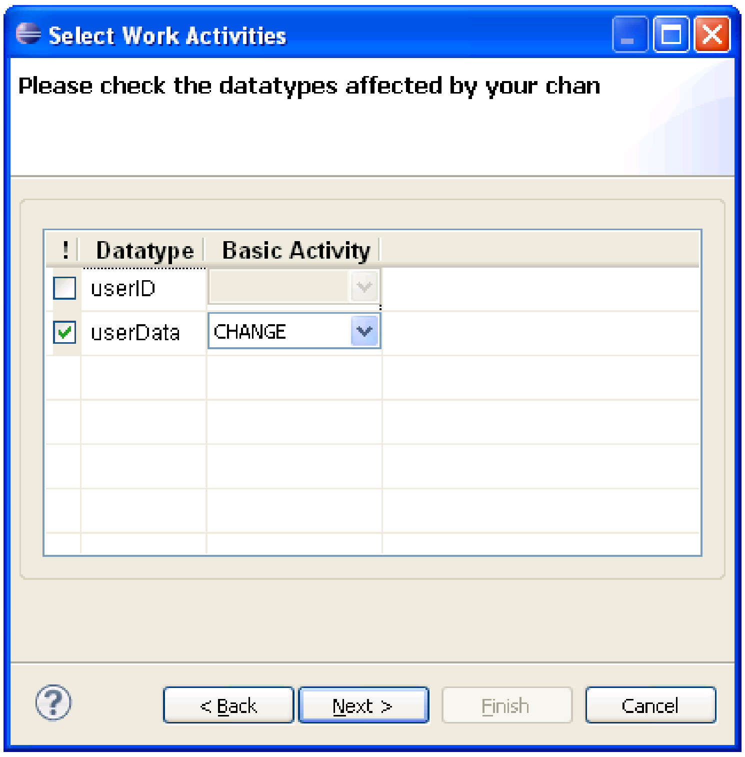
!	Datatype	Interface	Basic Activity
☐		GuiInterface	
☐		DataServiceInterface	
✓		DatabaseInterface	CHANGE

Figure 105: Selecting interfaces affected by a change request

The next wizard page is comparable to the page shown in Figure 103 regarding the interface ports. Here the interface ports can be specified which are affected due to the interface definition change marked before.

Select "Datatype Activities"
As third possible starting point, "Change Datatype Definition" can be selected. This leads to a wizard page, where the data types can be marked which are affected by the change request. KAMP can derive proposals for follow-up changes to interface definitions and, as seen in the previous section, interface port changes.

In the running example the datatype "userData" is marked with the basic activity "CHANGE" (see Figure 106).



Please check the datatypes affected by your chan

!	Datatype	Basic Activity
☐	userID	
✓	userData	CHANGE

Figure 106: Selecting datatypes affected by a change request

In the following wizard pages, interface definition changes and interface port changes can be specified, which are follow-up activities to the marked datatype change.

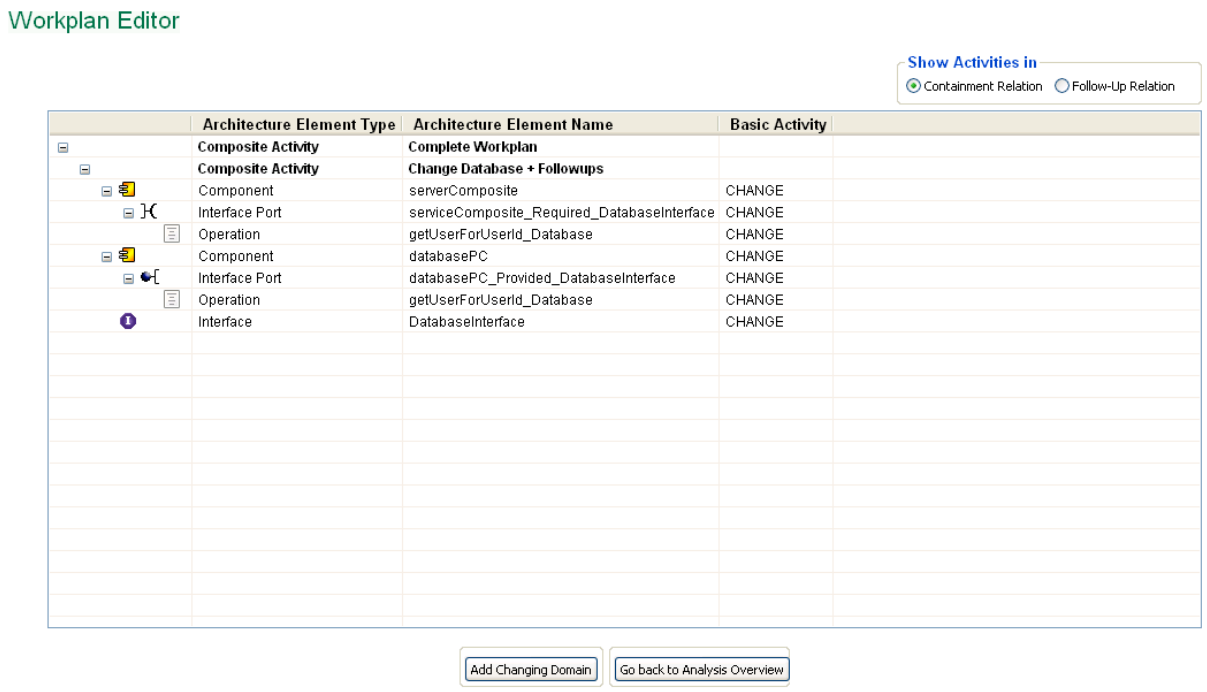
Automatic workplan derivation from subalternatives
The previous paragraphs covered the derivation of workplan by using a wizard dialog. Another way is to calculate differences between architecture models and translate them automatically in change activities in the workplan. For this the architect has to specify subalternatives where the appropriate changes are done. Target and source alternative are specified accordingly when adding the analysis instance. Moreover the change scenario should be set to automatic derivation. The derivation itself is triggered by pressing the cogwheel button in the analysis instance row. After derivation the work plan can be manually adapted as described in the next section.

Workplan editing
The workplan is shown in the workplan editor, which is a tree-table widget. Each line represents an activity. In the first column you see the tree structure and the symbol of the respective architecture element. In the second column the type of the architecture element is shown. The third column contains the name of the architecture element. Finally, in the last column, the basic activity is printed. The tree-structure depends on the selected relation mode in the top right corner.

Containment relation mode
“Containment Relation” means that the tree-structure represents the activity refinements on containment abstraction levels. In this mode component activities contain interface port

activities and these contain operation activities.

In Figure 107, a change to the component “serverComposite” contains a change to the interface port “...Required_DatabaseInterface” etc.


Workplan Editor

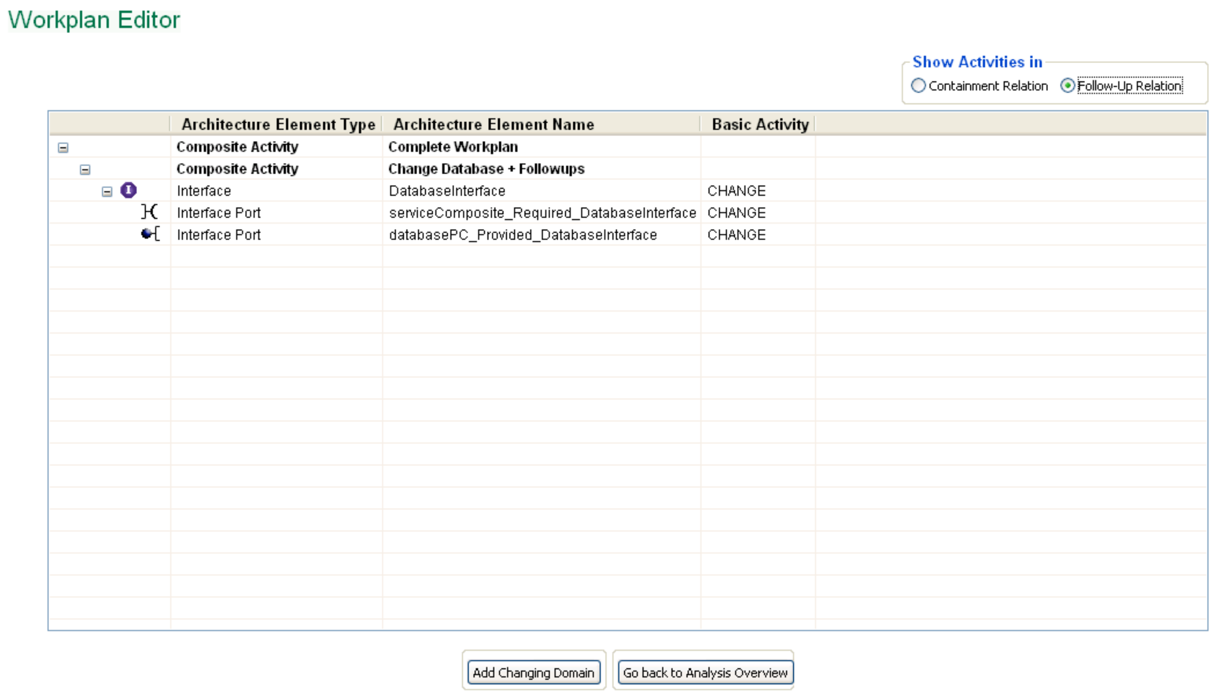
Show Activities in: [✓ Containment Relation] Follow-Up Relation

Architecture Element Type	Architecture Element Name	Basic Activity
Composite Activity	**Complete Workplan**	
Composite Activity	**Change Database + Followups**	
Component	serverComposite	CHANGE
Interface Port	serviceComposite_Required_DatabaseInterface	CHANGE
Operation	getUserForUserId_Database	CHANGE
Component	databasePC	CHANGE
Interface Port	databasePC_Provided_DatabaseInterface	CHANGE
Operation	getUserForUserId_Database	CHANGE
Interface	DatabaseInterface	CHANGE

Figure 107: The workplan editor in containment relation mode

Follow-Up Relation Mode

In follow-up relation mode, the activity hierarchy of the tree reflects the cause-effect relationship, e.g. interface change causes interface port change. In the example shown in Figure 108, a change to interface “DatabaseInterface” is followed by a change to interface ports for “serviceComposite...” and “databasePC...”.

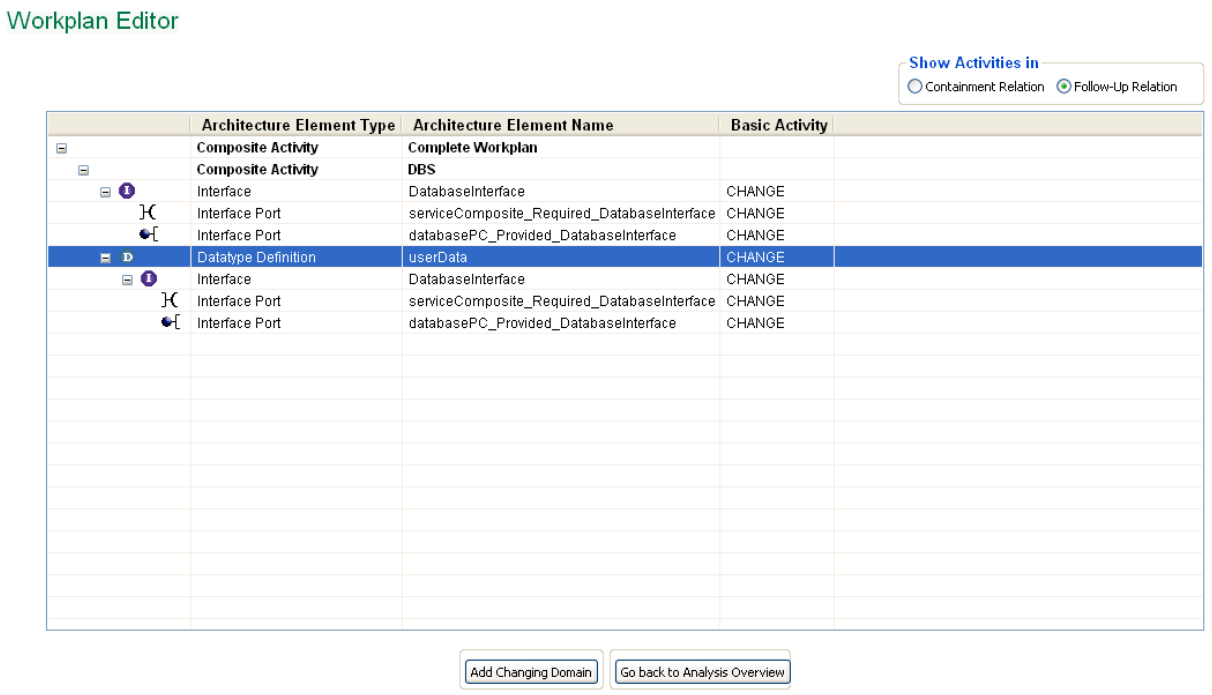

Workplan Editor

Show Activities in: Containment Relation [✓ Follow-Up Relation]

	Architecture Element Type	Architecture Element Name	Basic Activity
⊟	**Composite Activity**	**Complete Workplan**	
⊟	**Composite Activity**	**Change Database + Followups**	
⊟	Interface	DatabaseInterface	CHANGE
	Interface Port	serviceComposite_Required_DatabaseInterface	CHANGE
	Interface Port	databasePC_Provided_DatabaseInterface	CHANGE

Figure 108: The workplan editor in follow-up relation mode

The second example shown in Figure 109 also features a change to the datatype definition "userData" that triggers a change to the interface "DatabaseInterface", which itself triggers two interface port changes.


Workplan Editor

Show Activities in: Containment Relation [✓ Follow-Up Relation]

	Architecture Element Type	Architecture Element Name	Basic Activity
⊟	**Composite Activity**	**Complete Workplan**	
⊟	**Composite Activity**	**DBS**	
⊟	Interface	DatabaseInterface	CHANGE
	Interface Port	serviceComposite_Required_DatabaseInterface	CHANGE
	Interface Port	databasePC_Provided_DatabaseInterface	CHANGE
⊟	Datatype Definition	userData	CHANGE
⊟	Interface	DatabaseInterface	CHANGE
	Interface Port	serviceComposite_Required_DatabaseInterface	CHANGE
	Interface Port	databasePC_Provided_DatabaseInterface	CHANGE

Figure 109: The workplan editor in follow-up relation mode

Context menu for editing of activities

You can add, modify and delete activities in the workplan by applying commands in a context menu (see Figure 110).

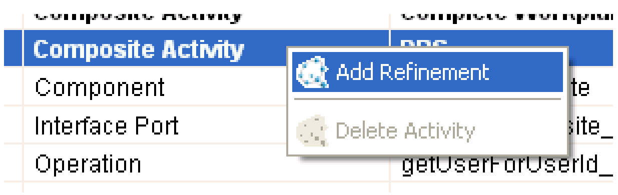
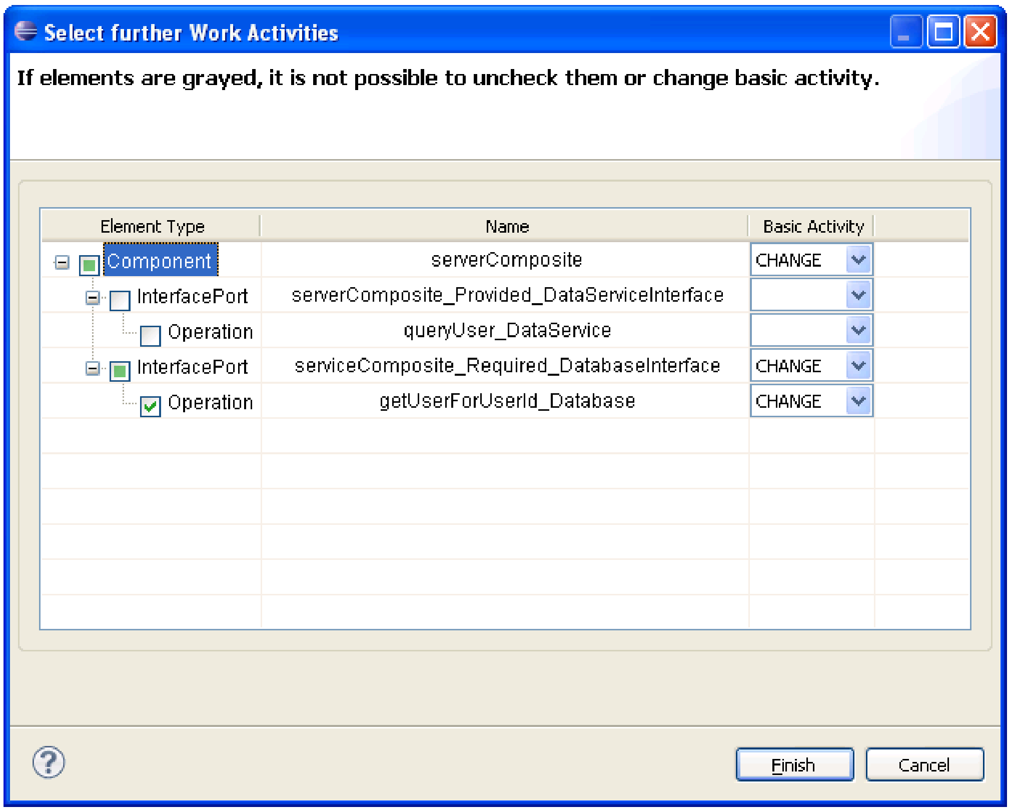


Figure 110: Context menu for editing of activities

In a dialog, activities can be marked or unmarked, and basic activities can be modified (see Figure 111).



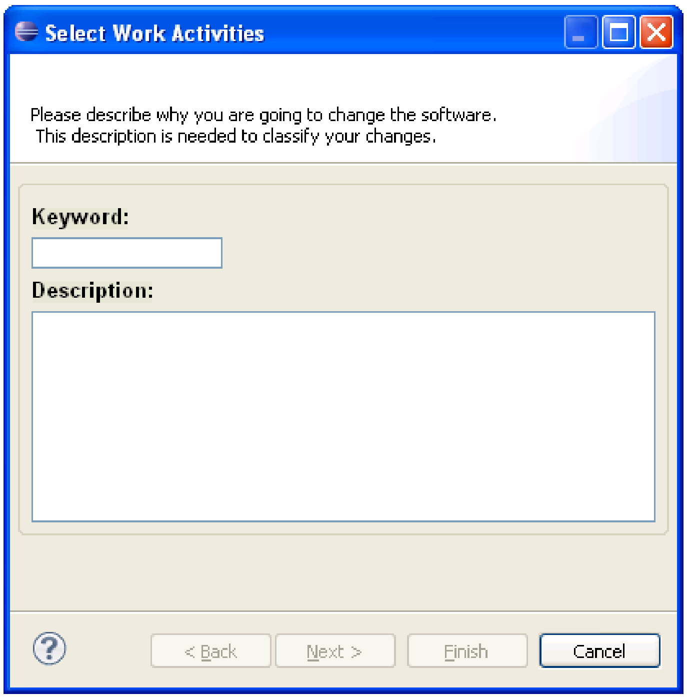
Select further Work Activities

If elements are grayed, it is not possible to uncheck them or change basic activity.

Element Type	Name	Basic Activity
Component	serverComposite	CHANGE
InterfacePort	serverComposite_Provided_DataServiceInterface	
Operation	queryUser_DataService	
InterfacePort	serviceComposite_Required_DatabaseInterface	CHANGE
✓ Operation	getUserForUserId_Database	CHANGE

Figure 111: Editing activities

Adding milestones (composite activities)
To add an additional milestone, press “Add Changing Domain” below the workplan table shown in Figure 109. A milestone can then be specified in the dialog shown in Figure 112.

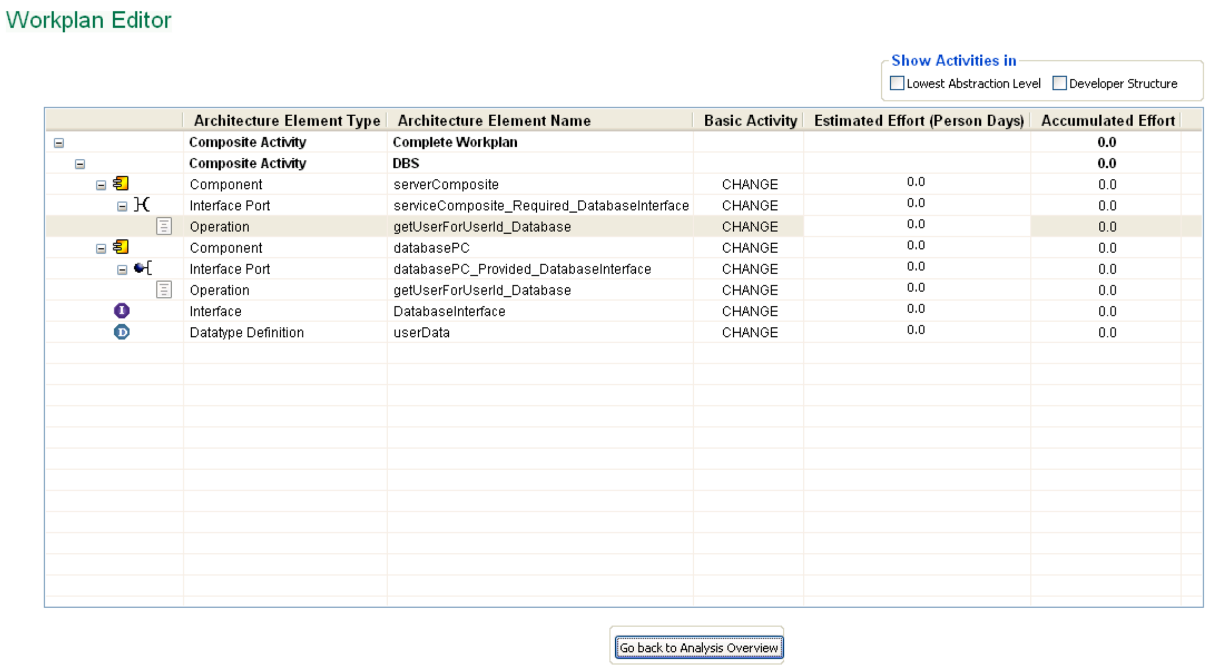


Please describe why you are going to change the software.
This description is needed to classify your changes.

Figure 112: Adding milestones

Effort estimation

The efforts for an analysis instance are determined by using a bottom-up estimation approach. This means that developers have to provide time effort estimates for sub-activities in the workplan. To open the effort estimation screen, select “Edit Effort Estimation” in the analysis instance overview page.


Workplan Editor

Architecture Element Type	Architecture Element Name	Basic Activity	Estimated Effort (Person Days)	Accumulated Effort
Composite Activity	**Complete Workplan**			**0.0**
Composite Activity	**DBS**			**0.0**
Component	serverComposite	CHANGE	0.0	0.0
Interface Port	serviceComposite_Required_DatabaseInterface	CHANGE	0.0	0.0
Operation	getUserForUserId_Database	CHANGE	0.0	0.0
Component	databasePC	CHANGE	0.0	0.0
Interface Port	databasePC_Provided_DatabaseInterface	CHANGE	0.0	0.0
Operation	getUserForUserId_Database	CHANGE	0.0	0.0
Interface	DatabaseInterface	CHANGE	0.0	0.0
Datatype Definition	userData	CHANGE	0.0	0.0

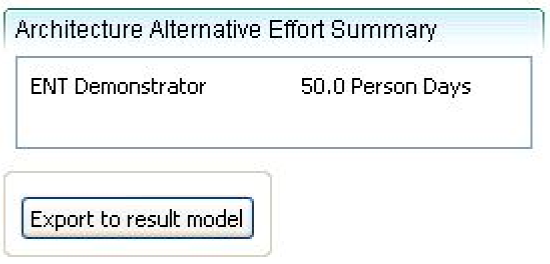
Figure 113: Effort estimation in the workplan editor

The screenshot in Figure 113 shows a tree-table similar to the workplan editor page. The difference lies in the fifth and sixth column. In the fifth column the developer can enter effort estimates for the respective work activity in person days. In the sixth column the effort estimates are accumulated.

Note: Place the cursor in the first cell and enter a value. Press “Return key” to go directly to the cell below.

Result export

On the bottom of the Maintainability Analysis Overview page, a summary of the estimation results can be found. In order to start exporting of the results to the result model of the current Q-ImPrESS project, select “Export to result model” (see Figure 114).

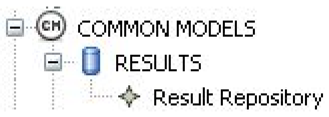

Architecture Alternative Effort Summary

ENT Demonstrator	50.0 Person Days

Figure 114: Result model export

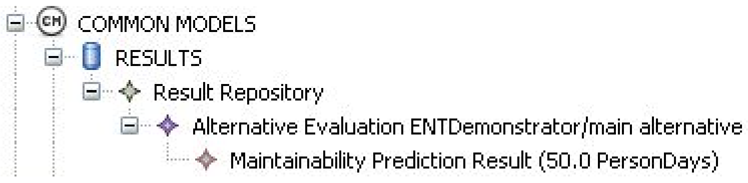
In the Project Explorer, you can check how results are added to the common result repository.

Before:



```
COMMON MODELS
  RESULTS
    Result Repository
```

After:



```
COMMON MODELS
  RESULTS
    Result Repository
      Alternative Evaluation ENTDemonstrator/main alternative
        Maintainability Prediction Result (50.0 PersonDays)
```

If there is no appropriate alternative evaluation already present KAMP will create a new one. If an appropriate alternative evaluation is found then KAMP will simply add a Maintainability Prediction Result element.

4.12 Trade-off analysis and results viewer (AHP)

4.12.1 Tool Description

4.12.2 Purpose of the tool

The AHP Wizard enables the user to perform a trade-off analysis. The results of execution of different analysis tools in the Q-ImPrESS IDE are saved within the Result Repository of the project for later refinement. The AHP Wizard is an implementation of the Analytical Hierarchical Process that helps the user to choose the best alternative by comparing results of analyses stored in Result Repository.

4.12.3 Tool relationship with the Q-ImPrESS workflow

In the Q-ImPrESS workflow, the trade-off analysis takes quality prediction results of multiple service architecture alternatives to create an alternative ranking (see Figure 115).

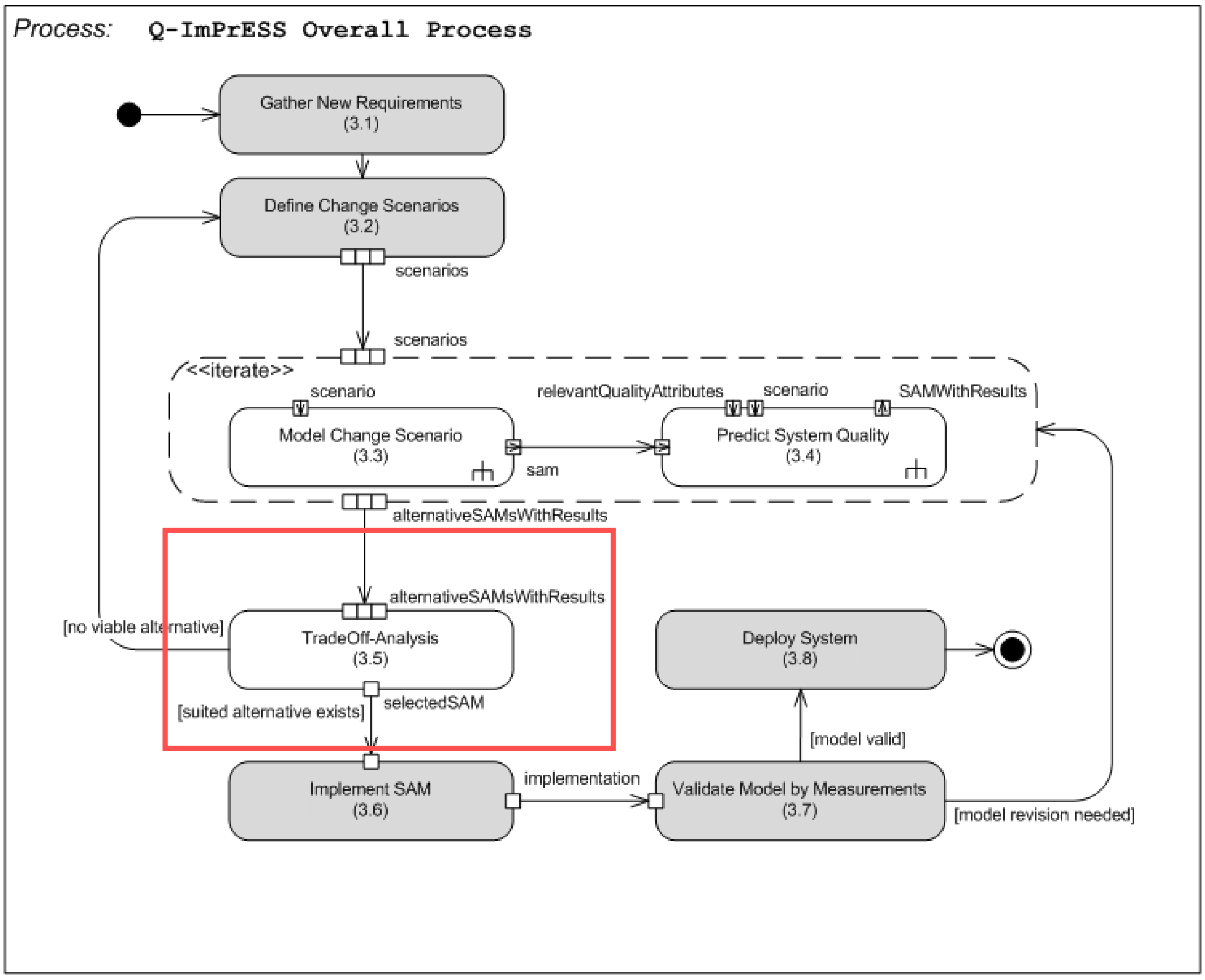

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
relevantQualityAttributes
scenario
SAMWithResults
Model Change Scenario (3.3)
sam
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
[suited alternative exists]
selectedSAM
Deploy System (3.8)
[model valid]
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]

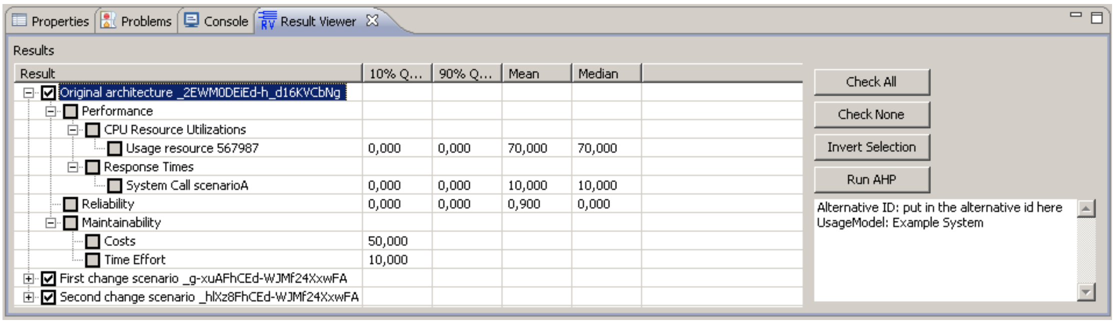
Figure 115: Performing the trade-off analysis (copied from D6.1)

4.12.4 Tool prerequisites

Results Repository of current working project needs to contain Alternative Evaluations for every Alternative that user wants to include in trade-off analysis.

4.12.5 Tool activation

Access and configuration of the AHP Wizard is provided by another tool in the Q-ImPrESS IDE, the Result viewer. To open the Result viewer simply right click on the Results folder in Project Explorer view of any Q-ImPrESS project and select option "Open Result Viewer". This is shown in Figure 116.



Result	10% Q...	90% Q...	Mean	Median
☑ Original architecture _2EWM0DEiEd-h_d16KVCbNg				
☐ Performance				
☐ CPU Resource Utilizations				
☐ Usage resource 567987	0,000	0,000	70,000	70,000
☐ Response Times				
☐ System Call scenarioA	0,000	0,000	10,000	10,000
☐ Reliability	0,000	0,000	0,900	0,000
☐ Maintainability				
☐ Costs	50,000			
☐ Time Effort	10,000			
☑ First change scenario _g-xuAFhCEd-WJMf24XxwFA				
☑ Second change scenario _hlXz8FhCEd-WJMf24XxwFA				

Alternative ID: put in the alternative id here
UsageModel: Example System

Figure 116: Result viewer

In the Result viewer we can compare results from different architecture alternatives. Results are expressed stochastically as random variables. The rationale behind this is that many aspects of larger software systems, especially in the business information systems area, cannot be modelled having complete information. Uncertainties can be found in many aspects of the architecture model. Two main sources stem, for example, from the behaviour of users and time spans of method executions (because we do not consider real-time environments, garbage collection, etc.).

The Result viewer is structured as follows: it provides an overview of analysis or simulation results for performance, reliability and maintainability metrics. For each of the quality attributes the Result Viewer provides a set of stochastic values for the related metrics. Firstly, in the case of performance, the response time for each system call scenario and utilisations for each CPU resource are provided. Secondly, in the case of reliability, the failure probability of the system alternative is provided. Thirdly, in the case of maintainability, cost and time efforts for developing a system alternative are provided. Each of the analysed metrics can by expressed in a form of the mean, or the median, the 10% Quantile or the 90% Quantile. For example, the 90% Quantile means that in 90% of cases will the response time for analysed System Call scenario be smaller as the specified value provided by the Result viewer. This way it is possible to identify the most probable system behaviour without including exceptional (outlier) cases in the further analysis. Additionally, the Result viewer provides mean (the expected value of a random variable) and median (the numeric value separating the higher half of a sample from the lower half, so called middle value) values for each metric.

4.12.6 Usage instructions and expected outputs

Persistence

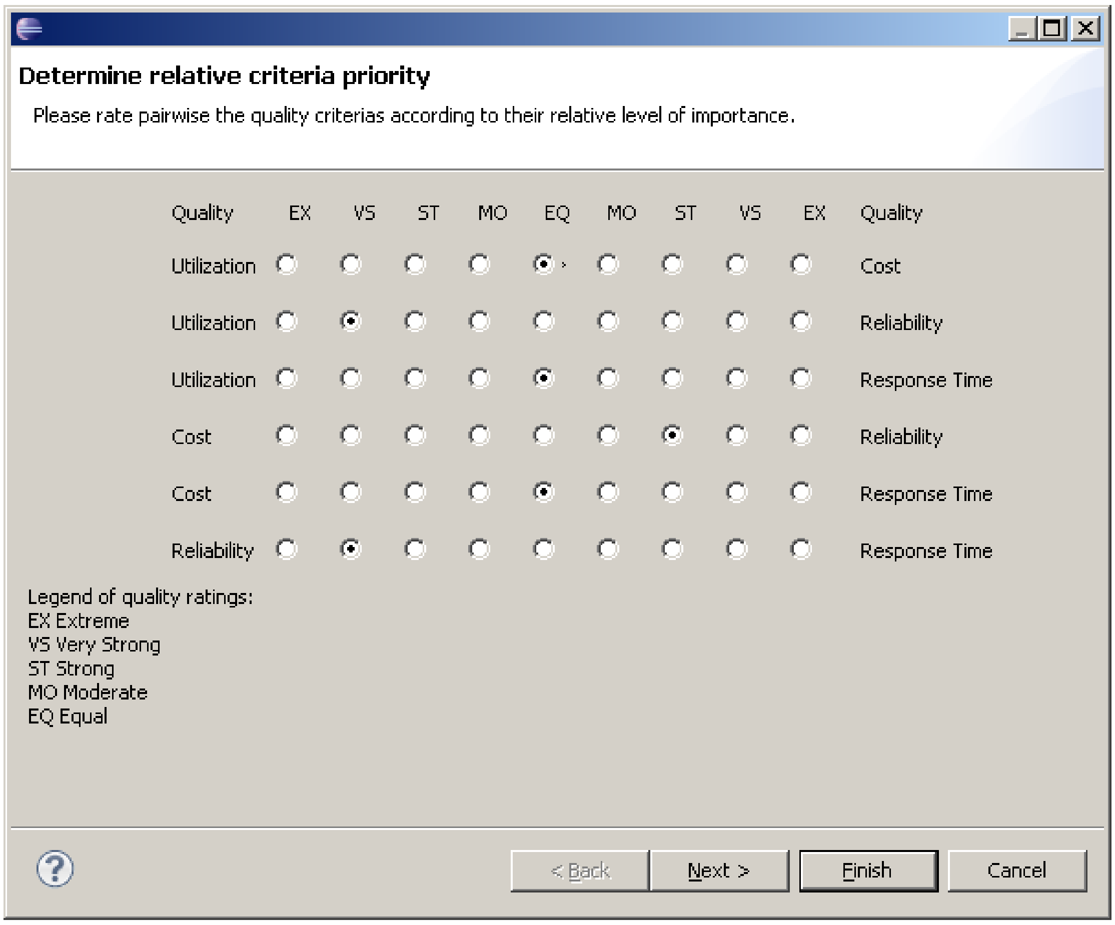
The tool automatically saves the last choices that the user has made for certain selection of alternative evaluations. These choices are automatically loaded at the moment the user activates the tool with the same set of Alternative Evaluations.

Note: The tool does not store the content of alternative evaluations themselves so it is up to the user to make adjustments if the data within alternative evaluations got altered.

Stage 1: Quality Comparison

When presented with the AHP Wizard interface as shown in Figure 117, enter your preferences for ranking of Q-ImPrESS qualities. Each of the qualities needs to be compared to each other quality.

Example: if the user thinks that "Utilization is very strongly preferred over Cost", user should select second option button from the left in the first row. Column name of that button is VS which indicates very strong preference and it leans towards Utilization quality.



Determine relative criteria priority

Please rate pairwise the quality criterias according to their relative level of importance.

Quality	EX	VS	ST	MO	EQ	MO	ST	VS	EX	Quality
Utilization	○	○	○	○	●	○	○	○	○	Cost
Utilization	○	●	○	○	○	○	○	○	○	Reliability
Utilization	○	○	○	○	●	○	○	○	○	Response Time
Cost	○	○	○	○	○	○	●	○	○	Reliability
Cost	○	○	○	○	●	○	○	○	○	Response Time
Reliability	○	●	○	○	○	○	○	○	○	Response Time

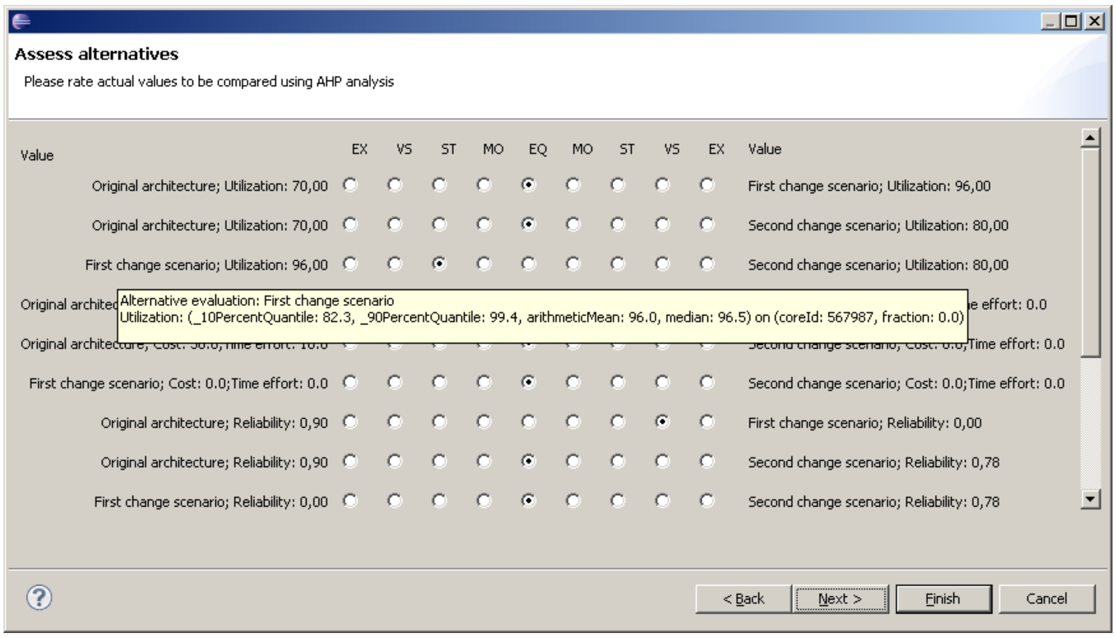
Legend of quality ratings:
EX Extreme
VS Very Strong
ST Strong
MO Moderate
EQ Equal

Figure 117: Quality comparison stage

Stage 2: Value Comparison

After clicking the "Next" button, user will be presented with list of comparisons between values for Alternative Evaluations for qualities as presented in Figure 118. Within each quality all pairs of results are compared to select which is preferred. This enables user to express any kind of preference (for example: user can choose to prefer higher response time). Comparison method is the same as described in the previous section.

Note that by hovering over the value, you will be presented with a tool tip that displays more information about currently observed value.



Assess alternatives

Please rate actual values to be compared using AHP analysis

Value	EX	VS	ST	MO	EQ	MO	ST	VS	EX	Value
Original architecture; Utilization: 70,00	○	○	○	○	●	○	○	○	○	First change scenario; Utilization: 96,00
Original architecture; Utilization: 70,00	○	○	○	○	●	○	○	○	○	Second change scenario; Utilization: 80,00
First change scenario; Utilization: 96,00	○	○	●	○	○	○	○	○	○	Second change scenario; Utilization: 80,00
Original archite										e effort: 0.0
Original architecture; Cost: 30.0;Time effort: 10.0										Second change scenario; Cost: 0.0;Time effort: 0.0
First change scenario; Cost: 0.0;Time effort: 0.0	○	○	○	○	●	○	○	○	○	Second change scenario; Cost: 0.0;Time effort: 0.0
Original architecture; Reliability: 0,90	○	○	○	○	○	○	○	●	○	First change scenario; Reliability: 0,00
Original architecture; Reliability: 0,90	○	○	○	○	●	○	○	○	○	Second change scenario; Reliability: 0,78
First change scenario; Reliability: 0,00	○	○	○	○	●	○	○	○	○	Second change scenario; Reliability: 0,78

Alternative evaluation: First change scenario
Utilization: (_10PercentQuantile: 82.3, _90PercentQuantile: 99.4, arithmeticMean: 96.0, median: 96.5) on (coreId: 567987, fraction: 0.0)

Figure 118: Value comparison stage

Stage 3: Interpretation of Results

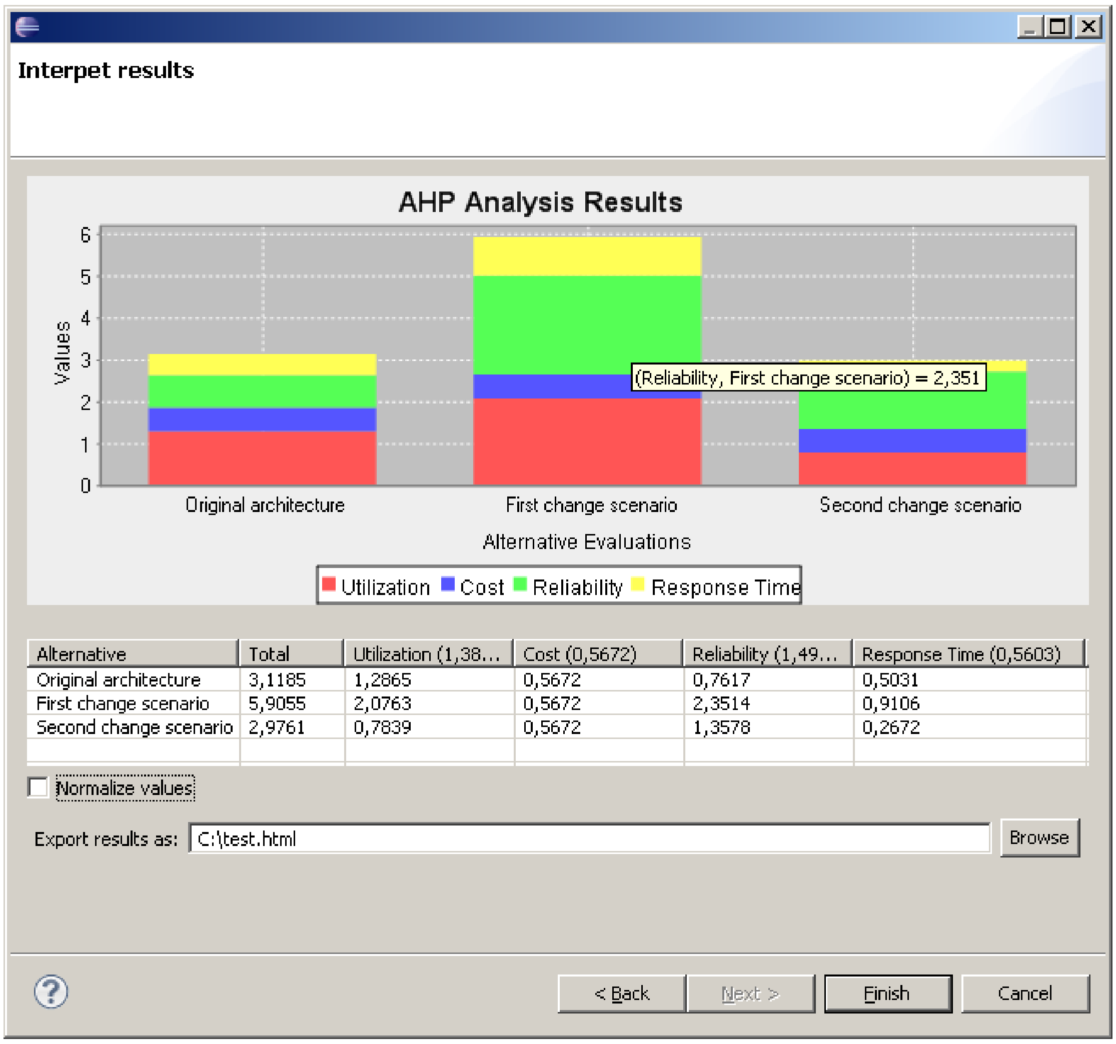
Results of a trade-off analysis are displayed as stacked bar graph. In this graph (shown in Figure 119), colours are used to represent qualities and heights of bars are total preference of one alternative evaluation over another.

The same data that is presented in stacked bar graph is also presented in a form of table below the bar graph.

When hovering over any part of bars in bar graph, information about the value that is used to display that part of bar is presented.

There is a check-box button “Normalize values” that enables the user to apply normalization to the final results of the trade-off analysis. The normalization will adjust all of the values so that sum of all qualities for all alternative evaluations is 1.

The user can choose an HTML file to export all of the settings that led to these results and results. The export is executed upon pressing Finish button. Besides a HTML file, a PNG file with the same filename is going to be created that contains the graphical representation of the AHP analysis results.



Alternative	Total	Utilization (1,38...	Cost (0,5672)	Reliability (1,49...	Response Time (0,5603)
Original architecture	3,1185	1,2865	0,5672	0,7617	0,5031
First change scenario	5,9055	2,0763	0,5672	2,3514	0,9106
Second change scenario	2,9761	0,7839	0,5672	1,3578	0,2672

☐ Normalize values

Export results as: C:\test.html

Figure 119: Results interpretation stage

Caveats

The tool does currently not provide option to not use some of the qualities. To leave out a quality from the AHP analysis, simply leave the setting of this quality in the second stage to Equal (EQ). This quality will not influence the final result then.

4.13 Consistency Checker Manual

4.13.1 Purpose of the tool

The Consistency checker is a tool for checking consistency between implementation of a service in the Java language and its behaviour model in the TBP formalism. We say that the Java implementation is consistent with the behaviour model in TBP, if the actual behaviour of the implementation reflects the behaviour model and vice versa.
The algorithm for consistency checking is described in Section 3 of the D5.1 document in detail.

4.13.2 Tool relationship with the Q-ImPrESS workflow

Consistency checking can be used to demonstrate that the implementation (code) and behaviour model are consistent after either the code or the behaviour model has been modified during evolution of the software system in any way supported by the Q-ImPrESS method. The consistency checking participates in the process of validating a model by measurements in the Q-ImPrESS workflow (see Figure 120). More details are provided in the D6.1 document.

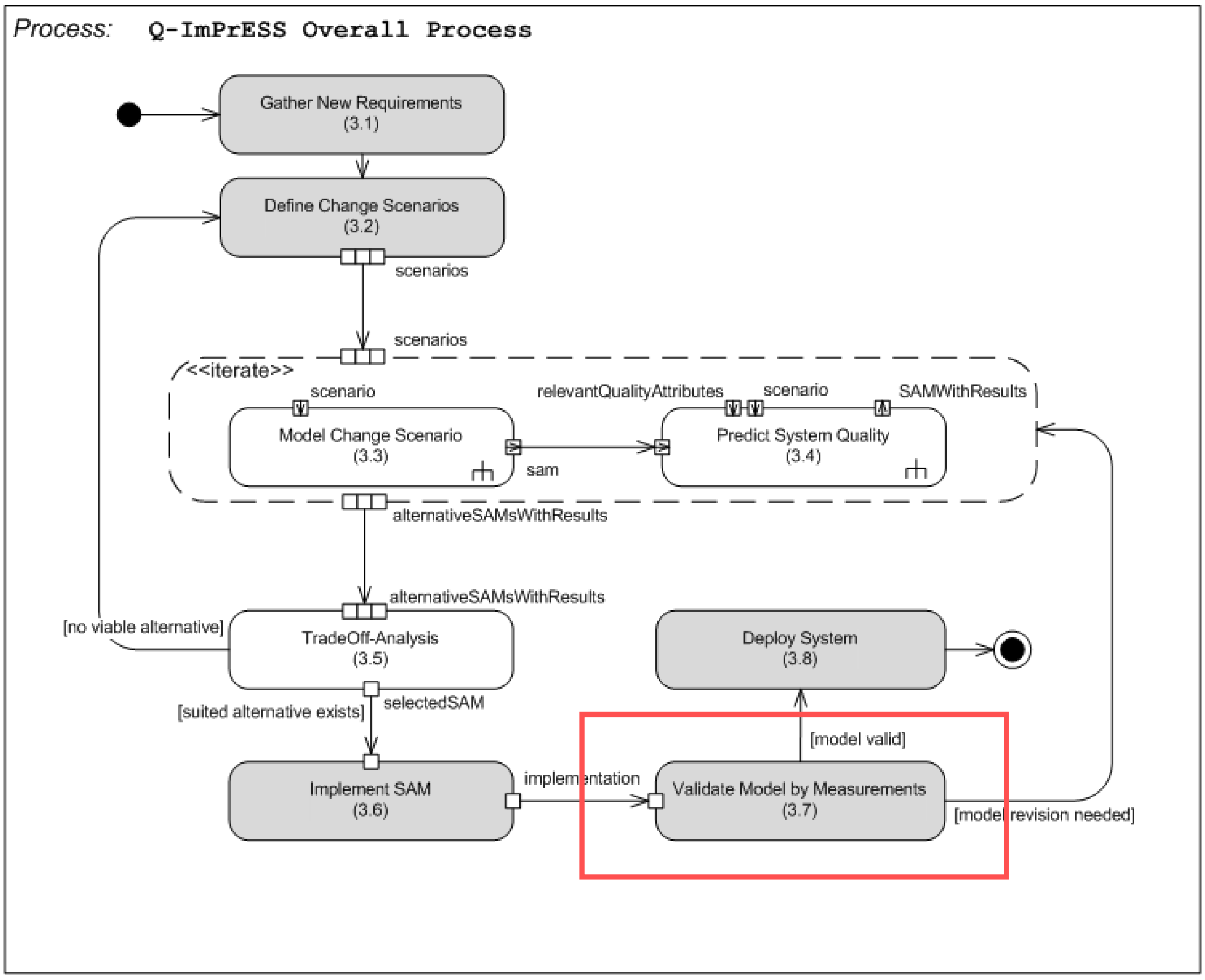

Process: Q-ImPrESS Overall Process
Gather New Requirements (3.1)
Define Change Scenarios (3.2)
scenarios
scenarios
<<iterate>>
scenario
relevantQualityAttributes
scenario
SAMWithResults
Model Change Scenario (3.3)
sam
Predict System Quality (3.4)
alternativeSAMsWithResults
alternativeSAMsWithResults
[no viable alternative]
TradeOff-Analysis (3.5)
Deploy System (3.8)
[suited alternative exists]
selectedSAM
[model valid]
Implement SAM (3.6)
implementation
Validate Model by Measurements (3.7)
[model revision needed]

Figure 120: Validating model by measurements (copied from D6.1)

4.13.3 Tool prerequisites

The Consistency checker has the following software dependencies: JDK 1.6 (or later), the Java PathFinder model checker (version 4) and libraries needed by Java PathFinder. It can be downloaded from its webpage at http://babelfish.arc.nasa.gov/trac/jpf .

While the Consistency checker imposes no strict requirements on the HW, we recommend using a modern CPU and at least 1 GB of memory for non-trivial services implemented in Java. In general, the memory requirements of the consistency checking process depend on the complexity of the Java implementation and the behaviour model in TBP. It is not needed to use multiple CPUs (or a multi-core CPU), since Java PathFinder and the Consistency checker are single-threaded programs.

The Consistency checker requires JDK, version 1.6 or later, since it uses the Java-based compiler that is a part of the JDK. It is not possible to use only JRE, which does not contain the Java-based compiler – full JDK has to be installed on the system. If you get an error message similar to “unable to find a javac compiler” (usually on Windows OS), make sure you have not installed a public JRE along with the JDK, since the public JRE disallows the virtual machine access to the javac compiler (this is an issue of Java on Windows system, not one of the consistency checker).

If you want to run the Consistency checker, the following artefacts are needed as an input:

- A compiled Java implementation of a service (a set of Java class files),
- a behaviour model of the service in the TBP formalism (obtained from G-AST via the Q-Abstractor plug-in described in a separate document, or created manually for new systems),
- a definition of all external interfaces (both provided and required) of the service, and
- a specification of method parameter values to be used by the abstract environment of the service subject to verification.

All the needed input data can be retrieved automatically from an instance of SAMM. The user is only required to manually create the specification of method parameter values and return values in the form of a Java class and put it into the SAMM instance.
An example of the specification for the CRMManager service from the eSOA showcase application is displayed in Figure 121. The Java class with the specification has to be a subclass of the `org.ow2.dsrg.fm.tbpjava.envgen.EnvValueSets` class. Actual parameter values are supplied in calls to the put<*Type*>Set methods, where *Type* can be the name of a primitive Java type (`int`, `long`, `double`, …), `String` or `Object`. All these methods except for `putObjectSet` have four arguments – name of the service, name of an interface, name of a method, and a set of values of a particular type (determined by the `put` method name). The `putObjectSet` method has five arguments – the first argument is the name of the type, and the other four arguments are the same as for the other `put` methods. When the interface name supplied to the `put` method identifies a provided interface, the given set of values is used for all method parameters of the supplied type. When the supplied interface name identifies a required interface, then the set of values is used for return values.
While it is recommended to specify parameter and return values for each method separately, it is possible to define the parameter values of a specific type for all methods of all interfaces in a single call to a `put` method by providing empty (“”) interface name and method name.

4.13.4 Tool activation

The following prerequisites have to be satisfied before it is possible to use the Consistency checker on a service’s implementation in Java:

- The project has to be a Java project and have the Q-ImPrESS nature set (see Section 4.2.6),
- at least one alternative has to exist,
- the alternative has to be filled with the models obtained either by executing the SoMoX tool, or manually, and
- source code of the service has to compile in the Eclipse IDE.

Other than that, no special activation procedure is needed.

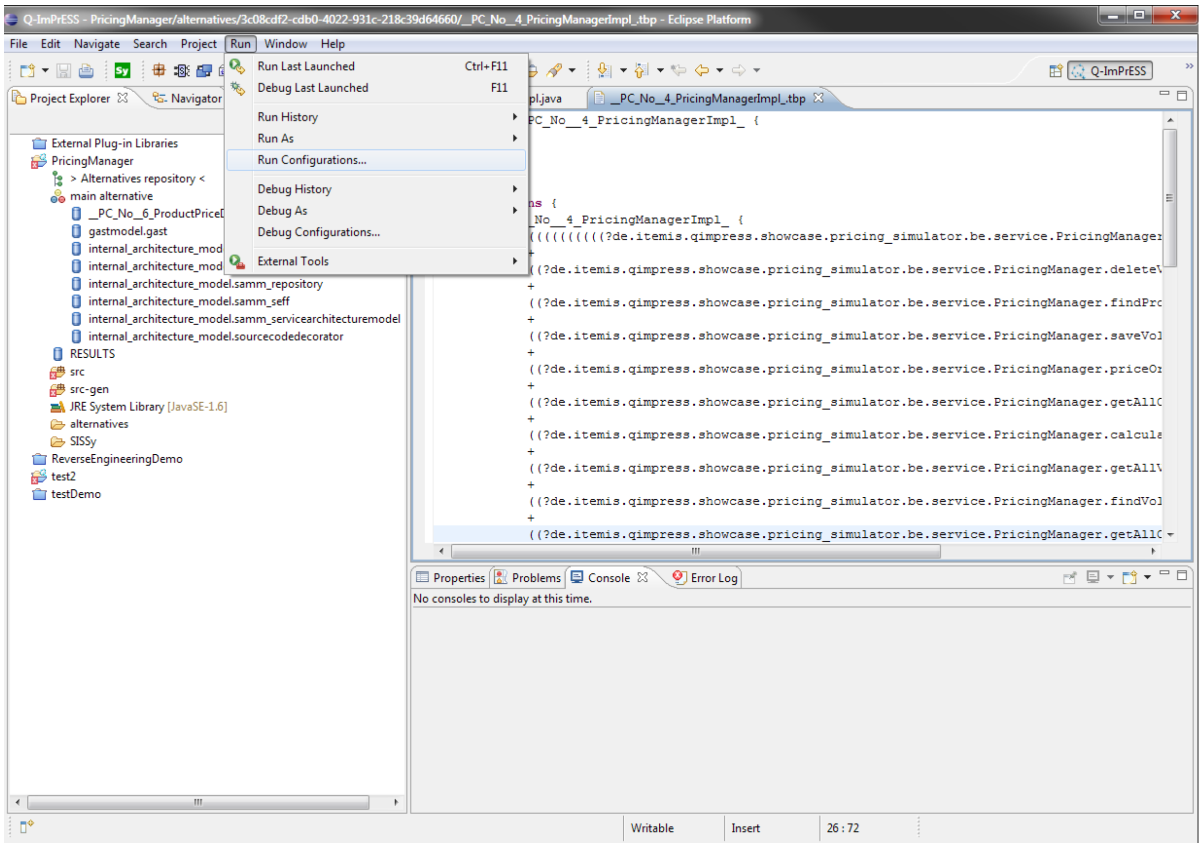
```
package de.itemis.qimpress.showcase.crm_simulator;

public class TestCRMManager extends org.ow2.dsrg.fm.tbpjava.envgen.EnvValueSets
{
 public TestCRMManager()
 {
  super();

  putObjectSet(
      "de.itemis.qimpress.showcase.crm_simulator.be.filter.CustomerFilter",
      "de.itemis.qimpress.showcase.crm_simulator.be.service.CRMManager",
      "de.itemis.qimpress.showcase.crm_simulator.be.service.CRMManager",
      "queryCustomers",
      new Object[]{null}
  );

  putObjectSet(…
      "java.util.List",
      "de.itemis.qimpress.showcase.crm_simulator.be.service.CRMManager",
      "de.itemis.qimpress.showcase.crm_simulator.be.dao.CountriesDao",
      "",   // all methods of the interface
      new Object[]{new java.util.ArrayList()}
  );

  // parameters for other methods
 }
}
```

Figure 121: Specification of method parameter values in a Java class

4.13.5 Usage instructions and expected outputs

The Consistency checker can be used on a service implemented in Java by performing the following four steps:

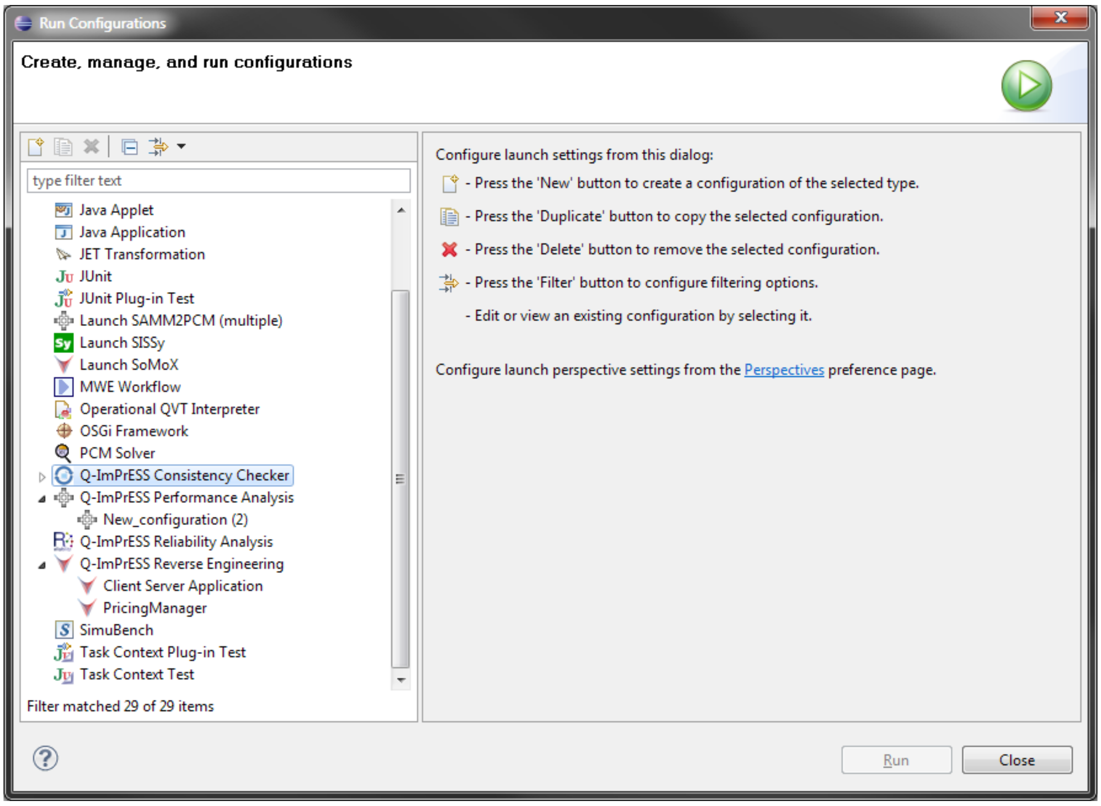
1. The dialog for definition of the run configuration has to be opened by selecting the “Run Configuration” item in the “Run” menu (Figure 122).
2. The “Q-ImPrESS Consistency Checker” run configuration has to be selected in the “Run Configurations” dialog (Figure 123).
3. The run configuration for the Consistency checker has to be completed. In particular, it is needed to select an alternative and the component to be checked (Figure 124), and also the behaviour model of the service in TBP and the specification of method parameter values in the form of a Java class have to be selected (Figure 125).
4. The analysis is started by clicking on the “Run” button in the “Run Configurations” dialog (Figure 125). The Consistency checker retrieves all inputs from the SAMM instance, generates the abstract environment for the service subject to checking, and runs Java PathFinder on the complete Java program composed of the service implementation and its abstract environment.


Q-ImPrESS - PricingManager/alternatives/3c08cdf2-cdb0-4022-931c-218c39d64660/_PC_No__4_PricingManagerImpl_.tbp - Eclipse Platform
File Edit Navigate Search Project Run Window Help
Run Last Launched Ctrl+F11
Debug Last Launched F11
Run History
Run As
Run Configurations...
Debug History
Debug As
Debug Configurations...
External Tools
Q-ImPrESS
Project Explorer
Navigator
External Plug-in Libraries
PricingManager
> Alternatives repository <
main alternative
_PC_No__6_ProductPriceI
gastmodel.gast
internal_architecture_mod
internal_architecture_mod
internal_architecture_model.samm_repository
internal_architecture_model.samm_seff
internal_architecture_model.samm_servicearchitecturemodel
internal_architecture_model.sourcecodedecorator
RESULTS
src
src-gen
JRE System Library [JavaSE-1.6]
alternatives
SISSy
ReverseEngineeringDemo
test2
testDemo
pl.java
_PC_No__4_PricingManagerImpl_.tbp
Properties
Problems
Console
Error Log
Writable
Insert
26 : 72

```
PC_No__4_PricingManagerImpl_ {

ns {
 No__4_PricingManagerImpl_ {
((((((((((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager
((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager.deleteV
+
((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager.findPro
+
((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager.saveVol
+
((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager.priceOr
+
((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager.getAllC
+
((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager.calcula
+
((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager.getAllV
+
((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager.findVol
+
((?de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManager.getAllC
```

No consoles to display at this time.

Figure 122: Opening the "Run Configurations" dialog



Create, manage, and run configurations

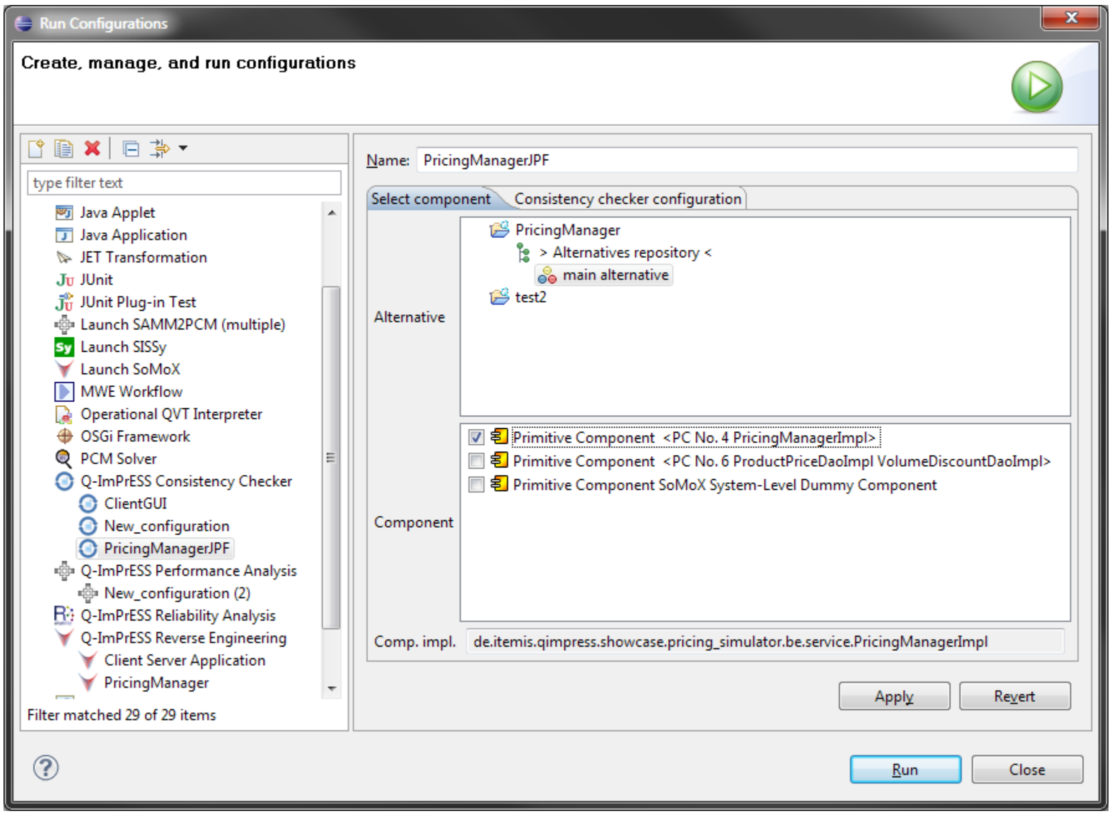
Configure launch settings from this dialog:

- Press the 'New' button to create a configuration of the selected type.
- Press the 'Duplicate' button to copy the selected configuration.
- Press the 'Delete' button to remove the selected configuration.
- Press the 'Filter' button to configure filtering options.
- Edit or view an existing configuration by selecting it.

Configure launch perspective settings from the Perspectives preference page.

Filter matched 29 of 29 items

Figure 123: Selecting the "Q-ImPrESS Consistency Checker" run configuration

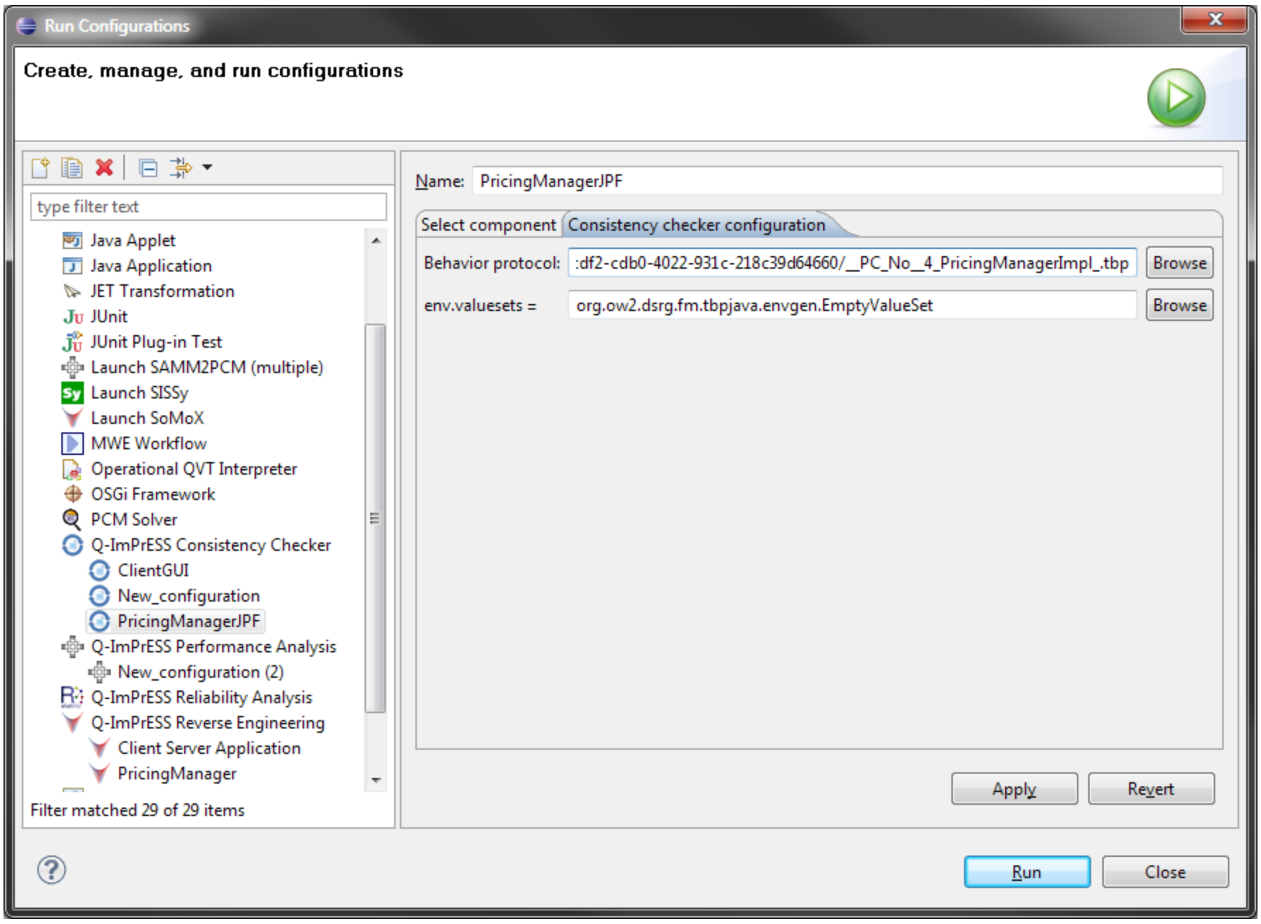


Name: PricingManagerJPF

- [✓] Primitive Component <PC No. 4 PricingManagerImpl>
- [ ] Primitive Component <PC No. 6 ProductPriceDaoImpl VolumeDiscountDaoImpl>
- [ ] Primitive Component SoMoX System-Level Dummy Component

Comp. impl. de.itemis.qimpress.showcase.pricing_simulator.be.service.PricingManagerImpl

Figure 124: Selecting an alternative and a component to be checked


Run Configurations

Create, manage, and run configurations

Name: PricingManagerJPF

Select component | Consistency checker configuration

Behavior protocol: :df2-cdb0-4022-931c-218c39d64660/__PC_No__4_PricingManagerImpl_.tbp

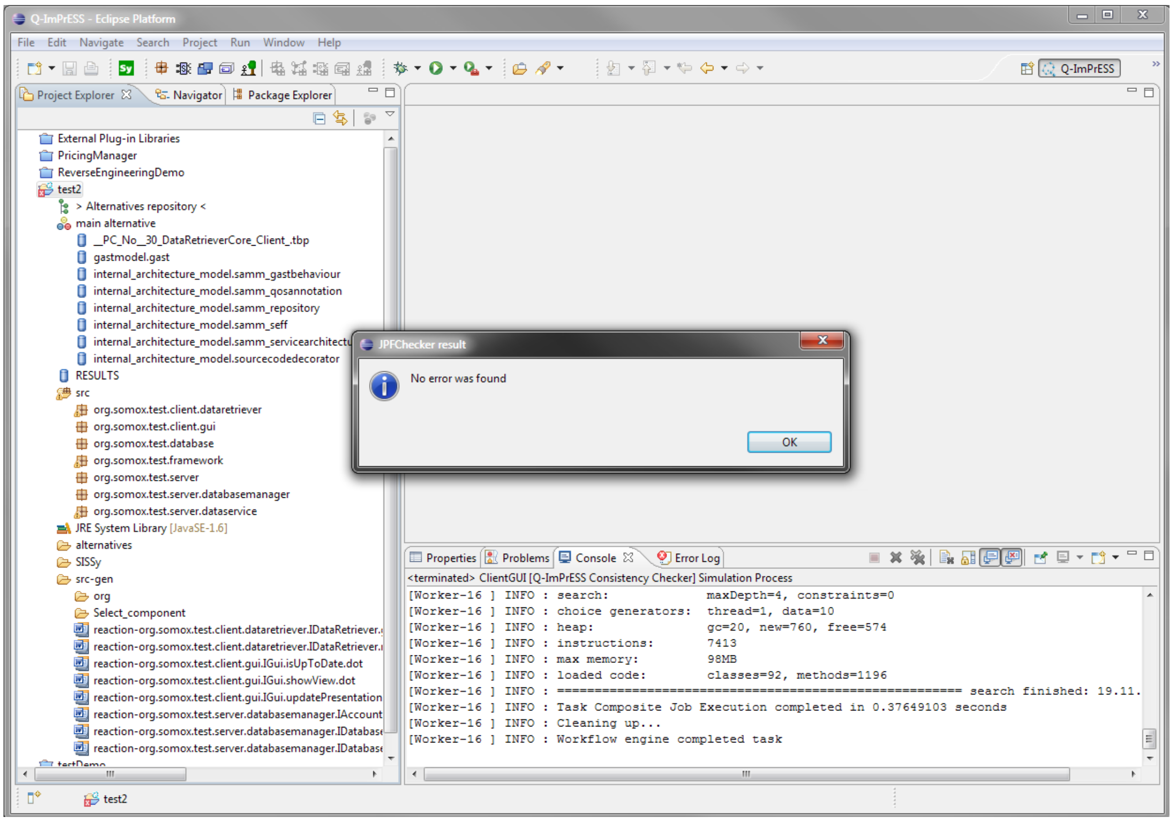
env.valuesets = org.ow2.dsrg.fm.tbpjava.envgen.EmptyValueSet

- Java Applet
- Java Application
- JET Transformation
- JUnit
- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- Q-ImPrESS Consistency Checker
  - ClientGUI
  - New_configuration
  - PricingManagerJPF
- Q-ImPrESS Performance Analysis
  - New_configuration (2)
- Q-ImPrESS Reliability Analysis
- Q-ImPrESS Reverse Engineering
  - Client Server Application
  - PricingManager

Filter matched 29 of 29 items

Figure 125: Selecting the behaviour model in TBP and the Java class with the specification of method parameter values; running the Consistency checker

The result of consistency checking is displayed in a way typical to the Eclipse IDE. More specifically, output of the Consistency checker is printed to the console, including a potential counterexample and some statistics, and a message box with a short checking summary is displayed. Figure 126 shows the output in the case that the Consistency checker found no inconsistency, while Figure 127 shows the output in case the Consistency checker detected an inconsistency between the implementation and the behaviour model.
A new edit window with the source of the component or the generated abstract environment is also opened if the Consistency checker found an inconsistency, and the cursor is placed to the source code line containing the statement that triggered the inconsistency. If a violation of the protocol specified in the *provision* part of the behaviour model in TBP is detected, then the cursor is put to the source code location where the service’s method is invoked in the generated environment. If a violation of a protocol specified in the *reaction* part of a TBP model is detected, then the cursor is put to the Java source code location in the service’s method implementation.


Q-ImPrESS - Eclipse Platform
File Edit Navigate Search Project Run Window Help
Q-ImPrESS
Project Explorer
Navigator
Package Explorer
External Plug-in Libraries
PricingManager
ReverseEngineeringDemo
test2
> Alternatives repository <
main alternative
__PC_No__30_DataRetrieverCore_Client_.tbp
gastmodel.gast
internal_architecture_model.samm_gastbehaviour
internal_architecture_model.samm_qosannotation
internal_architecture_model.samm_repository
internal_architecture_model.samm_seff
internal_architecture_model.samm_servicearchitectu
internal_architecture_model.sourcecodedecorator
RESULTS
src
org.somox.test.client.dataretriever
org.somox.test.client.gui
org.somox.test.database
org.somox.test.framework
org.somox.test.server
org.somox.test.server.databasemanager
org.somox.test.server.dataservice
JRE System Library [JavaSE-1.6]
alternatives
SISSy
src-gen
org
Select_component
reaction-org.somox.test.client.dataretriever.IDataRetriever.
reaction-org.somox.test.client.dataretriever.IDataRetriever.
reaction-org.somox.test.client.gui.IGui.isUpToDate.dot
reaction-org.somox.test.client.gui.IGui.showView.dot
reaction-org.somox.test.client.gui.IGui.updatePresentation
reaction-org.somox.test.server.databasemanager.IAccount
reaction-org.somox.test.server.databasemanager.IDatabase
reaction-org.somox.test.server.databasemanager.IDatabase
Properties
Problems
Console
Error Log
test2

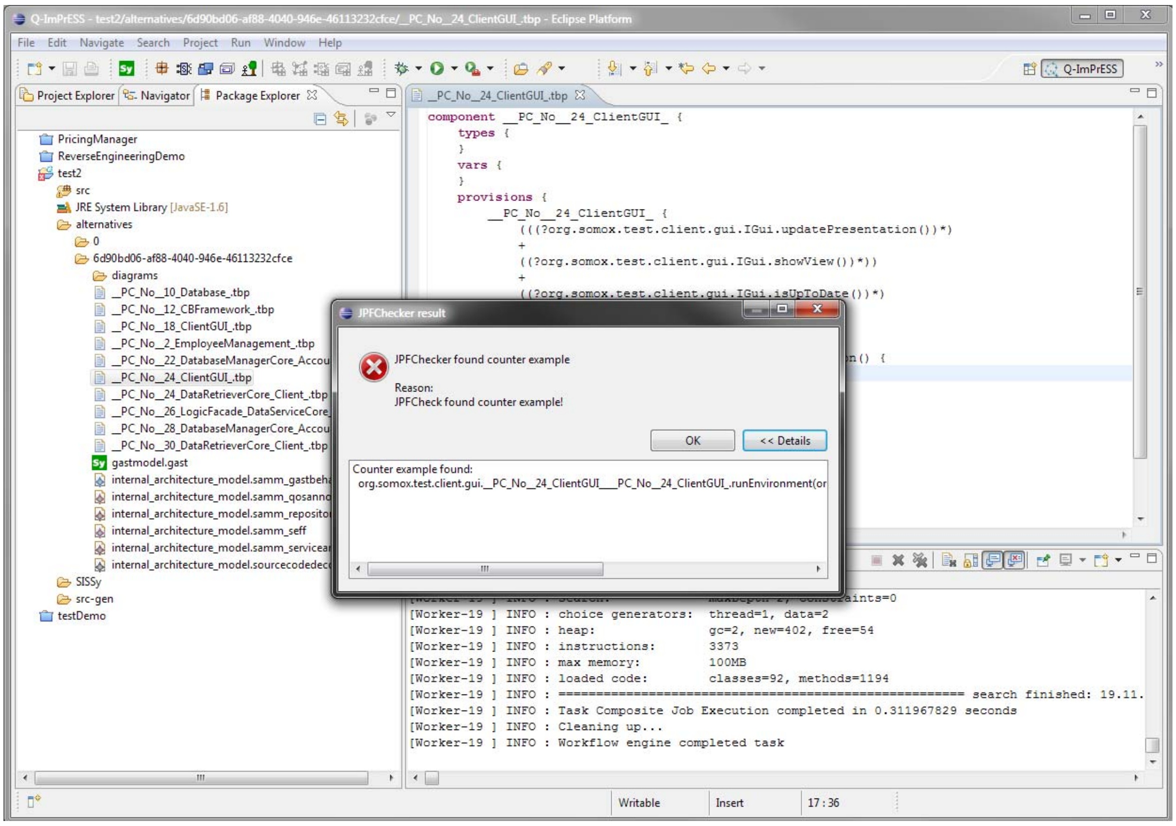
JPFChecker result

No error was found

OK

```
<terminated> ClientGUI [Q-ImPrESS Consistency Checker] Simulation Process
[Worker-16 ] INFO : search:              maxDepth=4, constraints=0
[Worker-16 ] INFO : choice generators:   thread=1, data=10
[Worker-16 ] INFO : heap:                gc=20, new=760, free=574
[Worker-16 ] INFO : instructions:        7413
[Worker-16 ] INFO : max memory:          98MB
[Worker-16 ] INFO : loaded code:         classes=92, methods=1196
[Worker-16 ] INFO : ===================================================== search finished: 19.11.
[Worker-16 ] INFO : Task Composite Job Execution completed in 0.37649103 seconds
[Worker-16 ] INFO : Cleaning up...
[Worker-16 ] INFO : Workflow engine completed task
```

Figure 126: Output of the Consistency checker when no inconsistency was found


Q-ImPrESS - test2/alternatives/6d90bd06-af88-4040-946e-46113232cfce/__PC_No__24_ClientGUI_.tbp - Eclipse Platform
File Edit Navigate Search Project Run Window Help
Q-ImPrESS
Project Explorer
Navigator
Package Explorer
PricingManager
ReverseEngineeringDemo
test2
src
JRE System Library [JavaSE-1.6]
alternatives
0
6d90bd06-af88-4040-946e-46113232cfce
diagrams
__PC_No__10_Database_.tbp
__PC_No__12_CBFramework_.tbp
__PC_No__18_ClientGUI_.tbp
__PC_No__2_EmployeeManagement_.tbp
__PC_No__22_DatabaseManagerCore_Accou
__PC_No__24_ClientGUI_.tbp
__PC_No__24_DataRetrieverCore_Client_.tbp
__PC_No__26_LogicFacade_DataServiceCore
__PC_No__28_DatabaseManagerCore_Accou
__PC_No__30_DataRetrieverCore_Client_.tbp
gastmodel.gast
internal_architecture_model.samm_gastbeh
internal_architecture_model.samm_qosanno
internal_architecture_model.samm_reposito
internal_architecture_model.samm_seff
internal_architecture_model.samm_servicear
internal_architecture_model.sourcecodedec
SISSy
src-gen
testDemo
__PC_No__24_ClientGUI_.tbp
Writable
Insert
17 : 36

```
component __PC_No__24_ClientGUI_ {
    types {
    }
    vars {
    }
    provisions {
        __PC_No__24_ClientGUI_ {
            (((?org.somox.test.client.gui.IGui.updatePresentation())*)
            +
            ((?org.somox.test.client.gui.IGui.showView())*))
            +
            ((?org.somox.test.client.gui.IGui.isUpToDate())*)
```

JPFChecker result

JPFChecker found counter example

Reason:
JPFCheck found counter example!

OK | << Details

Counter example found:
org.somox.test.client.gui._PC_No__24_ClientGUI___PC_No__24_ClientGUI_.runEnvironment(or

```
[Worker-19 ] INFO : choice generators:   thread=1, data=2
[Worker-19 ] INFO : heap:                gc=2, new=402, free=54
[Worker-19 ] INFO : instructions:        3373
[Worker-19 ] INFO : max memory:          100MB
[Worker-19 ] INFO : loaded code:         classes=92, methods=1194
[Worker-19 ] INFO : ===================================================== search finished: 19.11.
[Worker-19 ] INFO : Task Composite Job Execution completed in 0.311967829 seconds
[Worker-19 ] INFO : Cleaning up...
[Worker-19 ] INFO : Workflow engine completed task
```

Figure 127: Output of the Consistency checker when an inconsistency between the service's Java implementation and its behaviour model in TBP was detected

4.13.6 Caveats

The most common reason for the Consistency checker's failure is when it is applied to a service, whose implementation in Java uses libraries containing such native calls that are not yet supported by Java PathFinder. This is, in particular, the case of Java libraries for I/O (including logging via log4j), networking and database access (e.g. JDBC). There are two possible workarounds – removal of the library calls from the code for the purpose of consistency checking, or developing so called native peer classes for Java PathFinder.

Moreover, the user has to carefully create the specification of method parameter values such that all execution paths in the service's Java implementation are covered. When the coverage is incomplete, then the Consistency checker might miss some inconsistencies.

4.14 Java Performance Measurement Framework Manual

4.14.1 Purpose of the tool

The main purpose of the Java Performance Measurement Framework (JPMF) library is to simplify the process of obtaining performance data from running applications. Instead of having to develop a performance measurement harness for each application, the library provides a generic interface that allows the user to define performance event sources that emit performance events related to application execution. The user then configures what performance are to be collected with particular performance events and the JPMF library takes care of the actual collection and storage of the data in an efficient fashion. The user of the library thus only needs to concern herself with application instrumentation, which can be performed either manually at the source code level, or automatically at the Java byte code level, using tools provided by the library.

4.14.2 Tool relationship with the Q-ImPrESS workflow

Technically, the JPMF library is a standalone tool, independent of other tools found in the Q-ImPrESS tool chain in the sense that it neither processes input from other tools, nor provides directly consumable output to other tools. However, it is meant to be used for measurement purposes. The need to conduct performance measurements can arise either during the model validation phase, when a model needs to be validated against implementation, or during performance model design and performance prediction phases, when some model parameters need to be determined through measurement or when a system usage profile needs to be determined.

4.14.3 Key concepts

The JPMF library aims to provide a generic framework for collecting performance data from Java applications, without the need to tediously create a measurement infrastructure from scratch whenever there is a need to obtain performance data from some application. To this end, the JPMF library operates with several generic concepts that should be understood prior to using the library. However, since the purpose of this manual is to provide basic overview of the operation and usage of the library, many technical details are omitted for clarity and can be found in the library reference documentation.

Performance Events

The principle of the JPMF library operation is based on receiving named performance events from an application under test (AUT) and attaching performance data collected upon performance event reception to records describing the received events. This allows the library to be used in any context, as long as performance events can be delivered to the library.

The user of the library must ensure that the AUT registers performance events needed to collect performance data relevant to the performance metrics that need to be determined. Each performance event must have a unique name, which should be somehow related to the origin of the event in the application. For component-based applications, the architecture of the application provides a natural structure for naming performance events.

To provide support for hierarchical event naming schemes without prescribing a specific naming structure, the library utilises the **ObjectName** format defined in the Java JMX specification. An **ObjectName** is a string that comprises the following elements, in order:

- The domain.
- A colon (:).
- A list of key/value pairs, separated by a comma.

The boundaries of key/value pair are determined solely by the initial colon and intermediate commas. Whitespace characters have no special meaning, i.e. they are considered to be part of a key or its value. The following example represents an **ObjectName** with two keys, where each of the keys and the value associated with " key1 " begin and end with a space:

```
domain: key1 = value1 , key2 =value2
```

This allows grouping related performance events together and simplifies navigation and runtime event activity management (e.g., a group of events can be enabled or disabled using a single command).

Each performance event also has a type, which determines the basic data payload provided to the JPMF runtime and allows the user to use appropriate even type in different contexts. At the moment, the library supports the following performance event types:

- **AtomicEvent**, which is intended for generic standalone events,
- **IntervalEvent**, which is intended for pairs of events delimiting the start and the end of some generic action,
- **LoopEvent**, which is intended for pairs of events delimiting the start and the end of a generic loop in the code, including the number of loop iterations,
- **MethodEvent**, which is intended for pairs of events delimiting the start and the end of a method invocation, including (optionally) the cause for method return.

All performance event types carry a high-resolution time stamp, which allows extracting basic information such as duration of actions, loops, or method invocations from the events alone.

Event Sources

Since multiple related performance events will often originate from the same runtime entity (object instance, component, or a class), the JPMF library defines an **EventSource** interface, which represents a management entity for a group of related events. An event source is an application-side entity that provides information on supported events and their types, and control over which performance events should be emitted by the instrumented application entity. During automatic instrumentation, the instrumentation tool will typically create a single **EventSource** instance for each instrumented application entity, such as interface implementation, and register it with the JPMF library runtime. The JPMF runtime will then query the event source implementation for the supported performance events and their types and configure the event source to emit performance events specified by the user in an external configuration file.

This method of performance event registration is mainly intended for automatic instrumentation tools, because the cost of creating a custom **EventSource** implementation will be amortised by repeated use of the instrumentation tool.

Event Triggers

To simplify usage in situations where manual instrumentation is needed, the JPMF library provides an alternative method to register performance events. Instead of having to implement the **EventSource** interface, a user can instead request the library to implement the interface internally and provide the user with a simple trigger interface that can be used to send performance event notifications to the JPMF library.

Unlike event source, an event trigger only represents a single performance event and its interface depends on the represented event type. When requesting an event trigger from the JPMF library, a user must specify the desired event trigger interface in addition to the structured performance event name. At the moment, the library supports the following event triggers, directly corresponding to the performance event types mentioned above:

- **AtomicEventTrigger**
- **IntervalEventTrigger**
- **LoopEventTrigger**
- **MethodEventTrigger**

4.14.4 Basic API usage

The JPMF library itself is application agnostic, therefore it only provides API for registering performance events that must be used directly by user, or by an automatic instrumentation tool. Figure 128 shows the API provided by the `Jpmf` class, which serves as an entry point to the library. The first three methods provide control over the initialization and shutdown of the JPMF runtime, while the other two methods allow registration of event sources and construction of event triggers. Using any of the first three methods is optional.

```
public class Jpmf {
public static void init (Properties properties);
public static void flush ();
public static void shutdown ();

public static void registerEventSource (EventSource eventSource);
public static <T extends EventTrigger> T createEventTrigger (
Class <T> triggerType, String triggerName
);
}
```

Figure 128: Basic JPMF API

At runtime, the JPMF library provides a singleton implementation, which is initialised in a lazy manner when the first event source or event trigger is registered. Explicit initialization of the JPMF library is only required when the user wants to provide different initialization context represented by the `Properties` class. The `flush()` method can be called by the user to force flushing of buffers containing performance data to disk. And finally the `shutdown()` method can be called when the instrumented application is exiting. The JPMF library registers a shutdown hook with the JVM in order to ensure flushing of data from buffers to disk, but with manually instrumented applications (where the user is expected to be in control of application startup and shutdown), it is recommended to call the `shutdown()` method explicitly.

The `registerEventSource()` and `createEventTrigger()` methods serve for performance event registration. Each of those methods is targeted at different user. The `registerEventSource()` method is intended for automatic instrumentation tools, which will automatically create instances of the **EventSource** interface and register them with the framework. The `createEventTrigger()` method is intended for manual instrumentation and provides an implementation of a simplified event source that only supports a single performance event. When creating an event trigger, the user has to specify the desired trigger interface that will be used to trigger performance event notifications.

4.14.5 Instrumentation using event triggers

When using the JPMF library for manual instrumentation using event triggers, the user is responsible for creating and storing the event trigger instances and invoking their methods that trigger performance event notifications. The semantics of a particular trigger depends entirely on the user and her use of the trigger. When defined as an instance variable, its name should be different for different instances and the events emitted by the trigger are related to a particular instance. When defined as a static class variable, there will only be a single trigger instance per class, and the events emitted by the trigger are related to the class (or all instances of the class).

```
interface AtomicEventTrigger extends EventTrigger {
    void fire ();
}

interface IntervalEventTrigger extends EventTrigger {
    void start ();
    void stop ();
}

interface MethodEventTrigger extends EventTrigger {
    void enterMethod ();
    void leaveMethod ();
    void leaveMethod (MethodExitCause cause);
}

interface LoopEventTrigger extends EventTrigger {
    void enterLoop ();
    void leaveLoop (long loopCount);
}
```

Figure 129: Event trigger interfaces

Currently, the JPMF library supports four basic types of event triggers, with their interfaces shown in Figure 129. The library can be extended to support additional trigger types by implementing and registering trigger providers with the framework (this is currently beyond the scope of this manual, description of the interfaces can be found in the JPMF reference documentation.

The **AtomicEventTrigger** represents the simplest of performance event triggers. Atomic events are independent and in subsequent analysis, atomic events can be used to determine count, rate, or delay between individual events. The trigger interface inly provides a single method, `fire()`, which delivers an event notification (along with a high-resolution time stamp) to JPMF runtime.

The **IntervalEventTrigger** represents a pair of events delimiting the start and the end of a generic action or time interval. The interface provides two methods, `start()` and `stop()`, which should be used to enclose code representing the action. Both methods deliver an event notification to the JPMF runtime. In addition to time stamp, these two events are also marked as related, so that the duration of the interval can be easily determined.

The **MethodEventTrigger** also represents a pair of events, this time delimiting the start and the end of method invocation. It is basically a variant of the interval event trigger intended specifically for instrumenting method invocations. In addition to the `enterMethod()` and `leaveMethod()` methods, which should be used to delimit the method invocation, there is an additional method, `leaveMethod(MethodExitCause)`, which can be used to report abnormal return from a method, i.e. exception. Like in the case of interval events, the method invocation events are marked as related, so that the duration of method invocation can be easily determined.

The **LoopEventTrigger** also represents a pair of events, this time delimiting the start and the end of a loop. It is also a specific type of an interval event, intended specifically for instrumenting loops. To this end, the interface provides the `enterLoop()` method, which marks the start of a loop, and `leaveLoop(long)`, which marks the end of a loop and allows to associate the number of loop iterations with the event data. Like in the case of interval events, the loop start and end events are marked as related, so that the duration of a loop can be easily determined.

Figure 130 shows the usage of atomic event triggers to instrument Java code. There are two triggers, one global for the whole class named `__classTrigger`, and one local to a particular instance named `__instanceTrigger`. The global trigger is fired whenever a new instance of the class is created, the instance-local trigger is fired whenever the execution reaches a certain place in the `bar()` method code. When creating the triggers, the class of the desired trigger type along with a unique trigger name is passed to JPMF, which creates an internal event source implementation (so that the event source can be controlled from outside) for each trigger and returns a façade implementing the trigger interface. The `__getInstanceId()` method should be an internal method that is able to assign an identifier to the instance-specific trigger. The other trigger types are used in a similar way, the only difference is the interface type passed as an argument to the `createEventTrigger()` method and the methods invoked on the trigger instance.

```
import org.ow2.dsrg.jpmf.api.AtomicEventTrigger;

class Foo {
    private static final AtomicEventTrigger
        __classTrigger = Jpmf.createEventTrigger (
            AtomicEventTrigger.class,
            "package=.,class=Foo,id=InstanceCreated"
        );

    private final AtomicEventTrigger
        __instanceTrigger = Jpmf.createEventTrigger (
            AtomicEventTrigger.class,
            "package=.,class=Foo,method=bar,id="+ __getInstanceId()
        );

    // . . .

    public Foo () {
        __classTrigger.fire ();
        // . . . constructor code
    }

    public bar () {
        // method code before trigger
        __instanceTrigger.fire ();
        // method code after trigger
    }
}
```

Figure 130: Using atomic event triggers to instrument Java code

Instrumentation using event sources

For bulk instrumentation of multiple methods in a class, the JPMF library provides the **EventSource** service provider interface, which needs to be implemented by the user and be registered within the JPMF runtime. The interface allows JPMF to control multiple related events originating from a single place (e.g. a class).

```
public interface EventSource {
    String id ();
    List <Event> events ();

    final class Event {
        public Event (
            final String localId,
            final Class <? extends EventDelegate> delegateClass
        );
        public String localId ();
        public Class <? extends EventDelegate> delegateClass ();
    }

    void setTimerCounter (TimerCounter timer);
    void setEventDelegate (int eventIndex, EventDelegate delegate);

    void enable ();
    void disable ();
    boolean isEnabled ();

    void enableEvent (int eventIndex);
    void disableEvent (int eventIndex);
    boolean isEventEnabled (int eventIndex);
}
```

Figure 131: Overview of the EventSource interface

Figure 131 lists the methods defined by the **EventSource** interface. The first set of methods comprises the `id()` and `events()` methods, which provide information about an event source and the events it supports. Each event has a local identifier which, combined with the global event source identifier, makes up a fully qualified event name. The fully qualified name must be unique and should be related to application architecture. Each event also has an event type, which determines the event delegate interface required by a particular event in order to provide JPMF with event notifications.

The second set of methods comprises the `setTimerCounter(TimerCounter)` and `setEventDelegate(int, EventDelegate)` methods, which the JPMF uses to provide the event source with implementations of interfaces required from the framework. The framework may provide the event source with a common time source in form of a **TimerCounter** interface, which allows the event source to obtain timing information that is compatible with other event sources and the rest of the framework. However, more important is to provide the event source with an **EventDelegate** interface reference for each event it supports. The **EventDelegate** references will be used to submit event notifications to JPMF.

Finally, the third set of methods comprises the `enable()`, `disable()`, `isEnabled()`, `enableEvent(int)`, `disableEvent(int)`, and `isEventEnabled(int)` methods, which the JPMF uses to control the event notifications emitted by an event source. The `enable()` and `disable()` methods serve as a master switch, which allows JPMF to enable na disable event source operation (and, consequently, allow the event source to e.g. remove instrumentation from the class to reduce passive-state overhead). The `enableEvent(int)` and `disableEvent(int)` methods serve for fine-grained control and allow JPMF to select events for which the event source should emit event notifications.

The **EventSource** interface is to be implemented by performance instrumentation code and allows creating a single event source entity for a set of related events, such as e.g. events corresponding to interface method invocations. However, because of the support for event groups and event source configuration, the interface is relatively complex for casual use, when only a few unrelated performance events need to be defined. In such cases, the manual instrumentation using event triggers should be used instead. For more information on the **EventSource** and related interfaces, please see the reference documentation.

4.14.6 Tool prerequisites

The JPMF library itself requires a **Java Runtime Environment** version 1.5 or later, and (optionally) the **log4j** logging library version 1.2.15 or later. The instrumentation agent also requires **ASM** byte code manipulation library version 3.2 or later, which is however included in the distribution in a JPMF-specific package to avoid interference with other instances of the library that might be used by the instrumented application.

As for inputs, the JPMF library itself does not require any explicit input and by default, all the registered event sources are enabled. However, a user might wish to select a subset of performance events to record and the kind performance data to collect in addition to the data specific to performance event types. For this purpose, the library can be configured using a configuration file, the path to which can be specified using the `jpmf.conf` system property.

The instrumentation agent will also require a complete list of classes to instrument. Such a list will be derived from the list of classes the user wants to instrument by scanning the class path and identifying all classes that need to be modified in order to perform the instrumentation.

4.14.7 Tool activation

For information about downloading the tool, see http://www.q-impress.eu/wordpress/tool-overview/#additional_tools .
Being a software library rather than a standalone tool integrated in the Eclipse IDE, no special activation steps are required, apart from running the instrumented application. For the JPMF library to collect performance data, the AUT must be instrumented (manually, automatically, or both) and at least one of the registered performance events must be configured to emit notifications.

When using the automatic instrumentation agent, the Java Virtual Machine used for executing the application must be instructed to load the agent using the `-javaagent` command line option (see section 0).

4.14.8 Usage instructions and expected outputs

No special steps are required when using the library to collect application performance data. After executing the AUT, let the application perform the desired workload to generate workload-specific performance events and shut down the application. The JPMF library will produce output files containing the recorded performance events along with sampled performance data. These can be processed using the **JpmfStat** tool to obtain either basic statistical properties from selected events, or a text-based output suitable for further processing using heavy-duty statistical tools such as R.

Automatic load-time instrumentation

To simplify application instrumentation, the JPMF distribution provides an implementation of a Java agent that can be used to instrument generic Java applications. The user needs to provide a list of classes she wants to instrument and use a separate tool called **ClassesToInstr** to obtain a complete list of classed that will need to be modified by the instrumentation agent.

The input for the **ClassesToInstr** tool is a simple text file, with one fully qualified class name per line (an asterisk "*" can be used as a wildcard to match multiple classes). The **ClassesToInstr** tool will process all the classes reachable from the current class path and output a list of classes that will be instrumented by the agent, which then needs to be supplied to the agent.

When launching the AUT, the JVM needs to be instructed to load the JPMF instrumentation agent (packaged in a single jar file) using the `-javaagent` command line switch and providing a complete path to the agent jar file. Also, the name of the file containing the complete list of classes to instrument needs to be passed to the agent. The following example will instruct the JVM to load the JPMF agent from `/opt/jpmf/jpmf-agent.jar` file and pass `/tmp/instrument.cfg` as the name of the class list file:

```
-javaagent:/opt/jpmf/jpmf-agent.jar=/tmp/instrument.cfg
```

When the JVM is stared and the agent is activated, it intercepts all attempts to load a class and redefines (instruments) it if necessary. The instrumentation adds several fields and methods to the redefined class and also adds code at the beginning and at the end of each public method that will send performance event notifications to the JPMF runtime.

When an instrumented class is instantiated, the instrumentation code first creates an **EventSource** implementation for this particular instance, which will provide performance events for each instrumented method. The event source is then registered within JPMF.

At the moment, the downside of this approach is a limited ability to select the targets for instrumentation (only whole classes can be instrumented) and possibly slightly increased overhead compared to the manual instrumentation approach.

Configuration

The JPMF library can be configured from an XML configuration file, the location of which can be supplied through a Java system property specified on the command line:

```
-Djpmf.conf=/etc/jpmfconf.xml
```

If the `jpmf.conf` property is not set, the JPMF library by default attempts to load the configuration from a file named `jpmfconf.xml` for which it looks in the class path.

```
-d "data files" name of the data files without extension
(default: "data/eventdata")

-e "event name" selects only particular event
(default: include all)
(supports multiple occurrences)

-f "field name" selects only particular field
(default: include all)
(supports multiple occurrences)

-o "output file"
(default: console)

-s "skip count" skip first x results
(default: 100)

-t "table output mod" (separate/headers)
(default: none)
prints unprocessed data in a textual form.
separate - prints every event into a separate file
headers - events with the same header are printed into the same file
```

Figure 132: JpmfStat command line arguments

Three basic entities configurable via configuration file are events, event sources and transports. A sample configuration file named `jpmfconf.xml.sample` can be found in the JPMF `doc/` directory.

Simple data analysis

Output files produced by the JPMF are in binary format. To process these files, JPMF provides a simple tool called **JpmfStat**, which can either convert the binary files to human or machine readable text output, or calculate simple statistics. The statistics are calculated for each named event (see example below) and contains computed values such as mean, median, variance, median absolute deviation (MAD) and selected percentiles.

To execute the **JpmfStat** tool, the JVM must be instructed to execute the `org.ow2.dsrg.jpmf.JpmfStat` main class. On Linux, a simple wrapper script called `jpmfstat.sh` can be used. The **JpmfStat** tool accepts various command line arguments shown in Figure 132.

Figure 133 shows sample output of from the **JpmfStat** tool. The first part of the table contains statistical values for various types of sensors such as time in CPU clocks or application CPU time in seconds. The second part contains the computed percentiles.

```
jpmf.event:package=org.cocome...impl,class=StoreImpl,id=0,event=getProductWithStockItem/5
-----------------------------------------------------------------------------------------------
| type                  |          mean |        median |             variance |          MAD |
-----------------------------------------------------------------------------------------------
| time                  |  40012664.643 |  33473648.500 | 2428576578625785.000 |  3284980.000 |
| .../cpu.iowait#_all   |         0.071 |         0.000 |                0.164 |        0.000 |
| .../cpu.nice#_all     |         0.000 |         0.000 |                0.000 |        0.000 |
| .../cpu.user#_all     |         5.594 |         4.000 |              130.626 |        1.000 |
| .../cpu.system#_all   |         0.311 |         0.000 |                0.565 |        0.000 |
| .../cpu.softirq#_all  |         0.034 |         0.000 |                0.033 |        0.000 |
-----------------------------------------------------------------------------------------------
| type/percentiles      |            10 |            20 |            30 |            40 | ...
-----------------------------------------------------------------------------------------------
| time                  |  28917998.500 |  29580559.200 |  30577046.600 |  31885300.800 | ...
| .../cpu.iowait#_all   |         0.000 |         0.000 |         0.000 |         0.000 | ...
| .../cpu.nice#_all     |         0.000 |         0.000 |         0.000 |         0.000 | ...
| .../cpu.user#_all     |         3.000 |         3.000 |         3.000 |         3.000 | ...
| .../cpu.system#_all   |         0.000 |         0.000 |         0.000 |         0.000 | ...
| .../cpu.softirq#_all  |         0.000 |         0.000 |         0.000 |         0.000 | ...
-----------------------------------------------------------------------------------------------
```

Figure 133: Sample output from the JpmfStat tool

4.14.9 Caveats

When used with the automatic instrumentation agent, the JPMF library provides performance data per instrumented object instance, instead of class, which is common with profiling tools. This is intentional, because the JPMF library was intended for collecting performance data from component-based applications, where component instances are usually named and even though they may be instances of the same class, their performance characteristics may be different and need to be captured separately. When aggregate performance data are required for the whole class, they can be obtained either by aggregating the instance-specific data provided by the library, or by manually instrumenting the class using static triggers, or by using a custom instrumentation tool.
At the moment, the automatic instrumentation agent does not support fine-grained selection of entities to instrument. The configuration file can only list classes only lists classes that need to be instrumented and the agent will always instrument all public methods of given classes. When other (private or protected) methods need to be instrumented, triggers should be used to manually instrument the required code parts.

The JPMF library currently supports neither network-based performance data transports, nor multiple output files.

4.15 Random Program Generator Manual

4.15.1 Purpose of the tool

The purpose of the Random Program Generator (RPG) tool is to automatically generate software systems composed from primitive components, together with their models. Then, the generated systems can be directly executed with a simulated client load, and their performance (throughput, response times) measured. The corresponding models can be transformed to a particular performance model and to predict the performance.
By comparing the predicted and measured results, we can validate the quality predictions on a large number of systems, and, provided that the generated systems are representative enough, achieve a relatively robust validation of the given prediction method.

In the current version, the tool can generate software systems either from C++ components or from Java components. A number of components were created by porting workloads from the SPEC CPU2006 and SPEC jvm2008 benchmark suites. The models of the generated systems can be imported into the Q-ImPrESS IDE, where the usual workflow can then be applied for performance prediction. For the purposes of validation, a tool for transformation to SimQPN performance models has also been implemented.

Focusing more on developers than end users, the tool has a mostly command line interface and requires a POSIX compliant system (tested on Linux and Solaris) to run. The generated software systems have the same requirements. For more details on the requirements see section 4.15.3.

4.15.2 Tool relationship with the Q-ImPrESS workflow

The tool is not intended to be part of the standard Q-ImPrESS workflow. It has been used for validation of performance prediction of Q-ImPrESS models by comparing the measured and predicted performance of a large number of generated software systems in the Deliverable 4.2. This approach and the tool can, however, be useful to validate any future changes to the Q-ImPrESS implementation, or to validate virtually any other performance prediction methodologies and tools, provided that a transformation to such tool's input is implemented.

4.15.3 Tool prerequisites

The random system generator tool can be built on a recent Linux system (kernel 2.6) with standard build tools including GCC, make and binutils, and Java 1.6. The tool has been tested on x86, x86_64 and sparc architectures. The implementation of the 'fft' primitive component requires the FFTW library 3.0 or higher to be installed. The same prerequisites apply for executing the generated systems in order to obtain their measurements.

The models of the generated systems can be imported to the Q-ImPrESS IDE by a plugin, which is a part of the standard Q-ImPrESS IDE installation, and uses the files produced by the random system generator as its input.

The tool for transforming the models of the generated system to SimQPN models requires Java 1.6, and uses the files generated by the RPG tool random system generator as its input.

The scripts for visualization of results require the R project to be installed, with additional optional R packages detailed in the README file.

The `pydot` package for Python can be used to generate human-readable graphic representations of the generated application architectures. This prerequisite is optional.

The tool provides two different sets of component implementations (called **modules**), one for the C++ and the other for the Java language. An application can be generated using modules only from one of the sets, not both at the same time. The input of the generator tool is given by the means of configuration files, as described below.

4.15.4 Tool activation

Generating an application

The RPG tool is a command-line utility. Started using a shell script, it generates and compiles an application, according to the configuration options. After checking out, or downloading and extracting the source directory of the RPG tool, the standard `make` command will compile the random application generator and all the components of which the generated applications will be composed.

The application generators for C++ and Java can be invoked (from the RPG root directory) using the `bin/generate-application-{cpp,java}.sh` scripts.. Both scripts take one mandatory and one optional argument.

The first, mandatory argument specifies the configuration file (called profile) to be loaded from the configuration directory. For instance, configuration files defining the `reliable-multi-threaded` profile for C++ and Java modules can be found in the `bin/conf/{java,cpp}/reliable-multi-threaded.conf` configuration files. Both the path and the `.conf` suffix are automatically added to the command line argument.

The second, optional argument specifies the target directory where the new random application will reside. This directory will be created and must not exist beforehand. If not given, a random name starting with `rpg.` is being generated

The following command (invoked in the RPG root directory) will create a random Java application in the `~/rpg` directory, using the `reliable-multi-threaded` configuration profile.

```
bin/generate-architecture-java.sh reliable-multi-threaded ~/rpg
```

Measuring a generated application

The generated applications are invoked from command line as well, which produces measurements using a built-in benchmarking harness.

The random application can be executed using the `main` binary for C++ application or `run.sh` script for Java applications. This executes the built-in benchmarking harness which first measures the individual modules in isolation and then the whole application using a simulated client load. Measurement results will be written to standard output, so it is recommended to redirect them to a file for later processing.

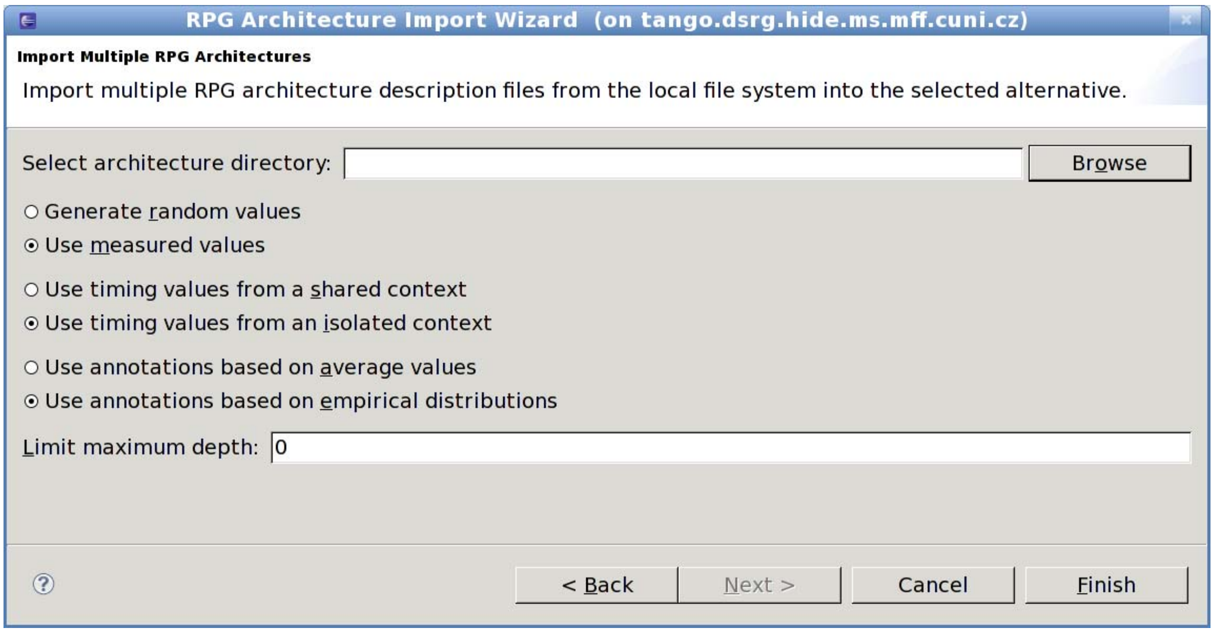
```
cd ~/rpg
./main > main.out
```

or (Java)

```
./run.sh > main.out
```

Predicting performance of a generated application

To import the model of generated application to the Q-ImPrESS IDE and predict its performance, store the output of the generated application (which contains the timings collected during the execution) into a file called `main.out` in the directory of the generated application. Then, import the architecture of the generated application into the Q-ImPrESS IDE using the “Import RPG Architecture” entry from the Eclipse import menu (see Figure 134).


RPG Architecture Import Wizard (on tango.dsrg.hide.ms.mff.cuni.cz)

Import Multiple RPG Architectures

Import multiple RPG architecture description files from the local file system into the selected alternative.

Select architecture directory:

○ Generate random values
⦿ Use measured values

○ Use timing values from a shared context
⦿ Use timing values from an isolated context

○ Use annotations based on average values
⦿ Use annotations based on empirical distributions

Limit maximum depth: 0

Figure 134: Importing an RPG architecture into the Q-ImPrESS IDE

The import facility comes in two flavours, one capable of importing a single architecture, one for importing multiple architectures stored in individual subdirectories. The second flavour is more suitable for mass prediction validation such as the prediction that has been carried out during the Q-ImPrESS project.

The import process can be configured using the radio buttons of the import dialog:

- The first pair of choices makes it possible to import an architecture whose measurements are not yet available. Since Q-ImPrESS models require annotations before predictions can be run, the import plugin will generate random values for all annotations. The predictions done on models with random annotations will naturally make little sense, however, the models can still be used to test various IDE features.

- The next pair of choices determines whether the Q-ImPrESS models will be annotated with measurements of quality attributes collected from one module at a time (isolated context) or from all modules executing together (shared context). This option is meaningful for validation and is explained in the Q-ImPrESS deliverable D4.2: Prediction Validation. In general, it can be said that measurements from shared context lead to more precise predictions, but are not always available in practice.

- The third pair of choices tells whether the Q-ImPrESS model annotations should contain mean timing values or complete distributions as observed during execution.

- Finally, it is possible to specify the maximum depth, from the root component, of the model. During import, all nested components below the maximum depth are coalesced into a single component in the model. Zero means unlimited depth.

The imported models are immediately usable for prediction.

4.15.5 Tool configuration

Both the application generator and the module instances in a generated random application use the same mechanism to access their configuration data. This data is loaded from human-readable text files.

The configuration files for the random generator tool are placed in the bin/conf/cpp or bin/conf/java directory, depending on which type of components is to be used in the generated application. Options that are shared by both variants are defined in the bin/conf/shared.conf file. In each language-specific directory, the configuration is again divided into shared part (cpp/shared.conf or java/shared.conf) defining available modules, global and default options, and specific configuration which include and override the shared defaults.

Each configuration file represents a set of parameters in the form of name-value pairs. Parameter names are divided in two parts separated by '::'. The first part can be either a name of a module, defining a module-specific parameter, a special name 'default' defining a fallback parameter for modules where a module-specific one is not given, or a special name 'core' defining global parameters that control behaviour of either the generator or the generated applications.
Parameter values can specify either a constant (string, integer, float or lists of these) or define

a random variable of several supported distributions to either randomly generate numbers or randomly select members of a list. This random generation can be either performed during the application generation, where the randomly selected value is fixed for all executions of the application, or performed in the generated application itself, typically on each invocation of a module.

Each module configuration describes at least a class of the module, which refers to the actual code implementing it and the relative probability of the module to be selected during the generation. There might be further parameters, if the module class supports them. Multiple module configurations can refer to the same class, but with different probability and set of extra parameters. For example, modules of one of the architectural module classes `sequence` and `branch` have a `slots` parameter determining the number of submodules called in the sequence, or selected from in the branch. The remaining architectural module class `loop` has an `iterations` parameter.

As an example. the following configuration file fragment defines two parameters, `time-millisec` and `time-nanosec`, both for a module called `waiter`, and a parameter `loopcount` for a `loop` module. The `time-nanosec` parameter is a constant. The `time-millisec` parameter is a random value from a uniform distribution selected during application generation. The `loopcount` parameter is a random value from a uniform distribution selected on each invocation of the `loop` module.

```
waiter::time-nanosec = 0
waiter::time-millisec = random-range (min = 50, max = 999)
loop::loopcount    = parameter (classname = "random-range", min
= 3, max = 5)
```

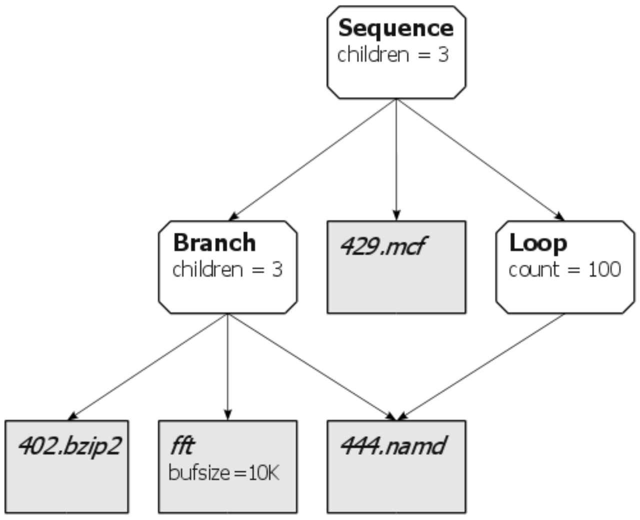
Two example configuration files are provided (reliable-single-threaded and reliable-multi-threaded) for both C++ and Java variants. Check out the provided configuration files for descriptions of configuration options if overriding the defaults is desired.

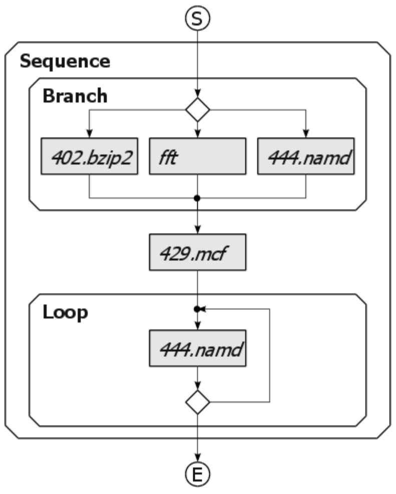
4.15.6 Expected outputs

Generating an application

The generated application directory contains:

- An executable binary `main` (C++), or script run.sh along with jars and class files in `jars`, `common` and `modules` subdirectories (Java).
- Input files for the modules in the `input` subdirectory.
- Runtime configuration for the modules and benchmark harness in `main.conf`.
- Architectural description of the application in `main.xml`.





The figures above show an example architecture and control flow diagram of a generated application. It consists of three instances of architectural modules (sequence, branch and loop), and four instances of leaf modules. The instance of namd module is called from two places of the control flow.

Internally, the module instances in a generated application are given an unique ID in the form of "ModuleX", where X is a number. These ID's are used to identify the module instances in the `main.conf` and `main.xml` files.

The `main.conf` file is read by the generated application. It has the same format as the generator configuration files. It contains parameter of the individual module instances, prefixed by their ID, and configuration of the measurement harness, prefixed by `app`, with parameters such as number of simulated clients, threads, number of isolated module measurements and whole app measurements to take. Values of these parameters are taken directly from the generator configuration. There is no need to modify this file, unless a single generated application is to be measured with e.g. varying number of clients or threads.

The `main.xml` file contains a description of the generated application's architecture. It describes the module instances, identified by their ID, their parameters and, for architectural modules, which modules are called from these modules. It contains the following XML elements:

- Root `architecture` element with `root-module-id` attribute identifying the root module of the architecture.
- For each module instance, a `module` element with attributes `id`, `classname` (class of the module) and `name` (the name of the module in the generator configuration).
- For each module parameter, there is a `param` element corresponding with an option in the `main.conf` file. These elements are grouped under a `params` element, which is a child of a `module` element.

- For modules of `sequence` or `branch` class, there is a slot element (child of `module` ement), with a `target-id` attribute holding the ID of module that is called from such module.

A graphic representation of the random application's architecture can be generated using the `viz-modules.py` script. The script parses the `main.xml` file (created by the application generator) and writes the resulting image into `main.png`. Provided that a shell variable `RPG_ROOT` contains the path to the RPG root directory and an application has been generated into the `~/rpg` directory, a graphic representation of the application can be obtained as follows:

```
cd ~/rpg && "$RPG_ROOT"/bin/utils/viz-modules.py
```

Measuring a generated application

The random application first measures the invocation time (both wall clock and processor time) of individual modules. Then, the performance of the whole application is measured subjected to a simulated client load.

The output of the generated application is logically a table with four columns, where the first three columns describe a value given in the fourth column. This table is output line-by-line, with the columns separated by semicolons.
In more detail, the four columns contain:

1. Logical source of the output value. This is either the whole application (denoted `app`) or an ID of a module instance (`Module`*X*).
2. Context of the value. This is either `config` (a value derived from configuration, such as number of threads or whether a module is protected by a lock), `isolated` (for isolated module timings), or `shared` (for measurements obtained under simulated load, both for the whole application and individual modules).
3. Description of the value. This is either a name of a configuration parameter (for `config` context), or a time value description. For module sources, this can be `monotonic` for wall clock time or `threadtime` for processor time duration of invocation. For the `app` source, `monotonic_client` gives the duration of the whole request as perceived by a simulated client, `monotonic_end` is a timestamp of when a request finishes, `monotonic` is again the duration of request, but excluding the time waiting for a thread to be acquired from the thread pool.
4. The value described by the previous columns. Times are given in nanoseconds.

4.15.7 Caveats

The tool relies on workload modules obtained from the SPEC CPU benchmark suite. The license for the SPEC CPU benchmark suite does not permit redistribution of code, the tool is therefore not redistributable in its entirety. Negotiations with the SPEC consortium are underway to provide a licensing solution, as the tool is deemed useful beyond the scope of the Q-ImPrESS project.

5 Appendix A: Getting started guide

5.1 Introduction

The Q-ImPrESS IDE ships with a simple Client/Server example. Here we use this example to give an introduction of the different parts of the Q-ImPrESS IDE tooling.
Basic knowledge about the Q-ImPrESS approach, as well as a readily installed Q-ImPrESS IDE, is required.

This appendix covers all parts of the Q-ImPrESS tooling that can be demonstrated with the Client/Server example. This includes the Q-ImPrESS IDE, the editors, the QoS prediction tools, the results viewer and the trade-off analysis. It does not cover the reverse-engineering tooling. For more information about the Q-ImPrESS reverse-engineering approach, see the Q-ImPrESS Reverse Engineering Manual.

5.2 The Q-ImPrESS IDE

When starting the Q-ImPrESS IDE, the user has to select a workspace which should be used by the tooling. If the user has installed the Q-ImPrESS IDE by using the Q-ImPrESS drop, a workspace with the Client/Server example system is already provided. If the IDE has been installed via the Q-ImPrESS update site, the example system project can be downloaded at http://www.q-impress.eu/wordpress/client-server-example/.

Q-ImPrESS projects are organised as Eclipse projects. In the workspace, new projects can be created, and existing projects can be imported.

A Q-ImPrESS project displays the Q-ImPrESS logo in the project explorer. It contains an alternatives repository, as well as additional model files. All Service Architecture Models (SAM) for a modelled system alternative are located in one alternative in the IDE. The alternatives repository displays all alternatives of the project and allows creating additional alternatives.

The Client/Server example project is called “Client-Server Example”. The alternatives repository contains a main alternative, as well as two additional alternatives, which feature some model changes, for which the QoS impacts can be analysed (see Figure 135).

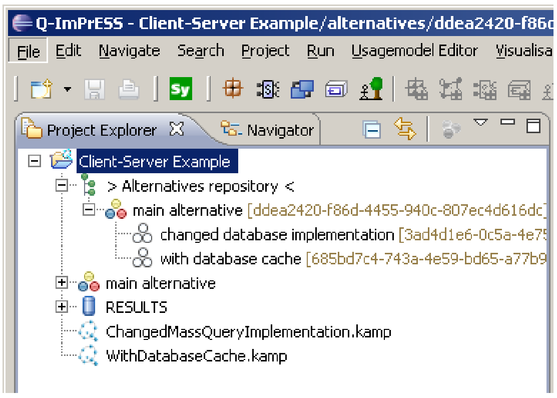
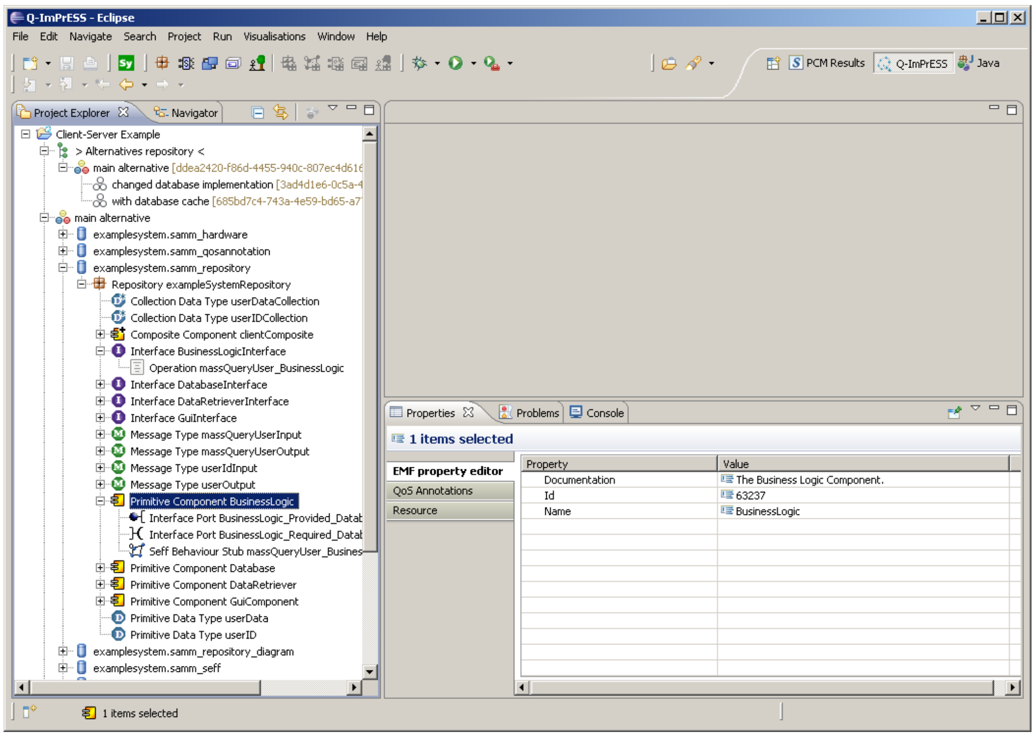

Q-ImPrESS - Client-Server Example/alternatives/ddea2420-f86
File Edit Navigate Search Project Run Usagemodel Editor Visualisa
Project Explorer
Navigator
Client-Server Example
> Alternatives repository <
main alternative [ddea2420-f86d-4455-940c-807ec4d616dc]
changed database implementation [3ad4d1e6-0c5a-4e7
with database cache [685bd7c4-743a-4e59-bd65-a77b9
main alternative
RESULTS
ChangedMassQueryImplementation.kamp
WithDatabaseCache.kamp

Figure 135: A Q-ImPrESS alternative repository

The Client/Server example features a model of a small service-oriented client-server application. The application features a business logic component and a database component. Only a simple service has been modelled, which can be used to query user data from the database. The business component provides a service that queries a bulk of user data information from the database. To enhance the QoS of the system, two different alternatives have been identified: One alternative consists in adding a database cache component, which speeds up query response times, as results can be buffered. The second alternative features a changed database access. Here the bulk information is not retrieved from the database with multiple simple database calls, but with a single mass query database call.

The Q-ImPrESS IDE displays all model elements for a selected alternative (the default alternative). To switch the default alternative, right-click on an alternative and select “Make alternative default”.
An alternative can contain different models, as well as model diagrams. Models have the file ending “.samm_xy”, model diagrams have the file ending “.samm_xy_diagram”. Every model file can be inspected in the project explorer. All model elements and attributes can be displayed and edited. Figure 136 shows model elements of the component repository for the main alternative of the example system. The model attributes are displayed in the “Properties” view.



```
Client-Server Example
  > Alternatives repository <
    main alternative [ddea2420-f86d-4455-940c-807ec4d61
      changed database implementation [3ad4d1e6-0c5a-4
      with database cache [685bd7c4-743a-4e59-bd65-a7
  main alternative
    examplesystem.samm_hardware
    examplesystem.samm_qosannotation
    examplesystem.samm_repository
      Repository exampleSystemRepository
        Collection Data Type userDataCollection
        Collection Data Type userIDCollection
        Composite Component clientComposite
        Interface BusinessLogicInterface
          Operation massQueryUser_BusinessLogic
        Interface DatabaseInterface
        Interface DataRetrieverInterface
        Interface GuiInterface
        Message Type massQueryUserInput
        Message Type massQueryUserOutput
        Message Type userIdInput
        Message Type userOutput
        Primitive Component BusinessLogic
          Interface Port BusinessLogic_Provided_Datat
          Interface Port BusinessLogic_Required_Datat
          Seff Behaviour Stub massQueryUser_Busines
        Primitive Component Database
        Primitive Component DataRetriever
        Primitive Component GuiComponent
        Primitive Data Type userData
        Primitive Data Type userID
    examplesystem.samm_repository_diagram
    examplesystem.samm_seff
```

1 items selected

Property	Value
Documentation	The Business Logic Component.
Id	63237
Name	BusinessLogic

1 items selected

Figure 136: Contents of a repository model

For some model elements, textual and/or graphical editors are available. These editors can be opened by right-clicking on the model element in the project explorer and selecting "Open in textual editor" or "Open in graphical editor".
For example, a graphical model editor is available for component repositories, composite component and service architecture models, as well as for SEFF behaviours. Textual editors are available for most model elements (see Text Editors Manual).
Graphical models can also be saved in a separate diagram file. For example, for a composite repository, a graphical model file can be created by right-clicking on the ".samm_repository" file and selecting "Initialize graphical model file".

For the example system, a diagram file is available for the component repository, the service architecture file, as well as some SEFF behaviours. Figure 137 shows the graphical model editor for the service architecture model of the main alternative.

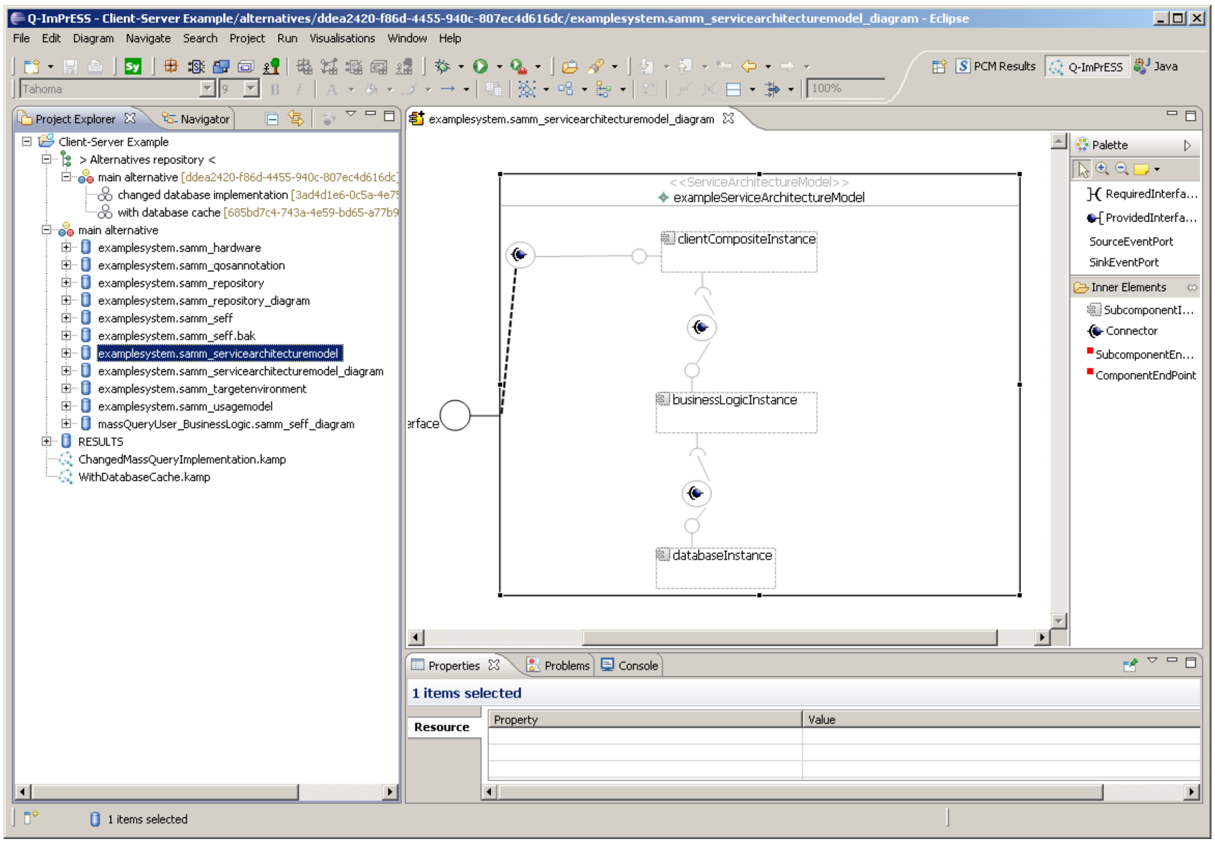

Q-ImPrESS - Client-Server Example/alternatives/ddea2420-f86d-4455-940c-807ec4d616dc/examplesystem.samm_servicearchitecturemodel_diagram - Eclipse
File Edit Diagram Navigate Search Project Run Visualisations Window Help
PCM Results
Q-ImPrESS
Java
Project Explorer
Navigator
Client-Server Example
> Alternatives repository <
main alternative [ddea2420-f86d-4455-940c-807ec4d616dc]
changed database implementation [3ad4d1e6-0c5a-4e7
with database cache [685bd7c4-743a-4e59-bd65-a77b9
main alternative
examplesystem.samm_hardware
examplesystem.samm_qosannotation
examplesystem.samm_repository
examplesystem.samm_repository_diagram
examplesystem.samm_seff
examplesystem.samm_seff.bak
examplesystem.samm_servicearchitecturemodel
examplesystem.samm_servicearchitecturemodel_diagram
examplesystem.samm_targetenvironment
examplesystem.samm_usagemodel
massQueryUser_BusinessLogic.samm_seff_diagram
RESULTS
ChangedMassQueryImplementation.kamp
WithDatabaseCache.kamp
examplesystem.samm_servicearchitecturemodel_diagram
<<ServiceArchitectureModel>>
exampleServiceArchitectureModel
clientCompositeInstance
businessLogicInstance
databaseInstance
erface
Palette
RequiredInterfa...
ProvidedInterfa...
SourceEventPort
SinkEventPort
Inner Elements
SubcomponentI...
Connector
SubcomponentEn...
ComponentEndPoint
Properties
Problems
Console
1 items selected
Resource
Property
Value
1 items selected

Figure 137: The Q-ImPrESS Composite Editor for service architecture models

The same diagram is also available for two derived alternatives of the Client/Server example. For example, the service architecture model of the “WithDatabaseCache” alternative features an additional component in the system, the database cache, which is placed between the business logic component and the database component.

The SEFF behaviour diagram of the business logic component in the main alternative is shown in Figure 138. It features loops that consist of database calls.

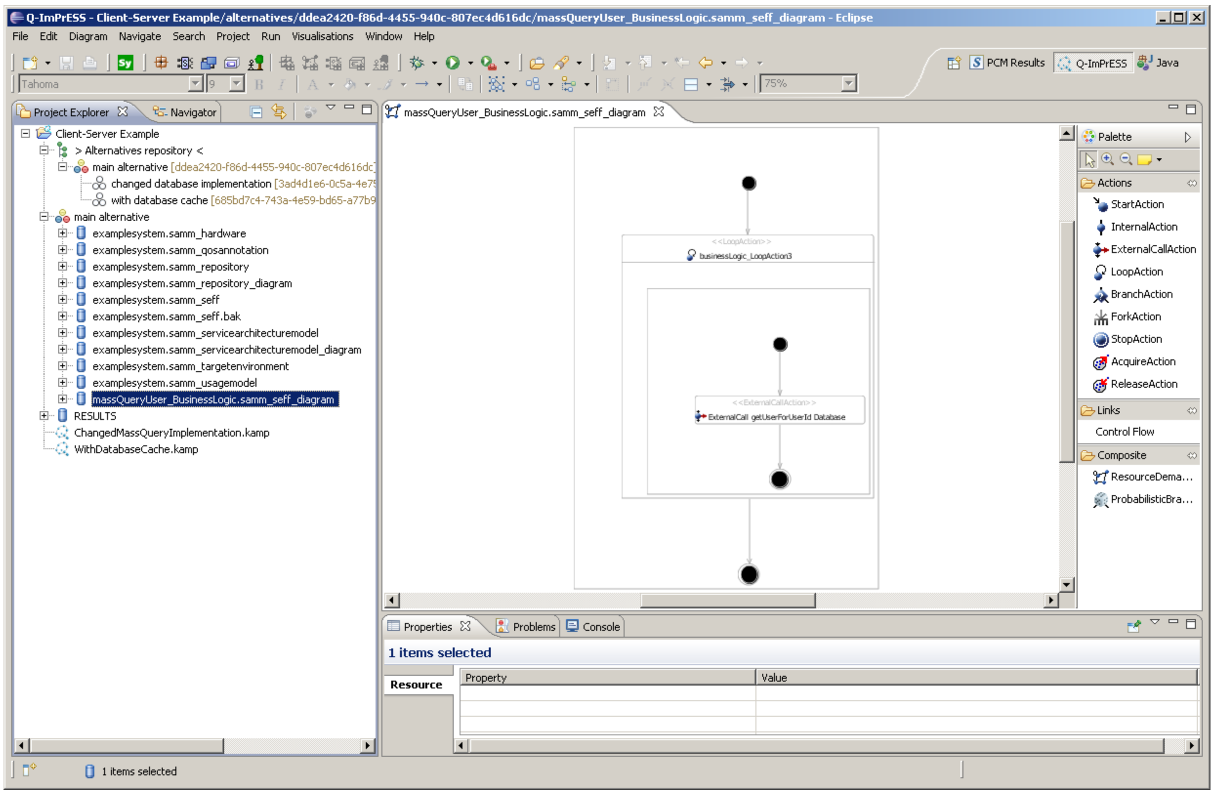

Q-ImPrESS - Client-Server Example/alternatives/ddea2420-f86d-4455-940c-807ec4d616dc/massQueryUser_BusinessLogic.samm_seff_diagram - Eclipse
File Edit Diagram Navigate Search Project Run Visualisations Window Help
PCM Results
Q-ImPrESS
Java
Project Explorer
Navigator
Client-Server Example
> Alternatives repository <
main alternative [ddea2420-f86d-4455-940c-807ec4d616dc]
changed database implementation [3ad4d1e6-0c5a-4e75
with database cache [685bd7c4-743a-4e59-bd65-a77b9
main alternative
examplesystem.samm_hardware
examplesystem.samm_qosannotation
examplesystem.samm_repository
examplesystem.samm_repository_diagram
examplesystem.samm_seff
examplesystem.samm_seff.bak
examplesystem.samm_servicearchitecturemodel
examplesystem.samm_servicearchitecturemodel_diagram
examplesystem.samm_targetenvironment
examplesystem.samm_usagemodel
massQueryUser_BusinessLogic.samm_seff_diagram
RESULTS
ChangedMassQueryImplementation.kamp
WithDatabaseCache.kamp
massQueryUser_BusinessLogic.samm_seff_diagram
<<LoopAction>>
businessLogic_LoopAction3
<<ExternalCallAction>>
ExternalCall getUserForUserId Database
Palette
Actions
StartAction
InternalAction
ExternalCallAction
LoopAction
BranchAction
ForkAction
StopAction
AcquireAction
ReleaseAction
Links
Control Flow
Composite
ResourceDema...
ProbabilisticBra...
Properties
Problems
Console
1 items selected
Resource
Property
Value
1 items selected

Figure 138: A SEFF behaviour diagram

5.3 Quality predictions

For all three Client/Server example alternatives, performance and reliability analyses have been performed. The results are stored in the Result Model (see below). For the two alternatives that have been derived from the main alternative, i.e. the database cache alternative and the changed database implementation alternative, a maintainability prediction is also available.

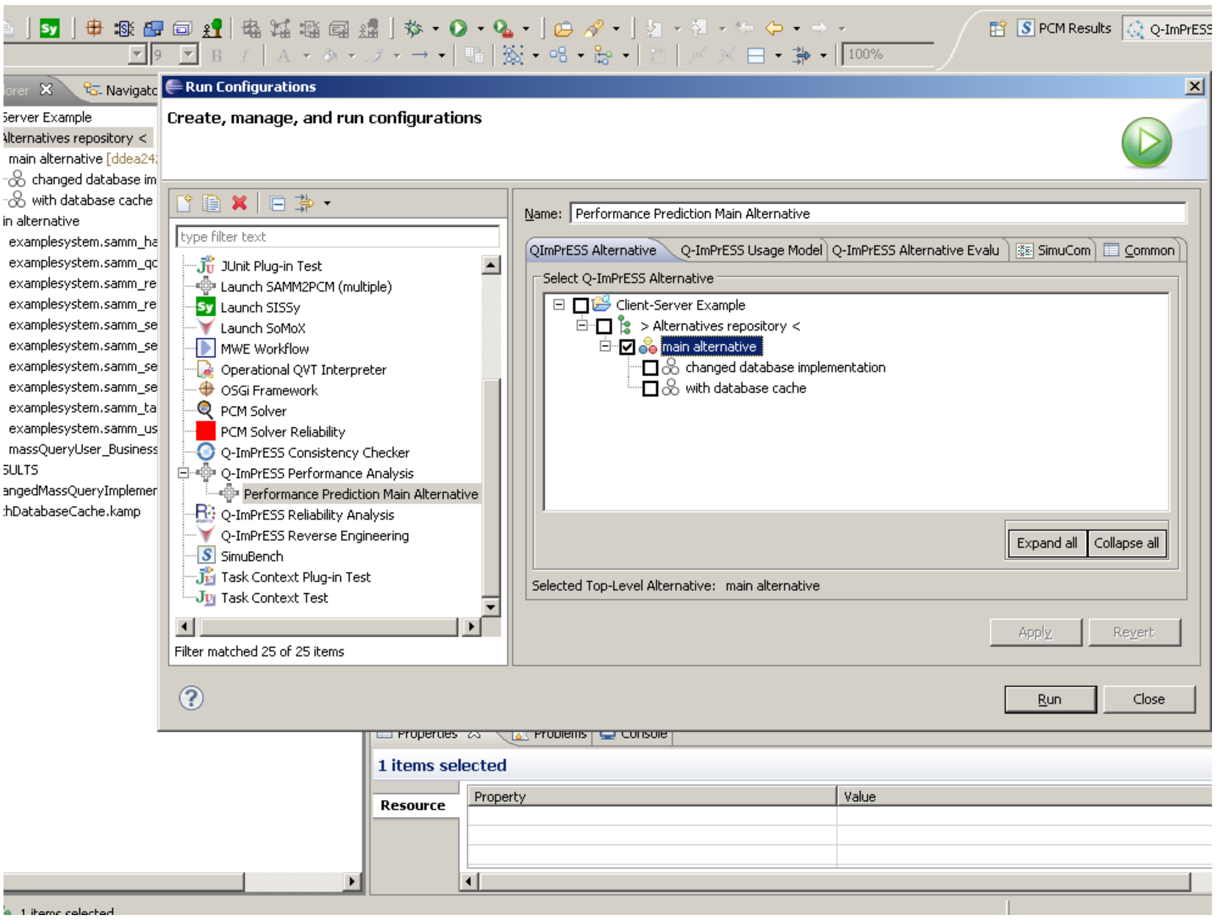
In Q-ImPrESS, service architecture models can be enriched with QoS annotations, which contain quality properties of the model that are relevant for the analysis. All QoS annotations are stored in the examplesystem.samm_qosannotation file in the example system alternatives. Such QoS annotations can be behaviour branch probabilities, loop counts, resource demands, as well as component failure probabilities. A detailed description of the QoS annotations can be found in chapter 4.6.

To repeat the performance or reliability prediction, similar steps have to be performed. A detailed description of the prediction can be found in the SAM Performance Prediction Manual and the SAM Reliability Prediction Manual.

Both predictions can be launched by creating an Eclipse run configuration. Select "Run" → "Run Configurations…" and create a new "Q-ImPrESS Performance Analysis" or

"Q-ImPrESS Reliability Analysis" in the run configurations dialog.
Both types of run configurations have to be configured in a similar way. A Q-ImPrESS model alternative has to be selected, as well as a usage model and an alternative evaluation (which is part of the result model that stores the analysis results).

Figure 139 shows the run configuration dialog for the performance prediction analysis.


Run Configurations

Create, manage, and run configurations

type filter text

- JUnit Plug-in Test
- Launch SAMM2PCM (multiple)
- Launch SISSy
- Launch SoMoX
- MWE Workflow
- Operational QVT Interpreter
- OSGi Framework
- PCM Solver
- PCM Solver Reliability
- Q-ImPrESS Consistency Checker
- Q-ImPrESS Performance Analysis
  - Performance Prediction Main Alternative
- Q-ImPrESS Reliability Analysis
- Q-ImPrESS Reverse Engineering
- SimuBench
- Task Context Plug-in Test
- Task Context Test

Filter matched 25 of 25 items

Name: Performance Prediction Main Alternative

QImPrESS Alternative | Q-ImPrESS Usage Model | Q-ImPrESS Alternative Evalu | SimuCom | Common

Select Q-ImPrESS Alternative

- ☐ Client-Server Example
  - ☐ > Alternatives repository <
    - ☑ main alternative
      - ☐ changed database implementation
      - ☐ with database cache

Expand all | Collapse all

Selected Top-Level Alternative: main alternative

Apply | Revert

Run | Close

1 items selected

Property	Value

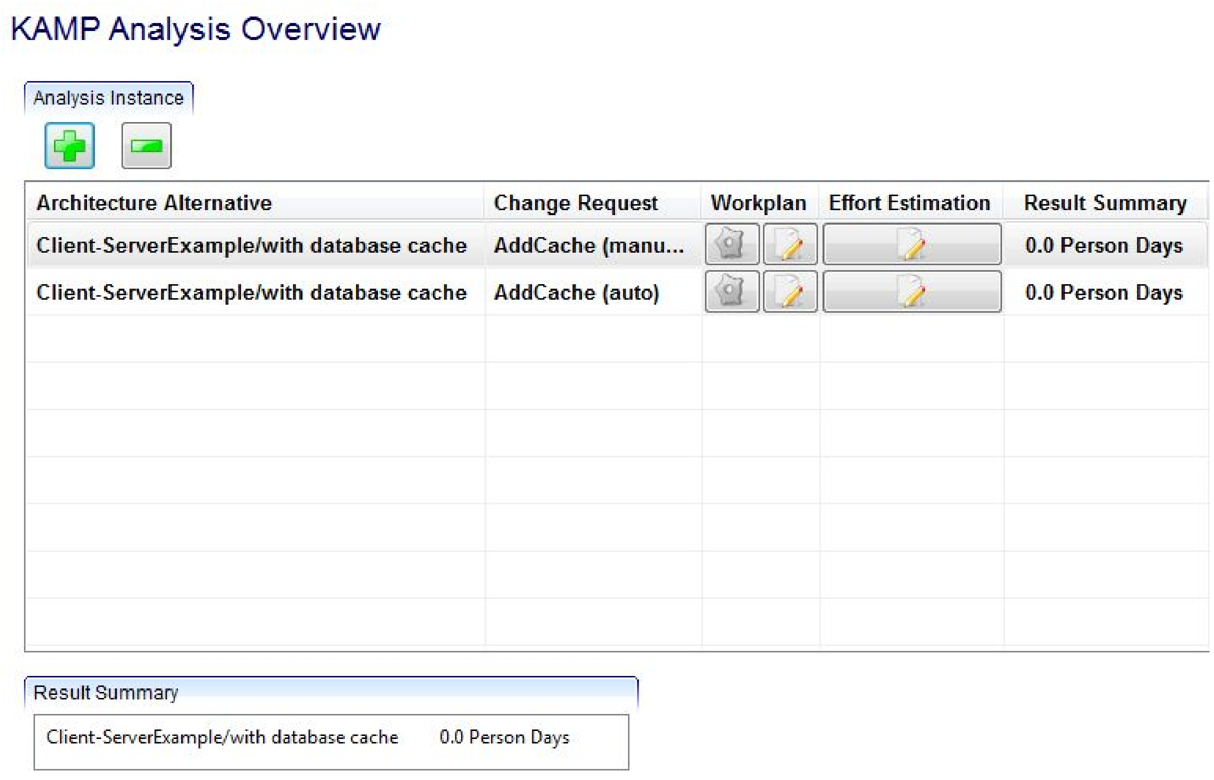
Figure 139: **The Q-ImPrESS launch configuration dialog for performance prediction**

The maintainability prediction works on basis of efforts for an alternative implementation. The analysis works on a ".kamp" file, which is stored in the workspace project. For the two derived example system alternatives, maintainability prediction files are available in the Client/Server example project ("WithDatabaseCache.kamp", "ChangedMassQueryImplementation.kamp").

KAMP supports the user by estimating implementation effort for change scenarios. In our example a database cache should be added to the basic client-server example. Time efforts for this change should be estimated using KAMP.

The KAMP file is opened in an editor that has a navigation bar on the left side that provides buttons for selecting preparation and analysis steps. In the first preparation page ("Specify Architecture Alternatives") the architecture alternative that should be estimated has to be specified. This is done automatically. On the second preparation page the change scenario has to be specified. We add a change scenario specification with name "Add Cache". We also select automatic derivation.

Next we go to the analysis overview, which is shown in Figure 140. Each line in the table represents a pair of architecture alternative and change scenario. We add a new line by pressing the + button. A new line appears in the overview table. We derive the workplan by pressing the button with the cogwheel symbol. It opens the workplan editor shown in Figure 141, where activities in the workplan can be derived from differences between models.


KAMP Analysis Overview

Analysis Instance

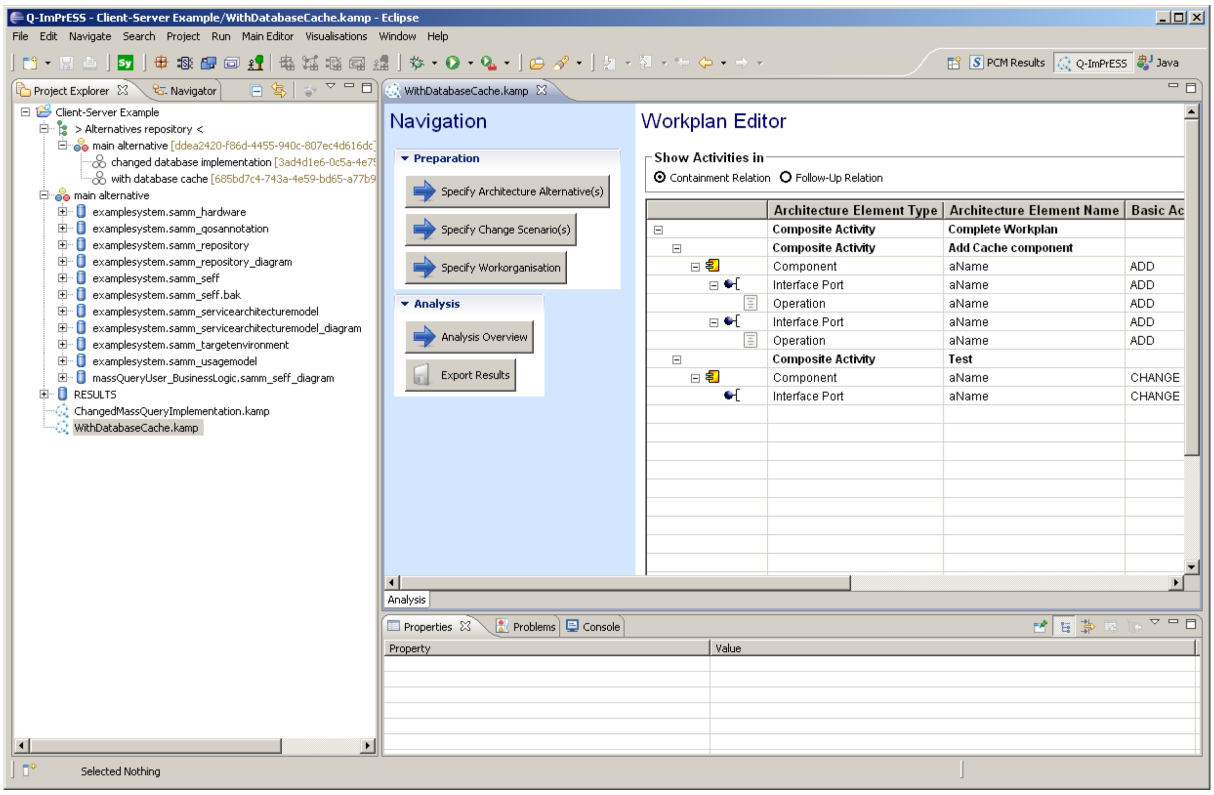
Architecture Alternative	Change Request	Workplan	Effort Estimation	Result Summary
Client-ServerExample/with database cache	AddCache (manu...			0.0 Person Days
Client-ServerExample/with database cache	AddCache (auto)			0.0 Person Days

Result Summary

Client-ServerExample/with database cache	0.0 Person Days

Figure 140: The KAMP editor analysis overview

Next we look at the workplan and adjust it manually by clicking on the edit button in the workplan column. When the workplan is adjusted we go back to the analysis overview and go to the effort estimation by clicking on the button in the effort estimation column. For each workplan activity we enter the corresponding time effort estimations. For a detailed description, please refer to the Maintainability Prediction Manuel in Section 4.11.


Q-ImPrESS - Client-Server Example/WithDatabaseCache.kamp - Eclipse

Project Explorer:

```
Client-Server Example
  > Alternatives repository <
    main alternative [ddea2420-f86d-4455-940c-807ec4d616dc]
      changed database implementation [3ad4d1e6-0c5a-4e75
      with database cache [685bd7c4-743a-4e59-bd65-a77b9
  main alternative
    examplesystem.samm_hardware
    examplesystem.samm_qosannotation
    examplesystem.samm_repository
    examplesystem.samm_repository_diagram
    examplesystem.samm_seff
    examplesystem.samm_seff.bak
    examplesystem.samm_servicearchitecturemodel
    examplesystem.samm_servicearchitecturemodel_diagram
    examplesystem.samm_targetenvironment
    examplesystem.samm_usagemodel
    massQueryUser_BusinessLogic.samm_seff_diagram
  RESULTS
  ChangedMassQueryImplementation.kamp
  WithDatabaseCache.kamp
```

Workplan Editor

Show Activities in: [✓ Containment Relation] Follow-Up Relation

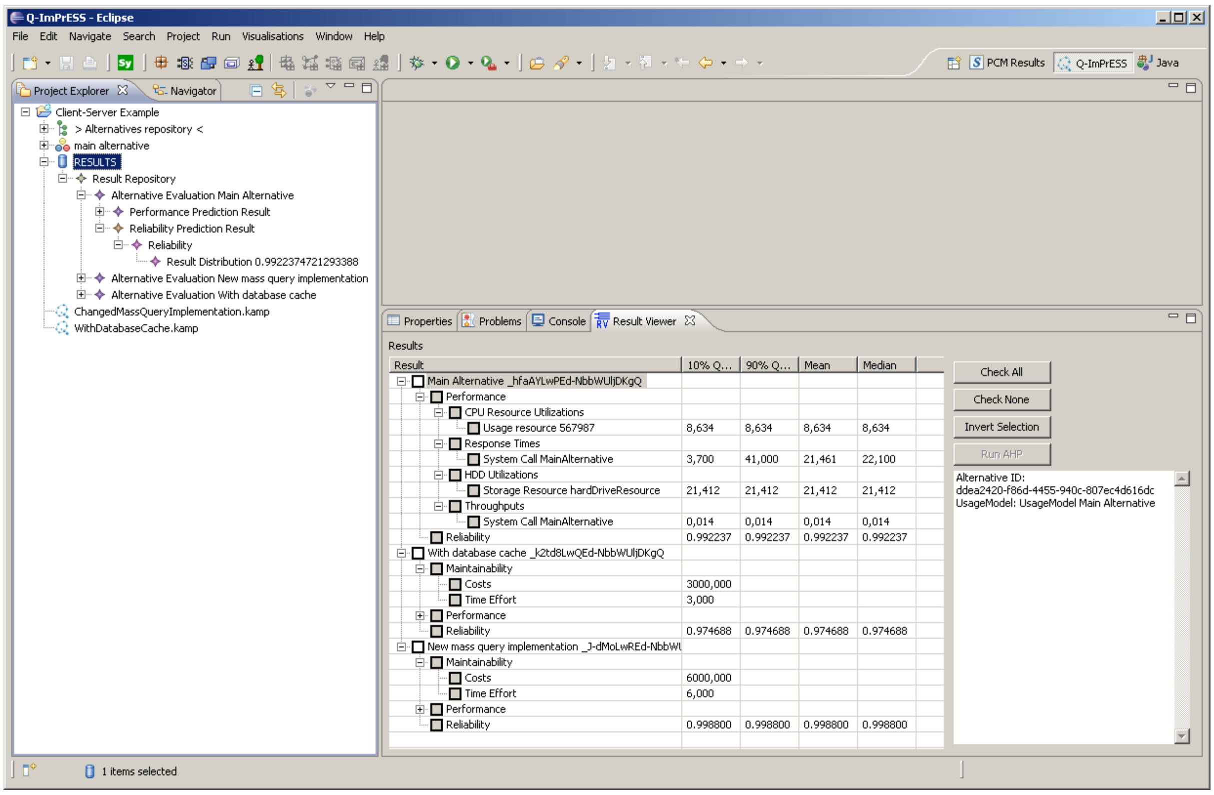
	Architecture Element Type	Architecture Element Name	Basic Ac
	Composite Activity	**Complete Workplan**	
	Composite Activity	**Add Cache component**	
	Component	aName	ADD
	Interface Port	aName	ADD
	Operation	aName	ADD
	Interface Port	aName	ADD
	Operation	aName	ADD
	Composite Activity	**Test**	
	Component	aName	CHANGE
	Interface Port	aName	CHANGE

Figure 141: The KAMP workplan editor

5.4 Result viewer and trade-off analysis

The Results Repository in a Q-ImPrESS project contains all analysis results for the project alternatives. As for the alternative model files, the results repository can be browsed in the project explorer (see the project explorer view in Figure 142). A detailed results viewer can also be opened by right-clicking on RESULTS and selecting “Open ResultViewer”.

Figure 142 shows the Result Viewer for the Client/Server example system. The shipped example includes performance and reliability prediction results for all three alternatives, as well as maintainability results (costs and time efforts) for implementing the two derived alternatives.



```
Client-Server Example
  > Alternatives repository <
  main alternative
  RESULTS
    Result Repository
      Alternative Evaluation Main Alternative
        Performance Prediction Result
        Reliability Prediction Result
          Reliability
            Result Distribution 0.9922374721293388
      Alternative Evaluation New mass query implementation
      Alternative Evaluation With database cache
  ChangedMassQueryImplementation.kamp
  WithDatabaseCache.kamp
```

Results

Result	10% Q...	90% Q...	Mean	Median
Main Alternative _hfaAYLwPEd-NbbWUljDKgQ				
Performance				
CPU Resource Utilizations				
Usage resource 567987	8,634	8,634	8,634	8,634
Response Times				
System Call MainAlternative	3,700	41,000	21,461	22,100
HDD Utilizations				
Storage Resource hardDriveResource	21,412	21,412	21,412	21,412
Throughputs				
System Call MainAlternative	0,014	0,014	0,014	0,014
Reliability	0.992237	0.992237	0.992237	0.992237
With database cache _k2td8LwQEd-NbbWUljDKgQ				
Maintainability				
Costs	3000,000			
Time Effort	3,000			
Performance				
Reliability	0.974688	0.974688	0.974688	0.974688
New mass query implementation _J-dMoLwREd-NbbWU				
Maintainability				
Costs	6000,000			
Time Effort	6,000			
Performance				
Reliability	0.998800	0.998800	0.998800	0.998800

Alternative ID:
ddea2420-f86d-4455-940c-807ec4d616dc
UsageModel: UsageModel Main Alternative

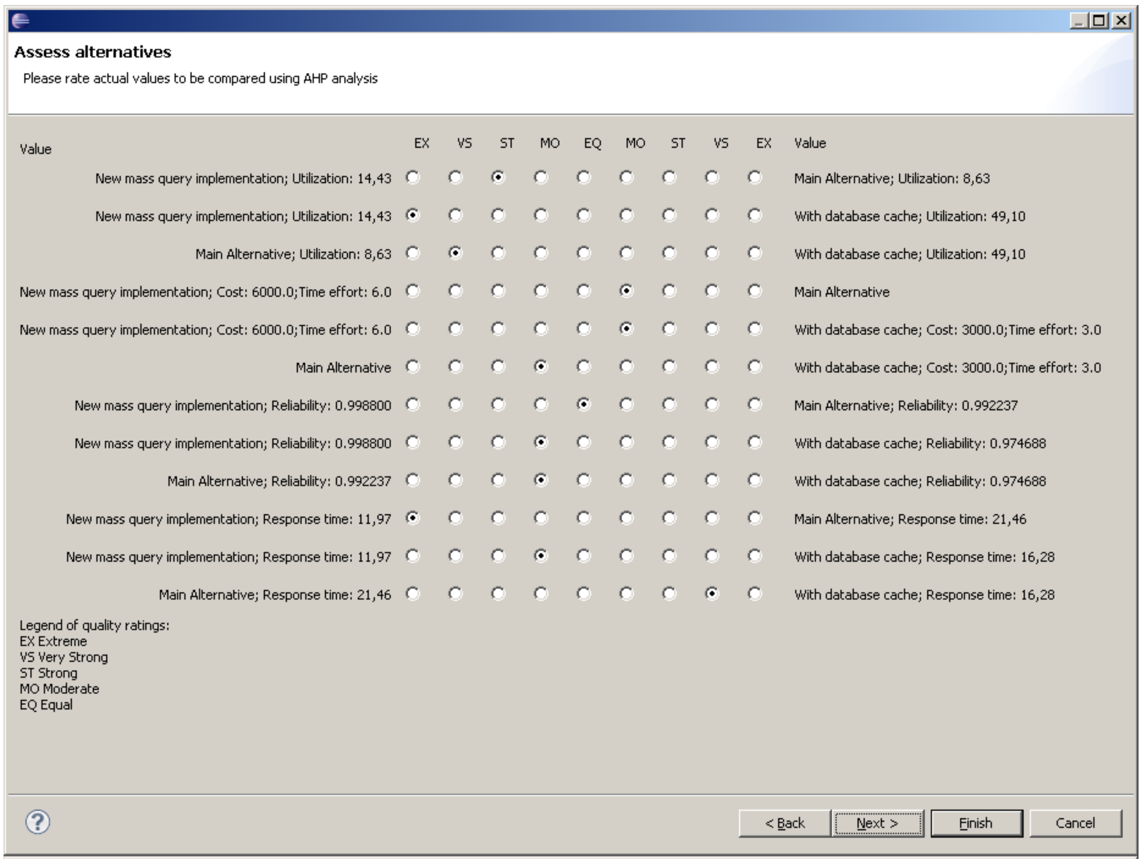
Figure 142: The Q-ImPrESS results repository and result viewer

By looking at the results, we can for example see that alternative 3 (changed database implementation) provides the best reliability results. However, it also incurs the highest change efforts. All three alternatives also have different performance results. The Results Viewer provides usage scenario response times and throughput results, as well as HDD and CPU utilisations.

In the Results Viewer, alternatives can be selected for which the AHP trade-off analysis should be performed. After selecting alternatives by enabling the corresponding checkboxes, the AHP trade-off analysis wizard can be launched by selecting “Run AHP”.

The trade-off analysis allows specifying a rating of the different quality criteria, as well as a rating of the actual result values. Based on these configurations, it provides a ranking of the alternatives based on weighted quality attributes. Figure 143 shows the two pages of the AHP trade-off wizard for the Client/Server example: the ranking of the result values (top) and the trade-off results (bottom). For the specified rankings, the third alternative (new database implementation) yields the best results in the trade-off analysis and should be preferred.

A detailed description of the Result viewer and the AHP wizard can be found in Section 4.12.

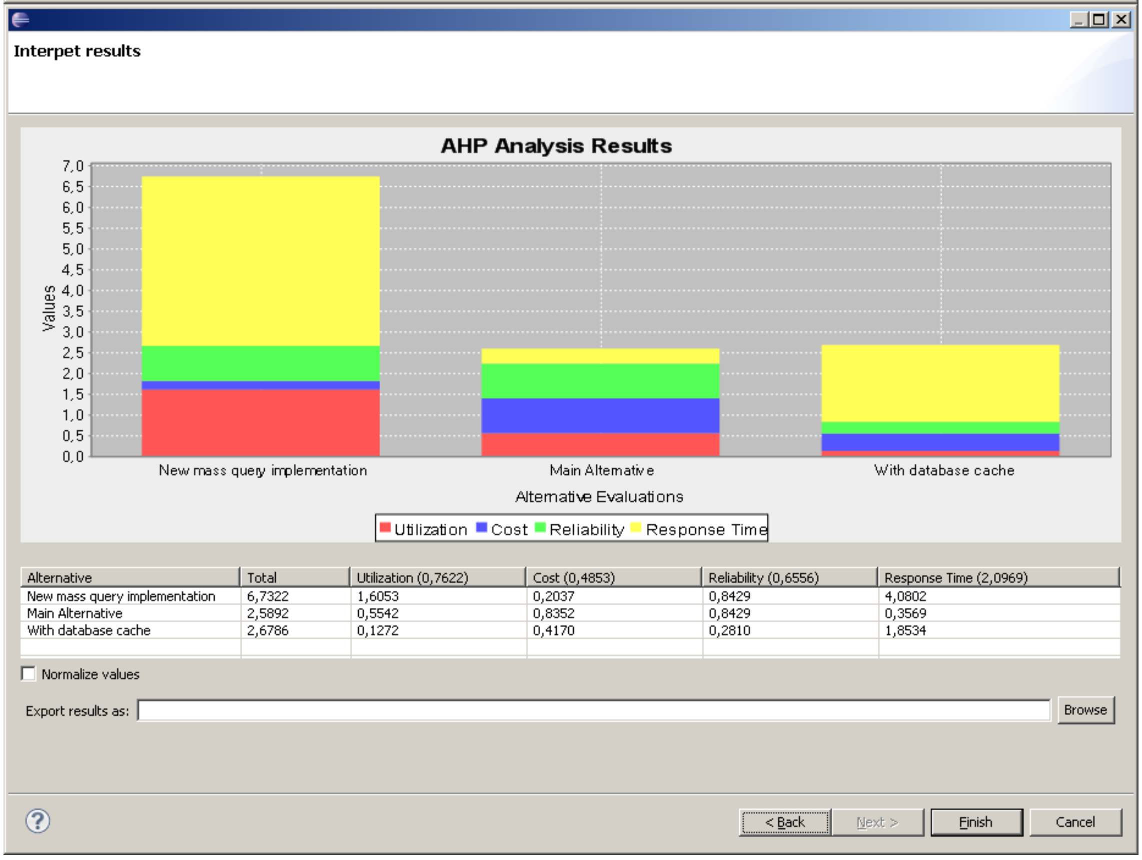


Assess alternatives

Please rate actual values to be compared using AHP analysis

Value	EX	VS	ST	MO	EQ	MO	ST	VS	EX	Value
New mass query implementation; Utilization: 14,43	○	○	●	○	○	○	○	○	○	Main Alternative; Utilization: 8,63
New mass query implementation; Utilization: 14,43	●	○	○	○	○	○	○	○	○	With database cache; Utilization: 49,10
Main Alternative; Utilization: 8,63	○	●	○	○	○	○	○	○	○	With database cache; Utilization: 49,10
New mass query implementation; Cost: 6000.0;Time effort: 6.0	○	○	○	○	○	●	○	○	○	Main Alternative
New mass query implementation; Cost: 6000.0;Time effort: 6.0	○	○	○	○	○	●	○	○	○	With database cache; Cost: 3000.0;Time effort: 3.0
Main Alternative	○	○	○	●	○	○	○	○	○	With database cache; Cost: 3000.0;Time effort: 3.0
New mass query implementation; Reliability: 0.998800	○	○	○	○	●	○	○	○	○	Main Alternative; Reliability: 0.992237
New mass query implementation; Reliability: 0.998800	○	○	○	●	○	○	○	○	○	With database cache; Reliability: 0.974688
Main Alternative; Reliability: 0.992237	○	○	○	●	○	○	○	○	○	With database cache; Reliability: 0.974688
New mass query implementation; Response time: 11,97	●	○	○	○	○	○	○	○	○	Main Alternative; Response time: 21,46
New mass query implementation; Response time: 11,97	○	○	○	●	○	○	○	○	○	With database cache; Response time: 16,28
Main Alternative; Response time: 21,46	○	○	○	○	○	○	○	●	○	With database cache; Response time: 16,28

Legend of quality ratings:
EX Extreme
VS Very Strong
ST Strong
MO Moderate
EQ Equal



Interpet results

Alternative	Total	Utilization (0,7622)	Cost (0,4853)	Reliability (0,6556)	Response Time (2,0969)
New mass query implementation	6,7322	1,6053	0,2037	0,8429	4,0802
Main Alternative	2,5892	0,5542	0,8352	0,8429	0,3569
With database cache	2,6786	0,1272	0,4170	0,2810	1,8534

☐ Normalize values

Export results as:

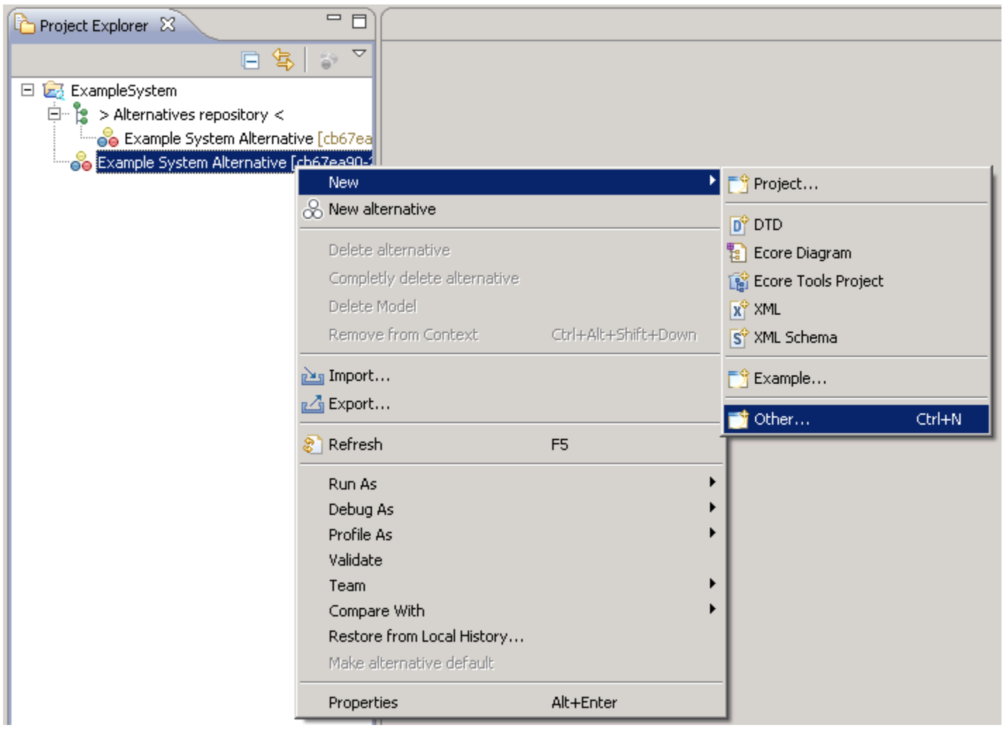
Figure 143: The AHP wizard

6 Appendix B: An example on how to edit models using the tree editor

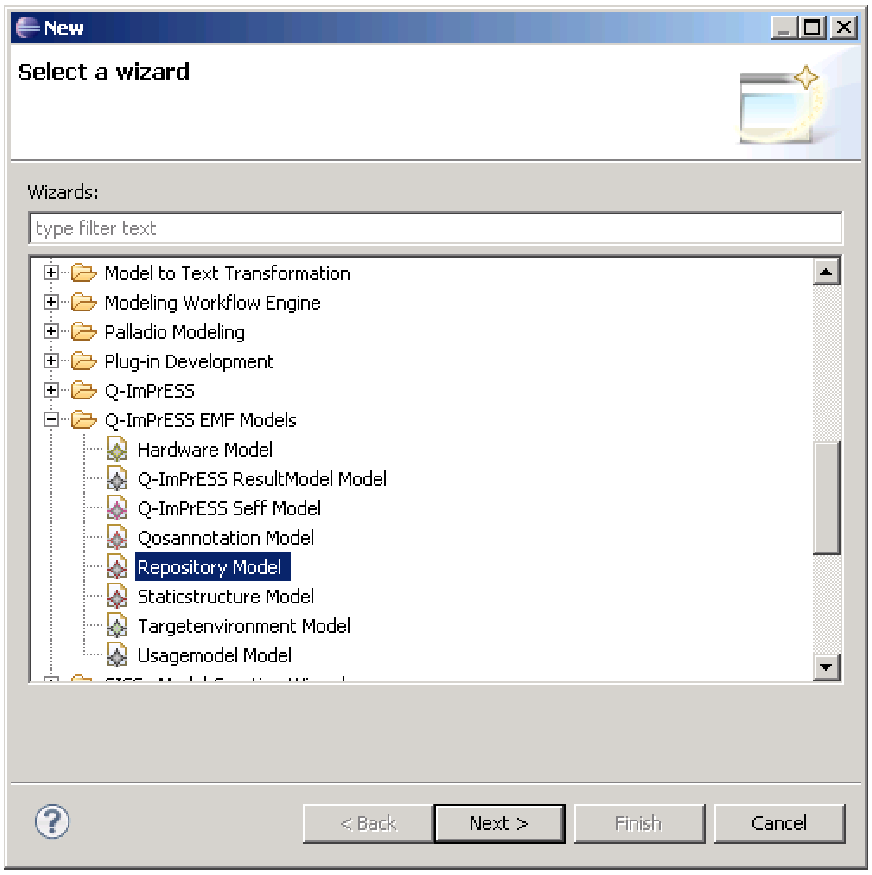
In a Q-ImPrESS project, model files can be inserted into the alternative by right-clicking on the alternative.
In the following, we create a Q-ImPrESS Repository Model, a Q-ImPrESS Hardware Model, a Q-ImPrESS TargetEnvironment Model, a Q-ImPrESS SEFF Behaviour Model, a Q-ImPrESS SAM Model, a Q-ImPrESS Usage Model, and a Q-ImPrESS QosAnnotation Model by using the tree editor. The tree editor is available for all Q-ImPrESS models, as they are based on the Eclipse Modeling Framework EMF. The framework has been used to auto-generate the EMF tree editors. For general documentation on the EMF tree editor see http://help.eclipse.org/ganymede/topic/org.eclipse.emf.doc/tutorials/clibmod/clibmod.html#step4.

6.1 Create a Repository Model

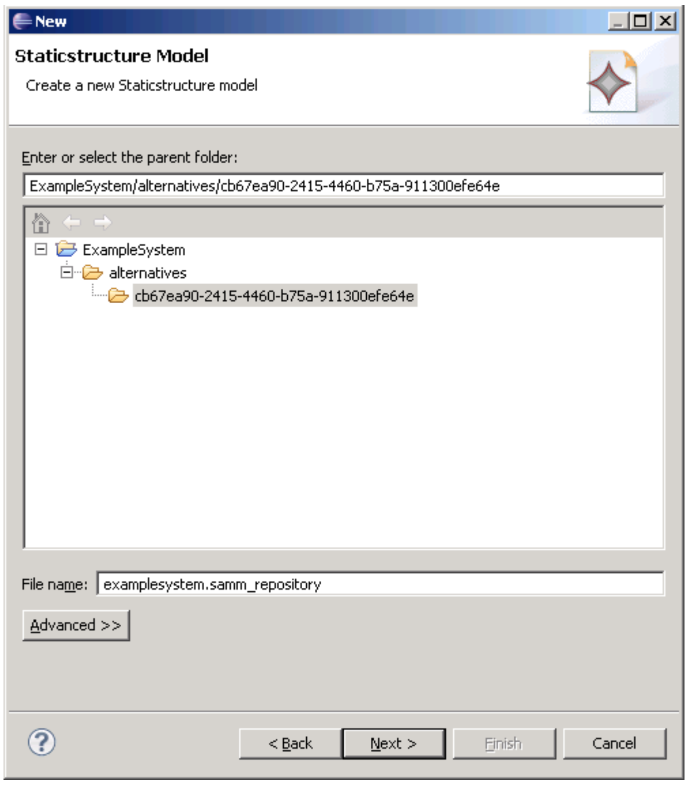
Create a new object in the alternative (Right-click on the alternative → New → Other…).



In the following dialog, select the “Q-ImPrESS EMF Models” category, and select “Repository model”.



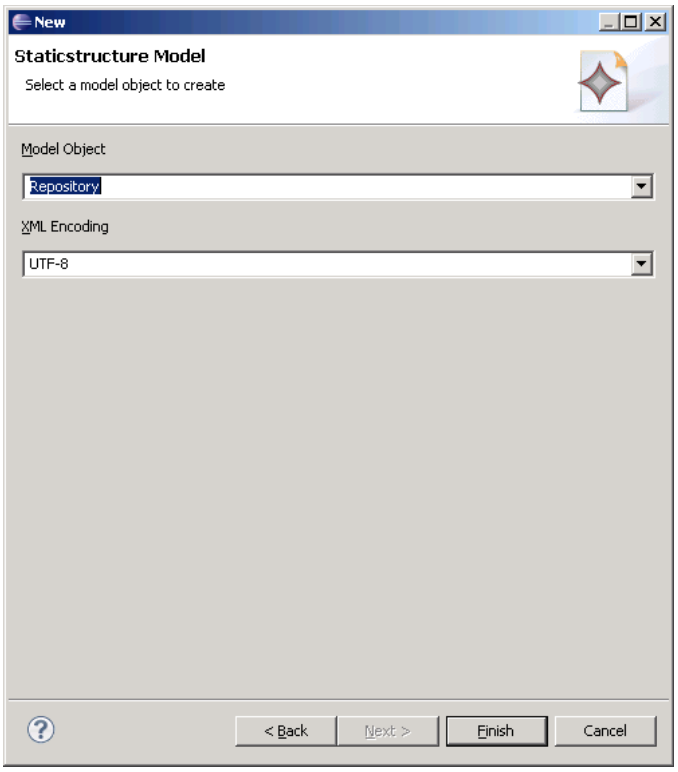
Provide a file name for the repository.


New
Staticstructure Model
Create a new Staticstructure model
Enter or select the parent folder:
ExampleSystem
alternatives
cb67ea90-2415-4460-b75a-911300efe64e
Advanced >>
< Back
Next >
Finish
Cancel

Enter or select the parent folder: ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e

File name: examplesystem.samm_repository

In the next dialog step, select the root object of the EMF model. In this case, this has to be the Repository element. Select "Repository" from the list.



New

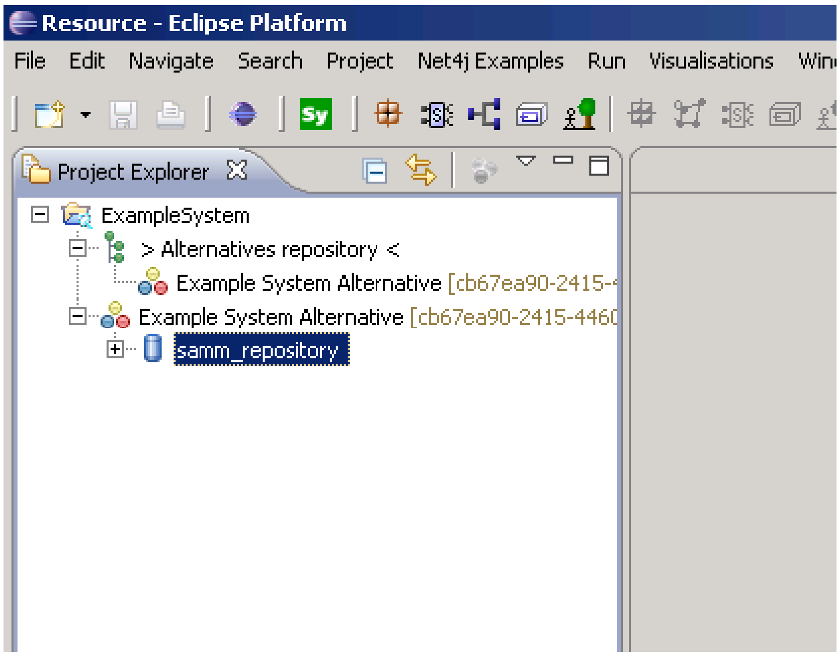
Staticstructure Model

Select a model object to create

Model Object: Repository

XML Encoding: UTF-8

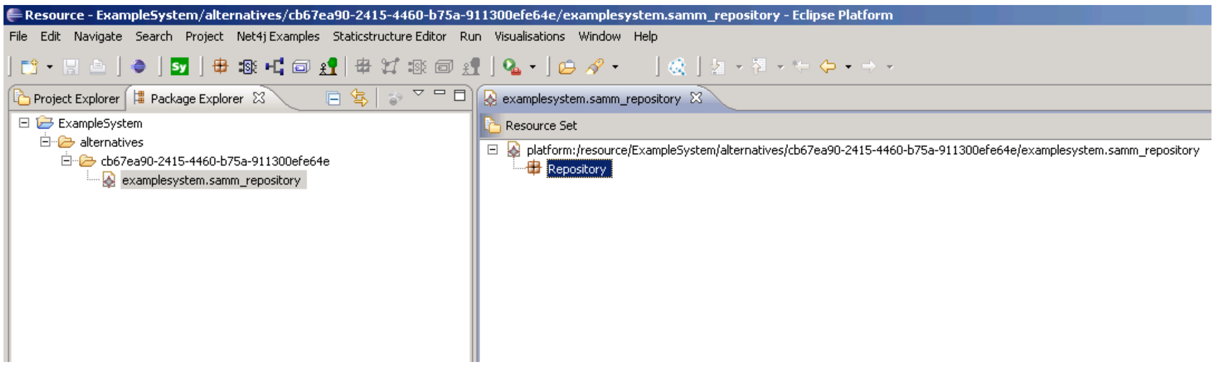
After clicking on finish, the EMF file is being created. These steps are similar for the other Q-ImPrESS models. In the "Q-ImPrESS EMF Models" category, the corresponding element has to be selected and the appropriate root object has to be selected.



Resource - Eclipse Platform

ExampleSystem
> Alternatives repository <
Example System Alternative [cb67ea90-2415-
Example System Alternative [cb67ea90-2415-446
samm_repository

If the model is not opened automatically, it can be opened from within the Eclipse Package Explorer view (currently, it is not possible to open the file from within the Project Explorer). Open the view (Window→Show View→Other…→select Package Explorer from the "Java" category) and navigate to the folder containing the EMF model element (the folder name is the alternative id).


Resource - ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_repository - Eclipse Platform
File Edit Navigate Search Project Net4j Examples Staticstructure Editor Run Visualisations Window Help
Project Explorer
Package Explorer
ExampleSystem
alternatives
cb67ea90-2415-4460-b75a-911300efe64e
examplesystem.samm_repository
examplesystem.samm_repository
Resource Set
platform:/resource/ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_repository
Repository

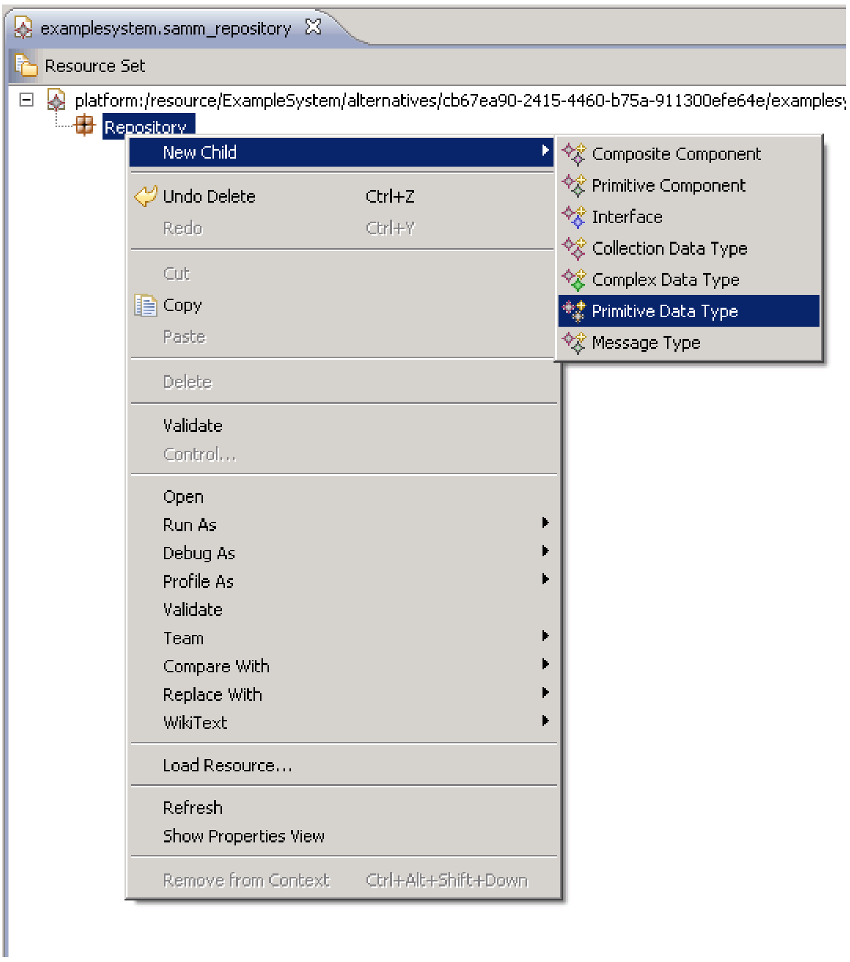
Open the file by clicking on it (or right click→Open With→Staticstructure Model Editor).

In the following, we create the Repository contents.

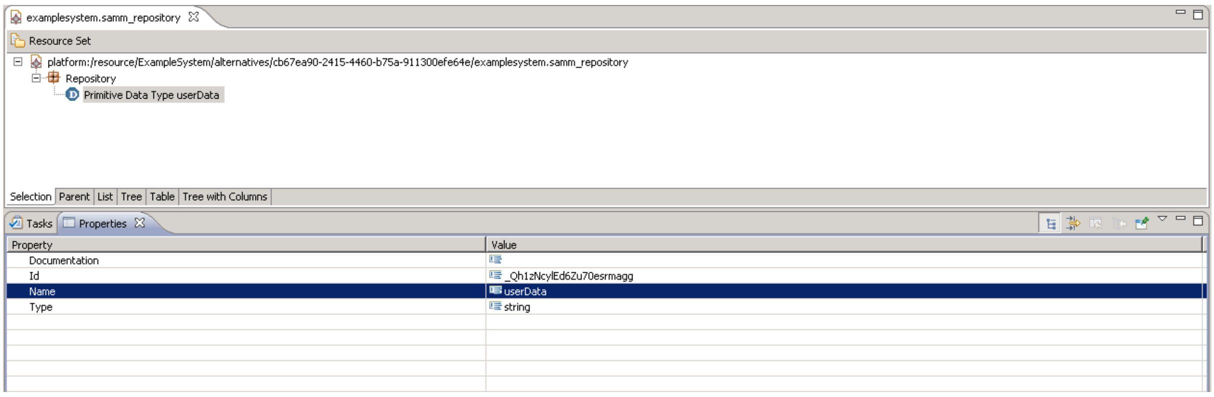
6.2 DataTypes

First, data types have to be created. The example system contains interfaces with an operation that takes the user id (integer) as parameter and returns user data (string).
Both parameter and return value data types have to be created.

We create the user id datatype by right-clicking on the repository root element, selecting "New Child", and selecting "Primitive Data Type".



For this datatype, the type attribute has to be set to string.
Attributes can be set in the properties view. If it is not displayed, right-click on the datatype element and select "Show Properties View". In the properties view, set the type to "string" and the name to "userData".



platform:/resource/ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_repository
Repository
Primitive Data Type userData

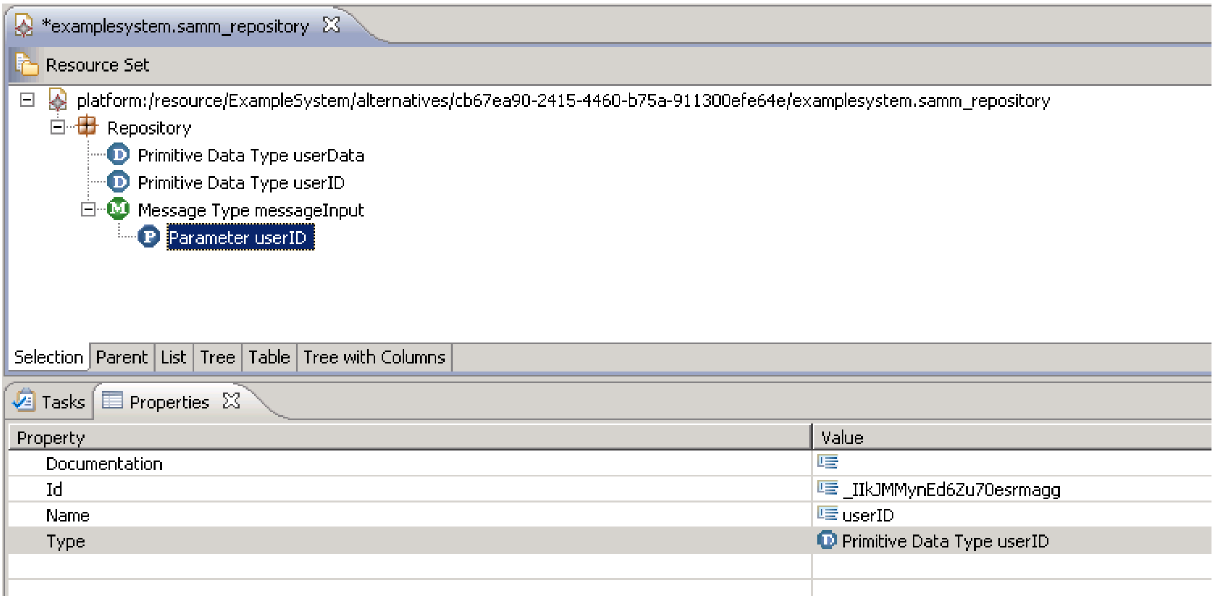
Property	Value
Documentation	
Id	_Qh1zNcylEd6Zu70esrmagg
Name	userData
Type	string

The same has to be done for the second primitive data type. Set the name of this data type to "userID" and the type to "int".

6.3 MessageTypes

For the operation parameters, input and output message types have to be created.

Right-click on the repository, select “New Child” and “Message Type”. Set the name of the message type in the properties view. The example system contains two message types simply named “messageOutput” and “messageInput”.
For a message type, you can provide references to parameters the message type contains.
For the message type “messageInput”, right-click on the message-type and select “New Child” and “Parameter”. For this parameter, set a name in the properties view and the parameter type (the userID parameter).



*examplesystem.samm_repository

Resource Set

```
platform:/resource/ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_repository
  Repository
    Primitive Data Type userData
    Primitive Data Type userID
    Message Type messageInput
      Parameter userID
```

Selection | Parent | List | Tree | Table | Tree with Columns

Tasks | Properties

Property	Value
Documentation	
Id	_IIkJMMynEd6Zu70esrmagg
Name	userID
Type	Primitive Data Type userID

A messageType “messageOutput” referencing the “userData” parameter type has to be created in the same way.

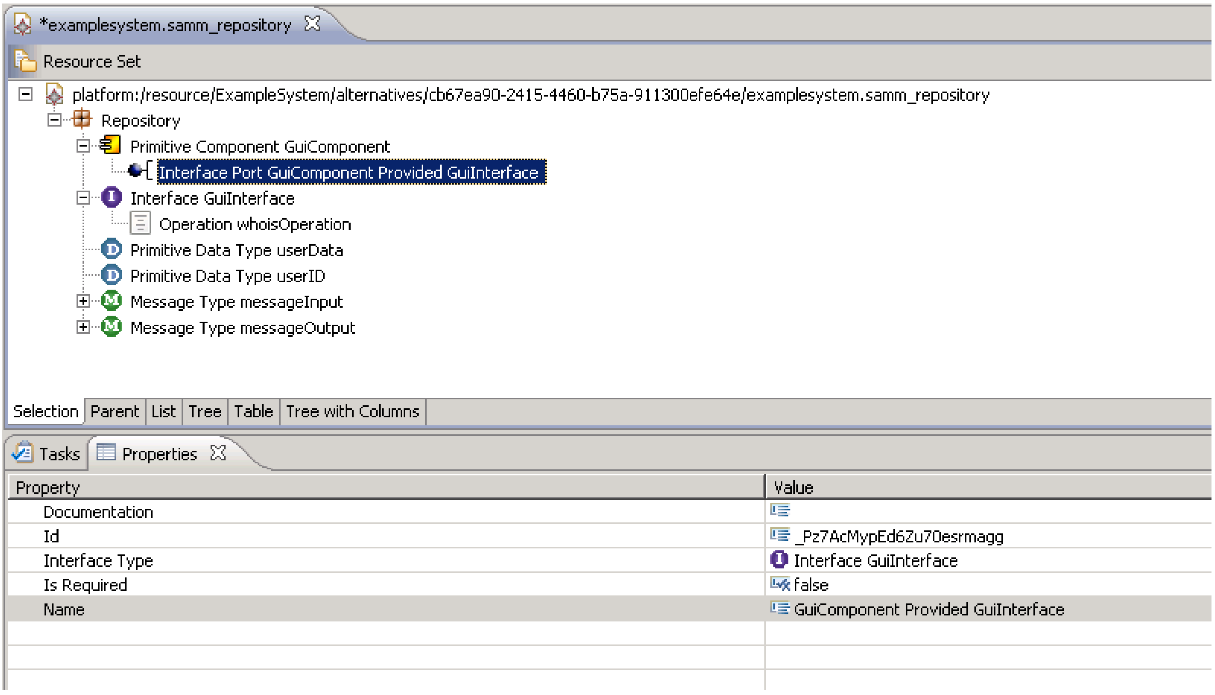
6.4 Interfaces

Once the message types are created, we can create the interfaces.
The GUI component of the example system provides one interface containing a operation “whoisOperation”.
Create this interface by right-clicking on the repository, then select “New Child” and “Interface”. Set the name of the interface in the properties view (e.g. “GuiInterface”). Add the operation to the interface by right-clicking on the interface, then select “New Child” and “Operation”.
In the properties view, set the name of the operation to “whoisOperation”. Set the operation Input attribute to the messageType “messageInput” and the Output attribute to the messageType “messageOutput”.

6.5 PrimitiveComponents

This interface is provided by the client component. This is a composite component containing two primitive components, the Gui component and the DataRetriever component.
We first create the two primitive components and then the composite component.

Create the primitive component GUI component by right-clicking on the repository, then select “New Child” and “Primitive Component”. Provide a name for the component by setting its name attribute in the properties view, e.g. “GuiComponent”.
To provide or require components, a component has to contain ports.
Add a provided interface port to the component by right-clicking on the component, then select “New Child” and “Provided Interface Port”. Set the name of the port by setting its name attribute in the properties view, e.g. “GuiComponent Provided GuiInterface”. Besides, set the interface type to the interface “GuiInterface”.


*examplesystem.samm_repository

Resource Set

- platform:/resource/ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_repository
  - Repository
    - Primitive Component GuiComponent
      - Interface Port GuiComponent Provided GuiInterface
    - Interface GuiInterface
      - Operation whoisOperation
    - Primitive Data Type userData
    - Primitive Data Type userID
    - Message Type messageInput
    - Message Type messageOutput

Property	Value
Documentation	
Id	_Pz7AcMypEd6Zu70esrmagg
Interface Type	Interface GuiInterface
Is Required	false
Name	GuiComponent Provided GuiInterface

In the example system, the GuiInterface also requires an interface. Since this interface contains the same operation, the GuiInterface element is being reused. To require the interface, we add a “Required Interface Port” to the component. This is done in a similar way as described above. Right-click on the component, then select “New Child” and “Required Interface Port”.

Behaviours can be specified for components or component operations. The example system contains SEFF behaviours for the primitive component operations.
The SEFF behaviour is specified in a SEFF Behaviour model (see below). However, a behaviour stub has to be created in the component element which is then be referenced by the actual behaviour.
To add a SEFF behaviour stub to a component, right-click on the component and select “New

Child" and "Seff Behaviour Stub". Set the operation in the property view for the stub. This is the operation for which the behaviour is to be specified, i.e. whoisOperation.

In the same way, we can now create the other primitive components of the example system (DataRetriever, DataService, DatabaseManager and Database). Confer to D2.1 or the example system instance for details.

6.6 CompositeComponents

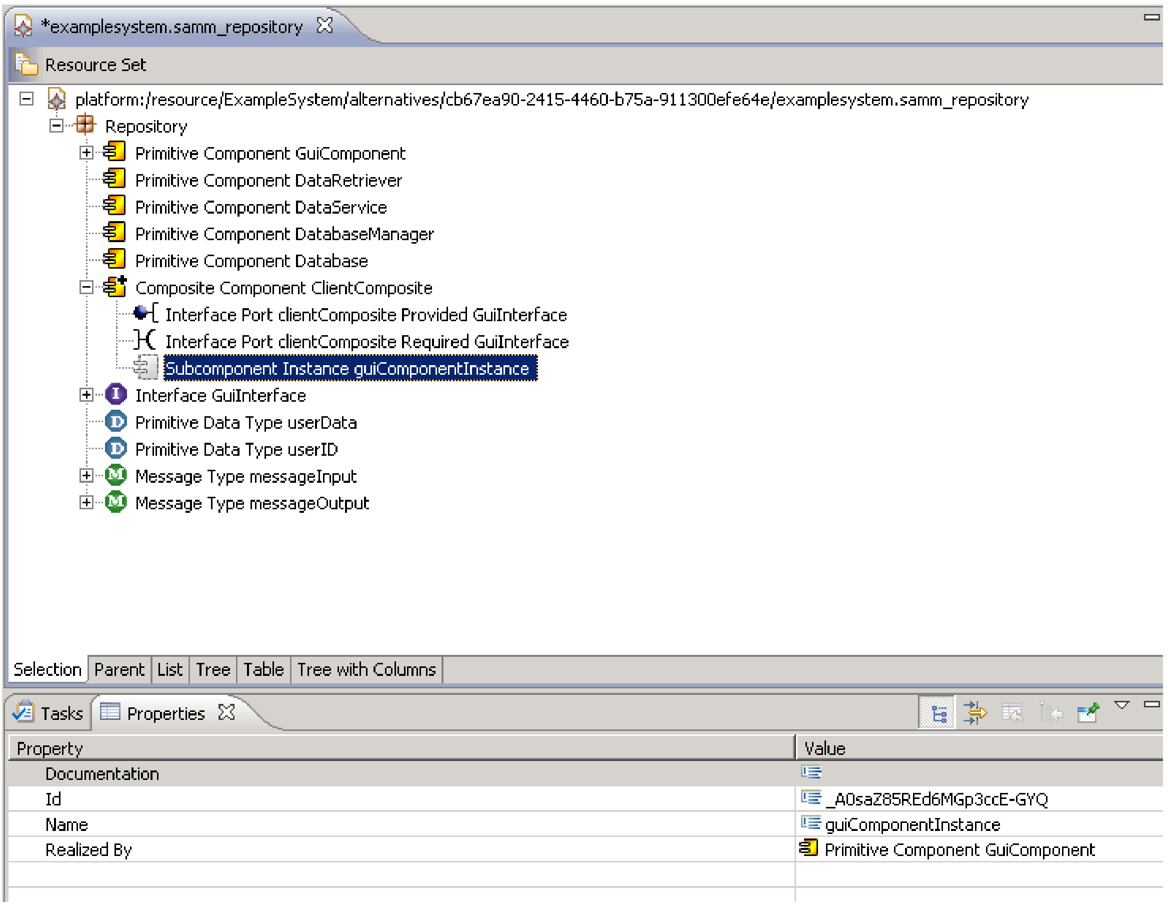
Once all primitive components have been created, composite components which hold encapsulated primitive components can be created.

We create a composite component that contains the two primitive components GuiComponent and DataRetriever. This component holds the client logic of the example system.

Right-click on the repository, select "New Child" and then "Composite Component". The composite component element is being created in the EMF tree. Set its name in the property view to ClientComposite.

A composite component can provide or require interfaces in exactly the same way as primitive components do. Add a provided and required interface to the ClientComposite component by adding a provided interface port and a required interface port. Both times, the GuiInterface can be used. In the example system, the ports of the ClientComposite component are called "ClientComposite Provided GuiInterface" and "ClientComposite Required GuiInterface".

In addition, the nested components have to be specified. This means that instances of existing component types (i.e. instances of the GuiComponent and the DataRetriever component) have to be specified for the composite component. Right-click on the composite component, select "Add Child" and "Subcomponent instance". The newly created subcomponent instance element has a property name which is to guiComponentInstance. Besides, its "Realized by" attribute is set to the primitive component GuiComponent.


*examplesystem.samm_repository
Resource Set
platform:/resource/ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_repository
Repository
Primitive Component GuiComponent
Primitive Component DataRetriever
Primitive Component DataService
Primitive Component DatabaseManager
Primitive Component Database
Composite Component ClientComposite
Interface Port clientComposite Provided GuiInterface
Interface Port clientComposite Required GuiInterface
Subcomponent Instance guiComponentInstance
Interface GuiInterface
Primitive Data Type userData
Primitive Data Type userID
Message Type messageInput
Message Type messageOutput

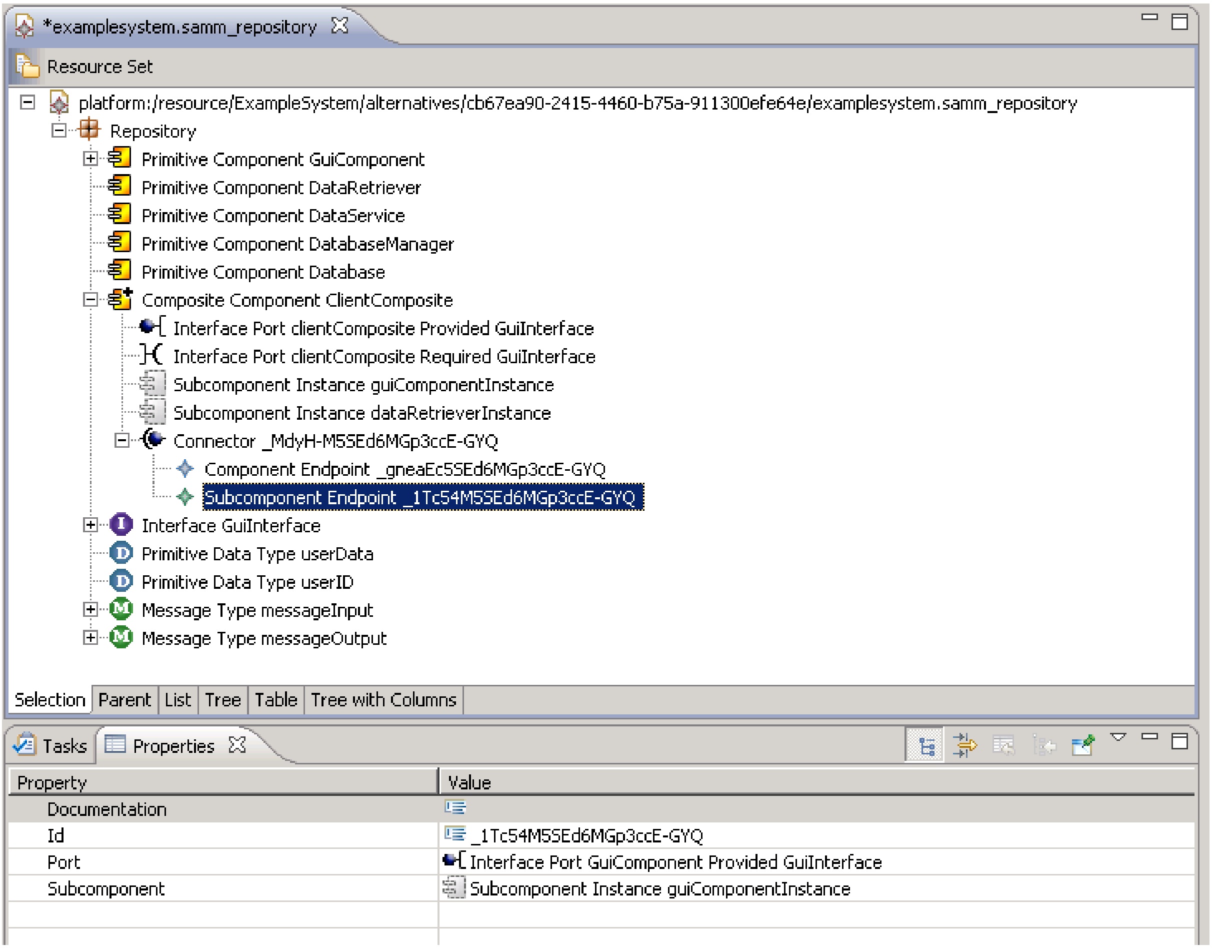
Property	Value
Documentation	
Id	_A0saZ85REd6MGp3ccE-GYQ
Name	guiComponentInstance
Realized By	Primitive Component GuiComponent

Repeat the steps described above to specify a subcomponent instance for the DataRetriever component.

Finally, the nested subcomponent instances have to be connected with the outer interfaces of the parent composite component.
The ClientComposite component has a GuiInterface provided port. Calls that occur on this port have to be delegated to the GuiInterface provided port of the nested GuiComponent. Calls on the GuiInterface required port of the GuiComponent have to be directed to the other nested primitive component, i.e. the GuiInterface provided port of the DataRetriever component. Finally, calls on the GuiInterface required port of the DataRetriever Component have to be delegated back to the GuiInterface required port of the outer ClientComposite component.

All three kinds of interface connectors are specified by the Connector element. First, we create the delegation connector that connects the outer GuiInterface provided port of the ClientComposite with the inner GuiInterface provided port of the GuiComponent. Right-click on the ClientComposite component and select “Add Child”, then “Connector”. A new Conector element is being created. For this connector, two endpoints have to be specified that reference the both interface port. Right-click on the connector, select “Add Child” and “Component Endpoint”. This is the endpoint that belongs to the outer GuiInterface provided port. In the properties view of this endpoint, select the outer interface port (“ClientComposite Provided GuiInterface”) for the port attribute.

Then right-click on the connector, select “Add Child” and “Subcomponent Endpoint”. This is the endpoint that belongs to the inner GuiInterface provided port of the nested GuiComponent. In the properties view of this endpoint, select the corresponding interface provided port (“GuiComponent Provided GuiInterface”) for the port attribute.
Besides, the subcomponent instance has to be specified for the subcomponent endpoint (since a component can be deployed twice in the same composite component, just specifying the interface port would be ambiguous here). Set the Subcomponent attribute to the Subcomponent instance guiComponentInstance.



```
*examplesystem.samm_repository
Resource Set
platform:/resource/ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_repository
  Repository
    Primitive Component GuiComponent
    Primitive Component DataRetriever
    Primitive Component DataService
    Primitive Component DatabaseManager
    Primitive Component Database
    Composite Component ClientComposite
      Interface Port clientComposite Provided GuiInterface
      Interface Port clientComposite Required GuiInterface
      Subcomponent Instance guiComponentInstance
      Subcomponent Instance dataRetrieverInstance
      Connector _MdyH-M5SEd6MGp3ccE-GYQ
        Component Endpoint _gneaEc5SEd6MGp3ccE-GYQ
        Subcomponent Endpoint _1Tc54M5SEd6MGp3ccE-GYQ
    Interface GuiInterface
    Primitive Data Type userData
    Primitive Data Type userID
    Message Type messageInput
    Message Type messageOutput
```

Property	Value
Documentation	
Id	_1Tc54M5SEd6MGp3ccE-GYQ
Port	Interface Port GuiComponent Provided GuiInterface
Subcomponent	Subcomponent Instance guiComponentInstance

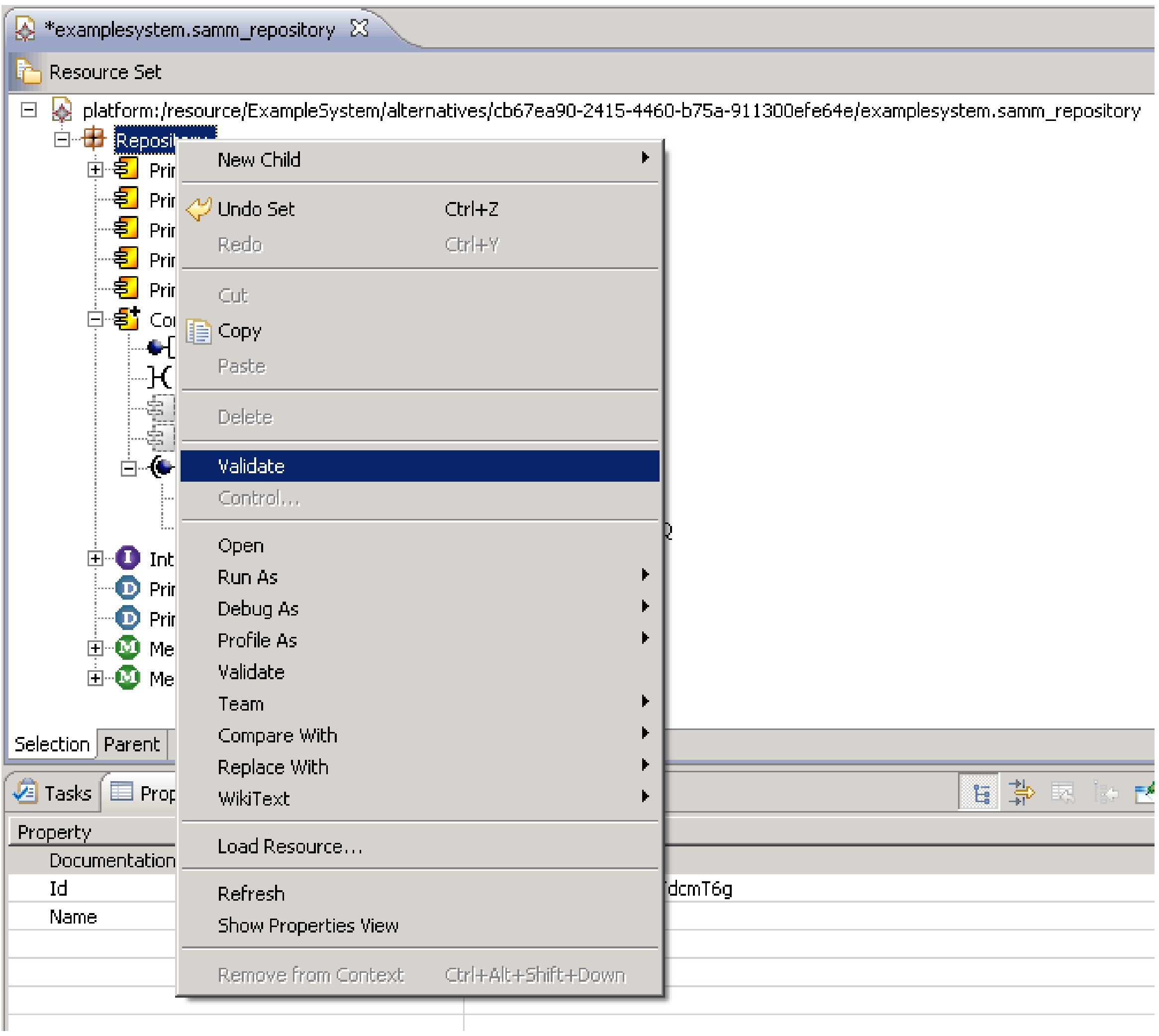
The connector connecting the two nested components has to be created in the same way. It holds two subcomponent endpoints instead of one component endpoint and one subcomponent endpoint. The last connector has a subcomponent endpoint referencing the required interface port of the nested DataRetriever component and a component endpoint referencing the required interface port of the ClientComposite endpoint. Confer to D2.1 or the example system instance for details.

The other composite component called ServerComposite has to be created in the same way. It contains subcomponent instances referencing the DataService and the DatabaseManager component.

Note that composite components holding other composite components as nested components can be created in the same way. The subcomponent instance has to reference a composite component in this case. However, the example system does not contain composite components that contain other composite components.

Now, all components have been created.

Finally, set the name of the repository. Select the repository root element and set its name in the properties view, e.g. “examplesystem Repository”. The example system repository should be complete now. To make sure no necessary information is missing (e.g. unset attributes), right-click on the Repository element and select “Validate”. An OCL validation is performed that checks if all attributes are set correctly. All validation errors should be fixed because further Q-ImPrESS tools depend on valid model instances.



The other models are specified in a similar way. Elements are created by selecting “New Child”, or are being specified as attributes in the property view.

6.7 Create a Hardware Model

Create a new element in the alternative. Select “Hardware Model” and set “Descriptor Repository” as root object.

A Hardware model is used to specify hardware resources that referenced by resource definitions in the target environment model later.

All elements reside in a hardware descriptor repository. Open the newly created file (in the example, it is named examplesystem.samm_hardware) and make sure its root element is set to “Descriptor Repository”.

For the example system, we create resource types for a processor, a network, a network interface, a memory, and a hard disk.

For the processor, right-click on the descriptor repository, select “New Child”, and “Processor Descriptor”. A processor can contain multiple cores. For every core, right-click on the processor descriptor, select “New Child”, and “Processor Core”. Additionally elements that can be specified for a processor descriptor are TLB and Caches. The Caches can be referenced then be processor cores (use the “Caches” attribute).

If the software system that has to be modeled contains multiple servers which all run on the same processor, only one processor descriptor needs to be specified. The different instances are specified in the target environment then. However, if you need to model multiple processors that contain a different number of cores, different processor descriptors have to be specified.

To specify a network element, right-click on the descriptor repository, select “New Child”, and “Network Element Descriptor”. A network element contains several attributes that can be specified if needed. This includes network properties such as latency and bandwidth.

A network interface element can be specified by right-clicking on the descriptor repository and selecting “New Child”, then “Network Interface Element”. A network interface contains several attributes that can be specified if needed. This includes network interface properties such as link latency and link speed.

To specify a memory element, right-click on the descriptor repository, select “New Child”, and “Memory Descriptor”. A memory resource allows for specifying different attributes, such as access latency, bandwidth, burst length, and front side bus frequency.

To specify a hard disk element, select “New Child”, and “Storage Device Descriptor”. Attributes that can be specified include read and write speed, cache size, or request latency.

6.8 Units

In the whole SAMM model, no concrete unit model exits. Thus, when specifying attributes that carry a unit, such as disk write speed or network bandwidth, units are not explicitly specified. Therefore such attributes have to be used in a consistent way. If for example disk write speed attributes are specified with a value that conforms to kb/s, the time unit is assumed to be seconds, and QoS predictions should yield results that actually denote time in seconds. If attributes are specified with values denoting an abstract unit like an abstract time unit, prediction results also can only be interpreted with abstract time units. Here, no absolute time results can be obtained, but different prediction results can still be compared against each other (e.g. the response time of one request takes twice as long as the response time of another request).

6.9 Create a Target Environment Model

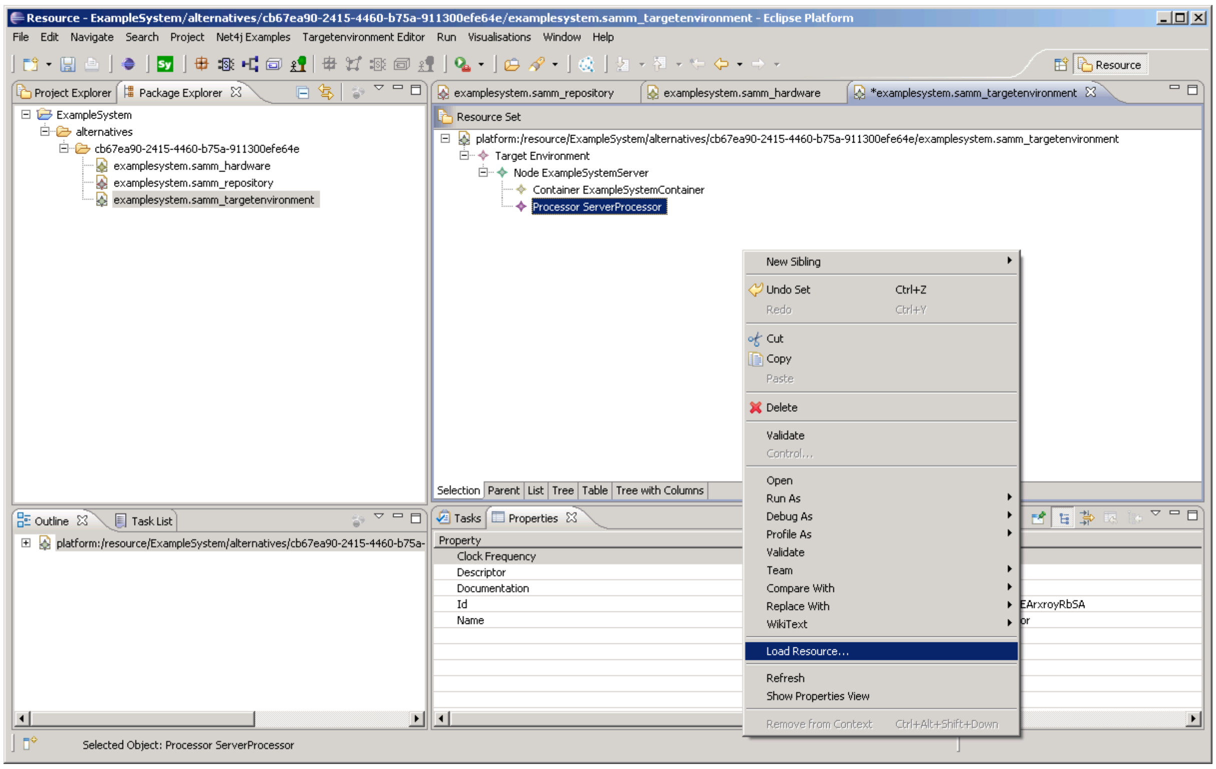
A target environment is used to specify the actual environment of the SAM model that makes use of resources specified in the hardware descriptor.

Create a new element in the alternative. Select “Targetenvironment Model” and set “Target Environment” as root object.

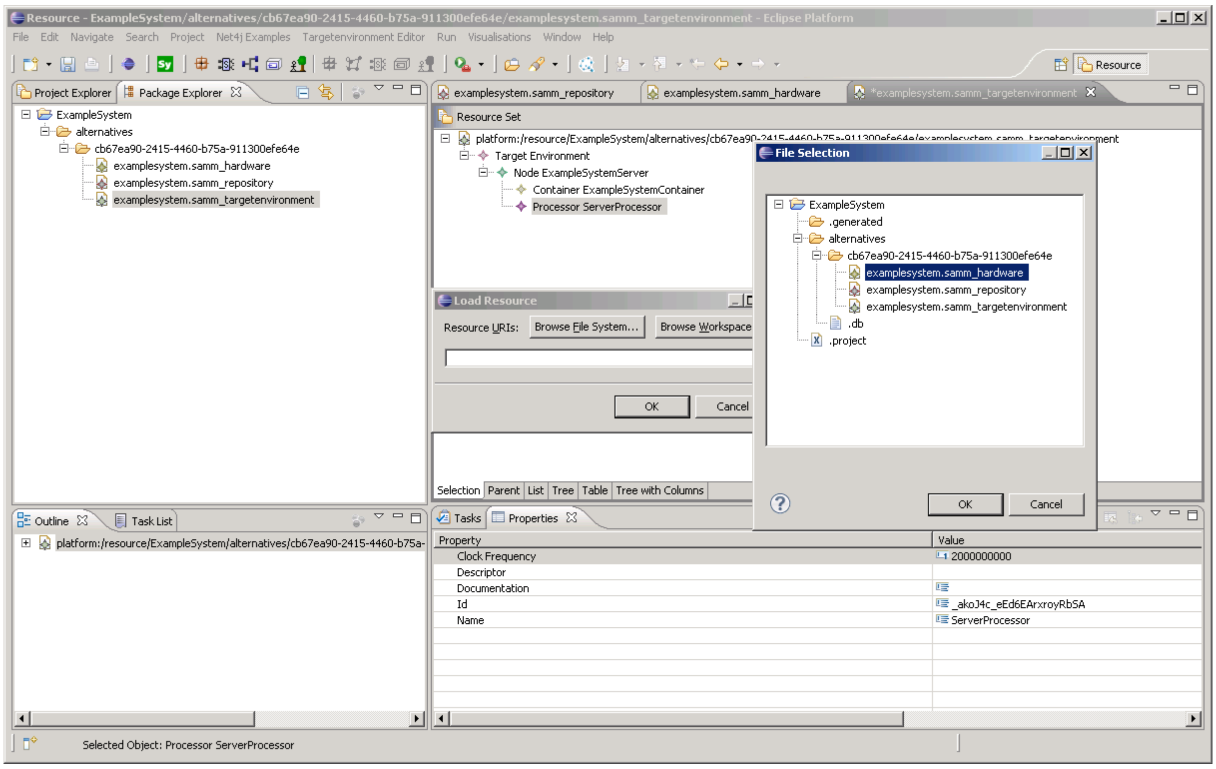
A target environment consists of nodes, which correspond to physical servers. On nodes, execution environments can be modelled, in which the software runs. This is done by the Container element. For a Container, it can be specified which hardware resources are available.

For the example system, we create one server node that contains one container. Right-click on the target environment root element, select “Add Child”, and then “Node”. A node is being created inside the target environment which represents the server. Set the name attribute of the node (e.g. to “ExampleSystemServer”). Add a Container to the node by right-clicking on the Node element, and selecting “Add Child” and “Container”. Specify a name for the container as well.

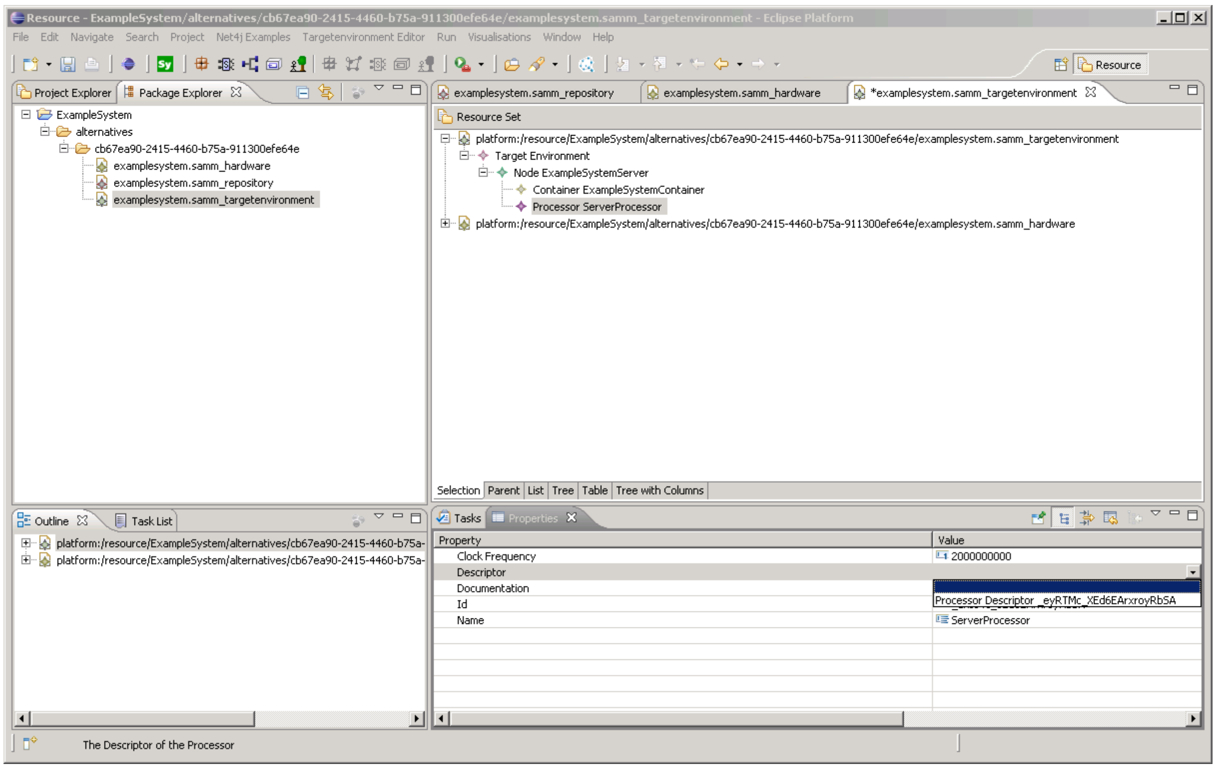
To allocate hardware resources to container, the actual hardware resources of the node have to be specified first. In the following, we specify a CPU resource that references a CPU Descriptor which has been specified before in the hardware model. Then, a share of the resource that is available to the container, is specified.
Right-click on the Node element, select “New Child” and then “Processor”. Specify a name for the processor, e.g. “ServerProcessor”. Besides, the clock frequency attribute can be set. If the unit of the clock frequency is being regarded as GHz, it has to be set to 2000000000 if the CPU is a 2GHz CPU.
What is missing is the link to the Processor descriptor in the hardware repository. Therefore, the hardware repository file has to be referenced by the target environment file. To do so, right-click in a free part of the editor, and select “Load Resource…” from the context menu.


Resource - ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_targetenvironment - Eclipse Platform
File Edit Navigate Search Project Net4j Examples Targetenvironment Editor Run Visualisations Window Help
Project Explorer
Package Explorer
ExampleSystem
alternatives
cb67ea90-2415-4460-b75a-911300efe64e
examplesystem.samm_hardware
examplesystem.samm_repository
examplesystem.samm_targetenvironment
Resource Set
platform:/resource/ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_targetenvironment
Target Environment
Node ExampleSystemServer
Container ExampleSystemContainer
Processor ServerProcessor
New Sibling
Undo Set Ctrl+Z
Redo Ctrl+Y
Cut
Copy
Paste
Delete
Validate
Control...
Open
Run As
Debug As
Profile As
Validate
Team
Compare With
Replace With
WikiText
Load Resource...
Refresh
Show Properties View
Remove from Context Ctrl+Alt+Shift+Down
Selection Parent List Tree Table Tree with Columns
Outline
Task List
Tasks
Properties
Property
Clock Frequency
Descriptor
Documentation
Id
Name
Selected Object: Processor ServerProcessor

In the upcoming dialog, select “Browse Workspace…”, browse to the hardware file, select it, and click “OK”.


File Selection
ExampleSystem
.generated
alternatives
cb67ea90-2415-4460-b75a-911300efe64e
examplesystem.samm_hardware
examplesystem.samm_repository
examplesystem.samm_targetenvironment
.db
.project
OK
Cancel
Load Resource
Resource URIs:
Browse File System...
Browse Workspace
OK
Cancel
Property
Value
Clock Frequency 2000000000
Descriptor
Documentation
Id _akoJ4c_eEd6EArxroyRbSA
Name ServerProcessor
Selected Object: Processor ServerProcessor

From now on, the hardware model is shown in the editor of the target environment as well. In the property view of the attributes for the Processor element (select the corresponding element to display the attributes), the "Descriptor" attribute can now be set to a Processor Descriptor element that is available in the hardware descriptor model in the referenced file.


Resource - ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_targetenvironment - Eclipse Platform
File Edit Navigate Search Project Net4j Examples Targetenvironment Editor Run Visualisations Window Help
Project Explorer
Package Explorer
examplesystem.samm_repository
examplesystem.samm_hardware
*examplesystem.samm_targetenvironment
Selection Parent List Tree Table Tree with Columns
Outline
Task List
Tasks
Properties
The Descriptor of the Processor

- ExampleSystem
  - alternatives
    - cb67ea90-2415-4460-b75a-911300efe64e
      - examplesystem.samm_hardware
      - examplesystem.samm_repository
      - examplesystem.samm_targetenvironment

Resource Set
- platform:/resource/ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_targetenvironment
  - Target Environment
    - Node ExampleSystemServer
      - Container ExampleSystemContainer
      - Processor ServerProcessor
- platform:/resource/ExampleSystem/alternatives/cb67ea90-2415-4460-b75a-911300efe64e/examplesystem.samm_hardware

Property	Value
Clock Frequency	2000000000
Descriptor	Processor Descriptor _eyRTMc_XEd6EArxroyRbSA
Documentation	
Id	
Name	ServerProcessor

Finally, a fraction of the CPU has to be assigned to the container. Right-click on the Container element, select "Add Child", and "Execution Resource". Set its attribute "Processor" to the Processor element "ServerProcessor" specified in the Node. If multiple Container share the same CPUs, a fraction can be specified for each container. This is done by the fraction attribute of the execution resource.

Similar model elements have to be created to model other hardware resources of the node: Create a Memory element, Storage Device element, and Network Interface element in the Node and a Memory Resource element, Storage Resource element and Network Resource element in the Container. For a detailed description of the different element semantics, refer to D2.1.

6.10 Create a SEFF Behaviour Model

Create a new element in the alternative. Select "Q-ImPrESS Seff Model" and set "Seff Repository" as root object.

The Seff Repository in the created file contains all SEFF behaviours of the model. Each behaviour is specified by a ResourceDemandingSEFF element. This element has a reference to a SEFF behaviour stub that has been specified in the repository file.

Create a ResourceDemandingSEFF by right-clicking on the SEFF Repository, selecting "New Child" and "Resource Demanding SEFF". In the property tab of the ResourceDemandingSEFF element, the "Seff Behaviour Stub" property has to be set. Since the stub is defined in a different file, i.e. in the examplesystem.samm_repository file, the file has to be loaded as a resource, as described in Section 6.9. Once the file has been loaded, a stub can be selected in the property tab.
Choose a stub for which a behaviour should be specified, for example the whoisOperation of the GuiComponent.

6.11 SEFF Actions

A SEFF consist of several actions, which specify the control flow of the called operation. Therefore, every action has a reference to its predecessor and its successor action. Besides, StartAction and StopAction elements exist. A StartAction only has to have the successor action reference to be specified, the ancestor reference can be empty. A StopAction only has to have the ancestor action reference to be specified, the successor reference can be empty.
In the following, we create a simple SEFF containing a StartAction, which is followed by an InternalAction. Afterwards, the SEFF contains an ExternalCallAction and finally a StopAction.
First, create the four Action elements. Right-click on the ResourceDemandingSEFF element, select "Add Child" and "Start Action", "Internal Action, "External Call Action", and "Stop Action", respectively. In the property tab for each action, specify the name attribute of the action.
Next, the predecessor and successor references have to be set. Select the StartAction and select the InternalAction in the StartAction "Successor Abstract Action" property. Afterwards, the predecessor reference of the InternalAction has been set automatically. In the same way, select the InternalAction and set its "Successor Abstract Action" property to the ExternalCallAction element. Finally, select the ExternalCallAction and set its "Successor Abstract Action" property to the StopAction element.
The InternalAction can for example be used to specify resource demands that occur at a certain step in the behaviour. Since resource demands are specified by QoS annotations, they are not specified in this model file, but in the QosAnnotations model file.
The External Call Action is used to specify calls to other components that occur at a certain step in the behaviour. Since a component does not know with which other component it is connected, the action only references a component's required port and the operation of the required interface that is being called. Select the ExternalCallAction and specify the required interface port in the "Called Interface Port" property. The selected port has to be a required port that belongs to the component for which the behaviour is specified. However, it is not yet checked automatically if a valid port has been selected. Selecting a provided port or a port that belongs to a different component must not be selected, although this is not detected when validating the model.
Besides, select the operation that has to be called. This has to be an operation that is being provided by the interface the required port references. Select the operation in the "Called Service" attribute in the property tab of the ExternalCallAction.

6.11.1 LoopAction, BranchAction, ForkAction

Besides the actions explained above, additional SEFF actions exist that allow for specifying additional SEFF control flow elements with nested SEFF behaviours.
A LoopAction allows for specifying a nested behaviour that is executed several times in a row, before the successor action of the LoopAction is being executed.
After creating a LoopAction, right-click on the loop action, select “Add Child” and “Resource Demanding Behaviour”. This leads to the creation of a nested behaviour element which is similar to the root ResourceDemandingSEFF element. For this element, nested actions can be specified again that form the nested behaviour. This set of actions must contain at least a StartAction and a StopAction. All nested actions have to be connected by specifying the “Predecessor Abstract Action” and “Successor Abstract Action” references.
The number of iterations of a LoopAction is specified in the QoSAnnotations model file.

A BranchAction allows for specifying several nested behaviours for which just one is taken in the control flow depending on the branch transition. For every branch, a “Probabilistic Branch Transition” element can be specified as a nested element in the BranchAction. The branch probability is specified in the QosAnnotations model file. The nested behaviour is specified by adding a ResourceDemandingBehaviour as nested element to the ProbabilisticBranchTransition. This element is comparable to the root ResourceDemandingSEFF in the way that nested actions can be specified that form the nested behaviour.

A ForkAction allows for specifying several nested behaviours which are executed concurrently in the control flow. For every concurrent nested behaviour, a “Forked Behaviour” element can be specified as a nested element in the ForkAction. This element is comparable to the root ResourceDemandingSEFF in the way that nested actions can be specified that form the nested behaviour.

6.12 Create a QoS Annotation Model

Create a new element in the alternative. Select “Qosannotation Model” and set “Qos Annotations” as root object.

In the following, we describe how to add the following QoS annotations to the model:

- SEFF Loop Action number of iterations
- SEFF Branch Action branch probability
- SEFF Internal Action CPU resource demand

All three kinds of QoS annotations need to reference a corresponding action of a SEFF model, e.g. the examplesystem.samm_seff file. Add the file as resource to the QoS annotations file as described in Section 6.9. Besides, specified resource demands need to reference a resource from a SAM target environment, e.g. the examplesystem.samm_targetenvironment file. Add the file as resource to the QoS annotations file as described in Section 6.9.

To add a QoS annotation for specifying the number of iterations of a LoopAction, right-click on the QoS Annotations root element, select “New Child” and “SEFF LoopCount”.

In the SEFF LoopCount property tab, set the “Loop Action” reference to the LoopAction element from the SEFF model for which the number of iterations should be specified. The actual QoS annotation can be a constant number, a distribution, a formula, or a parametric formula. They are created by selecting the LoopCount element, select “New Child” and then “Constant Number”, “Distribution”, “Formula”, or “Parametric Formula”, respectively.
A constant number is the simplest way of specifying a QoS annotation. It contains an attribute “Value” which allows for specifying a double value of the number. This constant number can be used for example as a fixed value, a mean or median value.
Support for specifying formulas or distribution functions is not yet provided.
Parametric formulas can be specified by using the “Specification” attribute. It contains a string which can hold a PCM StochasticExpression. For more information about Stochastic Expressions, have a look at the webinar at http://fast.fzi.de/index.php/pcm-variables, which shows use of Stochastic Expressions in the PCM.

To add a QoS annotation for specifying the branch probability of a BranchAction branch, right-click on the QoS Annotations root element, select “New Child” and “SEFF BranchProbability”.

In the SEFF BranchProbability property tab, set the “Probabilistic Branch Transition” reference to the ProbabilisticBranchTransition element from a BranchAction specified in the SEFF model for which the branch probability should be specified. The actual QoS annotation can specified in the same way as described for a LoopCount QoS annotation. Note that certain analysis tools might require that all branch probabilities of the same BranchAction always sum up to 1.0.

To add a QoS annotation for specifying CPU resource demands that occur in a SEFF InternalAction, right-click on the QoS Annotations root element, select “New Child” and “CpuResourceDemand”. In its property tab, set the “Execution Resource” attribute to a CPU execution resource specified in the target environment model. This is the resource on which the resource demand should occur. Set the “Internal Action” attribute to the InternalAction element of the SEFF model for which the resource demand should be specified. The actual QoS annotation can specified in the same way as described for a LoopCount QoS annotation.

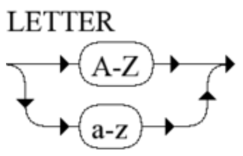
7 Appendix C: Concrete syntax for SAMM meta-model

The appendix contains definition of a concrete syntax for SAMM meta-model elements. The definition follows a structure of the SAMM meta-model and its packages and declares how its elements are shown in a textual form. The concrete syntax definition is visualized with help of so call "railroad diagram" showing terminal and non-terminal symbols of the associated grammar corresponding to the SAMM meta-model.
The following list contains definition of each element for each SAMM package.

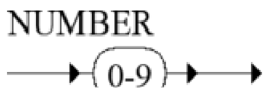
7.1 Predefined terminals

The concrete syntax contains several symbols representing particular sequences of characters.

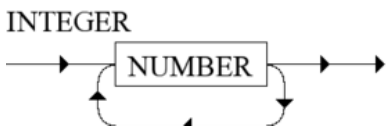
Letter



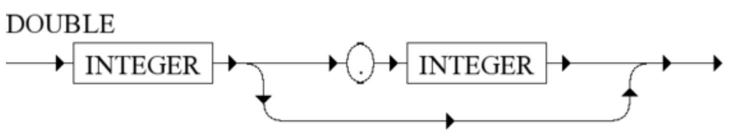
Number



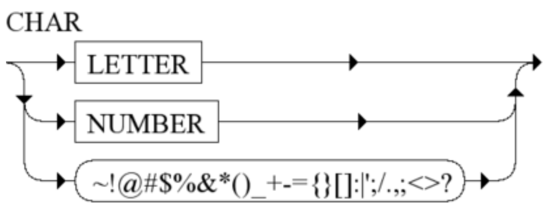
Integer



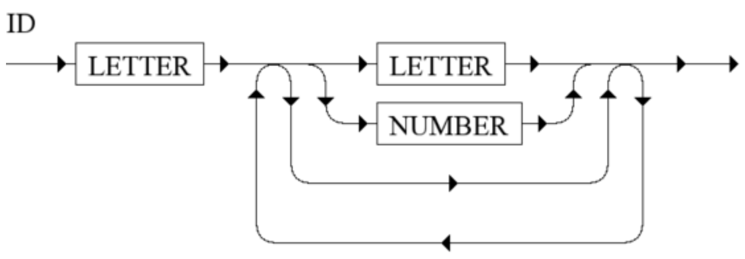
Double



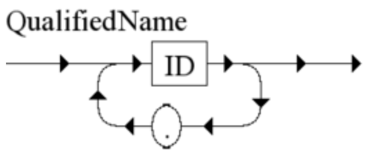
Char



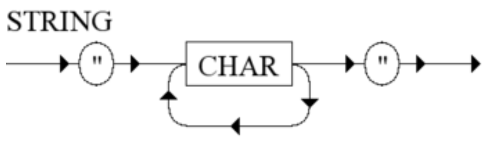
ID



Qualified name

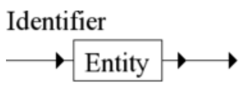


String

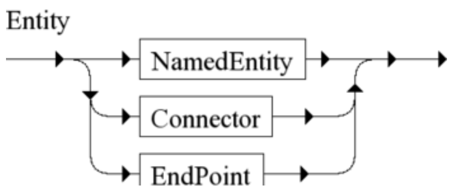


7.2 Core (package samm.core)

Identifier

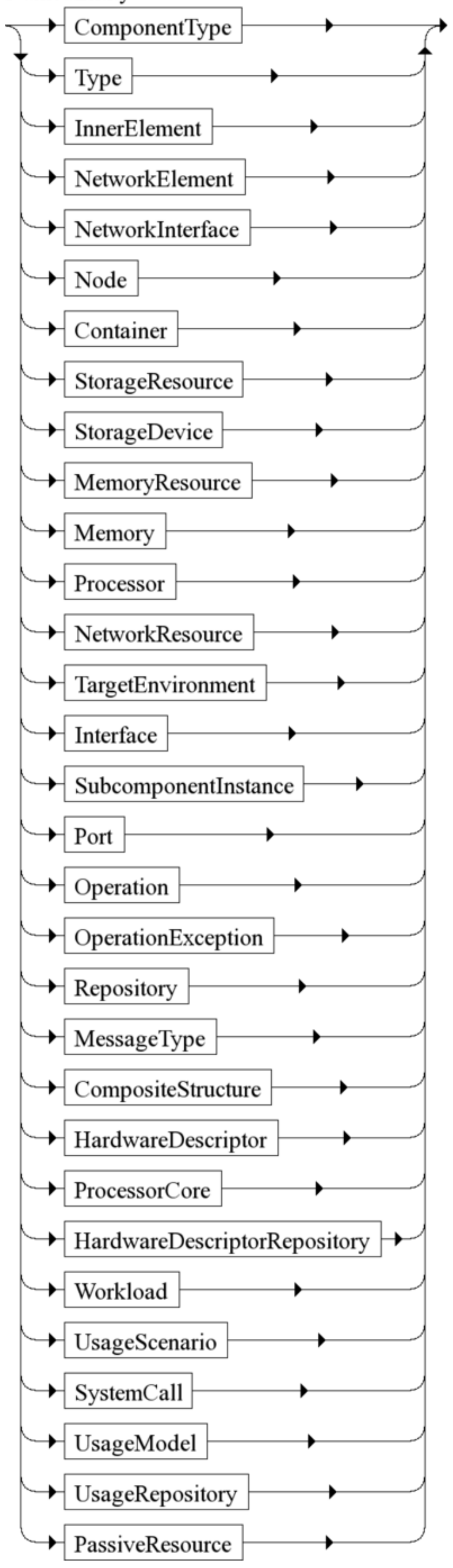


Entity



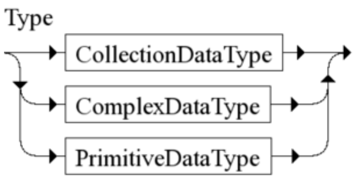
Named entity

NamedEntity

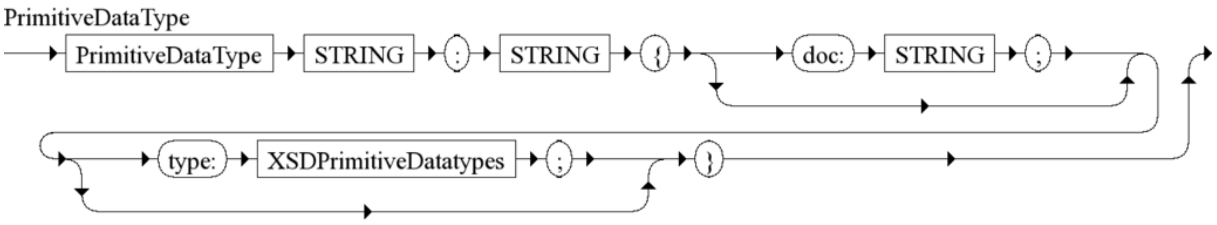


7.3 Data types (package samm.datatypes)

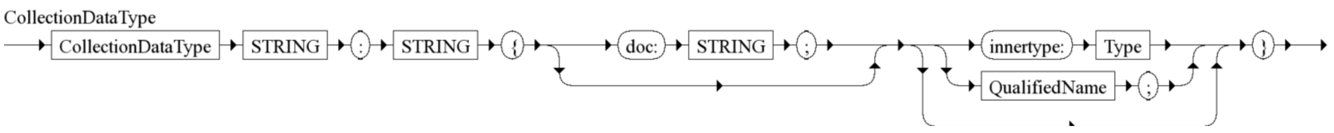
Type



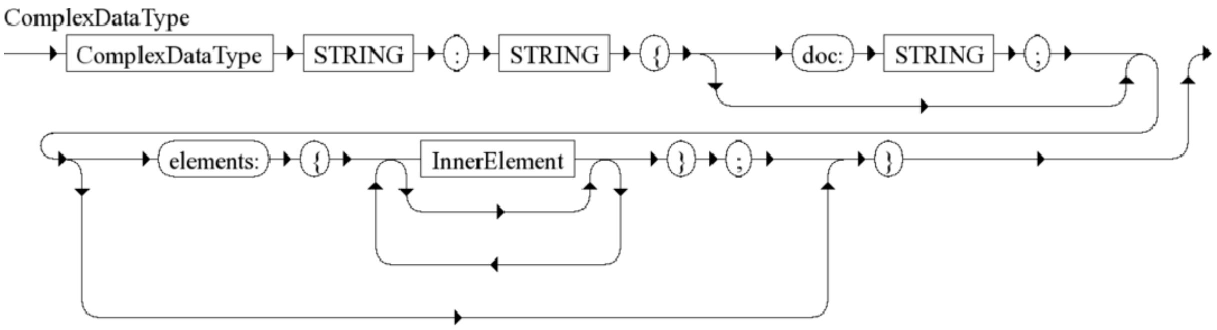
PrimitiveDataType



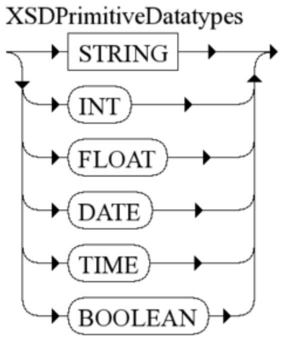
CollectionDataType



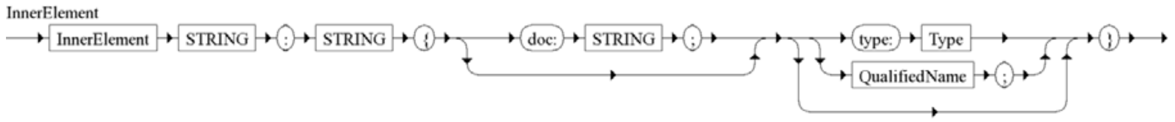
ComplexDataType



XSDPrimitiveDataTypes

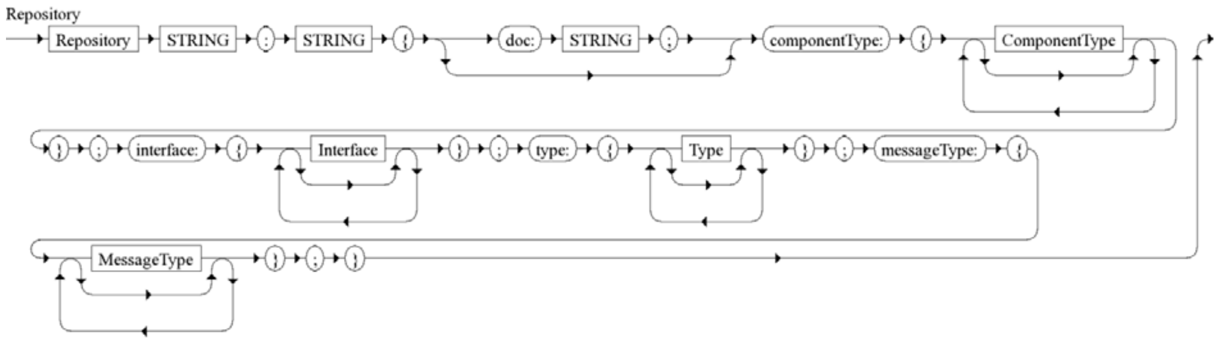


InnerElement

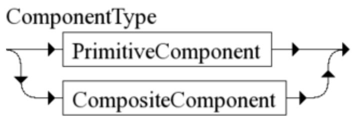


7.4 Static structure (package samm.staticstructure)

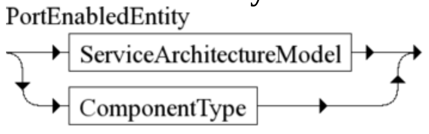
Repository



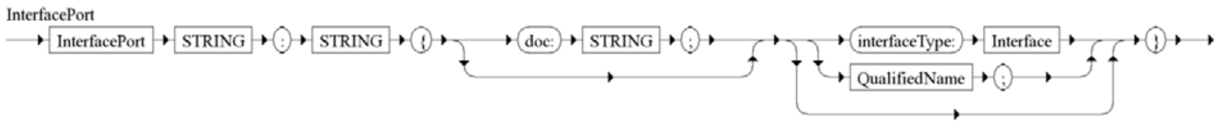
ComponentType



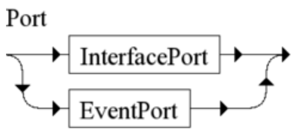
PortEnabledEntity



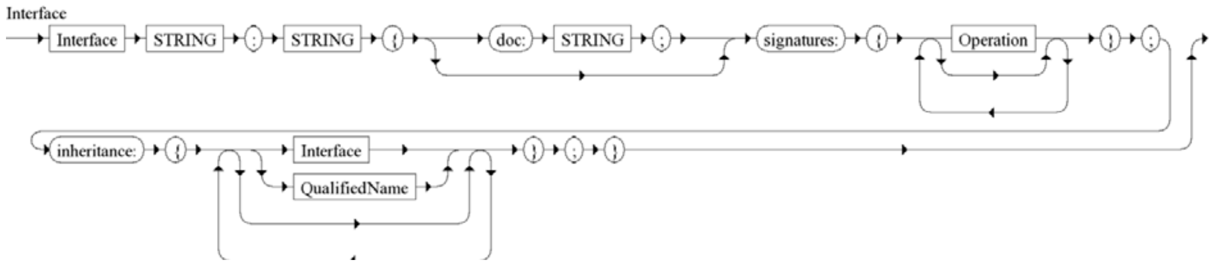
InterfacePort



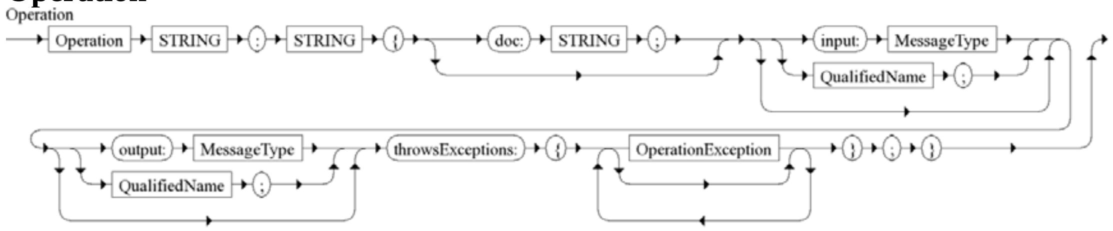
Port



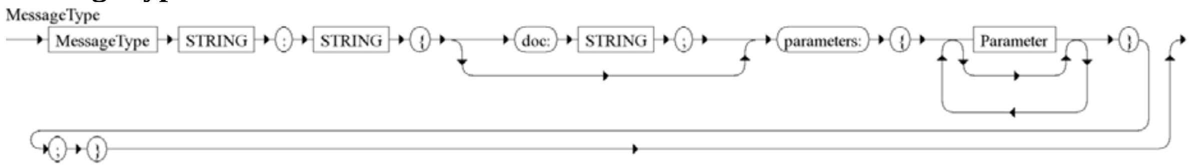
Interface



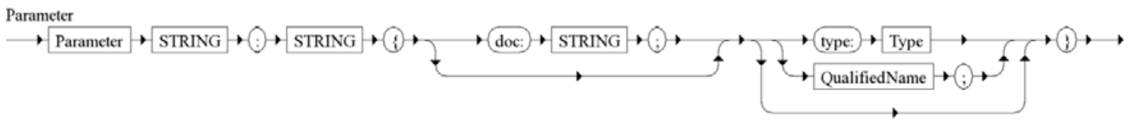
Operation



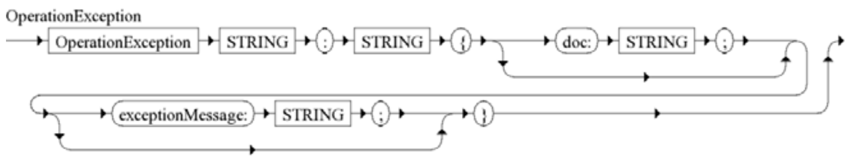
MessageType



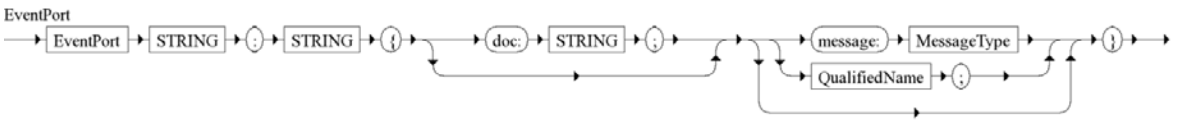
Parameter



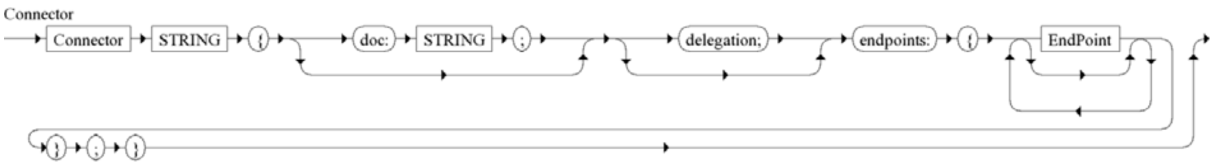
OperationException



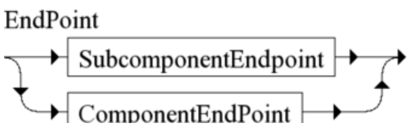
EventPort



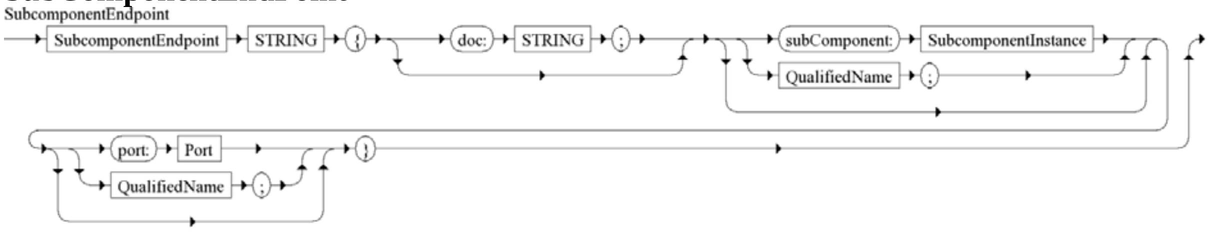
Connector



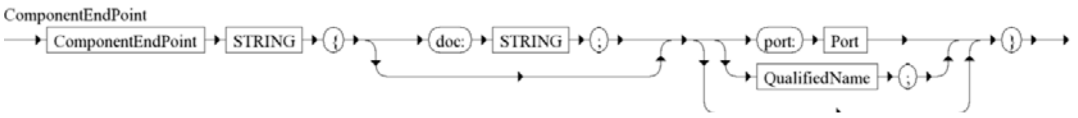
EndPoint



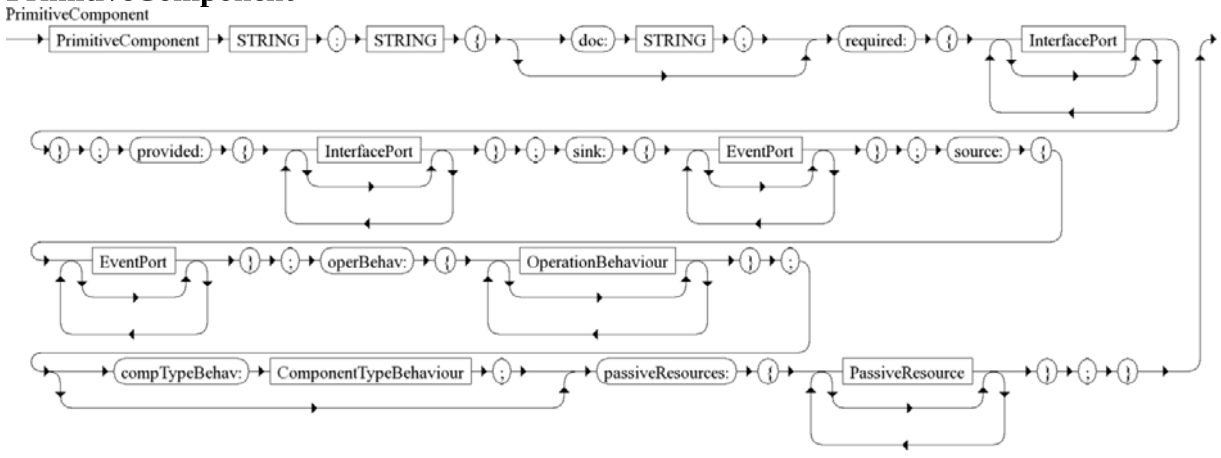
SubComponentEndPoint



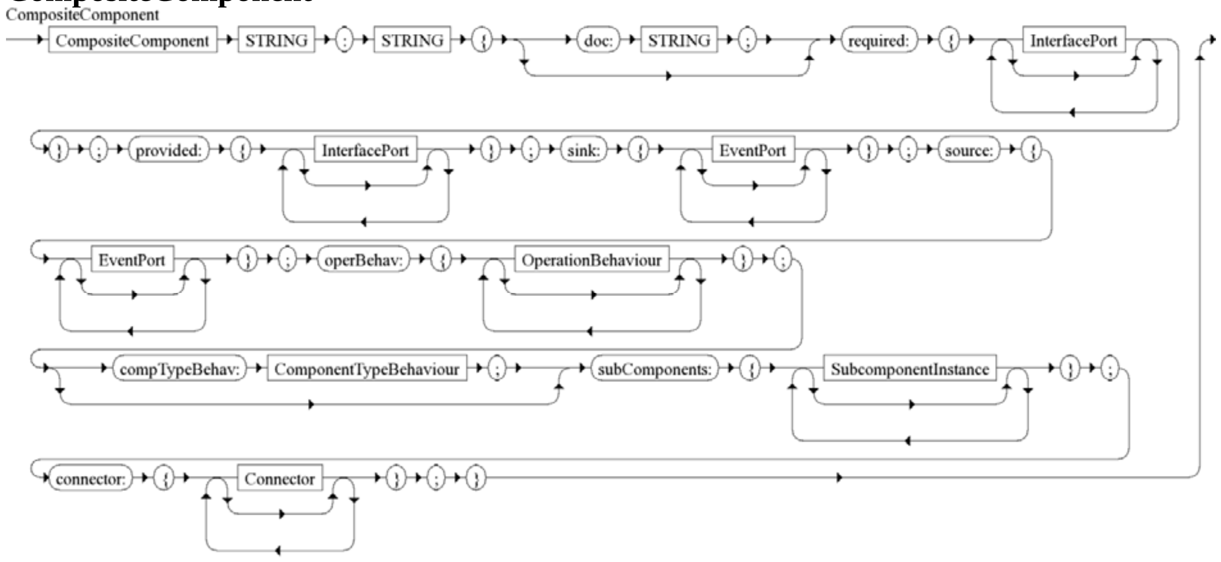
ComponentEndPoint



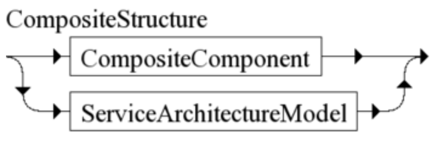
PrimitiveComponent



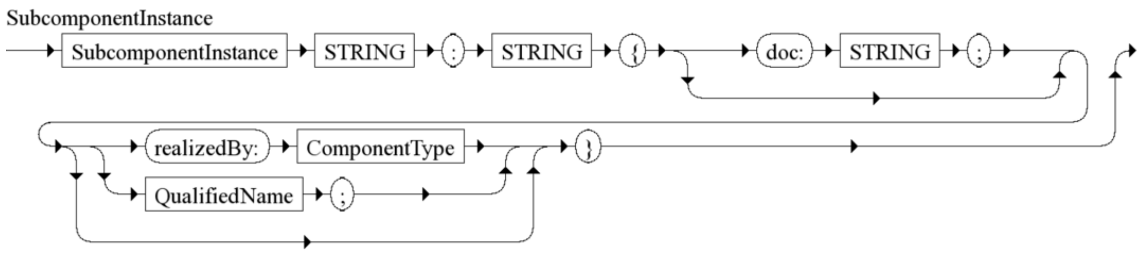
CompositeComponent



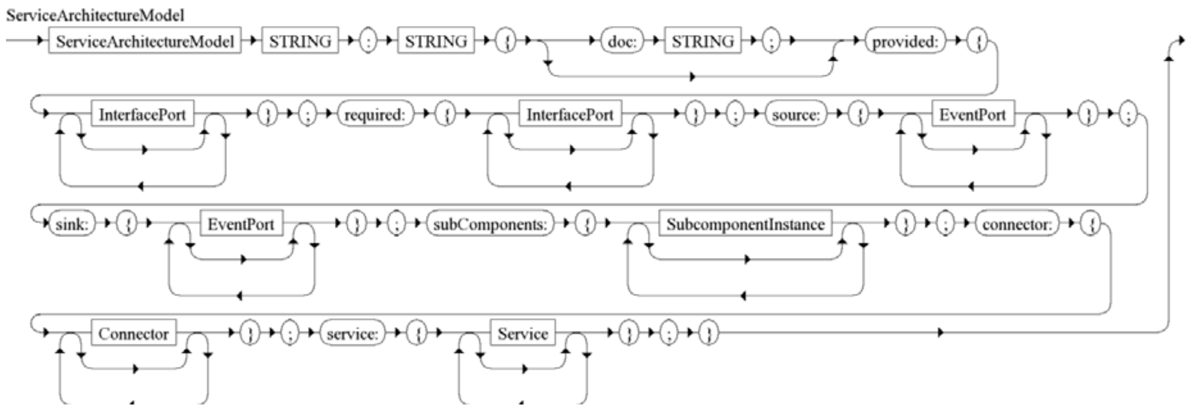
CompositeStructure



SubcomponentInstance

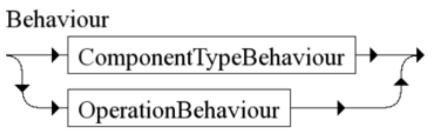


ServiceArchitectureModel

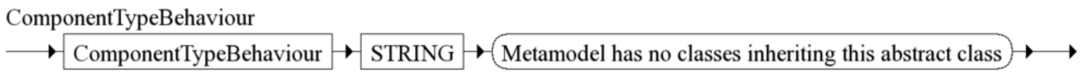


7.5 Behaviour (package samm.behaviour)

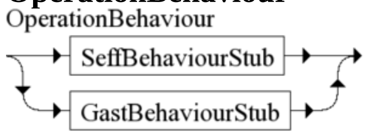
Behaviour



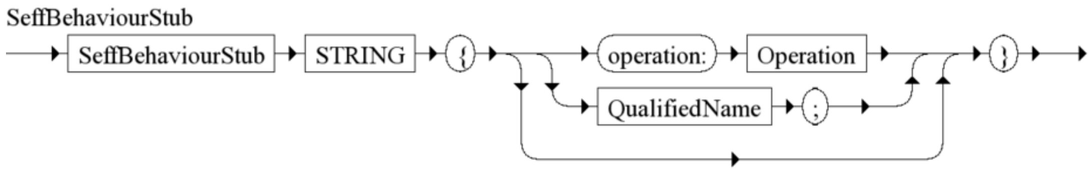
ComponentTypeBehaviour



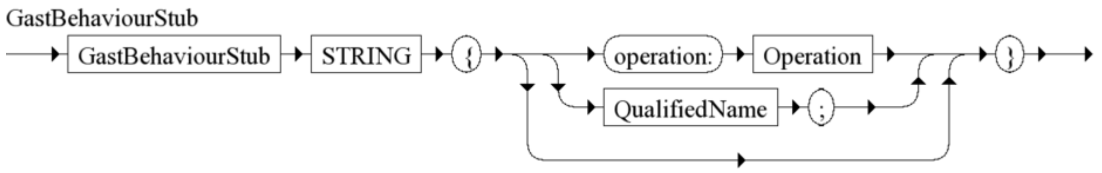
OperationBehaviour



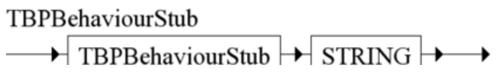
SeffBehaviourStub



GastBehaviourStub



TBPBehaviourStub

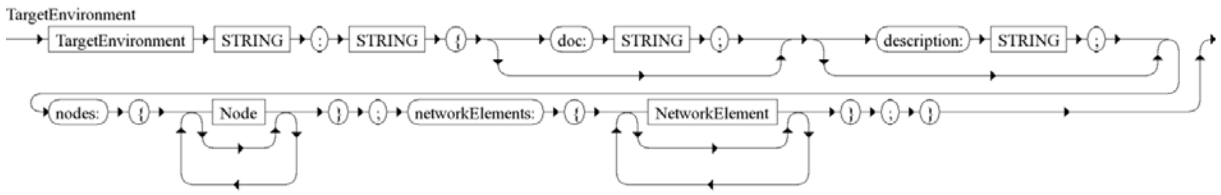


7.6 Deployment (package samm.deployment)

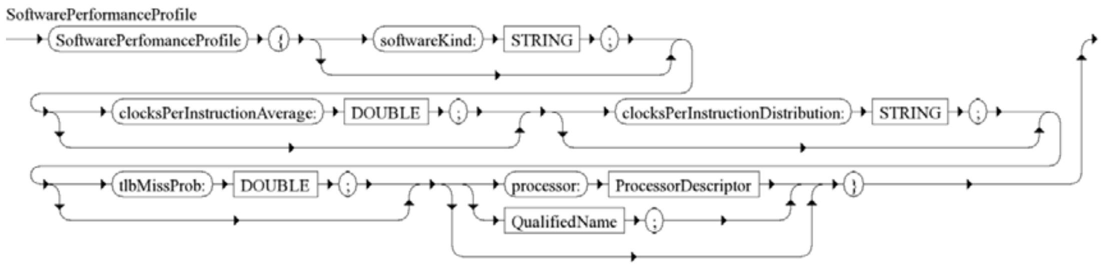
The deployment package is divided into three packages: *target environment*, *hardware*, and *allocation*.

7.6.1 Target environment (package samm.deployment.targetenvironment)

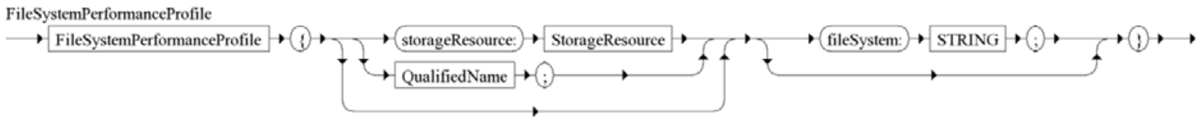
TargetEnvironment



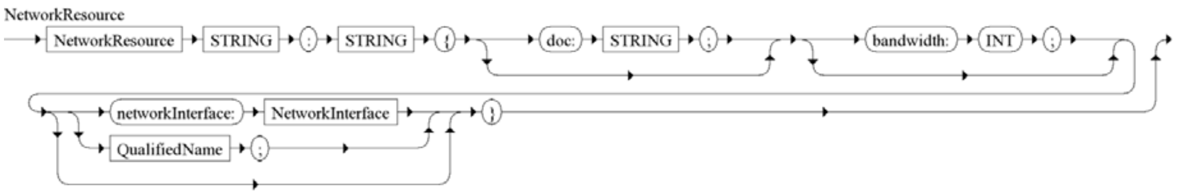
SoftwarePerformanceProfile


SoftwarePerformanceProfile
SoftwarePerfomanceProfile
{
softwareKind:
STRING
;
clocksPerInstructionAverage:
DOUBLE
;
clocksPerInstructionDistribution:
STRING
;
tlbMissProb:
DOUBLE
;
processor:
ProcessorDescriptor
QualifiedName
;
}

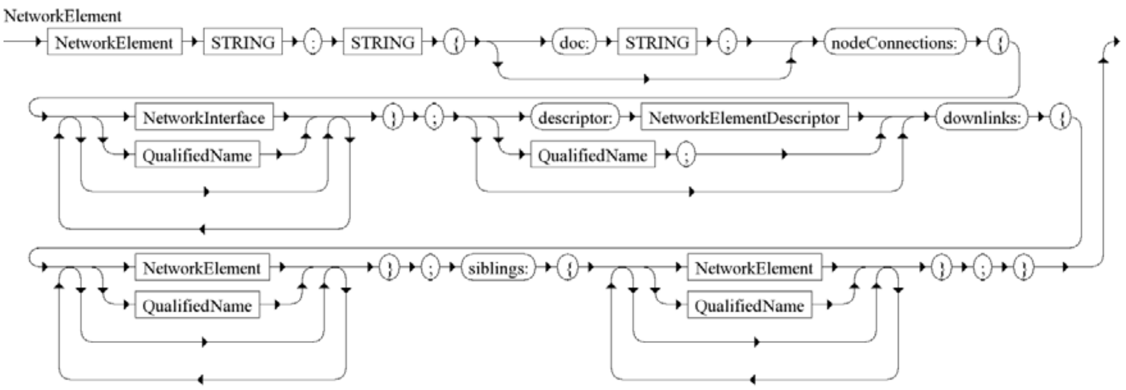
FileSystemPerformanceProfile



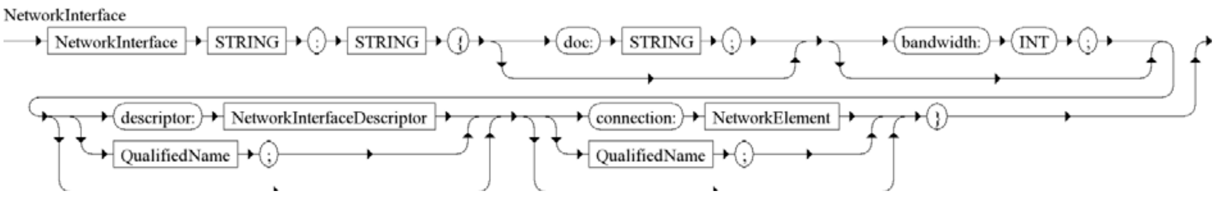
NetworkResource



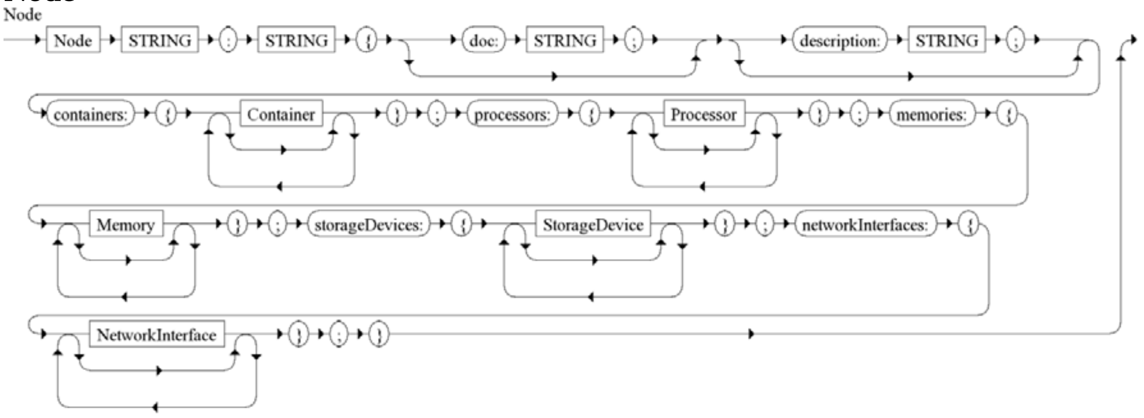
NetworkElement



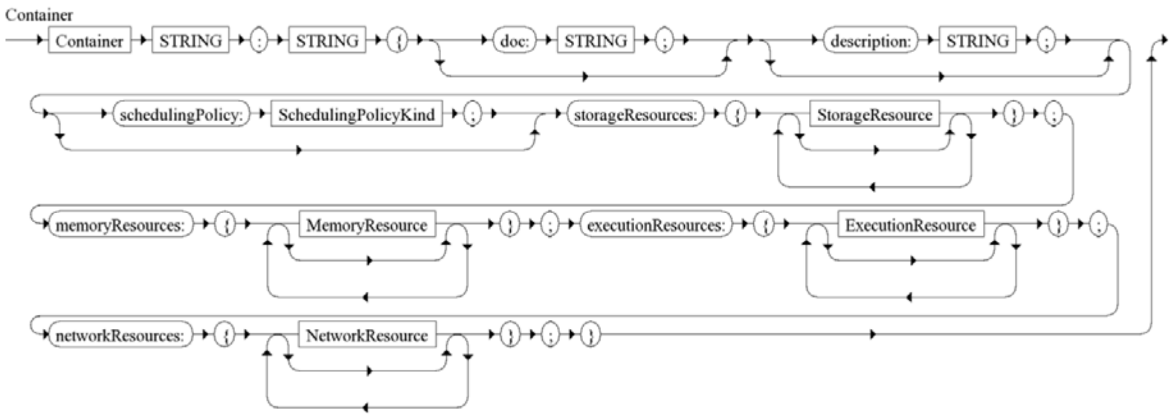
NetworkInterface



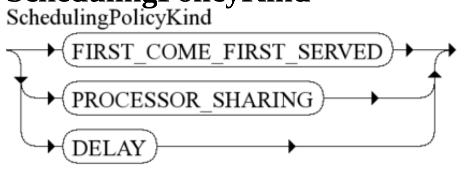
Node



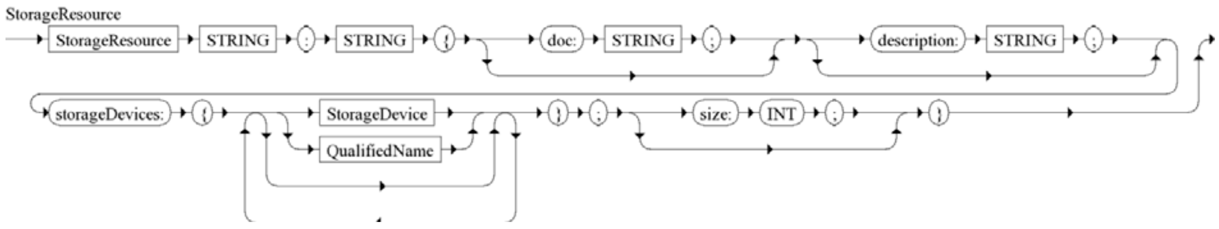
Container



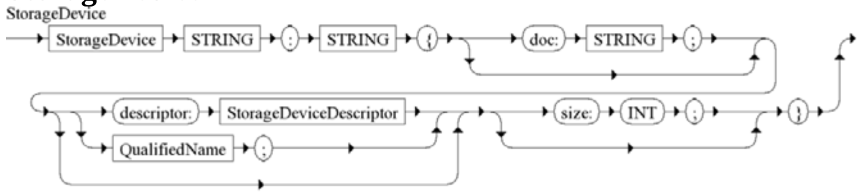
SchedulingPolicyKind



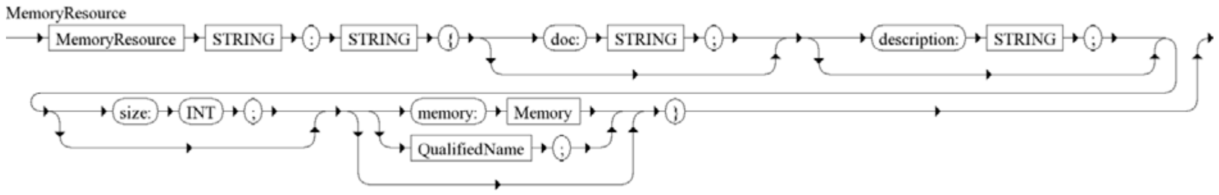
StorageResource



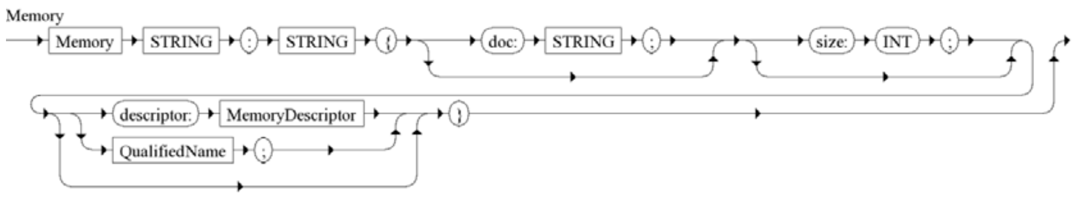
StorageDevice



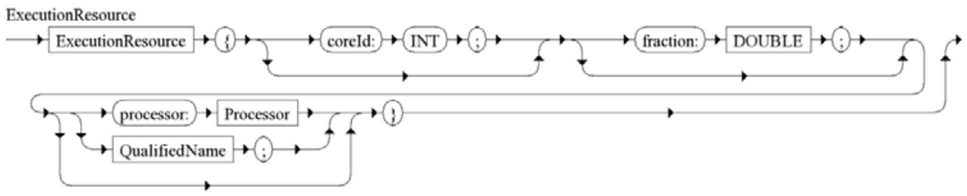
MemoryResource



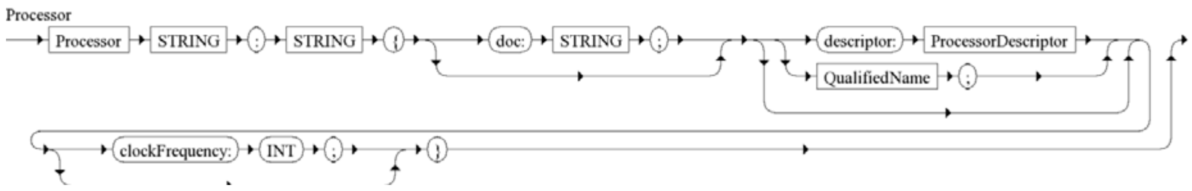
Memory



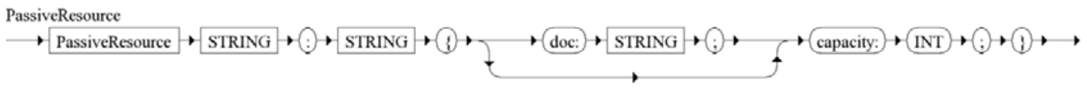
ExecutionResource



Processor

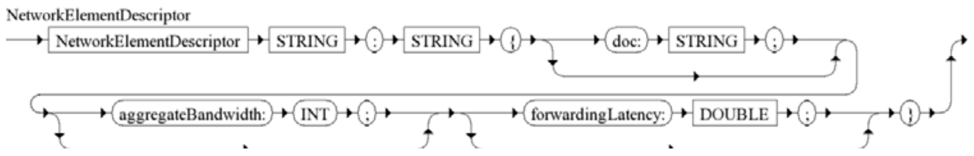


PassiveResource

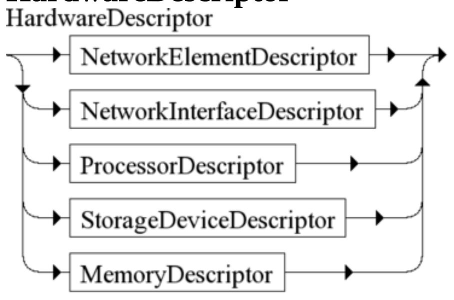


7.6.2 Hardware (package samm.deployment.hardware)

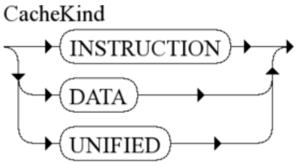
NetworkElementDescriptor



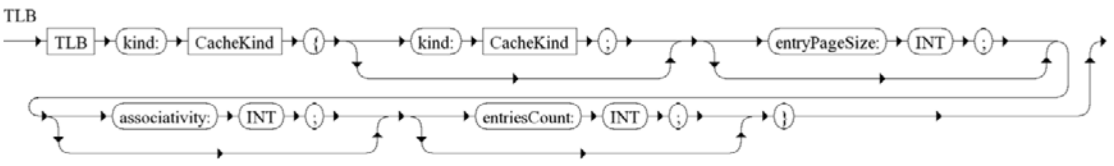
HardwareDescriptor



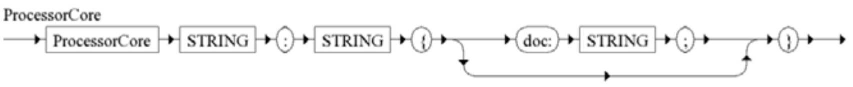
CacheKind



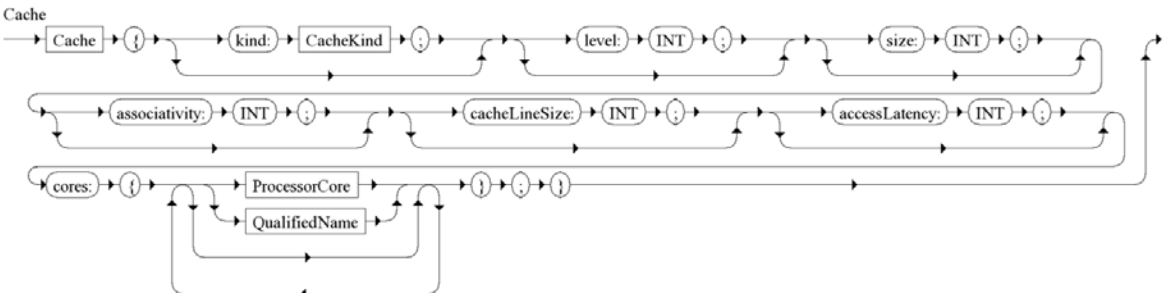
TLB



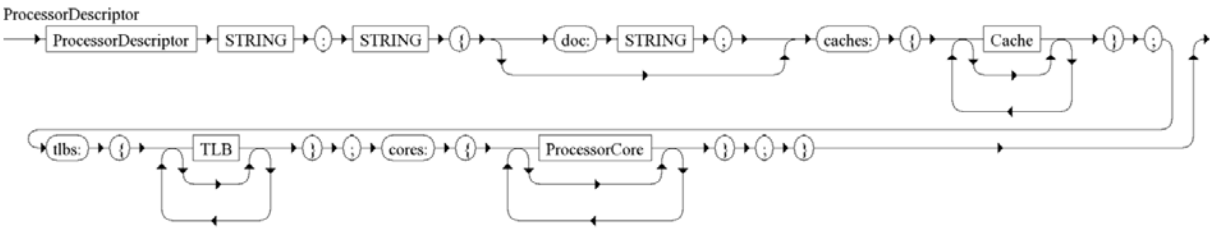
ProcessorCore



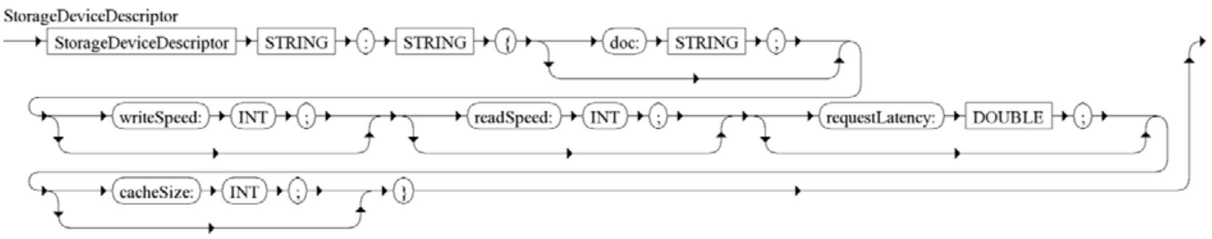
Cache



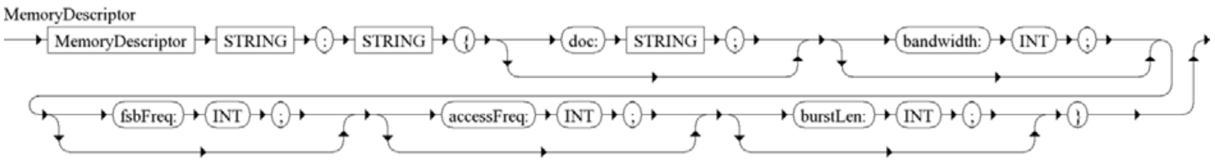
ProcessorDescriptor



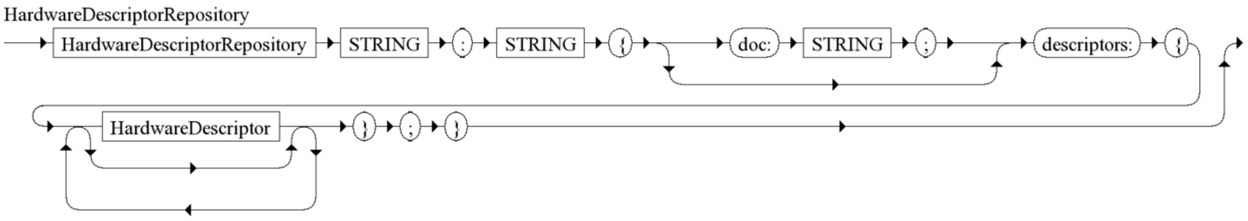
StorageDescriptor



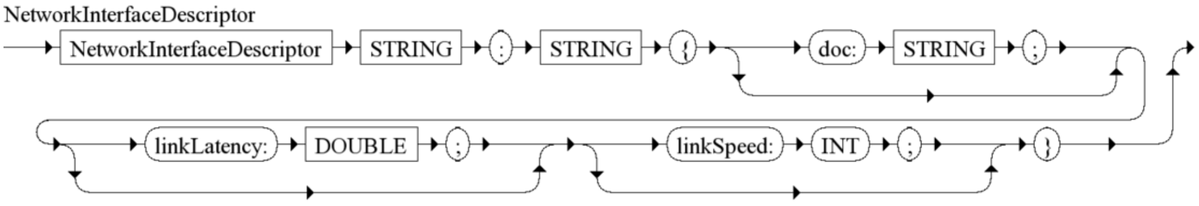
MemoryDescriptor



HardwareDescriptorRepository

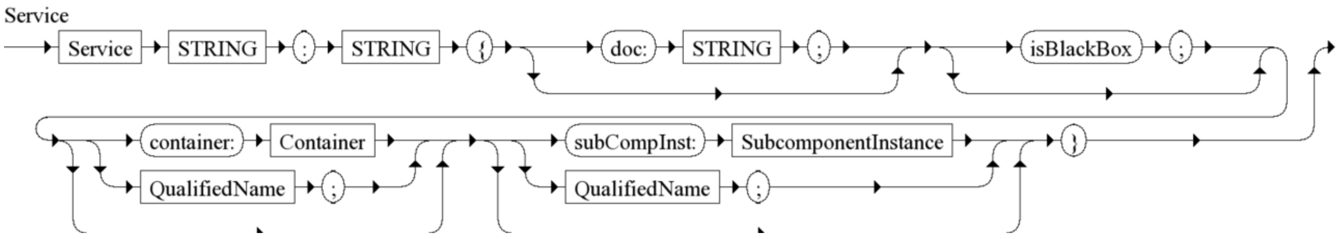


NetworkInterfaceDescriptor



7.6.3 Allocation (package samm.deployment.allocation)

Service



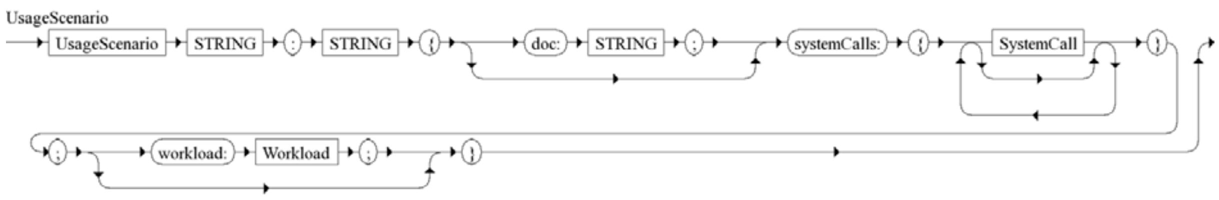
7.7 Annotation (package samm.annotation)

Annotation

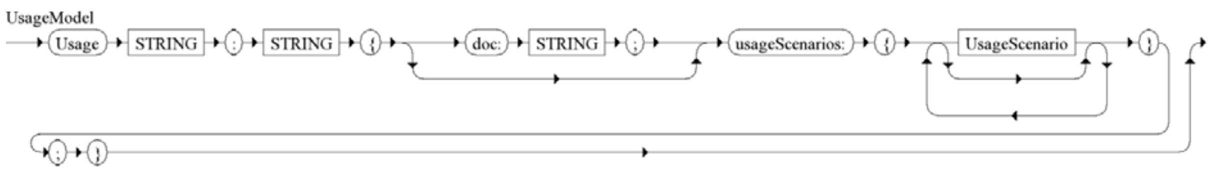
There is no concrete syntax for annotation.

7.8 Usage model (package samm.usagemodel)

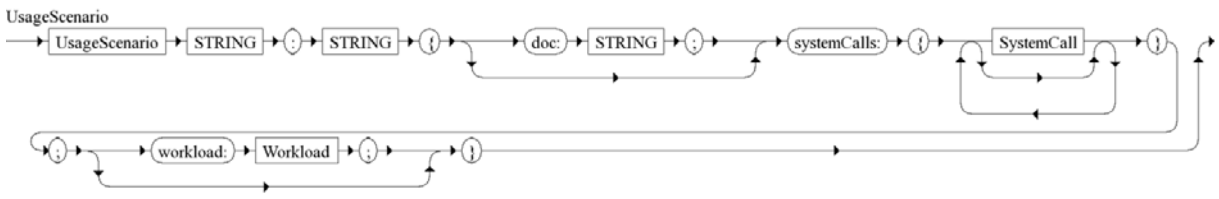
UsageScenario



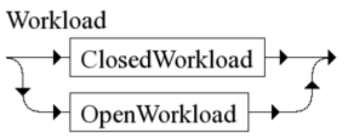
UsageModel



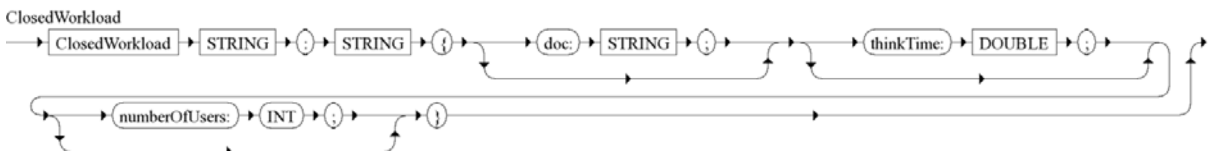
UsageScenario



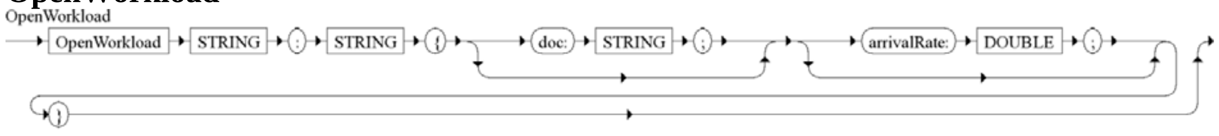
Workload



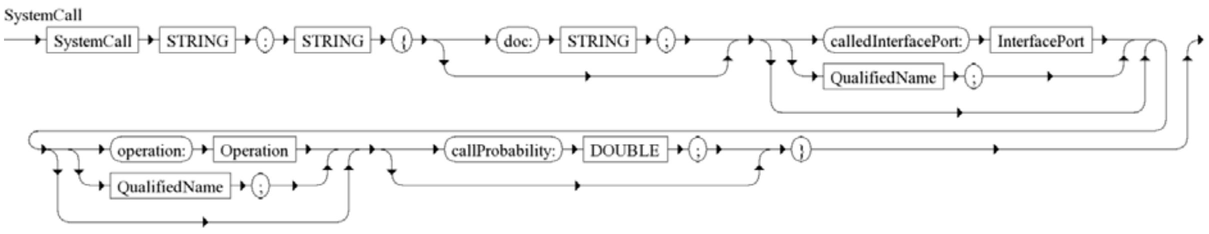
ClosedWorkload



OpenWorkload

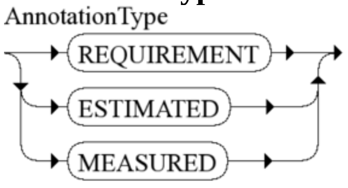


SystemCall

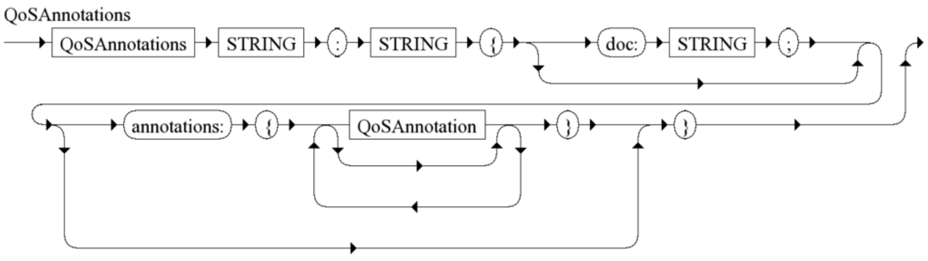


7.9 QoS Annotations (package samm.qosannotation)

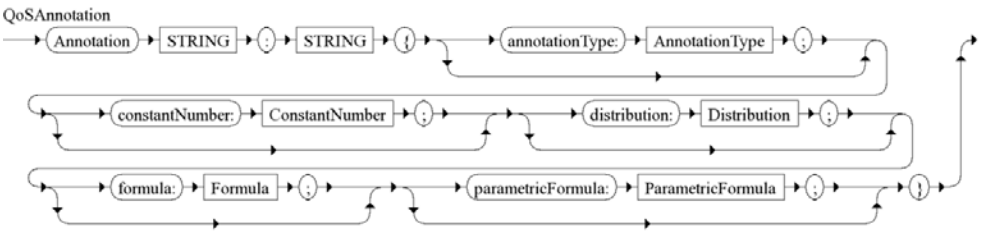
AnnotationType



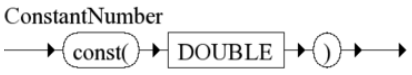
QosAnnotations



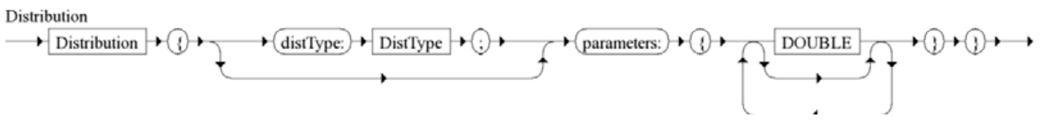
QoS Annotation



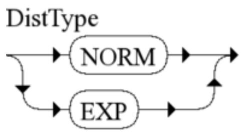
ConstantNumber



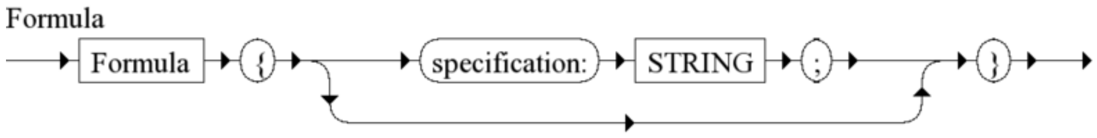
Distribution



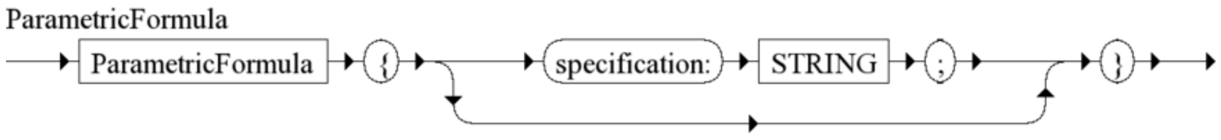
DistType



Formula



ParametricFormula



8 Appendix D: Glossary

This section contains definition of special terms contained in the text above.

Service architecture meta-model (SAMM) = Common meta-model which contains everything to describe the information needed for quality prediction analysis. It serves as shared data-repository for all quality analysis methods

Service architecture model (SAM) = an instance of the SAMM

Threaded Behaviour Protocols (TBP) = a behaviour model of a component/service specifying traffic on service provided and required interface ports as visible from outside, i.e., by other services communicating with this one

Java PathFinder (JPF) = a code model checker for java programs. It is able to automatically detect certain errors in the Java code (e.g., uncaught exceptions, assertion violations) via executing the code under consideration under all relevant threads' scheduling.