SIMSCRIPT III®

2-D Graphics Manual

CACI Products Company

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Table of Contents

PREFACE **5**

1. OVERVIEW **7**

1.1 GETTING STARTED 7
1.2 OBJECTS FOUND IN GUI.M 9

2. USING ITEMS CREATED IN SIMSTUDIO **12**

3. WINDOWS **14**

3.1 SIZE AND POSITION 14
3.2 CANVAS 14
3.2.1 Canvas Coordinates *15*
3.2.2 Background Color *15*
3.2.3 Printing the Canvas *15*
3.3 TITLE AND STATUS BAR 16
3.4 SCROLL BARS 16
3.5 HANDLING USER INPUT 17
3.6 READING MOUSE INPUT SYNCHRONOUSLY 19
3.7 USING A WINDOW 19

4. VIEW OBJECT **22**

4.1 VIEW BOUNDARIES 22
4.2 COORDINATE SYSTEM FOR GRAPHIC OBJECTS 22
4.3 OVERLAPPING VIEWS 23
4.4 PAN AND ZOOM 23

5. GRAPHICS IN A WINDOW **28**

5.1 DRAWING SHAPE PRIMITIVES 28
5.2 POINTS, STYLE, AND COLOR 30
5.3 LOCATION, ROTATION, AND SCALE 32
5.4 RESPONDING TO CLICKS ON A GRAPHIC 34

6. GRAPHS **37**

6.1 GRAPH OBJECTS 37
6.2 METER OBJECT: GRAPH A SINGLE VARIABLE 39
6.3 CLOCK OBJECT: SHOW THE TIME 41
6.4 PLOT OBJECT: SHOWING HISTOGRAMS AND TRACE PLOTS 43
6.4.1 Histograms *43*
6.4.2 Time Trace Plots *48*
6.4.3 X-Y Plots *50*
6.4.4 Setting up the X and Y axes *52*

7. ICONS **53**

7.1 CREATING AND LOADING AN ICON 53
7.2 BACKGROUND ICONS 53

7.3 Dynamic Icons 55
7.4 Animating an Icon object in a Simulation 57
7.5 Simulation Time and Real Time 58
7.6 Custom animation 60

8. FORMS 62

8.1 Using Form objects 62
8.2 DialogBox object 63
8.3 Using Field objects for data transfer 64
8.4 Event Notification 67
8.4 Enable and Disable fields 69
8.5 Trees 71
8.6 Tables 73
8.7 Menu bars 75
8.8 Palettes 77
8.9 PopupMenu Objects 79
8.10 MessageBox Objects 84

Preface

This document contains information on CACI's new SIMSCRIPT III, Modular Object-Oriented Simulation Language, designed as a superset of the widely used SIMSCRIPT II.5 system for building high-fidelity simulation models. It focuses on the description of the SIMSCRIPT III Graphics.

CACI publishes a series of manuals that describe the SIMSCRIPT III Programming Language, SIMSCRIPT III Object - Oriented 2-D and 3-D Graphics and SIMSCRIPT III development environment SimStudio. All documentation is available on SIMSCRIPT WEB site http://www.simscript.com/products/simscript_manuals.html

- *SIMSCRIPT III Graphics Manual* —this manual – is a detailed description of the presentation graphics and animation environment for SIMSCRIPT III.

- *SIMSCRIPT III User's Manual* – A detailed description of the SIMSCRIPT III development environment: usage of SIMSCRIPT III Compiler and the symbolic debugger from the SIMSCRIPT development studio, Simstudio, and from the Command-line interface.

- *SIMSCRIPT III Programming Manual* – A short description of the programming language and a set of programming examples.

- *SIMSCRIPT III Reference Manual* - A complete description of the SIMSCRIPT III programming language constructs in alphabetic order. Graphics constructs are described in the SIMSCRIPT III Graphics Manual.

Since SIMSCRIPT III is a superset of SIMSCRIPT II.5, a series of manuals and text books for SIMSCRIPT II.5 language, Simulation Graphics, Development environment, Data Base connectivity, Combined Discrete-Continuous Simulation, can be used for additional information:

- *SIMSCRIPT II.5 Simulation Graphics User's Manual* — A detailed description of the presentation graphics and animation environment for SIMSCRIPT II.5

- *SIMSCRIPT II.5 Data Base Connectivity (SDBC) User's Manual* — A description of the SIMSCRIPT II.5 API for Data Base connectivity using ODBC

- *SIMSCRIPT II.5 Operating System Interface* — A description of the SIMSCRIPT II.5 APIs for Operating System Services

- *Introduction to Combined Discrete-Continuous Simulation using SIMSCRIPT II.5* — A description of SIMSCRIPT II.5 unique capability for modeling combined discrete-continuous simulations.

• *SIMSCRIPT II.5 Programming Language* — A description of the programming techniques used in SIMSCRIPT II.5.

• *SIMSCRIPT II.5 Reference Handbook* — A complete description of the SIMSCRIPT II.5 programming language, without graphics constructs.

• *Introduction to Simulation using SIMSCRIPT II.5* — A book: An introduction to simulation with several simple SIMSCRIPT II.5 examples.

• *Building Simulation Models with SIMSCRIPT II.5* —A book: An introduction to building simulation models with SIMSCRIPT II.5 with examples.

The SIMSCRIPT language and its implementations are proprietary software products of the CACI Products Company. Distribution, maintenance, and documentation of the SIMSCRIPT language and compilers are available exclusively from CACI.

Free Trial Offer

SIMSCRIPT III is available on a free trial basis. We provide everything needed for a complete evaluation on your computer. **There is no risk to you**.

Training Courses

Training courses in SIMSCRIPT III are scheduled on a recurring basis in the following locations:

San Diego, California
Washington, D.C.

On-site instruction is available. Contact CACI for details.

For information on free trials or training, please contact the following:

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1. Overview

SIMSCRIPT III Graphics is implemented as a set of classes supplied in a GUI.M subsystem/module, which is part of every SIMSCRIPT III distribution.

The GUI.M module contains classes that can be used to develop a graphical user interface for a SIMSCRIPT III model. Included is support for windows, dialog boxes, menu bars, palettes, graphics, icons and presentation graphs.

GUI.M is an interface to SIMGRAPHICS III and supports the same collection of features offered by the display entities and procedural interface provided in SIMSCRIPT II.5. GUI.M supports the loading of ".sg2" files containing icons, graphs and forms created by the SimStudio. Existing dialog boxes, icons, palettes etc. created for a SIMSCRIPT II.5 application are fully compatible with GUI.M. This allows an application to be fully object-oriented and to provide all the capabilities supported in SIMSCRIPT graphics.

1.1 Getting Started

Using the objects provided in GUI.M, the application constructs a hierarchy of graphical objects. This hierarchy constructed by filing instances of GUI.M objects into sets owned by other instances of GUI.M objects. Generally speaking, GUI.M classes are used in the following manner:

1. Create an instance of an object found in GUI.M, or a suitably derived object.
2. Assign attributes to the instance.
3. File the instance in a set owned by another object that is to contain it.
4. Call the object methods to view or perform other tasks.

The *Window* object acts as a container for dialog boxes, palettes, a menu bar, as well as graphics that appear within its canvas. More specifically, a window owns a *form_set* containing objects derived from the *Form* and a *view_set* containing *View* objects. Form objects include dialog boxes, menu bars and palettes that are attached to a window. View objects represent a coordinate mapped region of the canvas of a window and act as containers for graphs and icons.

The GUI.M module supports loading objects derived from *Icon*, *Graph* or *Form* classes from the "graphics.sg2" file created by one of the SimStudio graphical editors. The *appearance* attribute declared by these classes can be assigned before the object is displayed, allowing the information saved by SimStudio to define the characteristics of the Icon, Graph or Form .

A simple GUI application might perform the following steps:

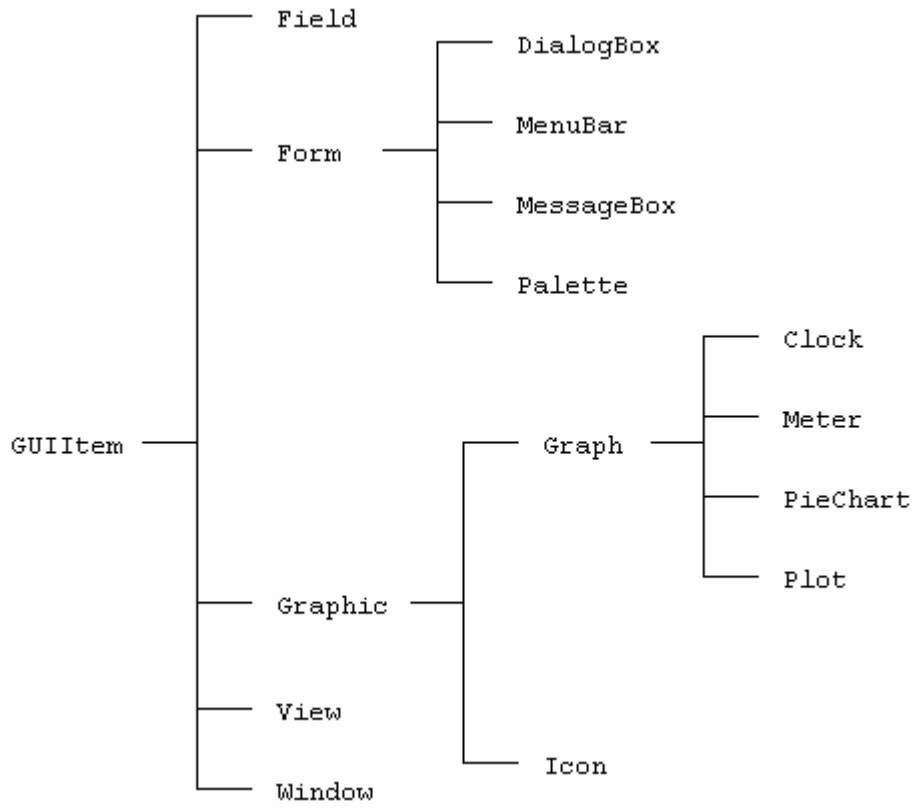
1. Create an instance of a Window, assign its position, title attributes. Then call the *display* method to show the window.
2. Create a View, assign its world coordinate system attributes, file it in the *view_set* owned by the window.
3. Create an Icon, assign its *appearnce*, file it in the *graphic_set* owned by the *view*. Then call the *display* method to show the icon.

The following program (Example1.sim) brings up a window to show an icon created by the SimStudio icon editor.

```
''Example1.sim
preamble including the gui.m subsystems
end

main
   define my_window as Window reference variable
   define my_view as a View reference variable
   define my_icon as an icon reference variable

   ''create the window and show it on the screen
   create my_window
   let title(my_window) = "Example 1: Showing a simple icon"
   call display(my_window)

   ''create a view to hold the icons, graphics, and graphs
   create my_view
   file this my_view in view_set(my_window)

   ''create an icon, load its appearance from SimStudio
   create my_icon
   let appearance(my_icon) = Templates'find("simple icon")
   file this my_icon in graphic_set(my_view)

   ''show the icon in the canvas
   call display(my_icon)

   ''wait for user to close the window
   while 1=1
      call handle.events.r(1)
end
```

1.2 Objects Found in GUI.M

All objects that can be displayed on the computer screen are derived from a *GuiItem* object. The diagram below shows the hierarchy. Derived objects are shown to the right of their base classes.



The *Form, GuiItem* and *Graph* classes are to be used as base classes and are not meant to be used in a *create* statement. The following table lists all classes defined in GUI.M. These classes will be described in greater detail later.

Name	Create	Super-classes	Belongs In set	Description
Clock	Yes	Graph Graphic GuiItem	graphic_set	A graph appearing inside a window that shows simulation time.
Color	No			A utility class for creating and decomposing a color.
DialogBox	Yes	Form GuiItem	form_set	Contains various data fields that can be viewed and adjusted by the user.
Field	Yes	GuiItem	field_set	A data field contained in a dialog box, menu bar or palette.
FillStyle	Yes			Defines patterns for drawing polygons, circles and pies. Used by the Graphic class.
Form	No	GuiItem	form_set	Base class for dialog boxes, message box, menu bar, and palette. Appearance must be defined using SimStudio.
FormEvent	No			Passed to the *action* method during interaction with form. Its attributes identify which data field was clicked on or changed.
Graph	No	Graphic GuiItem	graphic_set	Base class for all 2d charts, clock, dial, level meters, etc. Appearance must be defined in SimStudio.
Graphic	Yes	GuiItem	graphic_set	Base class for all objects that can appear in the window canvas. Can be used to draw polygons, circles, lines, etc.
GraphicEvent	No			Passed to the *action* method when a graphic is clicked on with the mouse.
GuiItem	No			Base class for all objects that can be displayed on screen.
Icon	Yes	Graphic GuiItem	graphic_set	A movable icon created in the SimStudio icon editor. Can be given a velocity and connected to a Simulation.
LineFont	Yes	TextFont		Predefined fonts for drawing scalable (vector based) text. Used by the Graphic class.
LineStyle	Yes			Defines dash styles and widths for drawing arcs and polylines. Used by the Graphic class.
MarkStyle	Yes			Defines types of markers that can be drawn. Used by the Graphic class.
MessageBox	Yes	Form GuiItem	form_set	Simple dialog box that can be defined at runtime or by SimStudio. Includes predefined response buttons.
Meter	Yes	Graph Graphic GuiItem	graphic_set	Graph that shows a single numerical value.
Palette	Yes	Form GuiItem	form_set	A palette or control panel attached to an edge of the window containing rows of buttons. The buttons can be toggled or dragged onto the canvas. Derived objects can override the *action* method to receive immediate notification of user input.
PieChart	Yes	Graph Graphic GuiItem	graphic_set	A pie shaped graph representing a 1-dim array.

Plot	Yes	Graph Graphic GuiItem	graphic_set	A 2-d chart that can display a histogram or trace plot.
PopupMenu	Yes	Form GuiItem		A context menu usually displayed when a user right-clicks in the canvas of a Window object
SystemFont	Yes	TextFont		Contains font name, italic, point_size for drawing non-scalable "raster" text. Used by the Graphic class.
Template	No			An instance corresponds to an Icon, Graph or Form appearance as defined in SimStudio. The instance can be returned using the *Templates'find* method.
Templates	No			Utility class for reading files created by SimStudio. Creates a template for each graphical item saved in SimStudio.
TextFont	No			Base class for both LineFont and SystemFont classes.
View	Yes	Graphic GuiItem	view_set	Defines a coordinate system as well as a holding area for Graphic objects. It can occupy a rectangular region in the canvas.
Window	Yes	GuiItem		A resizable, scrollable window containing graphics and forms.
WindowEvent	No			Passed to the *action* method of a Window when user does a click, drag, or adjusts the scrollbar.

2. Using Items Created in SimStudio

In SIMSCRIPT III icons, graphs, and forms are designed in one of the SimStudio graphical editors. Definitions created by the graphics editors are saved in a file with the extension ".sg2". (When a new project is created, a default file named "graphics.sg2" is created for the project). GUI.M provides a way for the application to load these saved definitions and associate them with an existing object. An instance of a *Template* object will represent the saved definition of a icon, graph, or form. A template instance can be assigned to the *appearance* attribute of any object derived from *Icon*, *Graph* or *Form*.

Template objects are not created in the application code, but instead are returned by the *find* method of a utility class called *Templates*. This class acts as a manager of templates that have been read into the application from the ".sg2" file saved by SimStudio. During initialization, the "graphics.sg2" file will be loaded automatically. At this time all icon, graph and form definitions from this file will be stored in memory. The *Templates'find* method can then be called to return a template. This method takes as its only argument the name given to the item in SimStudio.

The *Templates'read_sg2* method allows the application to read any ".sg2" file saved by SimStudio. In the following example, three identical icons are shown in a window. A template for these icons is obtained by the *Templates* class. The icons are saved in the file "Example2.sg2" which is read by the *Templates* class.

```
''Example2.sim

preamble including the gui.m subsystems
end

main
   define window as Window reference variable
   define view as a View reference variable
   define dialog as a Dialogbox reference variable
   define icon1, icon2, icon3 as Icon reference variables
   define car_template, dialog_template as Template reference variables

   ''tell the template manager to load everything in "Example2.sg2"
   call Templates'read_sg2("Example2.sg2")

   ''get the templates to be used from the template manager
   let car_template = Templates'find("car icon")
   let dialog_template = Templates'find("quit dialog")

   ''create the window and show it on the screen
   create window
   let title(window) = "Example 2: Interfacing with SimStudio"
   call display(window)

   ''create a view to hold the icons
   create view
   file this view in view_set(window)

   ''create 3 icons
```

```
   create icon1, icon2, icon3

   ''set the template of each icon
   let appearance(icon1) = car_template
   let appearance(icon2) = car_template
   let appearance(icon3) = car_template

   file this icon1 in graphic_set(view)
   file this icon2 in graphic_set(view)
   file this icon3 in graphic_set(view)

   ''show the icons in the canvas
   call display_at(icon1)(5000.0, 15000.0)
   call display_at(icon2)(15000.0, 15000.0)
   call display_at(icon3)(25000.0, 15000.0)

   ''show a simple dialog box
   create dialog
   let appearance(dialog) = dialog_template
   file this dialog in form_set(window)

   ''wait for user to hit any button in the dialog
   call accept_input(dialog)
end
```

3. Windows

The Window class in GUI.M allows the application to create independent windows, each having optional scroll bars, an optional status bar and a title. Subclassing a window and overriding the *action* method allows the application to be notified immediately of user interaction with the scrollbars, or of mouse input events.

Objects derived from *GuiItem* must either be attached to the window, or attached to another object that is itself attached to a window. An object can be attached by filing it into one of the sets owned by a Window. Objects derived from *Form* (dialog boxes, menu bar, palette) must be filed into the *form_set*. Another set owned by window called the *view_set* contains *View* objects (which in turn contains objects derived from *Graphic* such as the *Icon* and *Graph*).

Before being displayed assignment of the window's properties should be made. Note that even though some properties might be specifically defined as "methods", the expression referring to the property can be used on the left of the assignment operator (SIMSCRIPT III allows this). The *display* method should be called to make the window visible.

3.1 Size and Position

The *position_xlo, position_ylo*, *position_xhi*, and *position_yhi* properties will specify the geometry of the window. Coordinate values applied to these attributes should range from 0 to 32767. The point (0,0) defines the lower left corner of the computer screen, and (32767,32767) marks the upper right corner. Window size and position specifications *include* title bar, border and menu bar, (a window whose position_yhi is 16383 will NOT overlap another window whose polsition_ylo is 16383).

3.2 Canvas

The "canvas" of a window is the rectangular area inside the frame. This represents the drawing area for the application. Instances of *View* objects can appear in the canvas by filing them into the *view_set* owned by the *Window* object. Each *View* encompasses a rectangular section of the canvas and in turn contains *Graphic* objects (animated icons, backgrounds, and presentations graphs, etc.). See chapter 4### for more information on using the *View*.

3.2.1 Canvas Coordinates

Each *View* defines a coordinate system for the objects it contains. The *View* objects themselves obey a fixed "canvas" coordinate system. The canvas coordinate system is always square, and (0,0) is mapped to the lower left corner of the canvas, while (32768,32768) maps to the upper right corner (if the window is square). The window, however, may be sized to be non-square by the user. There are three choices as to how to map the square canvas coordinates to a rectangular window canvas. The *crop_mode* property can be assigned to one of the following values:

crop_none: Canvas coordinates will occupy the largest centered square within the canvas. All of coordinate system will be visible, but there may be gaps at the ends depending on how tall or wide the window is made.

crop_top: The maxium "x" coordinate (32768) is fixed to the right border. The top portion of the canvas coordinates will not be visible if the window is wider than it is tall.

crop_bottom: The maxium "y" coordinate (32768) is fixed to the top border. The right portion of the canvas coordinates will not be visible if the window is taller than it is wide.

The *get_viewable_area* method can be called to discover the visible canvas coordinate space in the window. Canvas coordinates are generally the default coordinate system used by *Graphic* objects. In other words, of no other coordinate system is explicitly described, canvas coordinates are used.

3.2.2 Background Color

The default background color for the window canvas is black. The *color* property of the window can be assigned to change the background color. A suitable color value can be returned from *Color'RGB* method. For example, to set the background color to red:

```
let color(my_window) = Color'rgb(1.0, 0.0, 0.0)
```

3.2.3 Printing the Canvas

The *print* method can be called to send the entire graphical content of the canvas to a printer. Pass "1" to the method to show a dialog box which allows the user to set printing options.

3.3 Title and Status Bar

A title bar is included at the top of every window. The *title* property can be assigned to change the text displayed in the title bar. A status bar can be shown at the bottom of the window frame. The status bar is composed of several panes, each containing a short text message that can be set at runtime.

The *status_pane_count* property must be set to a non-zero integer to enable the status bar. Each pane in the status bar should be assigned a width (in characters) using the *status_pane_width* property. The width of the first pane is determined automatically based on the width of the window. Therefore, the width specification for the first status pane (i.e. *status_pane_width(window)(1)*) is always ignored. The *status_pane_text* property sets the text in an individual pane.

3.4 Scroll bars

Both horizontal and vertical scroll bars can be displayed in a window. Scroll bars can provide a natural mechanism for panning across a scene too large to fit inside the boundaries of your window. This is common after *zooming* into a rectangular section of the canvas. To create the scrollable window, set the *scrollable_h* and/or *scrollable_v* properties to “1 before displaying the window.

You can set the width of a scroll bar thumb before or after the window has been displayed. This is accomplished via the *thumb_size_h* and *thumb_size_v* properties. These values should range from 0.0 to 1.0. This represents the percentage of the total scroll bar area you wish the thumb to occupy. If the scroll bars are used for pan and zoom, the thumb size should be equal to the ratio of viewable area to total area.

The *thumb_pos_h* and *thumb_pos_v* attributes hold the distance between the thumb and the left (or top) of the scroll bar. Possible values for *thumb_pos_h* and *thumb_pos_v* are in the range [0.0 .. 1.0- *thumb_size_h*] and [0.0 .. 1.0- *thumb_size_v*], respectfully.

3.5 Handling User Input

When a user resizes, moves, scrolls, or closes a window, it may be necessary for the program to take some sort of action. For example, if the user moves a scroll bar, you may want to "pan" the contents of the window. Applications needing to implement asynchronous notification should subclass the Window object and override the *action* method. This method is called automatically whenever the user moves or clicks in the window. Code can then be provided in this method to handle the event.

The *action* method takes a *WindowEvent* as a parameter. The *id* attribute of the *WindowEvent* indicates the type of event. The *id* will contain one of the constants defined in the *WindowEvent* class. The *WindowEvent* object holds additional event specific data that can be utilized by the action method. The following table lists the id constants, a description of the particular action, and which *WindowEvent* attributes can be used by the application.

EVENT ID	CAUSE OF EVENT	EVENT ATTRIBUTES USED	
_activate	Window has been brought to the front of all other windows.		
_close	Window has been closed. (User clicked on the "X" in the upper corner.)		
_key_down	User has pressed down on key	key_code, key_literal	key_code categorizes the key as alphanumeric or function (_literal_key, _f1_key, _f2_key,..)
_key_up	User has let up on a key	key_code, key_literal	__key_literal is the alpha value of the key. Only valid if key_code is _literal_key
_mouse_down	User has clicked down inside the window canvas with any button.	button_number	1 => left mouse button 2,3 => middle/right button
		click_count	1 => single click
		x,y	Location of click in CANVAS coordinates range [0..32767].
_mouse_up	User has clicked down inside the window canvas with any button. Also called after a double-click.	button_number	1 => left mouse button 2,3 => middle/right button
		click_count	1 => single click 2 => double click
		x,y	Location of click in CANVAS coordinates range [0..32767].
_mouse_move	User has moved the mouse inside the window canvas.	x,y	Location of mouse in CANVAS coordinates range [0..32767].
_reposition	The window has been dragged to a new location.	x,y	Location in screen coordinates. Range is [0..32767]
_resize	The window has been resized.	x,y	Size in screen coordinates. Range is [0..32767].
_scroll_x	The horizontal scroll bar has been used.	x	Location of horiz. Thumb. Range is [0..1].
_scroll_y	The vertical scroll bar has been used.	y	Location of vert. Thumb. Range is [0..1].

3.6 Reading Mouse Input Synchronously

Input from a *Window* object can also be handled synchronously. The method *accept_input* blocks execution until the user clicks in the canvas of the window. An anchored rubber band cursor which tracks the pointer can be shown. *accept_input* yields both the (x,y) coordinates of the mouse click, and a pointer to the *View* that was clicked in. These coordinates are bounded by the coordinate system assigned to the yielded *View*.

accept_input parameters include the (x,y) location (in NDC coordinates) of the anchor point of the cursor as well as an integer representing the cursor style. Available cursors are shown in the table below.

CONSTANT	DESCRIPTION
_cursor_none	Do not show a cursor.
_cursor_line	Show a rubber band line anchored at the given anchor point. The line is updated automatically as the mouse is moved.
_cursor_box	Show a rubber band box anchored at the given anchor point. The corner of the box is updated automatically as the mouse is moved.
_cursor_icon	Use this cursor style if a *Graphic* object should be moved with the mouse. The object should be provided as a parameter.

3.7 Using a Window

If the full features of a Window need to be employed in the application, the following steps should be taken into account:

1. In your preamble, subclass the Window object and override its action method.
2. In the *action* method, write code to check the *id* attribute of the given *WindowEvent* and respond accordingly.
3. In the program initialization, create your *Window* object and assign properties such as position, title etc.
4. Add instances of *View* object(s) to the view_set. Add *Graphic* object(s) to the graphic_set owned by the *View*.
5. Call the *display* method to show the window. Objects filed into the *view_set* will also be shown.

The following example shows a window with scroll bars and a status bar. In this example the *action* method is overridden, allowing the events and associated data to be reported through a dialog box.

```
''Example3.sim
''This example displays a window containing a status bar, scroll bars
''and a background image.  Mouse and scroll bar interaction is reported
''immediately via a small dialog box.

preamble including the gui.m subsystem

       ''subclass the Window and override the action method

       begin class MyWindow
          every MyWindow is a Window,
             overrides the action
       end

       define my_dialog as a DialogBox reference variable

end

''Action will be called upon user interaction with the window controls
''and with the mouse.
''Use a dialog box to list the WindowEvent attributes as user interacts
''with the window.
method MyWindow'action(event)

   let selected(find(my_dialog)("button_down")) = button_down(event)
   let value(find(my_dialog)("button_number")) = button_number(event)
   let value(find(my_dialog)("click_count")) = click_count(event)
   let value(find(my_dialog)("x")) = x(event)
   let value(find(my_dialog)("y")) = y(event)

   select case id(event)
      case WindowEvent'_activate
         let string(find(my_dialog)("id")) = "_activate"
      case WindowEvent'_close
         let string(find(my_dialog)("id")) = "_close"
      case WindowEvent’_key_down
         let string(find(my_dialog)("id")) = "_key_down"
      case WindowEvent’_key_up
         let string(find(my_dialog)("id")) = "_key_up"
      case WindowEvent'_mouse_down
         let string(find(my_dialog)("id")) = "_mouse_down"
      case WindowEvent'_mouse_up
         let string(find(my_dialog)("id")) = "_mouse_up"
      case WindowEvent'_mouse_move
         let string(find(my_dialog)("id")) = "_mouse_move"
      case WindowEvent'_reposition
         let string(find(my_dialog)("id")) = "_reposition"
      case WindowEvent'_resize
         let string(find(my_dialog)("id")) = "_resize"
      case WindowEvent'_scroll_x
         let string(find(my_dialog)("id")) = "_scroll_x"
      case WindowEvent'_scroll_y
         let string(find(my_dialog)("id")) = "_scroll_y"
   endselect

   call display(my_dialog)

   return with 1
end
```

```
main
   define my_window as a MyWindow reference variable
   define my_view as a View reference variable
   define my_icon as an Icon reference variable

   create my_window

   ''for non-square window, crop the top portion
   let crop_mode(my_window) = Window'_crop_top

   ''Place the window on the right side of screen
   let position_xlo(my_window) = 8000
   let position_ylo(my_window) = 2000
   let position_xhi(my_window) = 32768
   let position_yhi(my_window) = 32768

   ''Make the window scrollable in both the horizontal and
   ''vertical directions
   let scrollable_h(my_window) = 1
   let scrollable_v(my_window) = 1

   ''Make the thumbs 10% the size of the scroll bar.
   ''Position the top/left of the thumb to the 50% position.
   let thumb_size_h(my_window) = 0.10
   let thumb_size_v(my_window) = 0.10
   let thumb_pos_h(my_window) = 0.5
   let thumb_pos_v(my_window) = 0.5

   ''Specify 3 status bar panes.  Set the pane sizes to hold
   ''text strings 10, and 15 characters respectfully.
   ''(The width of pane 1 is determined automatically)
   let status_pane_count(my_window) = 3
   let status_pane_width(my_window)(2) = 10
   let status_pane_width(my_window)(3) = 15
   let status_pane_text(my_window)(1) = "Pane 1 text"
   let status_pane_text(my_window)(2) = "Pane 2 text"
   let status_pane_text(my_window)(3) = "Pane 3 text"

   ''set the text displayed on the title bar
   let title(my_window) = "Example 3: A full featured window"

   ''create a view to appear in the window
   create my_view
   file this my_view in view_set(my_window)

   ''create an icon to appear in the view
   create my_icon
   let appearance(my_icon) = Templates'find("background")
   file this my_icon in graphic_set(my_view)

   ''display window and contents of canvas
   call display(my_window)

   ''dialogs are explained later
   create my_dialog
   let appearance(my_dialog) = Templates'find("example3 dialog")
   file this my_dialog in form_set(my_window)
   call display(my_dialog)

   while visible(my_dialog) <> 0
      call handle.events.r(1)
end
```

4. View Object

The purpose of a *View* object is to define both a coordinate system and a bounding rectangle for the *Graphic* objects it contains. Each instance of a View object occupies a rectangular sub-region of the canvas. This feature allows multiple views to share the same canvas. A view should be "added" to a window canvas by filing it into the *view_set* owned by the window. Since the *View* object is derived from *GuiItem*, the *display* and *erase* methods can be used to show or hide all objects in the *view_set*.

4.1 View boundaries

The region occupied by the view is defined by calling the *set_boundaries* method. Arguments to *set_boundaries* specify a rectangle in the canvas and are given in window canvas coordinates (range: 0 to 32768).

```
call set_boundaries(view)(xlo, xhi, ylo, yhi)
```

The default boundaries for a view will encompass the entire window canvas (i.e. xlo=0, xhi=32768, ylo=0, yhi=32768). If the view should take up the entire window canvas, then it is not necessary to call *set_boundaries*.

4.2 Coordinate System for Graphic Objects

Each view also defines a coordinate system, of which applies to the *Graphic* objects filed into its *graphics_set*. All Graphic objects contained by the view will be positioned and scaled in size relative to this world coordinate system. The *set_world* method is called to provide the range of coordinates to the View object.

```
call set_world(view)(xmin, xmax, ymin, ymax)
```

There are no restrictions on the magnitude of these coordinates. However, if using an *Icon* object loaded from the SimStudio icon editor, the world coordinate system defined by the view should match the "SETWORLD.R parameters" found in the "Icon Properties" dialog box.

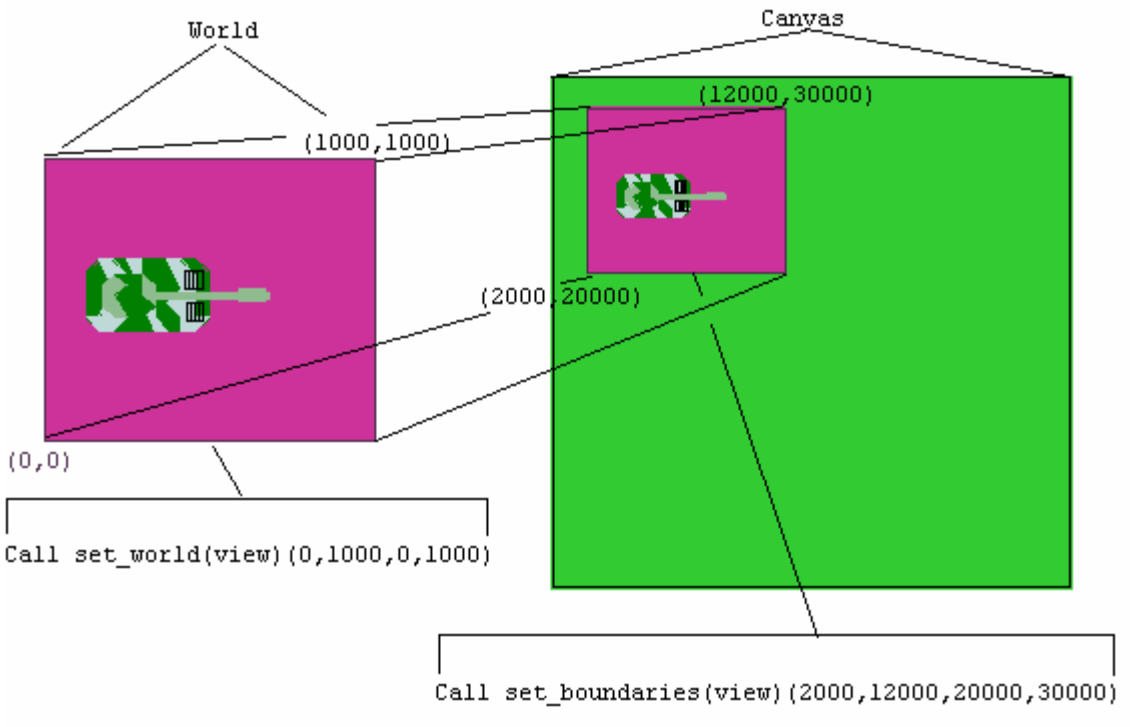


Figure 4.1: Using the *set_world* and *set_boundaries* methods.

4.3 Overlapping Views

If two overlapping *View* objects occupy the same canvas, the stacking order is always defined by the ordering of the views in the *view_set* owned by the window. View objects filed last in the set will appear on top. All *Graphic* objects filed into a view obey the stacking order defined by the view, in other words objects contained by different views will not be shown interleaved.

4.4 Pan and Zoom

The *set_world* method can be used to implement panning and zooming for a background. A pan can be implemented by shifting the boundaries of the coordinate system to the left to pan left, and to the right to pan right. Specifying a smaller range of coordinate boundaries will appear to "zoom in". In the following figure, a scene showing an original coorinate system of xmin=0, xmax=1000, ymin=0, ymax=1000 is zoomed by specifying a new coordinate system of xmin=300, xmax=700, ymin=500, ymax=900.

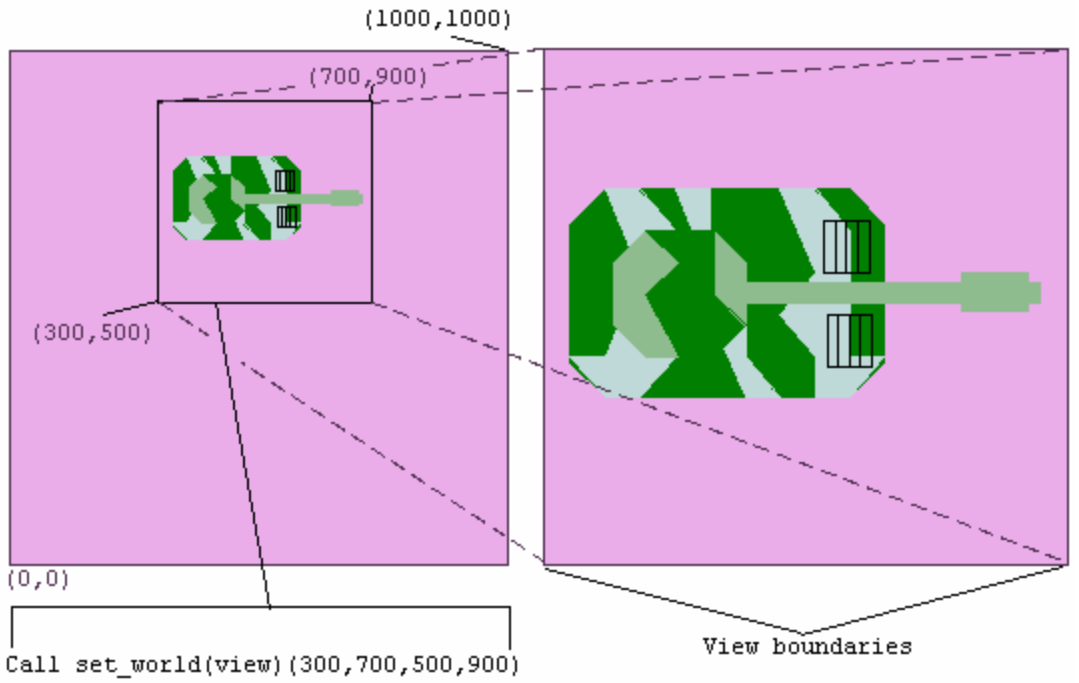


Figure 4.2: Using the *set_world* method to implement pan and zoom.

The following example shows a window with horizontal and vertical scrollbars. A *View* object containing a background is placed inside the canvas. When the user clicks in the canvas with the left mouse button, the view is "zoomed in" by a factor of 2. The click location is used as a center point for the zoom operation. Clicking with the right mouse button will zoom out all the way. Moving the scroll bars will "pan" the zoomed scene in the direction of the thumb movement. Both pan and zoom operations are implemented with the *View'set_world* method.

"Example4.sim

```
''This example displays a window containing scroll bars
''and a background image.  Moving the scroll bar thumbs will pan,
''clicking with the left mouse button will zoom in, clicking with the
''right mouse button will zoom out all the way.

preamble including the gui.m subsystem
''subclass the Window and override the action method

begin class MyWindow
   every MyWindow is a Window, and
      overrides the action
end

begin class MyView
   every MyView is a View and has
      a zoom_factor,
      a zoom method,
      a pan method
   define zoom as a method given
      1 double argument,     ''zoom factor
      2 double arguments     ''center of zoom area
   define pan as a method given
      2 double arguments     ''x,y position of world
   define zoom_factor as a double variable
end

       ''globals and constants
       define scene_xlo=0, scene_ylo=0, scene_xhi=1000, scene_yhi=1000 as
       constants
       define theWindow as a MyWindow reference variable
       define theView as a MyView reference variable
end  ''preamble
```

```
''"Action" will be called upon user interaction with scroll bars and
''the mouse.

method MyWindow'action(event)
   define view_x, view_y as double variables

   ''if user clicks down on the left mouse button, zoom into that spot
   ''each click will zoom in by a factor of 2
   if id(event) = WindowEvent'_mouse_click and button_down(event) <> 0 and
   button_number(event) = 0
      call get_view_xy(x(event), y(event)) yielding view_x, view_y, view
      call zoom(theView)(zoom_factor(theView) * 2, view_x, view_y)
   always

   ''if user clicks down on the right mouse button, zoom out
   if id(event) = WindowEvent'_mouse_down and button_down(event) <> 0 and
   button_number(event) <> 0
      call zoom(theView)(
        1.0, (scene_xhi-scene_xlo) / 2.0, (scene_yhi-scene_ylo) / 2.0)
   always

   ''handle scroll bar movement by user.  This will cause the  scene to pan
   if id(event) = WindowEvent'_scroll_x or id(event) = WindowEvent'_scroll_y
      call pan(theView)(
         x(event) * (scene_xhi-scene_xlo) + scene_xlo,
         y(event) * (scene_yhi-scene_ylo) + scene_ylo)
   always
   return with 0
end

''This method uses the "set_world" method of the View object to
''zoom in and out.

method MyView'zoom(factor, cx, cy)
   define sizex, sizey as double variables

   let zoom_factor = factor
   let sizex = (scene_xhi - scene_xlo) / factor;
   let sizey = (scene_yhi - scene_ylo) / factor;

   ''setting a new world will zoom in or out
   call set_world(cx - sizex / 2.0, cx + sizex / 2.0,
                  cy - sizey / 2.0, cy + sizey / 2.0)
   ''update the scroll bar thumb size and position
   let thumb_size_h(theWindow) = 1.0 / factor
   let thumb_size_v(theWindow) = 1.0 / factor
   let thumb_pos_h(theWindow) =
       ((world_xlo - scene_xlo) / (scene_xhi - scene_xlo))
   let thumb_pos_v(theWindow) =
       (scene_yhi - world_yhi) / (scene_yhi - scene_ylo)
   call display(theWindow)
end

''This method uses the "set_world" method of the View object to
''pan left, right, up and down.

method MyView'pan(x, y)
   ''to show the effect of panning, change the world boundaries
   call set_world(
      scene_xlo + x, scene_xlo + x + (world_xhi-world_xlo),
      scene_yhi - y - (world_yhi-world_ylo), scene_yhi - y)
end
```

```
main
   define theIcon as an Icon reference variable

   create theWindow

   ''for non-square window, crop the top portion
   let crop_mode(theWindow) = Window'_crop_top

   ''Make the window scrollable in both the horizontal and
   ''vertical directions
   let scrollable_h(theWindow) = 1
   let scrollable_v(theWindow) = 1

   ''set the text displayed on the title bar
   let title(theWindow) = "Example 4: Implementing Pan and Zoom"

   ''create a view to appear in the window
   create theView
   let zoom_factor(theView) = 1
   call set_world(theView)(scene_xlo, scene_xhi, scene_ylo, scene_yhi)
   file theView in view_set(theWindow)

   ''create an icon to appear in the view
   create theIcon
   let appearance(theIcon) = Templates'find("floor.icn")
   file theIcon in graphic_set(theView)

   ''display window and contents of canvas
   call display(theWindow)

   while visible(theWindow) <> 0
      call handle.events.r(1)
end
```

5. Graphics in a Window

The GUI.M module allows the application to not only animate icons created in SimStudio, but also custom defined graphics. The *Graphic* object provides the base class for all objects that can both appear in the canvas, and can be composed of a group of shape primitives. This includes the *Icon* and *Graph* objects. In order to draw into a window, the *Window* object must contain at least one *View* object (filed into its *view_set*). A *Graphic* object can then be made to appear inside a particular window by filing it into the *graphic_set* owned by one of the *View* objects belonging to the window. The *Icon* object inherits the capabilities of the *Graphic*, but can be constructed off-line in the SimStudio Icon editor. Icons can also be animated, in other words they can have a velocity and/or movement which is linked to the advancing simulation time.

5.1 Drawing Shape Primitives

Using the methods and attributes of the *Graphic* object, the application can draw groups of shape primitives and position them in the *View*. The shapes can also be rotated and scaled. Each shape has a unique color. "Style" objects can be created and are used in conjunction with draw methods to specify text font, line width, hatch styles, etc. The following table shows which shapes can be drawn:

Method name	Arguments	Description
draw_arc	X, y, radius, start_angle, stop_angle, color, style	Draws a semi-circular arc. (x,y) marks the center, and the arc is drawn counter-clockwise from start_angle to stop_angle. Angles are given in radians and measured from the positive x axis. A *LineStyle* object reference should be passed for the 'style' argument.
draw_circle	x, y, radius, color, style	Draws a circle. (x,y) marks the center, and a radius should also be given. A *FillStyle* object reference should be passed for the 'style' argument.
draw_polygon	points, color, style	Adds an n-sided polygon to the icon. The first dimension of the *points* argument selects the X or Y coordinate. The second dimension contains the point number.
draw_polyline	points, color, style	Adds an n-point connected line segment to the graphic. First and last points are not connected. (Format of *points* array is identical to *draw_polygon*)
draw_polymark	points, color, style	Adds point markers to the *Graphic* object. (Format of *points* array is identical to *draw_polygon*)
draw_pie	x, y, radius, start_angle, stop_angle, color, style	Draws a filled pie slice. (x,y) marks the center, and the pie is drawn counter-clockwise from start_angle to stop_angle. Angles are given in radians and measured from the positive x axis. A *FillStyle* object reference should be passed for the 'style' argument.
draw_rectangle	x,y, width, height, color, style	Draws a rectangle given its lower left corner point (specified by x,y) and both its width and height.
draw_text	x,y, color, style, string	Draws a text string using the attributes given in the *'style'* argument. (x,y) specifies the starting point for the drawing the string.

All calls to drawing methods made by a *Graphic* object instance should be bracketed by a call to the *begin_drawing* method and the *end_drawing* method. The *begin_drawing* method will eliminate all shapes previously drawn. The *end_drawing* method marks the end of a sequence of calls to *draw_* methods.

5.2 Points, style, and color

A 2-dim array of doubles is used to represent the points defining the shape of the draw primitive. In this array, the first index defines which of the coordinate (x or y) the value refers to. The second index is the point number. For example, to create an array of points for a triangle formed by the verticies (-50,-50), (50,-50), (0,50) use the following code:

```
Reserve points(*,*) as 2 by 3
let points(1,1) = -50    let points(2,1) = -50   ''south west corner
let points(1,2) = 50     let points(2,2) = -50   ''south east corner
let points(1,3) = 0      let points(2,3) = 50    ''north corner
```

Style objects can be created, initialized and passed as an argument to the drawing methods. If a "0" is passed instead of the style object, default values are used. As a convenience, the built in global value for each style object is created automatically. (For example, the global variable name *FillStyle* can be passed directly to *draw_polygon* without being created by the application.)

Style Object	Drawing methods	Attribute	Possible values
FillStyle	draw_circle draw_polygon draw_pie	pattern	_hollow, _solid, _narrow_diagonal, _medium_diagonal, _wide_diagonal, _narrow_crosshatch, _medium_crosshatch, _wide_crosshatch (default=_hollow)
LineStyle	draw_arc draw_polyline	pattern	_solid, _long_dash, _dotted, _dash_dotted, _medium_dash, _dash_dot_dotted, _short_dash, _alternate (default = _solid)
		width	integer in Canvas coordinates (default=0)
MarkStyle	draw_polymark	type	_dot, _cross, _asterisk, _square, _x, _diamond (default=dot)
		size	Integer size in Canvas units. (default=500)
LineFont	draw_text	font	_basic, _simple, _roman, _bold_roman, _italic, _script, _greek, _gothic, (default= _basic)
		angle	Integer rotation of text in 0 to 360 degrees. (default=0)
		size	Height of text characters in Canvas coordinate units. (default=560).
SystemFont	draw_text	bold	1 to indicate a bold face. 0 indicates plain.
		direction	_right=0, _up, _left, _down
		family	Name of font face. i.e. "Arial", "Courier", etc... (default is system dependant)
		italic	1 to indicate an italic face, 0 for non-italics
		point_size	Size in points of the text. (default =12)

All drawing methods accept a color argument that can be used to paint the primitive. Colors are stored as integer values, but are generally specified as percentages of red, green, and blue components (range 0.0 to 1.0). The *Color* class provided class methods that can convert between this single integer value and the three RGB components. The

Color'rgb method returns a color value given its RGB components. This value can be passed to a drawing method. The *Color'red*, *Color'green* and *Color'blue* methods return the RGB component value of a color value.

For example, to draw a dark green solid triangle (using the points supplied above):

```
call begin_drawing(myGraphic)
let pattern(FillStyle) = FillStyle'_solid
call draw_polygon(myGraphic)(points, Color'rgb(0.0, 0.5, 0.0), FillStyle)
call end_drawing(myGraphic)
```

5.3 Location, Rotation, and Scale

Using the location, rotation, and scale attributes allows several different *Graphic* object instances to share the same "points" but still be shown in different locations with a different geometry. A *Graphic* object is positioned relative to the coordinate system assigned to the *View* object that it is attached to. The *location_x* and *location_y* properties contain the "x" and "y" offset to the center of the graphic (0,0) from the (0,0) coordinate in the *View* that the *Graphic* is filed into.

Setting the *rotation* property of a Graphic object will rotate all shapes drawn into the object counter-clockwise about the (0,0) point. The angle is specified in radians. The position of drawn text will be rotated, but the text itself will remain horizontal.

A scale factor can be applied to a *Graphic* object as well. All points in the drawn shapes are multiplied by this factor before the *Graphic* object is displayed. Setting the *scale* property to a value between 0 and 1 will therefore make the object smaller while values greater that 1 will make it big.

In the following example, a green triangle is drawn into a view with the coordinate system (xlo=0,ylo=0, xhi=100, yhi=100). The triangle is rotated and scaled continuously to make it appear to be "spinning away" from the viewer.

```
''Example5.sim
''This example shows a spinning triange created by program code only.

preamble including the gui.m subsystem
end

main
       define theWindow as a Window reference variable
       define theGraphic as a Graphic reference variable
       define theView as a View reference variable
       define points as a 2-dim double variable

       create theWindow
       let title(theWindow) = "Example 5: Location, Rotation and Scale"

       ''create a view to appear in the window
       create theView
       call set_world(theView)(0, 100, 0, 100)
       file theView in view_set(theWindow)

       ''create the points necessary to define the triangle
       ''design points so that (0,0) is the center of the triangle
       Reserve points(*,*) as 2 by 3
       let points(1,1) = -50    let points(2,1) = -50   ''south west corner
       let points(1,2) = 50     let points(2,2) = -50   ''south east corner
       let points(1,3) = 0      let points(2,3) = 50    ''north corner

       ''create the graphic to hold the triangle
       create theGraphic

       ''start the drawing, draw the polygon, then end the drawing
       call begin_drawing(theGraphic)
       let pattern(FillStyle) = FillStyle'_solid
       call draw_polygon(theGraphic)(points, Color'rgb(0.0, 0.5, 0.0),
       FillStyle)
       call end_drawing(theGraphic)

       ''put the graphic in the middle of the View
       let location_x(theGraphic) = 50.0
       let location_y(theGraphic) = 50.0

       file theGraphic in graphic_set(theView)

       ''display window and contents of canvas
       call display(theWindow)

       ''loop until the user dismisses the window
       while visible(theWindow) <> 0 and scale(theGraphic) > 0.01
       do
          ''update rotation and scale with each loop
          let rotation(theGraphic) = rotation(theGraphic) + 0.02
          let scale(theGraphic) = scale(theGraphic) * 0.999

          call display(theGraphic)       ''redisplay after changes to geometry

          call handle.events.r(0)        ''handle any mouse events
       loop
end
```

5.4 Responding to Clicks on a Graphic

Occasionally, the application will need to allow the user to click on a *Graphic* object while the simulation is running. The program can then for example display a dialog box containing information about the object, or perform other actions in response to the selection.
To allow users to click on a *Graphic* object, a new class must be derived from *Graphic* and the *action* method should be overridden, as is shown here:

```
preamble including the gui.m subsystem
   begin class MyGraphic
      every MyGraphic is a Graphic and overrides the action
   end
end

method MyGraphic’action(event)
   write as “MyGraphic was selected!”, /
end
```

Note that the “event” argument is not used here. It has been included as a formal parameter to the *action* method for future enhancements. The following is a complete example showing the seven different shapes that can be created with the *Graphic* object. *Graphic* objects in this program can be clicked on.

```
''Example6.sim
''This example shows a all the different shapes that can be
''created using the Graphic object.  Clicking on a shape with
''the mouse will display it.

preamble including the gui.m subsystem
   begin class MyGraphic
      every MyGraphic is a Graphic and has
         a name, and
         overrides the action
      define name as a text variable
   end
   define theWindow as a Window reference variable
   define theView as a View reference variable
   define message_graphic as a Graphic reference variable
end

method MyGraphic'action(event)
   let event=event

   ''create a little message that will show the name of the object
   call begin_drawing(message_graphic)
   call draw_text(message_graphic)(250, 950, Color'_white, 0,
      name + " was selected")
   call end_drawing(message_graphic)
   call display(message_graphic)
   release points
   return with 0
end
```

```
main
   define aGraphic as a MyGraphic reference variable
   define points as a 2-dim double variable

   create theWindow
   let title(theWindow) = "Example 6: Shapes that a Graphic object can draw"

   ''create a view to appear in the window
   create theView
   call set_world(theView)(0, 1000, 0, 1000)  ''world from 0 to 1000
   file theView in view_set(theWindow)

   ''create a message to appear when objects are clicked on
   create message_graphic
   file this message_graphic in graphic_set(theView)

   ''1) draw a square polygon.  First, define points, style
   Reserve points(*,*) as 2 by 4  ''define corner points
   let points(1,1) = 100    let points(2,1) = 800
   let points(1,2) = 200    let points(2,2) = 800
   let points(1,3) = 200    let points(2,3) = 900
   let points(1,4) = 100    let points(2,4) = 900

   ''now create a "MyGraphic" instance.
   create aGraphic
   file this aGraphic in graphic_set(theView)
   let name(aGraphic) = "blue polygon"
   call begin_drawing(aGraphic)
   let pattern(FillStyle) = FillStyle'_solid
   call draw_polygon(aGraphic)(points, Color'rgb(0,0,1.0), FillStyle)
   let pattern(FillStyle) = FillStyle'_hollow
   call draw_polygon(aGraphic)(points, Color'_cyan, FillStyle)
   call end_drawing(aGraphic)

   ''2) draw a polyline.  Use the same points as above
   create aGraphic
   file this aGraphic in graphic_set(theView)
   let name(aGraphic) = "red polyline"
   call begin_drawing(aGraphic)
   let pattern(LineStyle) = LineStyle'_long_dash
   call draw_polyline(aGraphic)(points, Color'rgb(1.0,0,0), LineStyle)
   call end_drawing(aGraphic)
   let location_x(aGraphic) = 350   ''shift position of this shape

   ''3) draw a polymark.  Use the same points as above
   create aGraphic
   file this aGraphic in graphic_set(theView)
   let name(aGraphic) = "green polymark"
   call begin_drawing(aGraphic)
   let type(MarkStyle) = MarkStyle'_diamond
   let size(MarkStyle) = 600
   call draw_polymark(aGraphic)(points, Color'rgb(0,1.0,0), MarkStyle)
   call end_drawing(aGraphic)
   let location_x(aGraphic) = 700   ''shift position of this shape

   ''4) draw an arc.
   create aGraphic
   file this aGraphic in graphic_set(theView)
   let name(aGraphic) = "cyan arc"
   call begin_drawing(aGraphic)
   let pattern(LineStyle) = LineStyle'_solid
   call draw_arc(aGraphic)(150, 150, 50, pi.c / 4, 3 * pi.c / 4,
```

```
         Color'_cyan, LineStyle)
   call end_drawing(aGraphic)i

   ''5) draw a pie.
   create aGraphic
   file this aGraphic in graphic_set(theView)
   let name(aGraphic) = "majenta pie"
   call begin_drawing(aGraphic)
   let pattern(FillStyle) = FillStyle'_narrow_diagonal
   call draw_pie(aGraphic)(150, 150, 50, pi.c / 4, 3 * pi.c / 4,
        Color'_majenta, FillStyle)
   call end_drawing(aGraphic)
   let location_x(aGraphic) = 350   ''shift position of this shape

   ''6) draw a circle.
   create aGraphic
   file this aGraphic in graphic_set(theView)
   let name(aGraphic) = "yellow pie"
   call begin_drawing(aGraphic)
   let pattern(FillStyle) = FillStyle'_wide_crosshatch
   call draw_circle(aGraphic)(150, 150, 50, Color'_yellow, FillStyle)
   call end_drawing(aGraphic)
   let location_x(aGraphic) = 700   ''shift position of this shape

   ''display window and contents of canvas
   call display(theWindow)

   ''loop until the user dismisses the window
   while visible(theWindow) <> 0
      call handle.events.r(1)        ''handle any mouse events
end
```

6. Graphs

This chapter describes features of the SIMSCRIPT III language which support both the display of numerical information in a variety of static and dynamic chart formats, and the representation of changing values using a variety of graphs. Several classes are provided in GUI.M that can be created by the application and used to display a specially defined variable or attribute. (These classes will be referred to as "graph" objects since they are derived from a common object named *Graph*.) *Graph* objects are constructed in SimStudio, and loaded into the program at runtime.

All Graph object contain methods that can be called to update the value shown in the graph. However, the display variables and dynamic histograms described in SIMSCRIPT II.5 are supported in SIMSCRIPT III. SIMSCRIPT III also allows for object attributes and class attributes to be declared as a DISPLAY variable or as a DYNAMIC HISTOGRAM. This means that as the attribute or histogram can be "hooked up" to a *Graph* object such that the magnitude shown in the graph automatically reflects the current value of the attribute. This lifts the necessity for the programmer to locate every assignment of the attribute (both direct and indirect) then make a method call to update the value shown in graph.

6.1 Graph objects

The *Graph* objects found in GUI.M support all graphs constructed in SimStudio. The following table summarizes these objects.

Graph object	SimStudio Appearance	Description
Clock	Analog clock Digital clock	A clock showing the current time. Can be adjusted in SimStudio for 12 or 24 hour mode.
Meter	Dial Level meter Digital display	Show the current value of a single variable.
Plot	2D chart	2-dimensional chart and can either show a histogram or a time trace plot (where TIME.V is plotted on x axis).
Piechart	Pie chart	Each slice represents a data value. It is sized based on its percentage of the sum of all slices.

After creating an instance of a *Clock*, *Meter*, *Plot* or *Piechart* object, the program should assign the *appearance* property to a *Template* object obtained from the *Templates* class. The assignment will link this instance to the graph constructed by

SimStudio and saved in the **graphics.sg2** file. The instance should then be filed into the *graphic_set* owned by a *View* object. Call the *display* method to make the graph visible, or to update it after a change has been made. For example, suppose a “Level meter” is constructed in SimStudio and saved under the name “value 1”. The code to show the meter in a program might look something like this:

```
define myMeter as a Meter reference variable
...
create myMeter
let appearance(myMeter) = Templates'find("value 1")
file myMeter in graphic_set(myView)
call display(myMeter)
```

6.2 Meter Object: Graph a Single Variable

Setting the data value or values shown in a graph varies depending on which graph object is being used. The value shown in a *Graph* object can be updated directly by calling *Meter'set_value*, *Plot'plot_data*, *Piechart'set_slice*, or *Clock'set_time*. Graphs that have been properly connected to a "display variable" or dynamic histogram will be updated automatically when the variable changes.

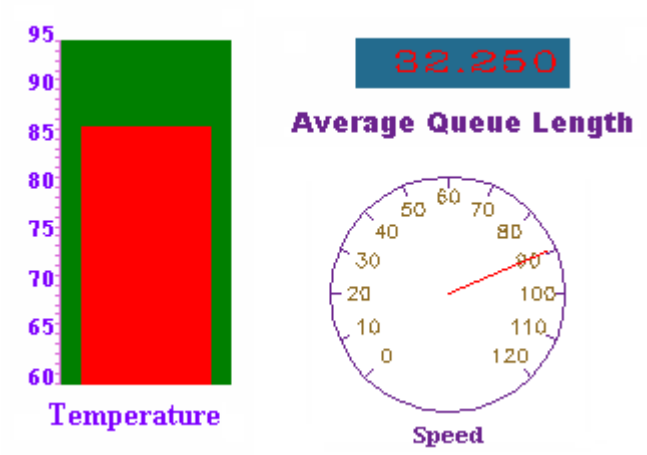


Figure 6.1: Meters

The *Meter* object is used to show the value of a single variable, object attribute or class attribute. This variable or attribute quantity must be defined as a "display variable". Display variables must be defined in the PREAMBLE using the following syntax:

```
DISPLAY VARIABLES INCLUDE variable1, variable2....
```

This declaration is made *in addition* to normal variable declarations. In other words the variables used in this statement must be known to SIMSCRIPT at the time the declaration is made. If the variables referenced above are object or class attributes, the statement must appear within the same BEGIN CLASS..END block that the attribute is declared in. Implicitly defined variables and attributes can be graphed. For example, the number of entities in a set call "queue" could be graphed even though "N.QUEUE" is not explicitly declared in the program.

The connection between the attribute and the *Meter* object is bridged using the SIMSCRIPT "SHOW WITH" statement. Instead of providing a text string after "WITH" as is done in SIMSCRIPT II.5, the *Meter* object reference can be specified. This is the generalized mechanism by which Graph objects are hooked up to display variables and dynamic histograms, i.e.

```
SHOW variable WITH graph_object_reference
```

In the following example suppose a “Level meter” is constructed in SimStudio and saved under the name “queue length”. We want the level meter to show the number of items in the set named “queue” owned by the class *Owner*. The bar in the level meter should rise as objects are filed into the set.

```
''Example7.sim
''Uses a level meter to show the number of objects in a set

preamble including the gui.m subsystem
   begin class Member
     every Member may belong to a queue
   end
   begin class Owner
     the class owns a Member'queue
     display variables include n.queue
   end
end

main
   define myMeter as a Meter reference variable
   define myWindow as a Window reference variable
   define myView as a View reference variable
   define i as an integer variable

   create myWindow, myView, myMeter
   file this myView in view_set(myWindow) ''set up graphics hierarchy
   file myMeter in graphic_set(myView)
   let appearance(myMeter) = Templates'find("queue length")
   show Owner'n.queue with myMeter ''connect n.queue to myMeter
   call display(myWindow)  ''draw everything
   for I = 1 to 10000
   do
      create a Member
      file this Member in Owner'queue  ''this will update myMeter's bar
      call handle.events.r(0)
   loop
end
```

6.3 Clock object: Show the Time

GUI.M provides a Clock object that can be used to show simulation time. Both analog (circular with hands) and digital clocks. The clocks are dynamic in nature and update automatically whenever the display variable (containing time) changes in value.

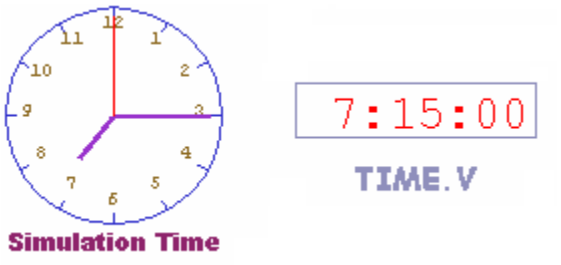


Figure 6.2: clocks

A *Clock* object is initialized in the same manner as any other Graph (such as the *Meter* explained previously). The *set_time* method may be called to update the time value given the hours, minutes and seconds. A *Clock* object can also be used like a Meter, where a single double or real variable is declared as a DISPLAY VARIABLE and graphed. This value indicates the number of "days", and is converted automatically to the hours, minutes and seconds shown on the clock. For example:

```
define clocktime as a double variable
display variables include clocktime
```

To have *clocktime* updated as the simulation time is advanced, a time synchronization routine can be written and assigned to the *TIMESYNC.V* system variable. This routine will then be called whenever SIMSCRIPT is about to update the value of *time.v* and will allow you to update the clock by assigning your display variable to the given TIME. The clock will be updating regardless of the number of concurrent processes. The following example shows how an automatic clock can be used in the simulation.

```
''Example8.sim
''Shows a clock that is updated as the simulation goes forth

preamble including the gui.m subsystem
   define clocktime as a double variable
   display variables include clocktime
   processes include dummy
end
routine clock_update given time yielding newtime
   let newtime = time
   let clocktime = time   ''update the time shown by the Clock object
end
process dummy
for i = 1 to 4000
   wait 1.25 / (24. * 60.) units  ''wait 1.25 simulated minute
end
main
   create a Window, View, Clock
   file this View in view_set(Window)
   file this Clock in graphic_set(View)
   let appearance(Clock) = Templates'find("analog clock")
   show clocktime with Clock
   call display(Window)
   let timescale.v = 100 * 24 * 60 ''1 real sec. per sim. minute
   let timesync.v = 'clock_update'
   activate a dummy now
   start simulation
end
```

6.4 Plot object: Showing Histograms and Trace Plots

The Plot object can be used for Histograms (dynamic and static), time trace plots, and X-Y plots. A Plot object can contain one or more *datasets*, each representing some statistic compiled on a global variable, object attribute or class attribute. Each dataset can contain a fixed number of "cells" (bar-graph, histogram, surface chart representation in SimStudio) or can collect a new data point each time the monitored value changes (continuous representation).

A Plot object is created at runtime, but must be loaded from the graphics.sg2 file created by SimStudio. Within SimStudio, a “2D-chart” must be constructed and saved to enable a Plot object to be used.

6.4.1 Histograms

The purpose of a histogram is to show the user how often a variable or quantity takes on a particular value, or range of values. For example, a bar located at X=15 with a height of Y=30 would mean that the graphed quantity Q is equal to 15 on 30 separate occasions. (If the histogram for Q is defined in an “accumulate” statement instead of a “tally”, then “Y=30” would instead refer to the number of units of simulation time when “Q=15”.) Histogram names should not be included in a DISPLAY VARIABLES INCLUDE… statement, but are instead declared through a TALLY or ACCUMULATE statement.

```
TALLY hist_name (low TO high BY interval) AS THE DYNAMIC
      HISTOGRAM OF var_name
```

or

```
ACCUMULATE hist_name (low TO high BY interval) AS THE DYNAMIC
      HISTOGRAM OF var_name
```

(where **var.name** is defined as an attribute or global variable).

In Figure 6.3 a histogram (constructed as a "2-D Chart" in SimStudio) is shown which was obtained from the example called "bank" which simulates bank customers waiting in line for a fixed number of "teller" resources. Each bar in the histogram shows the number of "customers" that waited between (n) and (n+1) minutes for a teller, where the number of minutes (n) is shown on the x-axis.

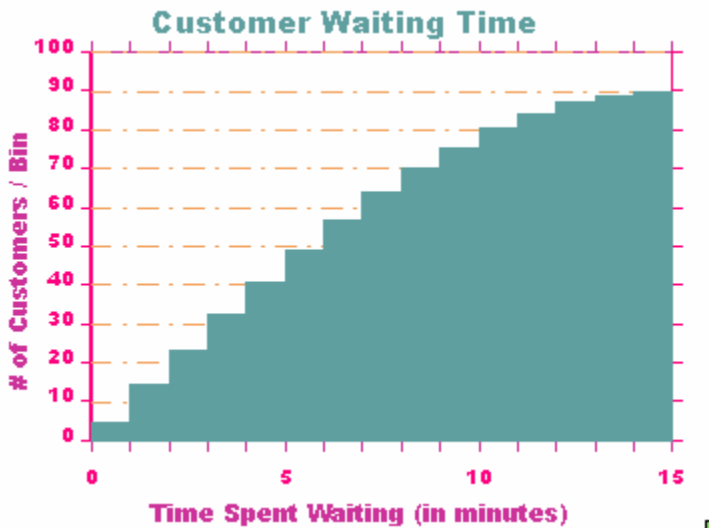


Figure 6.3 Bank model histogram.

The "SHOW HISTOGRAM" statement is used to link the histogram defined in an ACCUMULATE or TALLY statement with the *Plot* object. If the *Plot* object was saved by SimStudio while containing more than one dataset, the multiple histograms can be shown in the same Plot by including their names in the same "SHOW HISTOGRAM" statement. A reference to the Plot object should be supplied after the word "WITH".

```
SHOW HISTOGRAM hist.name1,hist.name2,... WITH plot_object_reference
```

The above statements must be invoked before any values are assigned to the tallied variable (and before any other reference is made to the histogram name). Assignments to the tallied variable will automatically update the bars in the Plot object.

The boundaries (*low* and *high*) specified in the "TALLY HISTOGRAM" statement should match the Minimum and Maxiumum values defined for the X axis in SimStudio. The "cell width" for each dataset added to the Plot in SimStudio should match the interval specified in the TALLY statement. If variable names are used for the histogram limits (*low* to *high* by *interval*) these will be automatically initialized from the X-axis graduations specified on the chart. If the value being tallied is an object attribute, these *low*, *high* and *interval* variables must be declared as class attributes of the same class.

Should the displayed bounds on the Y-axis be exceeded during the simulation, the histogram will rescale automatically. The X-axis will not be rescaled. Data points whose X value is greater than the maximum of the X-axis are plotted to the last (rightmost) cell. When the X value is less than the minimum of the X-axis are plotted to the first (leftmost) cell.

Dynamic histograms may be destroyed by specifying their names in an ERASE HISTOGRAM statement:

```
ERASE HISTOGRAM name1, ...
```

SIMSCRIPT will allow you to show more than one histogram in the same *Plot* object. Assuming you have added multiple datasets to your plot in the 2-d Chart editor, each of these data sets is connected to one of the histogram names listed in the SHOW statement.

The following program will show two histograms in the same chart. The first histogram will show a uniform random distribution while the second shows a normal distribution. A Plot object is employed to show the histograms. A Plot is shown at the top of the window containing a single histogram, while a second plot contains 2 histograms. The Tallied data for variable “randvar1” is linked to the first Plot, while data for both “randvar2” and “randvar3” are shown in dataset #1 and #2 (respectfully) in the second Plot. Each time either of these variables is assigned, the corresponding plot is updated automatically. Notice that each SHOW statement precedes the assignments to randvar1, randvar2 and randvar3. Histogram limits for both “histo2” and “histo3” are declared in terms of variables. These variables obtain their values from either the data set cell width, or (if that value is 0) the X-axis tic interval (major) of the 2-d chart created in SimStudio.

```
''Example9.sim
''Display one simple dynamic histogram, and another dynamic
''histogram containing 2 data sets

Preamble including the gui.m subsystem
   define randvar1, randvar2, randvar3, lo, hi, delta as double variables
   tally histo1(0 to 10 by 1) as the dynamic histogram of randvar1
   tally histo2(lo to hi by delta) as the dynamic histogram of randvar2
   tally histo3(lo to hi by delta) as the dynamic histogram of randvar3
end

main
   define count as integer variables
   define plot1, plot2 as Plot reference variables
   create Window, View, plot1, plot2
   file this View in view_set(Window)
   file this plot1 in graphic_set(View)
   file this plot2 in graphic_set(View)
   let appearance(plot1) = Templates'find("histogram1")
   let appearance(plot2) = Templates'find("histogram2")
   show histo1 with plot1 ''link HISTO1 and the Plot1 object
   show histo2,histo3 with plot2 ''link histo2 and 3 with Plot2 object
   call display(Window)   ''show everything
   for count = 1 to 50
      let randvar1 = exponential.f(5.0,1)
   for count = 1 to 500
   do
      let randvar2 = uniform.f(lo, hi, 1)
      let randvar3 = normal.f((hi + lo) / 2, (hi - lo) / 10, 1)
   loop
   while visible(Window) <> 0
      call handle.events.r(1)
end
```

Accumulated statistics are weighted by the duration of simulated time for which the value remains unchanged. The following example uses a process method to generate the sample data, waiting for simulation time to elapse between each sample. In this example, the ACCUMULATE statement is used in the declaration instead of the TALLY statement.

```
''example10.sim
''Shows how to ACCUMULATE a dynamic

preamble including the gui.m subsystem

begin class Holder
   every Holder has
      a randvar,
      a sample process method
   the class has
      a lo, a hi, and a delta
   accumulate hist(lo to hi by delta) as the dynamic histogram of randvar
   define randvar, lo, hi, delta as double variables
end
end

process method Holder'sample
   until time.v gt 500
   do
      wait exponential.f(5.0, 1) units
      let randvar = uniform.f(lo, hi, 2)
   loop
end

main
   create a Window, View, Plot, Holder
   file View in view_set(Window)
   file Plot in graphic_set(View)
   let appearance(Plot) = Templates'find("histogram3")
   show histogram hist(Holder) with Plot
   call display(window)
   activate a sample(Holder) now
   let timescale.v = 10
   start simulation
end
```

6.4.2 Time Trace Plots

SimStudio will allow you to create a *Plot* object that shows the value of a single variable plotted on the Y-axis while simulation time is plotted on the X-axis. In this case, instead of using a histogram a *display variable* is used in conjunction with the Plot object. Essentially the time trace plot allows the user to see how a single variable has changed over the duration of the simulation.

Include a trace plot by using SimStudio to create a “2-D Chart”. The following changes should be made in the editor: From the "Chart Properties" dialog box, check the "trace plot" check box. Also, ensure that every dataset in the graph has the "Continuous Surface" representation.

There are two options for when simulation time becomes greater than the maximum value on the chart. The first option is to "scroll" previous data to the left thus making room for more data. When TIME.V exceeds the X-axis maximum, a constant is added automatically to both the X-axis minimum and maximum. Therefore, time value data at the beginning (right side) of the plot is discarded. If this "scrolling window" is not appropriate, check the "Compress Data" box in the "X-Axis Properties" dialog box in SimStudio. Under this option, SIMSCRIPT will not increase the X-axis minimum when TIME.V becomes too large, thereby keeping all previous data points.

In the following example, an object attribute (defined as a display variable) is linked to a Plot object and incremented after waiting a random amount of time. The attributes history can be seen in the plot.

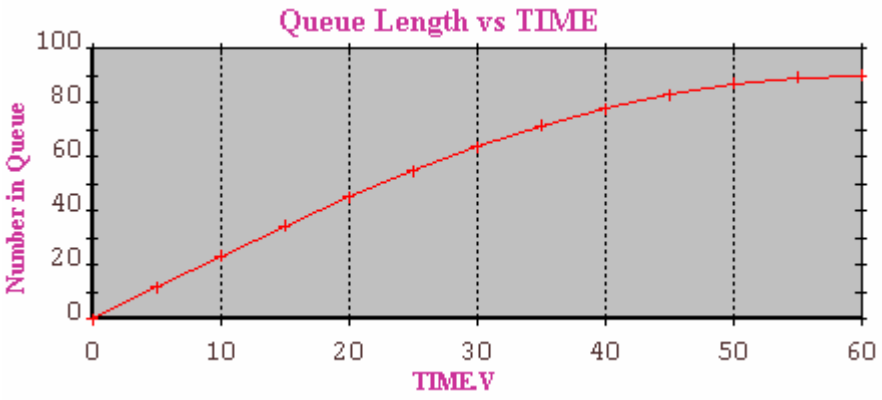


Figure 6.4 Time trace plot

```
''Example11.sim
''Using a Plot object for a time trace of a single variable

preamble including the gui.m subsystem

begin class Holder
   every Holder has
      a var,
      a sample process method
   display variables include var
   define var as a double variable
end
end

process method Holder'sample
until time.v gt 300
do
   wait exponential.f(5.0, 1) units
   add 1 to var   ''this will automatically update the Plot
loop
end

main
   create a Window, View, Plot, Holder
   let color(Window) = Color'_white
   file View in view_set(Window)
   file Plot in graphic_set(View)
   let appearance(Plot) = Templates'find("trace plot")
   call display(window)
   show var(Holder) with Plot
   activate a sample(Holder) now
   let timescale.v = 10 '' 0.1 sec per unit

   start simulation

end
```

6.4.3 X-Y Plots

The Plot object can be used to generate a simple line, surface, or bar graph without using display or histogram variables. The *Plot'plot_data* method can be called explicitly to either add a point to a "continuous surface" graph or change an existing bar in a bar, discrete surface or histogram type graph. (See the "Data set representation" section on the "Data Set Properties" dialog in the 2-d Chart editor). The *Plot'plot_data* method takes as parameters the data set number and the X and Y coordinates of the data point. (Data sets are numbered starting from one.) The *Plot'clear_data* method can be called to eliminate all data in the Plot.

In this example the function y = 100 / x+1 is plotted. There are no display variable or histogram declared, and the SHOW statement is not needed.

```
''example12.sim
''Plotting data without a "display" or "histogram" variable
```

Preamble including the gui.m subsystem

```
end

main
   create Plot, View, Window
   file View in view_set(Window)
   file Plot in graphic_set(View)
   let appearance(Plot) = Templates'find("x-y plot")
   for x = 1.0 to 100.0
      call plot_data(Plot)(1, x, 100.0 / x)   ''add data to the plot
   while visible(Window) <> 0
   call handle.events.r(1)
   call clear_data(Plot)
end
```

Bar charts and discrete interval surface charts can also be used to show the elements of an array declared as a DISPLAY VARIABLE. The value of each individual element of the array is plotted to the Y value of a bar in the chart. The index of an element is mapped not to the X axis, but to the cell number. Cells in this case are numbered from the left starting at "1". The data set representation should be either "Bar graph", "Discrete surface", or "Histogram". This example shows the elements of an object array attribute being graphed in real time using a bar graph.

```
''Example13.sim
''Using a Plot object to display the elements of an array
Preamble including the gui.m subsystem
   begin class Engine
      every Engine has a piston_y,
      and a piston process method
      define piston as a process method given 1 integer argument
      define piston_y as a 1-dim double variable
      display variables include piston_y
   end
   define rpm=20 as a constant  ''rotations per minute
end
process method Engine'piston(number)
   define s as a double variable
   let s = time.v
   while time.v < 100   ''run for 100 minutes
   do
      let piston_y(number) = 2. + 2. * cos.f(_rpm * (time.v-s) * 2. * pi.c)
      work 0.001 units
   loop
end
main
   create Plot, View, Window, Engine
   reserve piston_y(Engine) as 8
   file View in view_set(Window)
   file Plot in graphic_set(View)
   let appearance(Plot) = Templates'find("engine")
   show piston_y(Engine) with Plot
   call display(Window)
   activate a piston(Engine)(1) now
   activate a piston(Engine)(8) in 1 / (4. * _rpm) units
   activate a piston(Engine)(4) in 2 / (4. * _rpm) units
   activate a piston(Engine)(3) in 3 / (4. * _rpm) units
   activate a piston(Engine)(6) in 4 / (4. * _rpm) units
   activate a piston(Engine)(5) in 5 / (4. * _rpm) units
   activate a piston(Engine)(7) in 6 / (4. * _rpm) units
   activate a piston(Engine)(2) in 7 / (4. * _rpm) units
   start simulation
end
```

6.4.4 Setting up the X and Y axes

Sometimes the range of values to be plotted is not known at compile time. For this reason, the Plot object provides methods that allow the X and Y axis numbering, tic mark intervals and boundaries to be set at runtime. The following table shows Plot object properties relating to the axes that can be used on the left side of an assignment. All methods are of mode "double".

X Axis property	Y Axis property	Description
min_x	min_y	Minimum value shown on the axis
max_x	max_y	Maximum value shown on the axis
interval_x	interval_y	Major tic mark interval. For data sets with a zero cell width, interval_x is used as the width.
num_interval_x	num_interval_y	Numbering interval measured in the coordinates defined by the axis.
grid_interval_x	grid_interval_y	Grid line interval
minor_interval_x	minor_interval_y	Smaller tic mark intervals.
intercept_x	intercept_y	Intercept_x is the point along the X axis where the Y axis crosses. Similarly for intercept_y

7. Icons

The *Icon* object is derived from the *Graphic* object and is used to graphically represent any moving or static object inside a window. Like the Graphic objects, the Icon is composed of a group of shapes such as lines, polygons, text. In addition, an Icon object has an *appearance* property that can be loaded in from SimStudio. The SimStudio Icon Editor's JPEG image import feature allows an Icon object to be shown by a raster image. This allows photographs and images created by other programs to be shown in a SIMSCRIPT III application. Another important feature of the *Icon* object is its ability to have motion over simulation time. A velocity can be defined for the icon, which will cause its position to be updated automatically as simulation time is advanced.

7.1 Creating and loading an Icon

An *Icon* object will appear in the canvas of a Window object. It must be filed into the *graphic_set* owned by a *View* object that is in turn filed into the *view_set* owned by a *Window* object. An appearance for the *Icon* object can be constructed in the SimStudio Icon Editor. In this case a template whose name matches the name saved under the Icon Editor can be assigned to the appearance property of the *Icon* object.

7.2 Background Icons

At this point, a distinction should be made between a background icon and a dynamic icon. A background icon is static and not specifically intended to be animated. Usually the goal is for the background to appear with the same size and position in the program as it does in the SimStudio Icon editor. For background icons the following steps should be performed in the Icon editor:

1) From the "Icon properties" dialog (Edit/Icon properties… menu), make sure that the "Xlow, Xhi, Ylow, Yhigh" values match the coordinate system of the view that the *Icon* object is to be attached to.

2) Under "Center Point" the "Automatic recenter" check box should be cleared and both X and Y values should be set to "0". When using this method it is usually not necessary to assign the *location_x* and *location_y* properties of the *Icon* object at runtime.

For example, suppose that an icon saved under the name "big shape" should appear within the canvas of the object MyWindow. Also, assume that the shape is to be used as a static background icon under the coordinate system Xlow=100, Xhigh=200, Ylow=100, Yhigh=200.

```
''Example14.sim
''Displaying a background icon in a window

preamble including the gui.m subsystem
end

main
   define MyWindow as a Window reference variable
   define MyView as a View reference variable
   define MyIcon as an Icon reference variable

   create MyWindow, MyView, MyIcon

   file MyView in view_set(MyWindow)    ''attach view to window
   file MyIcon in graphic_set(MyView)   ''attach icon to view
   call set_world(MyView)(100, 200, 100, 200)

   ''Displaying an icon in a window
   let appearance(MyIcon) = Templates'find("big shape")

   call display(MyWindow)   ''display everything

   while visible(MyWindow) <> 0 call handle.events.r(1)  ''wait
end
```

7.3 Dynamic Icons

Dynamic icons are designed to represent either a moving object, or an object whose location is not known until runtime. Every Icon object inherits the location_x and location_y attributes from Graphic. These attributes should be assigned at runtime after the *appearance* attribute. The range of values for *location_x* and *location_y* depend on the coordinate system of the *View* object instance containing the *Icon* object. The display_at method will set both *location_x* and *location_y* properties before making the icon visible.

When constructing this variety of icon in SimStudio the following should be done:

1) From the "Icon properties" dialog (Edit/Icon properties… menu), make sure that the "Xlow, Xhi, Ylow, Yhigh" values match the coordinate system of the view that the icon object is to be attached to.

2) Under "Center Point", usually the "automatic recenter" box should be checked. In the application, this will force the *location_x* and *location_y* attributes to refer to the geographic center point of the icon. If "Automatic recenter" is not checked, then the correct center point (sometimes called the *hotspot*) should be entered before the icon is saved.

In this example, an icon is constructed in SimStudio and saved under the name "little shape". The rules listed above are followed when constructing this icon. Thousands of instances of this icon are created and filed into the view_set of a view with coordinates Xlow=0, Xhigh=100, Ylow=0, Yhigh=100.

```
''Example15.sim
''Displaying many dynamic icons in a window

preamble including the gui.m subsystem
end

main
   define MyWindow as a Window reference variable
   define MyView as a View reference variable
   define MyIcon as an Icon reference variable

   create MyWindow, MyView

   file MyView in view_set(MyWindow)
   call set_world(MyView)(0, 100, 0, 100)  ''must match "Icon Properties"
   call display(MyWindow)   ''draw the window

   ''scatter thousands of Icon objects at random locations
   for i = 1 to 10000
   do
      create MyIcon
      file MyIcon in graphic_set(MyView)   ''attach icon to view
      let appearance(MyIcon) = Templates'find("little shape")
      call display_at(MyIcon)(uniform.f(0, 100, 1), uniform.f(0, 100, 1))
      call handle.events.r(0)
   loop

   while visible(MyWindow) <> 0
      call handle.events.r(1)  ''wait for window to be dismissed
end
```

7.4 Animating an Icon object in a Simulation

The Icon object defines several attributes allowing it to be animated by SIMSCRIPT. The most common way to add animation is by assigning a velocity to the Icon. As simulation time progresses, the location is automatically updated as determined by the velocity, causing the entity to be redrawn. The *set_speed_course(speed, direction)* method can be called to specify both the **speed** with which the icon should travel and its direction. The speed is in View Coordinate Units per Simulated Time Unit. The direction is specified in radians and is measured counter-clockwise from the positive X axis.

For example, suppose you want to move the Icon reference variable called “MyIcon” in a north-east direction at the speed of 100 coordinate units per time unit:

```
call set_speed_course(100, pi.c/4 ''45 degrees (north-east'' )
```

Another way to change the velocity of an icon object is to assign the components of the velocity vector directly. The velocity_x and velocity_y attributes can be assigned to the speed at which the icon is moving “left/right” and the speed it is moving “up/down” respectfully.

In order for the icon to actually “move” simulation time must be advanced through the use of a “wait” or “work” statement. As simulation time is advanced, the positions of all Icon objects that have a non-zero velocity component are updated automatically.

For example, to move an icon strait up for 2 units of time:

```
Let velocity_x(MyIcon) = 0
Let velocity_y(MyIcon) = 100
Wait 2 units  ''move 200 up
```

It is important to set the initial position of the icon before setting its velocity. The *location_x* and *location_y* attributes (inherited from Graphic) should be assigned before the first wait statement is encountered.

7.5 Simulation Time and Real Time

In a SIMSCRIPT III program, simulation time is normally advanced to the time at which the next event, process or process method is due to execute. However, when graphics are added to a simulation, large jumps ahead in simulation time are normally not desirable. This would cause the Icon objects to "jump around" the window thus giving a false impression to the user of the true nature of the motion. When GUI.M is used, SIMSCRIPT III will automatically perform "time scaling". With time scaling, SIMSCRIPT III will increment the value of TIME.V is slowly. The position of every moving icon in the simulation is updated each whenever TIME.V is changes, thus smoothing out the motion of the Icons.

Time scaling is controlled by the global variable called TIMESCALE.V. The value of TIMESCALE.V establishes a scaling between real-time and simulation time. TIMESCALE.V refers to the number of 1/100 second intervals of real time per unit of simulation time. Setting TIMESCALE.V = 100 establishes a one-to-one mapping of simulation time units and real elapsed seconds. Therefore, decreasing the value of TIMESCALE.V has the effect of making the simulation run faster, provided there is enough computer power to do both the computational simulation and the animated graphics. There is no guarantee that this ratio of real time to simulation time will be maintained as the simulation runs. When there is not enough processing speed, additional elapsed real time will be taken, but simulation time is not affected. I.e. the results of the simulation will not be altered.

In this example, an icon will move from the lower left corner (0,0) to the upper right corner of the view with a speed of 4000 coordinates per time unit.

```
''Example16.sim
''shows an Icon object moving with a velocity during a simulation

preamble including the gui.m subsystem
   begin class MyIcon
      every MyIcon is an Icon and has a
        move_about process method
   end
end

process method MyIcon’move_about
   let location_x = 0
   let location_y = 0
   call set_speed_course(4000.0, PI.C / 4.0)  ''move north east
   work 10 units
   call set_speed_course(0.0, 0.0)  ''stop the shape
   work 5 units
end

main
   create a Window, View, MyIcon
   file View in view_set(window)
   file MyIcon in graphic_set(view)
   let appearance(MyIcon) = Templates'find("shape")
   let timescale.v = 100   ''1 second per time unit
   activate a move_about(MyIcon) now
   start Simulation
end
```

7.6 Custom animation

There may be some cases where modeling an object with a simple linear velocity is not adequate. Obtaining non-linear motion with automatic update of Icon positions is still possible to achieve. The *Icon* object defines methods that allow an application defined motion. The three methods typically used in this case are *motion*, *start_moving*, and *stop_moving*.

The *motion* method is called automatically whenever simulation time is advanced. If TIMESCALE.V is non zero, this means that the *motion* method will be called repeatedly during a WORK or WAIT statement to facilitate smooth movement of icons. To implement customized motion over time, the *Icon* class should be subclassed and the *motion* method overridden. The amount of time elapsed since the last call to motion is passed as a parameter. This can be used by the implementation of *motion* to compute the next position of the icon.

Calling the *start_moving* method will add the *Icon* object to a private set of moving objects. The *motion* method will be called periodically after the call to *start_moving*. Call the *stop_moving* method to halt the calls to *motion* and remove the *Icon* object from the set of moving objects. Note that when a non-zero velocity is assigned to the *Icon* object, *start_motion* is called implicitly. The motion method will be called periodically after assigning a velocity or calling the *set_speed_course* method.

In the following example program, the *Icon* object is subclassed and the *motion* method is overridden. The implementation of this override moves the Icon in an elliptical orbit.

```
 ''Example17.sim
''Using customized motion while animating Icon objects

preamble including the gui.m subsystem

begin class MyIcon
   every MyIcon is an Icon and has
      an about_x, an about_y, a theta,
      a move_in_circles process method, and
      overrides the motion
   define about_x, about_y, theta as double variables
   define move_in_circles as a process method given
      2 double arguments
end
end

process method MyIcon'move_in_circles(x,y)
   let about_x = x
   let about_y = y
   call start_moving
   work 25 units      ''"motion" method called during work
   call stop_moving
   wait 3 units       ''pause to see the icon stopped
end

method MyIcon'motion(dt)
   add dt to theta
   call display_at(about_x + 2000.0 * cos.f(theta),
                   about_y + 6000.0 * sin.f(theta))
end

main
   define icon1, icon2 as MyIcon reference variables
   create a Window, View, icon1, icon2
   file View in view_set(window)   ''set up the view
   call display(Window)            ''show the window
   file this icon1 in graphic_set(view)   ''set up the icons
   file this icon2 in graphic_set(view)
   let appearance(icon1) = Templates'find("shape") ''use the "shape" icon
   let appearance(icon2) = Templates'find("shape") ''for both
   let timescale.v = 50   ''0.5 second per time unit
   activate a move_in_circles(icon1)(8000, 16000) now
   activate a move_in_circles(icon2)(22000, 16000) in pi.c units
   start Simulation
end
```

8. Forms

Many times an application will require a robust set of tools for user interaction. Users may expect to control the whole application through a menu-bar displayed at the top of the window, or to use a smaller context menu to dynamically make changes to an individual item. Dialog boxes are used as a convenient way to communicate data quantities to a program. GUI.M provides *Form* objects that include menu bars, dialog boxes, tool bars (palette), and popup message boxes. SIMSCRIPT supports these objects using JAVA which allowing programs to be recompiled and executed on different operating systems without recoding or retooling the graphical user interface. All objects derived from the *Form* object are portable from platform to platform.

8.1 Using Form objects

The *DialogBox*, *MenuBar* and *Palette* objects are derived from *Form*. Dialog boxes are windows containing a variety of input controls including buttons, text labels, tabular controls, single and multi-line text, combo, value, list, radio, and check boxes. Menu bars can appear at the top of the canvas of a *Window* object. A *Palette* is attached to the top, left, right or bottom of a *Window* object and contains rows of buttons that can be dragged onto the Window's canvas.

All objects derived from *Form* (with the exception of *MessageBox*) must be constructed using the SimStudio Dialog box, Menu bar or Palette editors. As with *Graph* and *Icon* objects, the *Form* object defines an *appearance* property that can be assigned a *Template* object. The *Templates'find* method returns a *Template* given the name with which it was saved in the SimStudio editor. Every Form object instance must be attached to a Window object. This is accomplished by filing the *Form* instance into the *form_set* owned by *Window*.

8.2 DialogBox object

The *DialogBox* object is derived from the *Form* object and represents both modal and modeless dialogs. Dialog boxes provide an interactive way for the user to enter input data. A dialog box is a window containing a variety of input controls including buttons, text labels, tabular controls, single and multi-line text, combo, value, list, radio, and check boxes. Tabbed dialogs can also be created in SIMSCRIPT. A dialog must be constructed in the SimStudio dialog box editor and loaded into the application as described above. The *DialogBox* object supports both modal and modeless interaction.

In a modeless dialog execution does not stop when the object is displayed. A modeless dialog box should be constructed in the SimStudio dialog box editor by un-checking the "modal interaction" box in the "Dialog box Properties" dialog. If a modeless interaction is needed, the *display* method should be used to make the dialog visible. Modal dialogs are used when the application needs to wait for the user to make a selection from the dialog before continuing. The *DialogBox* class defines an *accept_input* method that can be called to display the dialog and wait for user interaction.

Modal interaction is halted when the user presses a "terminating" button, at which *accept_input* returns. A button in the dialog can be marked as terminating through the "Button properties" dialog. (Usually, the "Cancel" and "OK" buttons are terminating.) Another check box in the "Button properties" dialog called "Verifying" can be useful for dialog boxes that contain numerical fields (i.e. value boxes). Pressing a "Verifying" button will range check values in all value boxes in the dialog. If a value is out of range, characters "<<<" will be shown after the value the dialog will "beep". Usually "OK" buttons are marked as verifying.

In the following example a dialog box is constructed in SimStudio and saved under the name "simple dialog". The dialog contains a single "Verifying" button that can be pressed to dismiss it.

```
''Example18.sim
''Displaying a simple dialog box

Preamble including the gui.m subsystem
End

main
   create DialogBox, Window
   call display(Window)

   ''assume a dialog named "simple dialog" has been created in SimStudio
   let appearance(DialogBox) = Templates'find("simple dialog")

   ''attach the dialog box to this window
   file this DialogBox in form_set(window)

   ''show the dialog.  This will not return until user clicks on button
   call accept_input(DialogBox)
end
```

8.3 Using Field objects for data transfer

The *Field* object provides an interface for passing data back and forth between the executing program and an item (check box, text box, etc) in a form. *Field* objects must be filed into the *field_set* owned by Form. In most cases, the *Field* object is created and filed into this set automatically at the time the *appearance* attribute is assigned. A corresponding field is created for each item in a dialog box, each menu item in a menu bar, and each button in a palette.

The *name* attribute of the field is initialized to the "Field name" given to the corresponding item in the SimStudio editor. This allows the program to obtain a reference to a particular field given its *name*. The *find* method defined by the *Form* class does just that. Given the text "name" of a field, *Form'find* will return the *Field* reference value for the item.

The *Field* object defines several properties that can be used on the left or right side of an assignment. When the property is assigned, the text, value or selection state shown by the corresponding item in the dialog box will change to show the new value. When the property is "read", the current text or value typed in by the user will be returned by the method. The table below describes many different data types and dialog box items that can be.

Method	Data type	Dialog Items	Description
image	text	tree item	Sets the name of the icon shown with the item. (Without the ".jpg" extension).
selected	integer (0 or 1)	button, check box, tree item, radio button	Gets/sets the current selection state of an item that can be toggled. '1' means selected, while '0' means unselected.
selected_at	integer (0 or 1)	list box, radio box, table	Gets/sets the current selection state of an item in the dialog composed of a list of selectable cells or buttons. The first argument refers to the row number of the item or button starting from "1". For tables, row '0' refers to the column headers, and the second argument refers to a column number. A value of '1' assigned to this field means to select the item, while a value of '0' means to de-select it.
string	text	combo box, menu item, text box, tree item, label	Gets/sets text data in the field.
string_at	text	list box, table	Gets/sets text item in a field given the row and column of the item.
strings	1-dim array of text	combo box, list box, multi-line box, table	Gets/sets an array of text data in the field. If used on the left, the items in the list shown in the dialog will be replaced by the text in the array.
value	double	label, progress bar, value box	Gets/sets the numerical value shown in an item in a dialog box. For labels, the "Formatted Real" button in the "Label properties" dialog should be checked.

The *accept_input* method of the *DialogBox* object will return with the *Field* reference pointer for the terminating button that was selected to dismiss the dialog. The *name* attribute of this Field can be inspected to determine which button was clicked on. Note that if the user dismisses the dialog box by clicking on the "X" in the window frame, *accept_input* will return with "0".

In this example a dialog box is shown that contains several different fields. Assigning the *Field* object properties before the dialog is displayed initializes dialog box items. The *Form'find* method is used here to obtain the *Field* object reference pointer.

```
''Example19.sim
''Displaying a dialog box containing many different fields

Preamble including the gui.m subsystem
End

main
   define items as a 1-dim text array
   define db as a DialogBox reference variable

   ''create window, dialog box and load it from a template
   create db, Window
   call display(Window)
   let appearance(db) = Templates'find("field dialog")
   file this db in form_set(window)

   ''initialize the fields in the dialogs before showing it
   ''set the check box to "checked" state
   let selected(find(db)("check_box")) = 1

   ''set text and value boxes
   let string(find(db)("text_box")) = "Initial text"
   let value(find(db)("value_box")) = 60.25

   ''set the items in the multi line edit box
   reserve items(*) as 3
   let items(1) = "The quick brown fox"
   let items(2) = "jumped over the"
   let items(3) = "lazy dog's back."
   let strings(find(db)("edit_box")) = items(*)
   release items(*)

   ''set cell row 2, column 1 in the table
   let string_at(find(db)("table"))(2,1) = "Cell text"

   ''select the second radio button
   let selected_at(find(db)("radio_box"))(2,0) = 1

   ''show the dialog.  Wait for a terminating button to be pressed
   let field = accept_input(db)

   ''now read the fields and print them out
   if field <> 0 and name(field) = "ok"
      write selected(find(db)("check_box")) as "Check box: ", I 2, /
      write selected_at(find(db)("radio_box"))(2,0) as
            "2nd Radio button: ",I 2,/
      write string(find(db)("text_box")) as "Text box: ", T *, /
      write value(find(db)("value_box")) as "Value box: ", D(8,2), /
      let items(*) = strings(find(db)("edit_box"))
      for i = 1 to dim.f(items(*))
         write i, items(i) as "Edit box line ", I 3, ": ", T *, /
   always
end
```

8.4 Event Notification

In some cases, you will want to provide code to immediately handle Form object input events generated by the user (such as button clicks, text box modification, menu selection etc) while the simulation is running. Whenever a user clicks on a button or makes a change to a dialog box item, the *Form'action* method is called automatically. An application requiring this immediate notification can subclass the *Form* object and override its *action* method. This is a useful way to perform immediate validation or cross-checking of fields. The action method is defined as follows:

```
define action as an integer method given
    1 FormEvent reference argument
```

The single argument to the action method is an instance of the *FormEvent* object. The "field" attribute of this object contains a reference pointer to the *Field* object that was clicked on or changed. The *name* attribute of this *Field* object can be compared against the field names of known items. The "id" field of the *FormEvent* object contains a constant indicating one of several varieties of event. The following table lists the possible values for "id", the meaning of each value, and which of the other attributes of the FormEvent object are used.

Id	FormEvent Attributes	Dialog Items	Description
_button_dropped	drop_x drop_y drop_view field	palette button	Indicated that a palette button marked in the SimStudio "Palette Button Properties" dialog as "Draggable" was dragged from the palette and dropped. drop_x, drop_y indicate the Canvas coordinates of the drop location. drop_view is the View object containing the drop point.
_button_pushed	field	button menu item table cell tree item	One of the items was clicked on by the user.
_close	-----	------	Indicated that the user has clicked on the "X" in the corner of a dialog box's window.
_data_changed	field	check box combo box radio button text box value box	This event is sent when data being shown in a dialog item has been changed by the user. The return key must be pressed after entering data into a text/value box. The "Selectable using return" check box must be marked in the "Value box properties" or "Text box properties" dialog in the SimStudio dialog box editor.

On of the following constants defined in the Form class should be returned from the *action* method overridden by the subclass.

_continue - Accept the input and continue.
_terminate - Terminate the interaction and return from the *accept_input* method.

In this example, a dialog box containing several different items is displayed. The *DialogBox* object is subclassed and the *action* method overridden. Code in the action method displays information about the item that was clicked on or changed by the user.

```
''Example20.sim
''Showing how the "action" method can be overridden

Preamble including the gui.m subsystem
   begin class TestDialogBox
      every TestDialogBox is a DialogBox and
         overrides the action  ''called when user acts on an item
   end
end

method TestDialogBox'action(event)
   if field(event) <> 0
      let string(find("sel_name")) = name(field(event))
   always
   select case id(event)  ''determine which event has happened
      case FormEvent'_button_pushed
      case FormEvent'_data_changed
         ''display the data contained by the event's field
         let selected(find("sel_state")) = selected(find(name(field(event))))
         let string(find("sel_text")) = string(find(name(field(event))))
         let value(find("sel_value")) = value(find(name(field(event))))
      case FormEvent'_close
         write as "User has closed the dialog!", /
         return with _terminate    ''return from accept_input()
   endselect
   return with _continue   ''keep going
end

main
   ''create window, dialog box and load it from a template
   create TestDialogBox, Window
   call display(Window)
   let appearance(TestDialogBox) = Templates'find("action dialog")
   file this TestDialogBox in form_set(window)

   ''show the modal dialog
   call accept_input(TestDialogBox)
end
```

8.4 Enable and Disable fields

In many cases, you may want to activate and deactivate items in your dialog box in response to the user changing one of the fields. When the *activated* property of the *Field* object is assigned a value of ‘0’, the corresponding item in the dialog box or menu bar is deactivated and can no longer be selected or edited by the user. The item will not disappear but instead appear greyed out. For example, to deactivate the field named “my check box field” in the dialog referenced by “my_dialog”:

```
Define check_field as a Field reference variable
Let check_field = find(my_dialog)("my check box field")
let activated(check_field) = 0
```

It is also possible to hide and show fields using the SIMSCRIPT "display" and "erase" methods inherited from the GuiItem object. i.e.

```
call erase(field)   ''make the field disappear
call display(field) ''make field visible
```

This example shows how typically the activated property is used. While the user is making changes to items in the dialog, the correct activation state of related items can be maintained by overriding the action method.

```
''Example21.sim
''Using the "activate" property
''Clicking on radio buttons will change which control is enabled

Preamble including the gui.m subsystem
   begin class TestDialogBox
      every TestDialogBox is a DialogBox and
         overrides the action  ''called when user acts on an item
   end
end

''override the action method so that items can be deactivated while the
''program is waiting in accept_input

method TestDialogBox'action(event)
   if field(event) <> 0
      select case name(field(event))
         case "use_text"
            let activated(find("text_box")) = 1
            let activated(find("value_box")) = 0
         case "use_value"
            let activated(find("text_box")) = 0
            let activated(find("value_box")) = 1
         default
      endselect
   always
   return with _continue   ''keep going
end

main
   ''create window, dialog box and load it from a template
   create TestDialogBox, Window
   call display(Window)
   let appearance(TestDialogBox) = Templates'find("activate dialog")
   file this TestDialogBox in form_set(window)

   ''initially, deactivate the value box
   let activated(find(TestDialogBox)("value_box")) = 0

   ''show the modal dialog
   call accept_input(TestDialogBox)
end
```

8.5 Trees

One of the items that can be added to a dialog in the SimStudio editor is the tree. A tree contains a list of items that can be viewed hierarchically, with items containing other items. Each item in the tree consists of a label and an optional jpeg image, and each item can have list of sub items associated with it. By clicking an item at runtime, the user can expand and collapse the associated list of sub items.

Using SimStudio you can specify the initial set of items and sub items in the tree. However, most applications will need to set up the tree at runtime. The hierarchy shown in the tree can be constructed at runtime by creating instances of Field objects and filing them appropriately into the field_set owned by the tree field. Filing a Field into a field_set is the equivalent of adding a new item to the tree. The *string* attribute of the Field is the label of the tree item. For example, to add the items labelled “One” and “Two” to a tree field named “little tree”:

```
define field1, field2 as Field reference variables
create field1, field2
let string(field1) = "One"
let string(field2) = "Two"
file this field1 in field_set(find("little tree"))
file this field2 in field_set(find("little tree"))
```

If we wanted the item labeled “Two” to contain items labeled “A” and “B” the additional code could be added:

```
define field3, field4 as Field reference variables
create field3, field4
let string(field3) = "A"
let string(field4) = "B"
file this field3 in field_set(field2)
file this field4 in field_set(field2)
```

An item in a tree can be shown with a small image next to it. The *image* property of the Field object can be assigned the name of a file containing a bitmapped image. This image should be small enough to fit into the list of items and in be JPEG format. (A typical size is usually 16x16 or 24x24 pixels). The name should be specified without the “.jpg” extension. The following example shows how an application can populate a tree with a hierarchy of items. JPEG images are shown with the items, and the application assumes that the files “I.jpg”, “II.jpg” and “III.jpg” exist.

```
''Example22.sim
''Using a tree in a dialog box

Preamble including the gui.m subsystem
end

main
   define tree, field1, field2, field1_1, field1_2, field1_2_1
          as Field reference variables

   ''create window, dialog box and load it from a template
   create DialogBox, Window
   call display(Window)
   let appearance(DialogBox) = Templates'find("tree dialog")
   file this DialogBox in form_set(window)

   let tree = find(DialogBox)("tree")
   create field1, field2, field1_1, field1_2, field1_2_1

   ''set the label and image file name for each item in the tree
   let string(field1) = "Level 1 First Item"
   let string(field2) = "Level 1 Second Item"
   let string(field1_1) = "Level 2 First Item"
   let string(field1_2) = "Level 2 Second Item"
   let string(field1_2_1) = "Level 3 First Item"
   let image(field1) = "I"   ''assume "I.jpg" exists
   let image(field2) = "I"
   let image(field1_1) = "II"   ''assume "II.jpg" exists
   let image(field1_2) = "II"
   let image(field1_2_1) = "III"   ''assume "III.jpg" exists

   ''build the hierarchy
   file this field1 in field_set(tree)
   file this field2 in field_set(tree)
   file this field1_1 in field_set(field1)  ''field1 will contain 2 items
   file this field1_2 in field_set(field1)
   file this field1_2_1 in field_set(field1_2)  ''field1_2 will contain 1

   ''initially select the item at the lowest level
   let selected(field1_2_1) = 1

   ''show the modal dialog
   call accept_input(DialogBox)
end
```

8.6 Tables

A table is an item in a dialog composed of a two dimensional arrangement of selectable text fields or "cells". The table can be scrolled both horizontally and vertically. All cells in the same column have the same width, but you can define the width of this column. A table can have both column and row headers. The headers are fixed and will remain in view when the table is scrolled.

The end user can navigate through a table using the left-, right-, up- and down-arrow keys. The *action* method is invoked whenever a cell is clicked on or an arrow key is used to move to focus on a different cell. The table can be set up to automatically add a new row of cells at the bottom when the user attempts to move below the last row. Use SimStudio to add a table to a dialog box.

As with other items, a Field object will be created automatically for each table in a dialog. The *Field'string_at* method can be used on the left to specify the text of a particular cell. The arguments to this method are the row and column of the cell in the table. If the table is constructed in SimStudio to use column headers (on the top) the text of a header is assigned by specifying "0" as the row number argument to the *string_at* method. Similarly, "0" can be specified as the column number to assign a text value to a row header.

Another way to specify the cell text values is to put all the text into a 1-dim array and assign the array to the *strings* method. The array must be reserved big enough to hold all the cells. Text values are laid out in row major order. For example, assume the table has '.NUM_COLUMNS' columns (including row headers) and '.NUM_ROWS' rows. The index into the array for cell (COLUMN,ROW) is computed as follows:

```
let table_values((ROW-1) * .NUM_COLUMNS + COLUMN) = "hello"
```

The *action* method of the *DialogBox* object containing the table can be overridden to handle events generated by the table. The *selected_at* method can be called to get or set the currently selected cell in the table.

In the following example, a table constructed in SimStudio is populated with data at runtime. In this example the column headers are set in the SimStudio DialogBox editor, while the row headers are set in the program.

```
''Example23.sim
''Using a table

Preamble including the gui.m subsystem
   define _header=0, _name_col, _company_col, _occupation_col as constants
end

main
   define table_field as a Field reference variable

   ''create window, dialog box and load it from a template
   create DialogBox, Window
   call display(Window)
   let appearance(DialogBox) = Templates'find("table dialog")
   file this DialogBox in form_set(window)

   let table_field = find(DialogBox)("table")
   let string_at(table_field)(1, _header) = "1"
   let string_at(table_field)(1, _name_col) = "Zapp Brannigan"
   let string_at(table_field)(1, _company_col) = "DOOP"
   let string_at(table_field)(1, _occupation_col) = "Starship Captain"
   let string_at(table_field)(2, _header) = "2"
   let string_at(table_field)(2, _name_col) = "Mom"
   let string_at(table_field)(2, _company_col) = "Mom's Old Fashion Robot Oil"
   let string_at(table_field)(2, _occupation_col) = "President/CEO"
   let string_at(table_field)(3, _header) = "3"
   let string_at(table_field)(3, _name_col) = "Morbo"
   let string_at(table_field)(3, _company_col) = "Channel Radical 2 News"
   let string_at(table_field)(3, _occupation_col) = "News Anchor Monster"
   let string_at(table_field)(4, _header) = "4"
   let string_at(table_field)(4, _name_col) = "Richard M. Nixon"
   let string_at(table_field)(4, _company_col) = "Government"
   let string_at(table_field)(4, _occupation_col) = "President of Earth"
   let string_at(table_field)(5, _header) = "5"
   let string_at(table_field)(5, _name_col) = "Dr. Zoidberg"
   let string_at(table_field)(5, _company_col) = "Planet Express"
   let string_at(table_field)(5, _occupation_col) = "Medical Doctor"

   ''show the modal dialog
   call accept_input(DialogBox)
end
```

8.7 Menu bars

In many typical applications, the user interacts with a menu bar attached to the top of the window. In many cases the entire range of functionality is accessible through the menu bar. Given its widespread use, most users expect to be able to control the program through the menu bar.

A menu bar is composed of several menus arranged in a row on a bar across the top of a window frame. Clicking on one causes its menu-pane to be displayed. Clicking on an item inside a menu causes it to be selected. Cascading menus are supported, meaning that menus can contain other menus and so on.

The menu bar is implemented by creating a *MenuBar* object. Like other object derived from *Form*, a menu bar is constructed in SimStudio and loaded into the program by assigning the *appearance* attribute. At this time a *Field* object is created for each menu in the menu bar. A *Field* object is filed in to the *field_set* owned by the menu or menu item that contains it. A menu bar is always modeless and is shown by calling its *display* method. The application must subclass the *MenuBar* object and override the *action* method to receive notification of menu item selection while the simulation is running.

A program can dynamically set and clear check marks next to any menu item. To display the check mark, set the *selected* attribute of the menu item field to "1". Clear the mark by setting the attribute to "0". Before the check mark is actually drawn or erased from the menu, the corresponding *Field* object must be re-displayed by calling the *display* method.

In the following example, a menubar is created in SimStudio consisting of two menus. One of the menus contains a submenu that allows the user to change the background color of the window.

```
''Example24.sim
''Using a menu bar.

Preamble including the gui.m subsystem

   begin class MyMenuBar
      every MyMenuBar is a MenuBar, and
         has a current_color, and
         overrides the action
      define current_color as a text variable
   end
end

method MyMenuBar'action(event)
   if current_color <> ""
      let selected(find(current_color)) = 0 ''erase menu item check
   always
   let current_color = name(field(event))
   let selected(find(current_color)) = 1   ''show menu item check

   ''see which menu item was selected by comparing the field name
   select case name(field(event))
      case "black"   let color(Window) = Color'_black
      case "white"   let color(Window) = Color'_white
      case "red"     let color(Window) = Color'_red
      case "green"   let color(Window) = Color'_green
      case "blue"    let color(Window) = Color'_blue
      case "cyan"    let color(Window) = Color'_cyan
      case "magenta" let color(Window) = Color'_majenta
      case "yellow"  let color(Window) = Color'_yellow
      case "exit"    return with _terminate
   endselect
   call display(Window)
   return with _continue
end

main
   ''create window, dialog box and load it from a template
   create Window, MyMenuBar
   call display(Window)
   let appearance(MyMenuBar) = Templates'find("menu bar")
   file this MyMenuBar in form_set(Window)
   call display(MyMenuBar)          ''display the menu bar
   ''wait til user closes window or uses the exit menu
   while visible(MyMenuBar) <> 0 and visible(Window) <> 0
      call handle.events.r(1)
end
```

8.8 Palettes

Toolbars and palettes are also popular components in a user interface. (For the sake of SimStudio, we will refer to either component as a *palette*.) A palette is basically a horizontal or vertical bar containing a row (or column) of buttons, with each button showing a little picture image. An application may need a palette at the top of the window to provide quick access to commonly used items. Many applications also allow users to "drag" the image shown on a palette button onto the canvas of the window. A palette can be attached to any edge of the window. The buttons contained on a palette can be typical push buttons, or can toggle (stay down when pressed.)

Palettes are implemented with the *Palette* object which is derived from the *Form* object. Palettes must therefore be constructed in SimStudio and loaded into the program by assigning a Template to the *appearance* attribute of the Palette object instance.

Buttons marked in SimStudio as "draggable" (using the "Palette Button Properties" dialog) enable drag and drop. In this case your program is notified of the action allowing you to create a display entity representing the object that was dragged. To get the notification of a drag event, the Palette object must be subclassed and the *action* method overridden. The *id* attribute of the *FormEvent* argument will be *_button_dropped*. The drop_x, drop_y and drop_view attributes can be used to determine the drop location (in canvas coordinates) and the *View* containing the point at which the button was dropped.

In the following example, a Palette object is constructed in the SimStudio Palette editor and displayed in a window. When the user drags buttons from the palette to the canvas an *Icon* object is created and placed in the drop location.

```
''example25.sim
''Using a Palette.

preamble including the gui.m subsystem

begin class TestPalette
   every TestPalette is a Palette,
      overrides the action
end
end

''override the action method to get notification of palette button
''clicks and drops
method TestPalette'action(event)
   define my_icon as an Icon reference variable

   select case id(event)
      case FormEvent'_button_pushed
         write name(field(event)) as T *, " was pressed", /
      case FormEvent'_button_dropped
         if drop_view(event) <> 0
            ''put a new icon in the drop location
            create an my_icon
            let appearance(my_icon) = Templates'find(name(field(event)) +
                ".icn")
            file this my_icon in graphic_set(drop_view(event))
            call display_at(my_icon)(drop_x(event), drop_y(event))
         always
      default
   endselect

   return with _continue
end

main
   create Window, TestPalette, View
   file this TestPalette in form_set(Window)
   file this View in view_set(Window)
   let appearance(TestPalette) = Templates'find("palette")
   call display(Window)

   while visible(Window) <> 0
      call handle.events.r(1)
end
```

8.9 PopupMenu Objects

Popup menus allow an end user to right click in the canvas of a window to display a small menu showing a list of choices. They are sometimes referred to as *context menus* because a different menu can easily be displayed depending on both where and when the user right-clicks in the window.

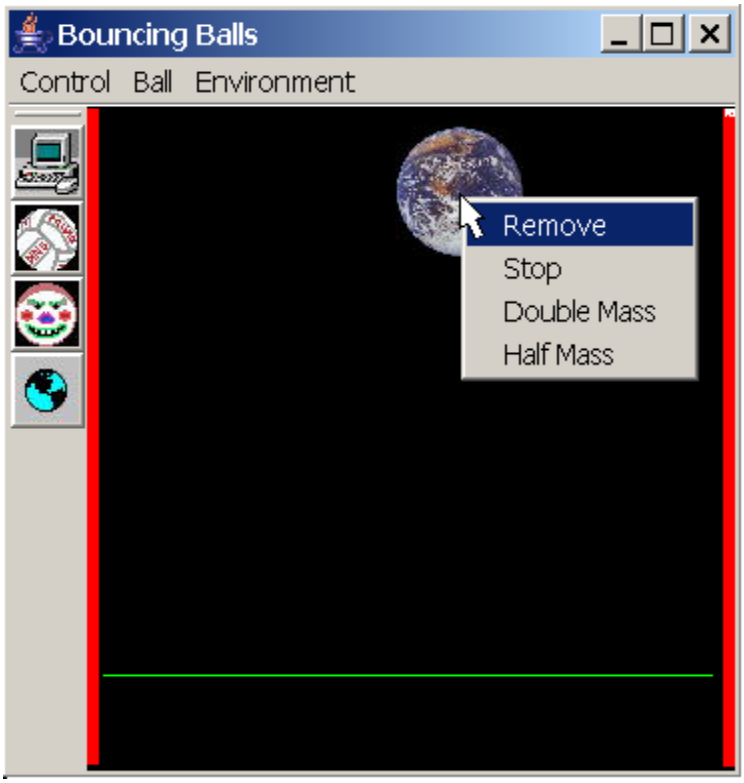


Figure 8.1: A popup menu

A popup menu is implemented through GUI.M by creating a *PopupMenu* object. To construct a popup menu in SimStudio, use the Menu bar editor to create a menu bar. The first (leftmost) menu in this menubar will be used as the popup while all other menus are ignored. The name given to the menubar will be passed in the application to the *Templates'find* method. The corresponding Template is then assigned to *appearance* attribute of the *PopupMenu* object. For example, assume the menu bar is saved under the name "shape popup":

```
create a PopupMenu
file this PopupMenu in form_set(Window)
let appearance(PopupMenu) = Templates'find("shape popup")
```

If the items to be contained in the menu are not known until runtime, the popup menu can be constructed by program code. This can be done as follows:

1) create a *Field* object for each item to be placed in the menu.

2) Assign the name used to identify the item to the *name* attribute of the field.
3) Assign the label shown on the item to the *string* attribute of the field.
4) File each field in the *field_set* owned by the *PopupMenu* object.

For example, to create a popup menu with two items, one labeled “Start” and the other labeled “Stop”:

```
define field1, field2 as Field reference variables
create a PopupMenu
create a field1, field2
let string(field1) = "Start"
let string(field2) = "Stop"
let name(field1) = "start_picked"
let name(field2) = "stop_picked"
file this field1 in field_set(PopupMenu)
file this field2 in field_set(PopupMenu)
file this PopupMenu in form_set(Window)
```

The *accept_input* method is used to show a popup menu. The method will block execution until the user selects an item. A reference to the selected *Field* object is returned from *accept_input*. The application can then inspect the *name* attribute of this field to determine the proper action. If the user does not make a selection (i.e. the <escape> key is pressed before an item is picked) the zero is returned by *accept_input*.

In the following example program two objects called *StyleGraphic* and *ColorGraphic* subclass the *Graphic* object. Each object overrides the *action* method to display a different popup menu when an instance of the graphic is clicked on with the right mouse button. The popup menu for *StyleGraphic* allows the user to change the fill style while the menu for *ColorGraphic* allows the color to be changed. The popup menu for *StyleGraphic* is constructed in SimStudio and the menu for *ColorGraphic* is constructed in the program.

```
''example26.sim
''Using a popup (context) menu
preamble including the gui.m subsystem
normally, mode is undefined
begin class StyleGraphic
   every StyleGraphic is a Graphic,
      overrides the action
end
begin class ColorGraphic
   every ColorGraphic is a Graphic,
      overrides the action
end
end

''the method is called whenever the ColorGraphic is clicked on
method ColorGraphic'action(event)
   define color as an integer variable
   define field1, field2, field3 as Field reference variables

   if button_number(event) > 1  ''right mouse button pressed
      ''build a popup menu from scratch.  create three fields, set the
      ''name and label of each field, then file the the field_set owned
      ''by the popup menu
      create a PopupMenu
      create a field1, field2, field3
      let string(field1) = "Red"
      let string(field2) = "Green"
      let string(field3) = "Blue"
      let name(field1) = "red"
      let name(field2) = "green"
      let name(field3) = "blue"
      file this field1 in field_set(PopupMenu)
      file this field2 in field_set(PopupMenu)
      file this field3 in field_set(PopupMenu)
      file this PopupMenu in form_set(Window)

      ''show the popup menu then wait for user to click on an item.
      let Field = accept_input(PopupMenu)
      if Field <> 0
         ''see which field in the popup menu was selected
         select case name(field)
            case "red"    let color = Color'_red
            case "green"  let color = Color'_green
            case "blue"   let color = Color'_blue
            default
         endselect

         ''draw the solid square using the new color
         let pattern(FillStyle) = FillStyle'_solid
         call begin_drawing(ColorGraphic)
         call draw_rectangle(ColorGraphic)
               (17000, 10000, 10000, 10000, color, FillStyle)
         call end_drawing(ColorGraphic)
         call display(ColorGraphic)
      always
   always
   return with Graphic'action(event)
end
```

```
''the method is called whenever the StyleGraphic is clicked on
method StyleGraphic'action(event)
   if button_number(event) > 1  ''right mouse button pressed
      create a PopupMenu
      file this PopupMenu in form_set(Window)

      ''load a menu bar created in SimStudio.  Its first menu will be
      ''used as the popup menu
      let appearance(PopupMenu) = Templates'find("style popup")

      ''show the popup menu then wait for user to click on an item.
      let Field = accept_input(PopupMenu)
      if Field <> 0
         ''see which field in the popup menu was selected
         select case name(field)
            case "hollow"
               let pattern(FillStyle) = FillStyle'_hollow
            case "solid"
               let pattern(FillStyle) = FillStyle'_solid
            case "narrow_diagonal"
               let pattern(FillStyle) = FillStyle'_narrow_diagonal
            case "medium_diagonal"
               let pattern(FillStyle) = FillStyle'_medium_diagonal
            case "wide_diagonal"
               let pattern(FillStyle) = FillStyle'_wide_diagonal
            case "narrow_crosshatch"
               let pattern(FillStyle) = FillStyle'_narrow_crosshatch
            case "medium_crosshatch"
               let pattern(FillStyle) = FillStyle'_medium_crosshatch
            case "wide_crosshatch"
               let pattern(FillStyle) = FillStyle'_wide_crosshatch
            default
         endselect

         ''draw the red square using the new fill style
         call begin_drawing(StyleGraphic)
         call draw_rectangle(StyleGraphic)
               (5000, 10000, 10000, 10000, Color'_red, FillStyle)
         call end_drawing(StyleGraphic)
         call display(StyleGraphic)
      always
   always

   return with Graphic'action(event)
end
```

```
main
   create Window
   let title(Window) = "Popup Menu Test"
   call display(Window)

   create View
   file this View in view_set(Window)

   ''create object derived from Graphic, draw a red square.
   create StyleGraphic
   file this StyleGraphic in graphic_set(View)
   call begin_drawing(StyleGraphic)
   call draw_rectangle(StyleGraphic)(5000, 10000, 10000, 10000, Color'_red, 0)
   call end_drawing(StyleGraphic)
   call display(StyleGraphic)

   ''create object derived from Graphic, draw a green square.
   create ColorGraphic
   file this ColorGraphic in graphic_set(View)
   call begin_drawing(ColorGraphic)
   call draw_rectangle(ColorGraphic)
        (17000, 10000, 10000, 10000, Color'_green, 0)
   call end_drawing(ColorGraphic)
   call display(ColorGraphic)

   ''wait for the window to be dismissed
   while visible(Window) <> 0
      call handle.events.r(1)
end
```

8.10 MessageBox Objects

In some cases you will want only to display a simple message that allows the user to answer "yes", "no", or "cancel". Toolkits provide built in dialog boxes just for that purpose. The *MessageBox* object allows you to add these built in message boxes to your program to make use of these dialogs.

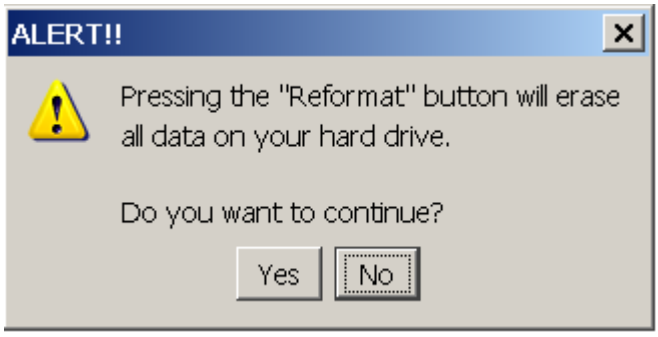


Figure 8.2: *MessageBox* object.

A *MessageBox* object can be constructed in SimStudio using the “message box editor”. It is loaded in from the “.sg2” file in the same way as the *DialogBox* object- by assigning a *Template* to the *appearance* attribute. A *MessageBox* differs from a *DialogBox* object in that it does not contain data “fields”. A message boxes is more simplified than a dialog box and does not allow the user to enter information. Instead, it will contain one of the following sets of response buttons:

a) OK button only
b) OK and Cancel buttons
c) Yes and No buttons
d) Yes, No and Cancel buttons
e) Retry and Cancel buttons
f) Abort, Retry and Ignore buttons

Any one of these buttons can be designated in SimStudio as the *default* button. This button is activated when the user presses the <return> key. Message boxes come in different styles, with each style showing a different icon in it the dialog. The following five styles are available:

a) Plain
b) Stop Sign
c) Question
d) Exclamation
e) Information

All *MessageBox* objects are modal and the *accept_input* method should be called to display the dialog and wait for user input. The interaction is ended and the dialog disappears when the user clicks on any button. The *accept_input* method will return with an integer indicating which button was pressed. The constants *_ok_button, _cancel_button, _yes_button, _no_button, _abort_button, _retry_button, _ignore_button* are possible return values.

Normally, the text of the message can be entered in SimStudio when constructing the dialog. If this text is not known until runtime, the *MessageBox* object provides two attributes that can be assigned to set the text to be displayed. A single line message can be assigned to the *message_line* attribute. Longer messages should be placed into a 1-dim text array and assigned to the *message_lines* attribute. (each element of the array will show as a line of text in the dialog).

The following program displays two *MessageBox* objects. The first is constructed entirely within the SimStudio message box editor. The multiple lines of text shown in the second box are assigned at runtime.

```
''example27.sim
''Using a MessageBox object.
preamble including the gui.m subsystem
normally, mode is undefined
end

main
   define box1, box2 as MessageBox reference variables
   define lines as a 1-dim text array

   create Window
   call display(window)

   create box1, box2

   ''show the first message dialog.  Wait for user to press button
   let appearance(box1) = Templates'find("message1")
   file this box1 in form_set(window)
   select case accept_input(box1)
      case MessageBox'_abort_button  write as "Abort was pressed!", /
      case MessageBox'_retry_button  write as "Retry was pressed!", /
      case MessageBox'_ignore_button write as "Ignore was pressed!", /
   endselect

   ''show the second message dialog.  Assign the message at runtime
   let appearance(box2) = Templates'find("message2")
   file this box2 in form_set(window)
   reserve lines(*) as 3
   let lines(1) = "This is a very long message whose"
   let lines(2) = "text has been set in the program"
   let lines(3) = "code and not in the message box editor."
   let message_lines(box2) = lines(*)
   let title(box2) = "Title also set in program"
   call accept_input(box2)
end
```

All example programs from this Manual are in SIMSCRIPT directory guim_manual _examples.