

C Tutorial for Rational Rhapsody



Before using the information in this manual, be sure to read the “Notices” section of the Help or the PDF available from **Help > List of Books**.

This edition applies to IBM[®] Rational[®] Rhapsody[®] 7.4 and to all subsequent releases and modifications until otherwise indicated in new editions.

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Getting Started

Welcome to the *C Tutorial for IBM Rational Rhapsody*! IBM® Rational® Rhapsody® is the Model-Driven Development environment of choice for systems engineers and software developers of either embedded or real-time systems.

Rational Rhapsody in C generates full production C code for a variety of target platforms based on UML 2.0 behavioral and structural diagrams. The Rational Rhapsody product also provides for the reverse engineering of C code for reuse of your intellectual property within a Model-Driven environment.

Note

Before you can work through any of the lessons in this tutorial, you must create the Stopwatch project, which is detailed in [Setting Up for the C Tutorial](#). After which, you should work through the tutorial in the order of the lessons.

Rational Rhapsody in C Tutorial Overview

This tutorial teaches you the basics of using Rational Rhapsody in C by building a stopwatch model. It provides step-by-step instructions on using the main features of the Rational Rhapsody product to analyze, design, and build a model of a stopwatch using a file-based modeling approach.

C Tutorial Objectives


When you have completed this tutorial, you will have performed the following standard tasks:

- ◆ Created a Rational Rhapsody project
- ◆ Create a file diagram
- ◆ Create a flow chart
- ◆ Create a statechart
- ◆ Create a message diagram
- ◆ Generated, viewed, located, and edited code

- ◆ Animated the model, including compared message diagrams

Documentation Conventions

This document uses the following conventions:

- ◆ **Boldface** for names of GUI objects and controls, including selection choices; and emphasis. Examples:
 - From the **Type** drop-down list box, select the **FunctionalC** profile.
 - Hold the **Ctrl** key and use the mouse to drag the **Release** configuration in to **Test**.
 - Click the **Dependency** button  on the **Drawing** toolbar.
 - If the Rational Rhapsody browser does not display, select **View > Browser**.
 - A project file, called **<project_name>.rpy**.
- ◆ Courier font in 10 point for pathnames, system messages, and items that you have to type. Examples:
 - These C sample models are in the `<Rational Rhapsody installation>\Samples\CSamples` directory.
 - The Output window displays the message `Animation session terminated`.
 - In the **Project name** box, replace the default project name with `Stopwatch`.
 - Type `show` for the function name, and press **Enter**.
- ◆ *Italics* for the first mention of a concept with an explanation.

About the Rational Rhapsody Product

Rational Rhapsody in C offers a large feature set for developers to employ key enabling technologies in a natural, easy-to-use tool environment. Rational Rhapsody makes a seamless and efficient environment for systems, software, and testability. It enables you to perform these tasks:

- ◆ **Analyze**, during which you can define, analyze, and validate the system requirements.
- ◆ **Design**, during which you can specify and design the architecture.
- ◆ **Implement**, during which you can automatically generate code, and then build and run it within the Rational Rhapsody product.
- ◆ **Model Execution**, during which you can animate the model on the local host or a remote target to perform design-level debugging within animated views.

UML Diagrams

The following are the UML diagrams in the Rational Rhapsody product:

- ◆ **Use Case Diagrams** show the main functions of the system (use cases) and the entities (actors) outside the system.
- ◆ **Structure Diagrams** show the system structure and identify the organizational pieces of the system.
- ◆ **Object Model Diagrams** show the structure of the system in terms of classes, objects, files, and the relationships between these structural elements.
- ◆ **Sequence Diagrams** show sequences of steps and messages passed between structural elements when executing a particular instance of a use case.
- ◆ **Activity Diagrams** specify a flow for classifiers (classes, files, blocks, actors, use cases), objects, and operation/function.
- ◆ **Statecharts** show the behavior of a particular classifier (class, file, actor, use case) or object over its entire life cycle.
- ◆ **Collaboration Diagrams** provide the same information as sequence diagrams, emphasizing structure rather than time.
- ◆ **Component Diagrams** describe the organization of the software units and the dependencies among units.
- ◆ **Deployment Diagrams** show the nodes in the final system architecture and the connections between them.

In addition, Flow Charts are available in the Rational Rhapsody product. You can use a flow chart to describe a function or class operation and for code generation.

Diagrams in the FunctionalC Profile

The FunctionalC profile tailors Rational Rhapsody in C for the C coder, allowing the user to functionally model an application using familiar constructs such as files, functions, call graphs, and flow charts. A Rational Rhapsody profile “hosts” domain-specific tags and stereotypes.

The FunctionalC profile tailors the diagram view for the C developer by providing the following diagrams:

- ◆ **Build Diagrams** to show how the software is to be built.
- ◆ **Call Graph Diagrams** to show the relationship of function calls as well as the relationship of data.
- ◆ **File Diagrams** to show how files interact with one another (typically how the `#include` structure is created).
- ◆ **Flow Charts** to show a function or class operation and for code generation.
- ◆ **Message Diagrams** to show how the files functionality can interact through messaging (synchronous function calls or asynchronous communication).

In addition, you can also create activity diagrams, statecharts, and use case diagrams (as described in [UML Diagrams](#)) when you use the FunctionalC profile.

Note that not all diagrams are used in this tutorial. For more information about the diagram types, refer to the *IBM Rational Rhapsody User Guide*.

Starting the Rational Rhapsody Product

Windows

To start the Rational Rhapsody product in Windows: Select **Start > All Programs > IBM Rational > IBM Rational Rhapsody *version number* > Rhapsody Development Edition > Rhapsody in C**.

Linux

To start the Rational Rhapsody product in Linux, follow these steps:


1. From the Terminal, browse to the Rational Rhapsody home directory.
2. Execute the `RhapsodyInC` script. For example:

```
[RhapsodyUser@MyHostMachine]# cd /home/Rhapsody  
[RhapsodyUser@MyHostMachine Rhapsody]# ./RhapsodyInC
```

In this example, “RhapsodyUser” is the username, “MyHostMachine” is the host machine and “/home/Rhapsody” is the installation directory.

Closing the Rational Rhapsody Product

To exit the Rational Rhapsody product, follow these steps:

1. Save your work.
2. Choose **File > Exit** or click the **Close** button .

Setting Up for the C Tutorial

You must create and set up the Stopwatch project before you can work through this tutorial.

Note

This tutorial assumes that you have installed the compiler necessary to generate code.

Creating the Stopwatch Project


This section describes how to:

- ◆ Create a project
- ◆ Save a project
- ◆ Open the Stopwatch project

Creating a Project

A Rational Rhapsody project includes the UML diagrams, packages, and code generation configurations that define the model and the code generated from it. When you create a new project, Rational Rhapsody creates a directory containing the *project files* in the specified location. The name you choose for your new project is used to name project files and directories, and it appears at the top level of the project hierarchy in the Rational Rhapsody browser. Rational Rhapsody provides several default elements in the new project, including a default package, component, and configuration.

To create a new project, follow these steps:

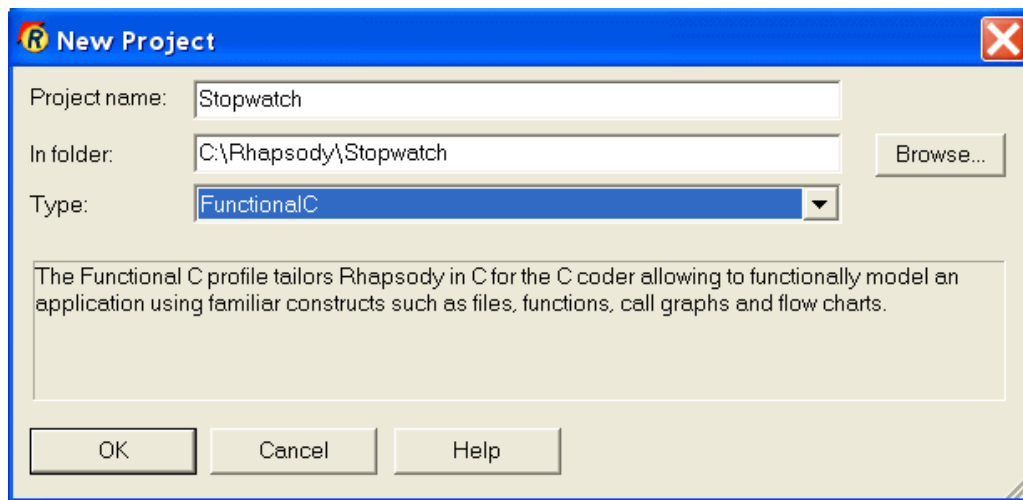
1. Start the Rational Rhapsody product if it is not already running. See [Starting the Rational Rhapsody Product](#), if necessary.
2. Click the **New** button  on the main toolbar or select **File > New** to open the New Project dialog box.
3. In the **Project name** box, replace the default project name (*Project*) with *Stopwatch*.
4. In the **In folder** box, enter a new directory name or browse to find an existing directory.

Note: To avoid potentially long pathnames, do not create the project on the desktop.

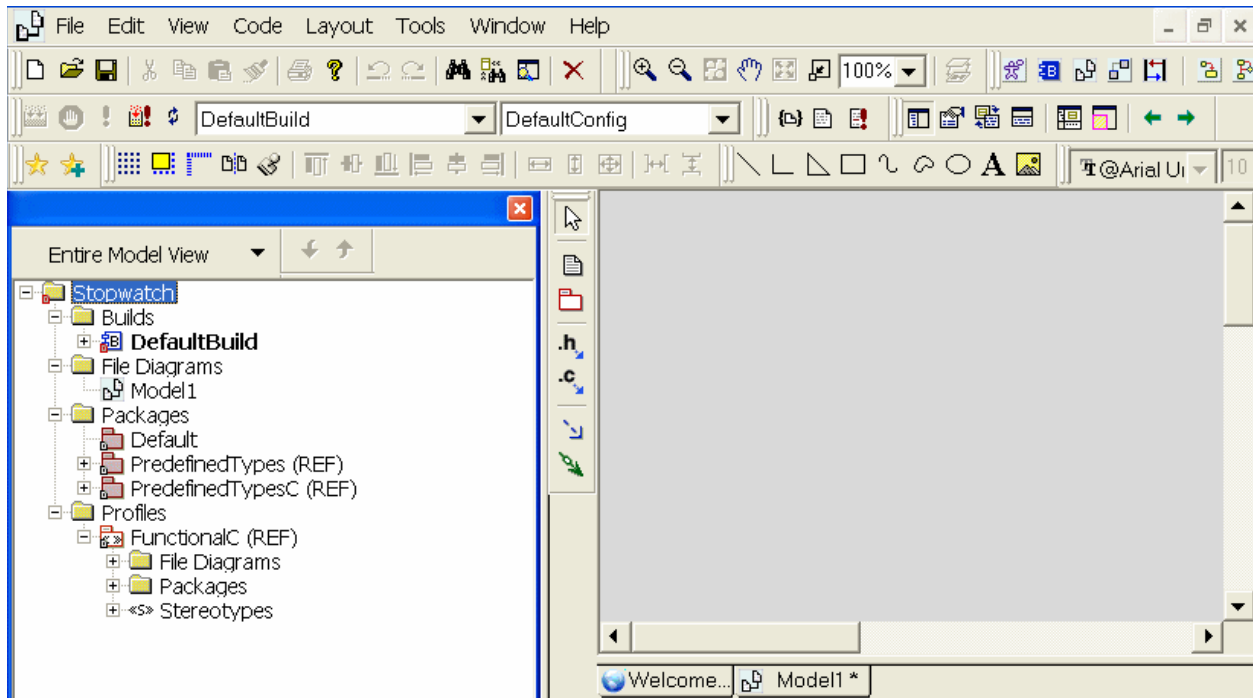
- From the **Type** drop-down list box, select the **FunctionalC** profile.
The **FunctionalC** profile tailors Rational Rhapsody in C for the C coder, allowing the user to functionally model an application using familiar constructs such as files, functions, call graphs, and flow charts.

Note: For a description of the available project profile types that you can select from the **Type** drop-down list, refer to the *IBM Rational Rhapsody User Guide*. (Do a search of the user guide PDF file for “specialized profile.”)

Your dialog box should resemble the following figure.



- Click **OK**. The Rational Rhapsody product verifies that the specified location exists. If it does not, Rational Rhapsody asks whether you want to create it. Click **Yes**. Rational Rhapsody creates a new project in the **Stopwatch** subdirectory, opens the project, and displays the Rational Rhapsody browser in the left pane. Open the folders in the browser to see the starting point for the project, as shown in the following figure.



Note: If the Rational Rhapsody browser does not display, select **View > Browser**.

Managing Projects

This section provides you with more information about the Rational Rhapsody product. It covers how to save and open a project, how to save packages separately (to help you with configuration management and improve project organization), and how to create automatic backups. In addition, it talks about naming conventions and provides you with details about the Rational Rhapsody user interface.


Saving a Project

Use the **Save** command to save the project in its current location. The **Save** command saves only the modified units, reducing the time required to save large projects. In Rational Rhapsody, a *unit* is any element of a project that is saved in a separate file. You can partition your model into units down to the class/file level. Creating units simplifies collaboration in team environments.

To save the project to a new location, use the **Save As** command.

The Rational Rhapsody product performs an autosave every ten minutes to back up changes made between saves. Modified units are saved in the autosave folder, along with any units that have a time stamp older than the project file.

You might want to save your project more frequently. To save the project in the current location, use one of the following methods:

- ◆ Click the **Save** button  on the main toolbar, or
- ◆ Select **File > Save**.

Note

You can set a property to create backups of your model every time you save your project. This gives you the opportunity to revert to a previously saved version if you encounter a problem. By default, Rational Rhapsody does not create backups. For more information about creating backups, see [Creating Backups](#). You can also refer to the *IBM Rational Rhapsody User Guide*.

About Project Files and Directories

The Rational Rhapsody product creates the following files and subdirectories in the project directory:

- ◆ A project file, called **<project_name>.rpy**
- ◆ A repository directory, called **<project_name>_rpy**, which contains the unit files for the project, including UML diagrams, packages, and code generation configurations
- ◆ An event history file, called **<project_name>.ehl**, which contains a record of events injected during animation, and active and nonactive breakpoints
- ◆ Log files, which record when projects were loaded and saved in the product
- ◆ A **.vba** file, called **<project_name>.vba**, which contains macros or wizards
- ◆ Backup project files and directories
- ◆ An **_RTC** directory, which holds any tests created using the TestConductor™ add-on


Note

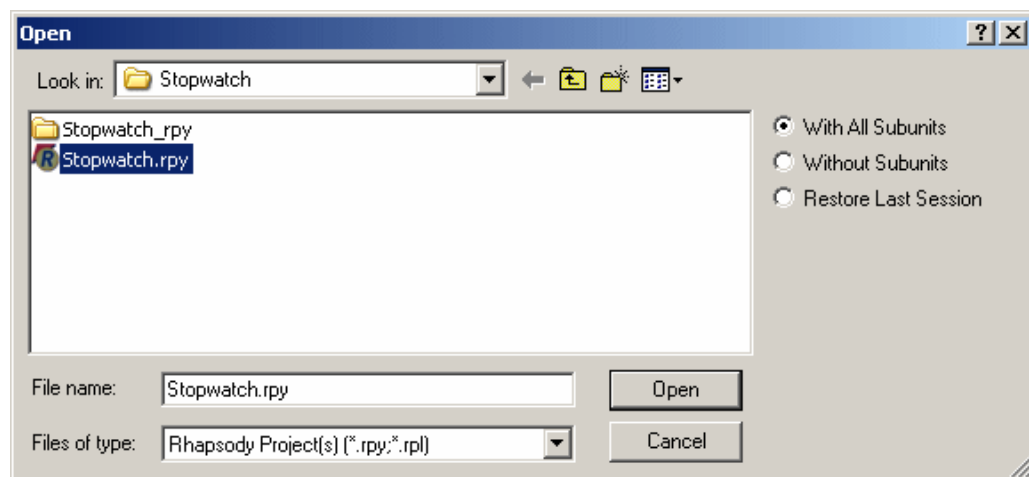
To be able to generate source code and to simulate the model, Rational Rhapsody requires the presence of the project file (**<project_name>.rpy**) and the repository directory (**<project_name>_rpy**).

Opening a Project

Once you have created a Rational Rhapsody project, you can open and work on it at any time.

To open a project, follow these steps:

1. Start Rational Rhapsody if it is not already running.
2. Click the **Open** button  on the main toolbar or select **File > Open** to open the Open dialog box.
3. Navigate to the location in which you saved the project.
4. Select the project file, which has an extension of `.rpy` (for example, **Stopwatch.rpy**), or type the name of the project file in the **File name** box, as shown in the following figure.



5. Accept the default option, **With All Subunits**.

Refer to the *IBM Rational Rhapsody Team Collaboration Guide* for information about the other options.

6. Click **Open**. Rational Rhapsody opens the selected project.

Saving Packages Separately

To assist with configuration management and improve project organization, you might want to store packages in separate subdirectories within a parent folder. Rational Rhapsody has two directory schemes: flat and hierarchical.

- ◆ In *flat* mode, all package files are stored in the project directory, regardless of their location in the project hierarchy.
- ◆ In *hierarchical* mode, a package is stored in a subdirectory one level below its parent. It is possible to have a hybrid project, where some packages are stored in flat mode, and others are organized in a hierarchy of folders.

To change the directory scheme so new packages are stored in separate directories by default, follow these steps:

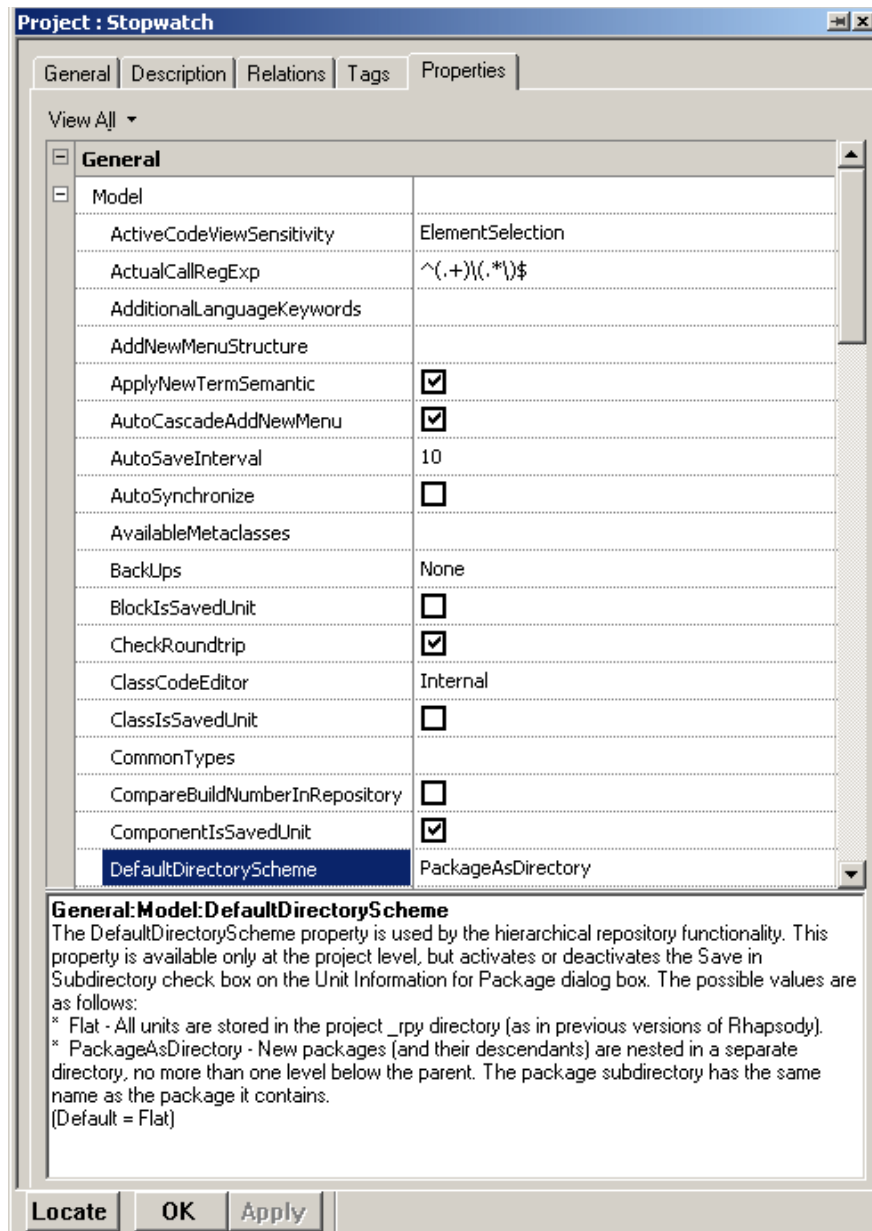
1. Right-click the project name in the Rational Rhapsody browser (for example, **Stopwatch**) and select **Features** to open the Features dialog box.
2. On the **Properties** tab, click the drop-down arrow and select **All**. (The label appears as **View All** after you make the selection.)

Note: The **Properties** tab lists the properties associated with an element. The **Properties** tab of the Features dialog box includes a Help pane below the list of properties. This pane displays help text for the selected property. Help is displayed for each of the levels: subject, metaclass, property (for example, **General, Model, DefaultDirectoryScheme**). For an example of this pane, see the figure shown in step 4.

3. Expand the **General** subject and then expand the **Model** metaclass.

Note: Rational Rhapsody descriptions use a notation method with double colons to identify the location of a specific property, for example,
`General::Model::DefaultDirectoryScheme`.

4. Locate the **DefaultDirectoryScheme** property and use the drop-down menu to change the default value of **Flat** to **PackageAsDirectory**, as shown in the following figure.

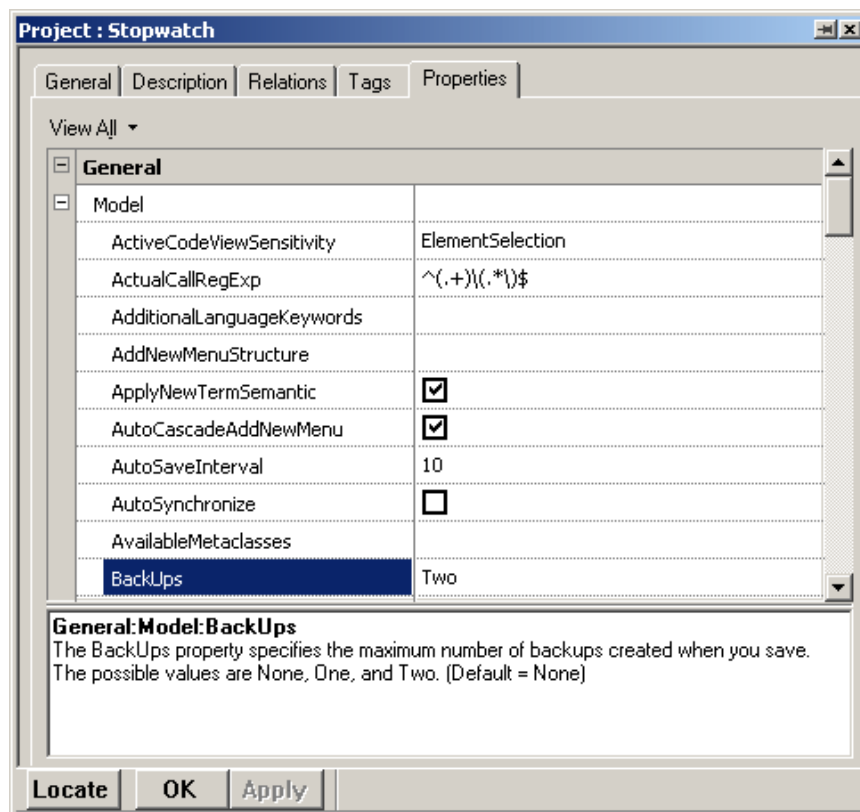


5. Click **OK**.

Creating Backups

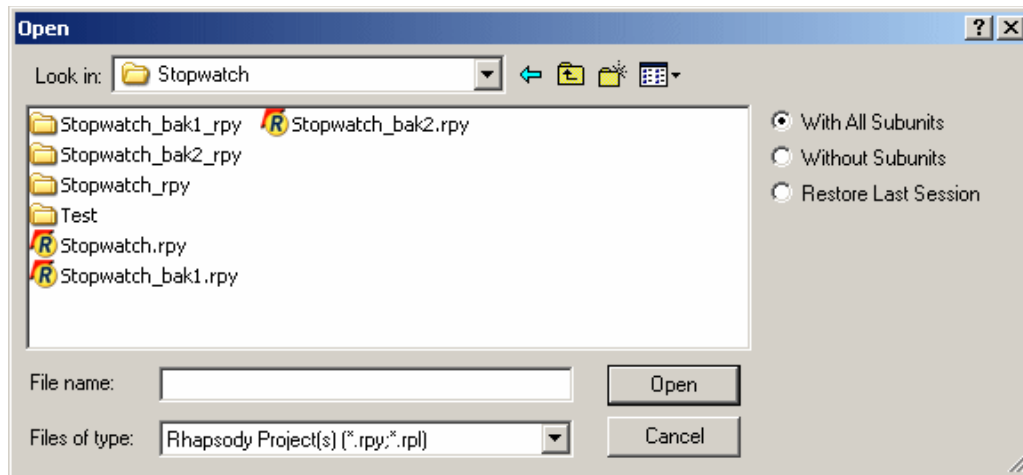
To set up automatic backups for your project, follow these steps:

1. Right-click the project name in the Rational Rhapsody browser (for example, **Stopwatch**) and select **Features** to open the Features dialog box.
2. On the **Properties** tab, click the drop-down arrow and select **All**.
3. Expand the **General** subject, and then the **Model** metaclass.
4. Locate the **BackUps** property and use the drop-down menu to change the default value of **None** to **Two**, as shown in the following figure. With the **Two** setting, Rational Rhapsody creates up to two backups of every project in the project directory.



5. Click **OK**.

After this change, saving a project more than once creates **<projectname>_bak2.rpy**, which contains the most recent backup and **<projectname>_bak1.rpy**, which is the previous backup, as shown in the following figure.



To restore an earlier version of a project, you can open either of these backup files.

Naming Conventions and Guidelines

To assist all members of your team in understanding the purpose of individual items in the model, it is a good idea to define naming conventions. These conventions help team members to read the diagram quickly and remember the model element names easily.

Note

Remember that the names used in the Rational Rhapsody models are going to be automatically written into the generated code. Therefore, the names should be simple and clearly label all of the elements.

Standard Prefixes

Lower and upper case prefixes are useful for model elements. The following is a list of common prefixes with examples of each:

- ◆ Event names = “ev” (evStart)
- ◆ Trigger operations = “op” (opPress)
- ◆ Condition operations = “is” (isPressed)
- ◆ Interface classes = “I” (IHardware)

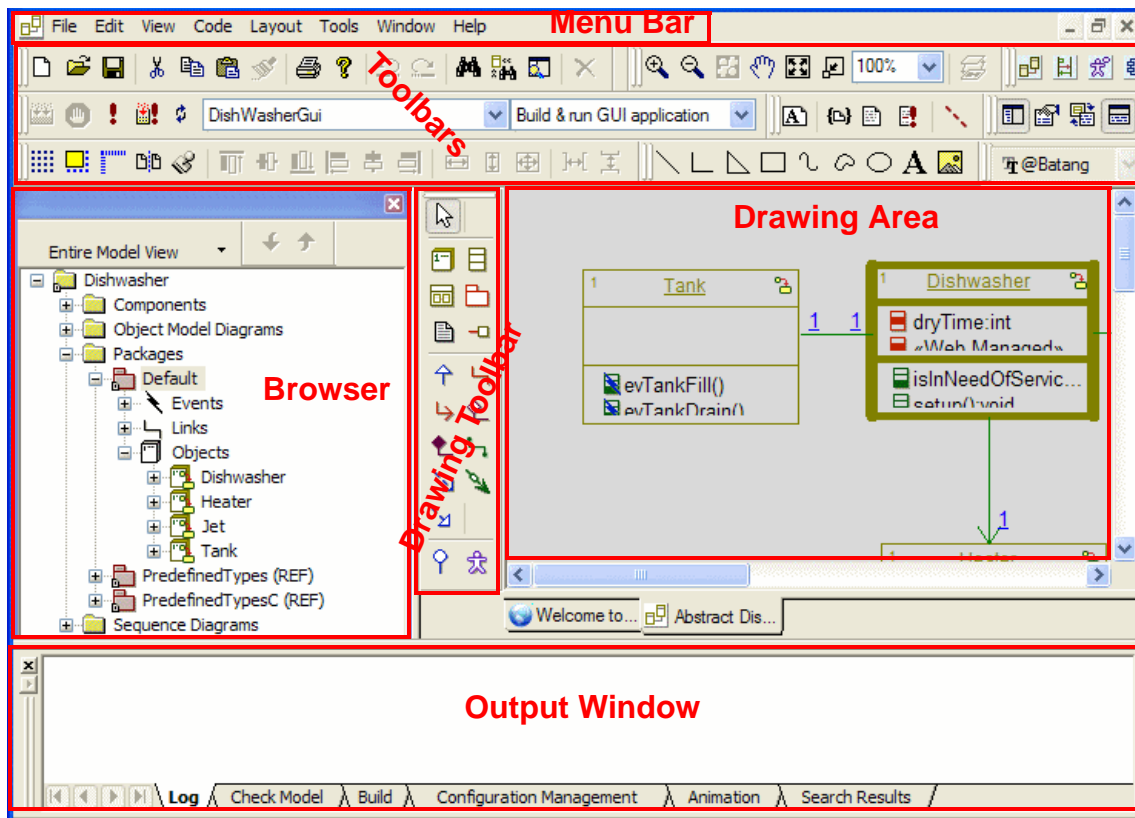
Guidelines for Naming Model Elements

The names of the model elements should follow these guidelines:

- ◆ Class names begin with an upper case letter, such as “System.”
- ◆ Operations and attributes begin with lower case letters, such as “restartSystem.”
- ◆ Upper case letters separate concatenated words, such as “checkStatus.”
- ◆ The same name should not be used for different elements in the model because it will cause code generation problems. For example, no two elements, such as a class, an interface, and a package, should not have exactly the same name.

Rational Rhapsody User Interface

Before proceeding with this tutorial, you should become familiar with the main features of the Rational Rhapsody graphical user interface (GUI). The Rational Rhapsody GUI is made up of three key window panes (browser, drawing area, and output window) and many toolbars at the top of the interface and for each of the diagram types (drawing toolbars). The following figure shows a view of the Rational Rhapsody GUI.



Toolbars

The Rational Rhapsody toolbars provide quick access to the commonly used commands. These commands are also available from the menus. The Rational Rhapsody product has the following toolbars:

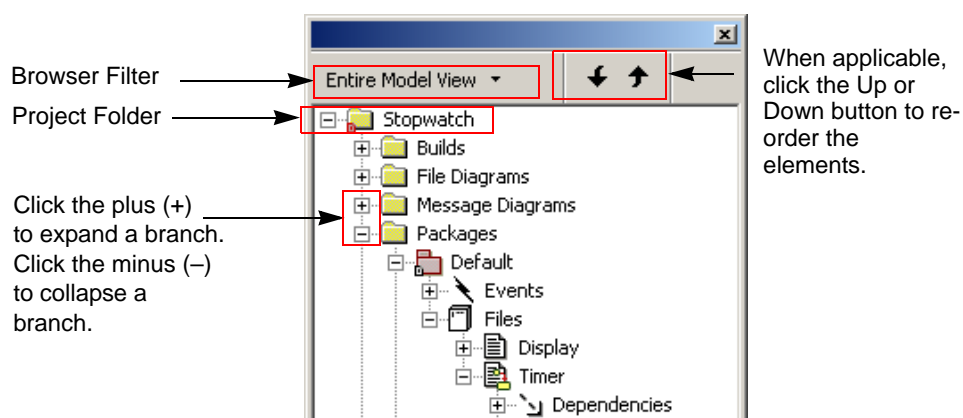
- ◆ **Standard** has buttons for the frequently used options on the File, Edit, and Help menus. Examples: **New, Open, Save; Copy, Paste, Locate in Browser; About.**
- ◆ **Code** has buttons for the frequently used options on the Code menu, such as **Make, Run executable** and **G/M/R** (for **Generate/Make/Run**).
- ◆ **Windows** has buttons for the frequently used options on the View menu, such as **Show/Hide Browser** and **Show/Hide output window.**
- ◆ **Diagrams** has buttons for the part of the Tools menu that give you quick access to the diagrams in the project, such as **Use Case Diagram** and **Open Statechart.**
- ◆ **VBA** provides access to the VBA options, such as **VBA Editor** and **Show Macros Dialog.** Note that VBA is for Windows only.
- ◆ **Animation** has buttons for the animation options during an animation session, such as **Go, Animation Break,** and **Quit Animation.**
- ◆ **Layout** has buttons that help you with the layout of elements in your diagram, such as **Snap to Grid, Align Top,** and **Align Left.**
- ◆ **Drawing** has buttons for the graphics editor used to create and edit diagrams. Each **Drawing** toolbar is unique to its particular diagram type. For example, the **Drawing** toolbar for a file diagram is different from that for a statechart.
- ◆ **Common Drawing** has buttons to add requirements, comments, and other annotations to any diagram, such as **Note** and **Requirement.**
- ◆ **Free Shapes** has buttons for basic drawing shapes, such as **Polyline** and **Polycurve.**
- ◆ **Zoom** has buttons to zoom options, such as **Zoom In, Zoom Out,** and **Pan.**
- ◆ **Format** has buttons for various text formatting options and line/fill options, such as **Italic** and **Font Color.**

You can use the **View > Toolbars** menu to make a toolbar appear or not appear in the Toolbars area. Refer to the *IBM Rational Rhapsody User Guide* for detailed information about the toolbars.

Browser

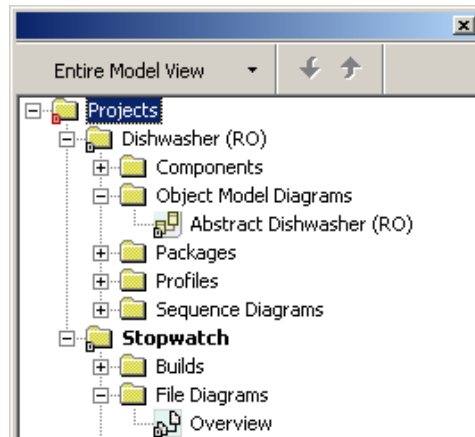
The Rational Rhapsody browser shows the contents of the project in an expandable tree structure. By default, it is the upper, left-hand part of the Rational Rhapsody GUI. The top-level folder, which contains the name of the project, is the *project folder* or *project node*. Although this folder contains no elements, the folders that reside under it contain elements that have similar characteristics. These folders are referred to as *categories*.

A project consists of at least one package in the **Packages** category. A package contains UML elements, such as classes, files, and diagrams. Rational Rhapsody automatically creates a default package called **Default**, which it uses to save model parts unless you specify a different package. The following figure shows an example of the browser.



Note

Rational Rhapsody allows you to have more than one project open at a time. When this is the case, the top-level folder is called **Projects** and all project folders reside under it, as shown in the following figure. For more information about working with multiple projects, refer to the *IBM Rational Rhapsody User Guide*.



Filtering the Browser

The browser filter lets you display only the elements relevant to your current task.

To filter the Rational Rhapsody browser, click the drop-down arrow at the top of the browser window, and select the view you want to see from the menu. Refer to the *IBM Rational Rhapsody User Guide* for information on the view options.

Re-ordering the Browser Elements

With Rational Rhapsody version 7.0, you can re-order the elements in the Rational Rhapsody browser. Choose **View > Browser Display Options > Enable Ordering** to activate the **Up** and **Down** buttons for the browser. Once activated, select an element in

the browser and then click the appropriate **Up** or **Down** button .

Moving the Browser

To make more room, you can move the browser out of the Rational Rhapsody GUI as a separate window.

To move the Rational Rhapsody browser, click-and-drag it to another location.

Drawing Toolbars

The Rational Rhapsody product displays a separate **Drawing** toolbar for each UML diagram type. By default, it places the **Drawing** toolbar to the left of the diagram.

To move the toolbar, click and drag it to another location. To make the **Drawing** toolbar appear or not appear, choose **View > Toolbars > Drawing**.

Drawing Area

The drawing area displays the graphic editors and code editors, and it is the region for drawing diagrams. By default, it is the upper, right-hand section of the Rational Rhapsody GUI. Rational Rhapsody displays each diagram with a tab that includes the name of the diagram and an icon that denotes the diagram type. When you make changes to a diagram, Rational Rhapsody displays an asterisk next to the diagram name on the tab and after the name of the diagram in the title bar to indicate that you must save your changes.

Output Window

The Output window displays Rational Rhapsody messages. By default, it is the lower section of the Rational Rhapsody GUI. It includes tabs that display the following types of messages:

- ◆ Log
- ◆ Check Model
- ◆ Build
- ◆ Configuration Management
- ◆ Animation
- ◆ Search Results

Typically, the Output window appears when you generate code and run animation. If the Output window does not appear, choose **View > Output Window**.

Features Dialog Box

The Features dialog box lets you view and edit the features of an element in the Rational Rhapsody product.

To open the Features dialog box, do one of the following in the Rational Rhapsody browser or a diagram:

- ◆ Double-click an element (for example, **mins** [a variable]), or
- ◆ Right-click an element (for example, **Execution** [a diagram]) and then select **Features**, or
- ◆ Select an element and press **Alt + Enter**, or
- ◆ Select an element and select **View > Features**

You can resize the Features dialog box and hide the tabs on this dialog box if you want. For more information about using the Features dialog box, refer to the *IBM Rational Rhapsody User Guide*

Note

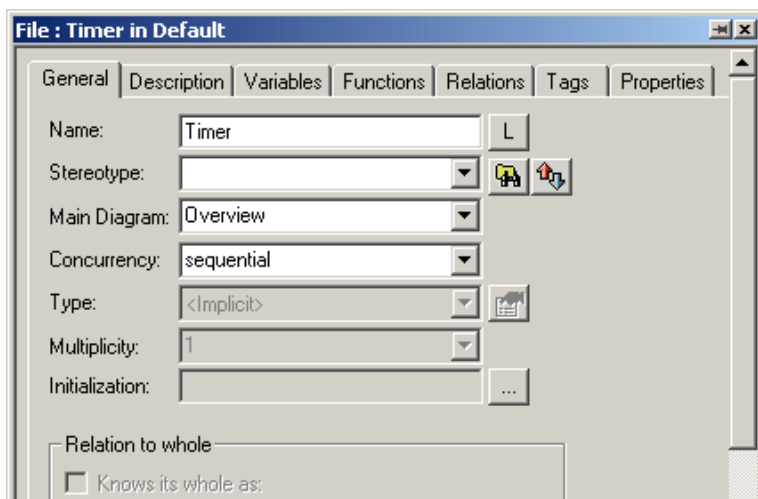
Once you open the Features dialog box, you can leave it open and select other elements to view their features. You must save your model to save all the changes you might have made.

Tabs for the Features Dialog Box

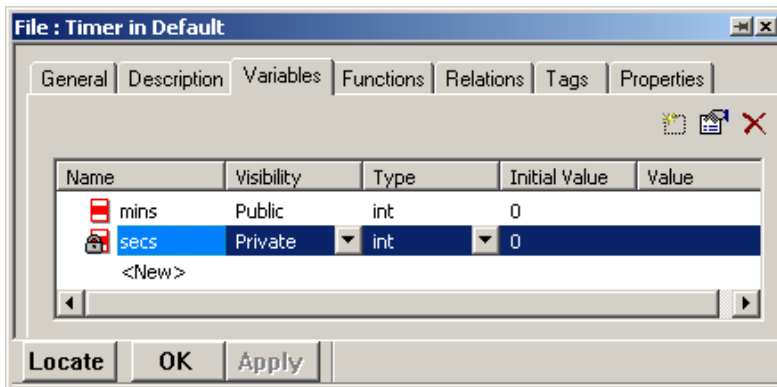
The Features dialog box has different tabs at the top of the dialog box and different boxes on the tabs depending on the element type.

The following tabs are ones used most often in this tutorial. For more information about these tabs, as well as the other tabs that you might see in a Features dialog box, refer to the *IBM Rational Rhapsody User Guide*.

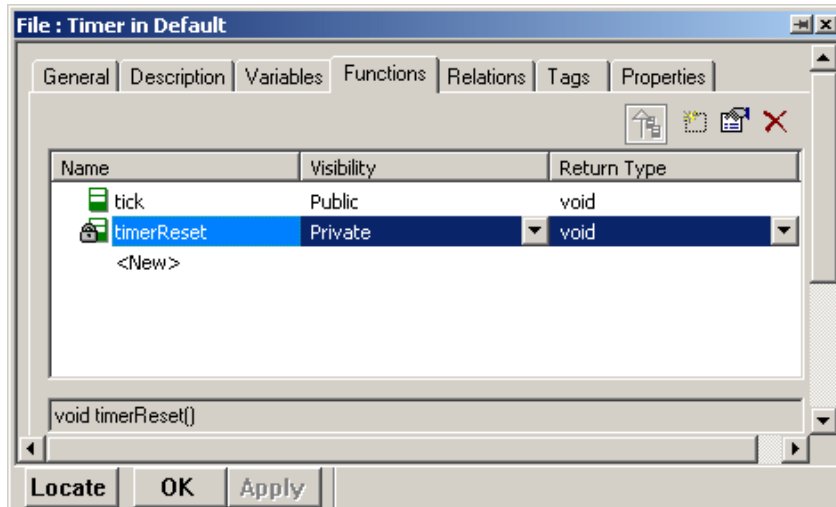
- ◆ **General** typically contains the name of the element and other general options, as shown in the following figure.



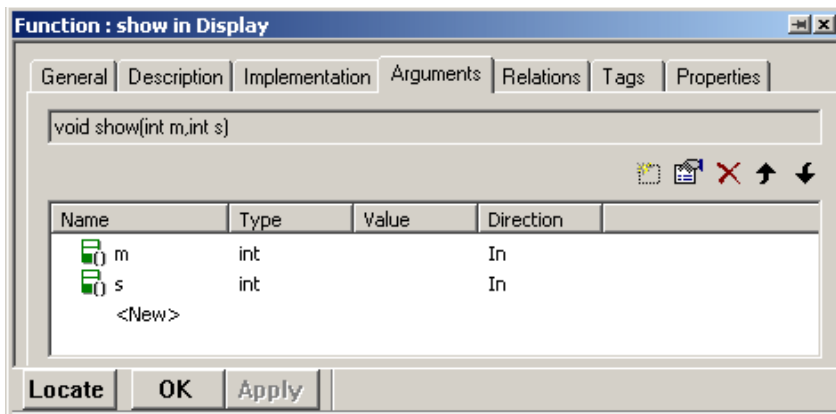
- ◆ **Variables** lets you add, edit, or remove variables from the file. This tab contains a list of all the variables belonging to the file, as shown in the following figure.



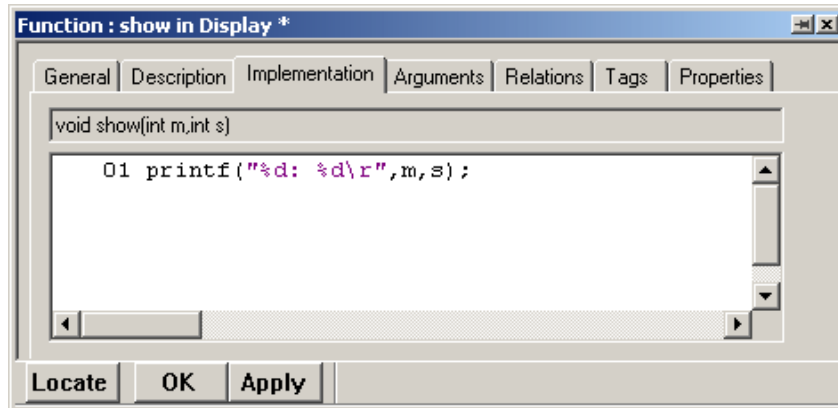
- ◆ **Functions** lets you add, edit, or remove functions from the file. This tab contains a list of all the functions defined in the file, as shown in the following figure.



- ◆ **Arguments** lets you add, edit, or remove arguments from the file. It contains a list of all the arguments defined in the file, as shown in the following figure.



- ◆ **Implementation** lets you add code for the file. You can also edit or remove any previously entered code from the file, as shown in the following figure.



- ◆ **Properties** lists the properties associated with the element. The **Properties** tab of the Features dialog box includes a Help pane below the list of properties. This pane displays help text for the selected property. Help is displayed for each of the levels: subject, metaclass, property. For an example of this tab, see [Saving Packages Separately](#), Step 4.

Moving the Features Dialog Box

The Features dialog box is a floating window that can be positioned anywhere on the screen, or docked to the Rational Rhapsody GUI.

To dock the Features dialog box in the Rational Rhapsody window, do one of the following:

- ◆ Double-click the title bar. The dialog box docks. You can now drag it to another location if you want.
- or
- ◆ Right-click the title bar and select **Docking by Drag** and then drag the dialog box to another location.

To undock the Features dialog box, do one of the following:

- ◆ Double-click the title bar to undock it, or
- ◆ Right-click the title bar and clear **Docking by Drag** and then drag the dialog box to another location.

Summary

In this section, you became familiar with the Rational Rhapsody product and its features. You learned how to do the following:

- ◆ Start and close the Rational Rhapsody product
- ◆ Set up for the tutorial by creating the Stopwatch project
- ◆ Learned about the Rational Rhapsody GUI

You are now ready to proceed to the next sections, where you are going to create a file diagram.

Note that for ease of presentation, this guide organizes the sections by diagram type and general workflow. However, when modeling systems, diagrams are often created in parallel or might require elements in one diagram to be planned or designed before another diagram can be finalized. For example, you might identify the communication scenarios using sequence diagrams before defining the flows, flow items, and port contracts in the structure diagrams. In addition, you might perform black-box analysis using activity diagrams, sequence diagrams, and statecharts; and white-box analysis using sequence diagrams before decomposing the system's functions into subsystem components.

When you do *black-box analysis*, such as when you do a black-box sequence diagram, you are showing the sequence of messages between external actors and the system as a whole. When you do *white-box analysis*, such as when you do a white-box sequence diagram, you are showing messages to and from the internal individual parts.

Lesson 1: Creating File Diagrams

File diagrams show how files interact with one another. Typically, file diagrams show how the `#include` structure is created. File diagrams provide a graphical representation of the system structure. The Rational Rhapsody code generator directly translates the elements and relationships modeled in file diagrams into C source code.

Note

Before you can work through any of the lessons in this tutorial, you must create the Stopwatch project, which is detailed in [Setting Up for the C Tutorial](#). In addition, you should work through the tutorial in the order of the lessons.

Goals for this Lesson

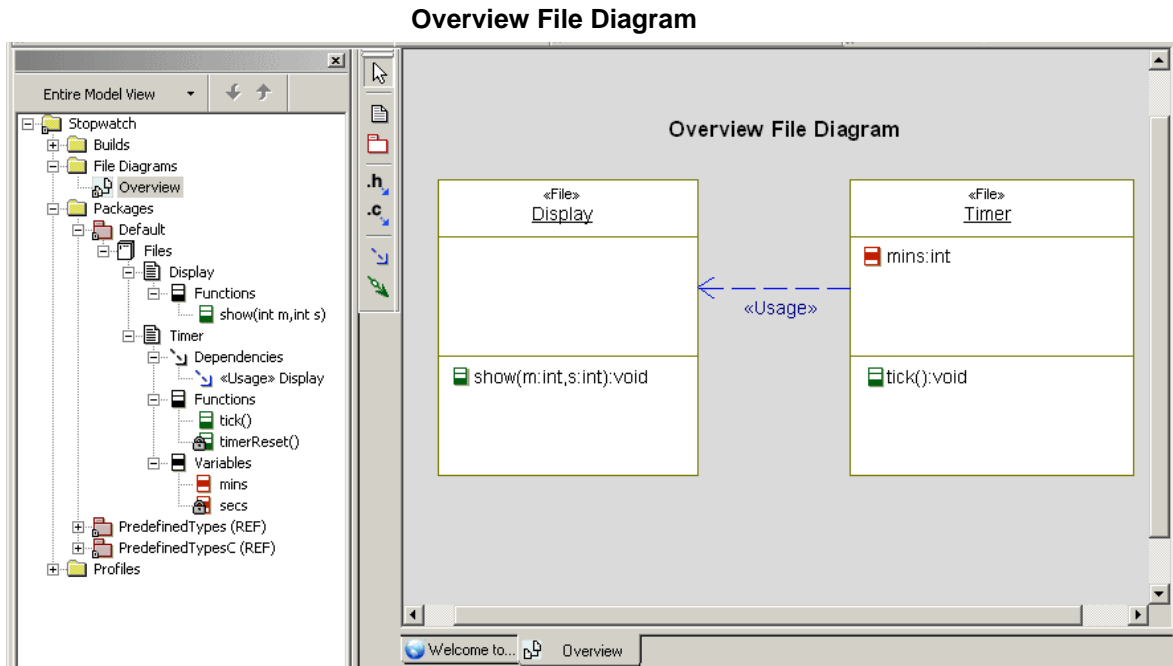
In this lesson, you create a file diagram called Overview. You learn about the following elements for a file diagram:

- ◆ Files
- ◆ Functions
- ◆ Variables
- ◆ Dependencies
- ◆ Arguments

Exercise 1: Creating the File Diagram

The elements in a file diagram provide an overview of the system. A file diagram shows the types of files in the system, the attributes/variables and operations/functions that belong to those files, and the static relationships that can exist between classes (types).

The following diagram shows the Overview file diagram that you create in this exercise.



Task 1a: Creating the File Diagram

You draw a file diagram using the following general steps:

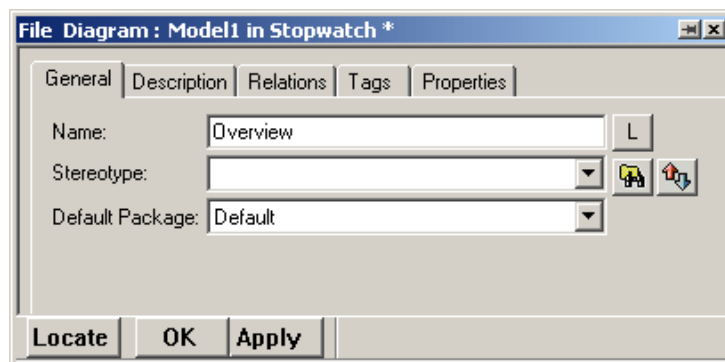
1. Draw files
2. Add functions, variables, and dependencies
3. Add implementation code

The following tasks describe each of these steps in detail.

By default, when you created the Stopwatch project, the Rational Rhapsody product added the **File Diagrams** category and created a file diagram named **Model1**. In this task, you rename the diagram as *Overview*.

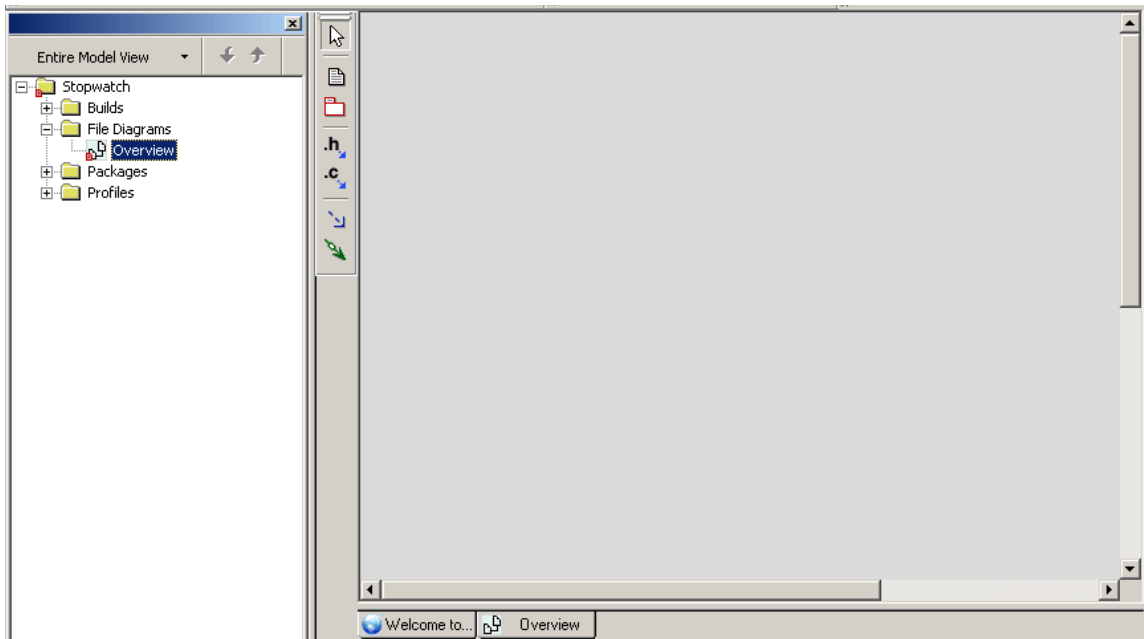
To rename a file diagram, follow these steps:

1. Start Rational Rhapsody and open the stopwatch model if they are not already open.
2. In the Rational Rhapsody browser, expand **File Diagrams**.
3. Right-click **Model1** and select **Features** to open the Features dialog box.
4. On the General tab, in the **Name** box, replace the default name with *Overview*, as shown in the following figure.



5. Click **OK**.

Notice the name change for the diagram in the browser and on the diagram tab, as shown in the following figure.



6. Click the **Save** button  to save your work.

Note


To create a new file diagram, right-click the **File Diagrams** category in the Rational Rhapsody browser and then select **Add New File Diagram**. You can also create a file diagram using the Tools menu or the **Diagrams** toolbar. Refer to the *IBM Rational Rhapsody User Guide* for more information about creating diagrams.

Task 1b: Drawing Files

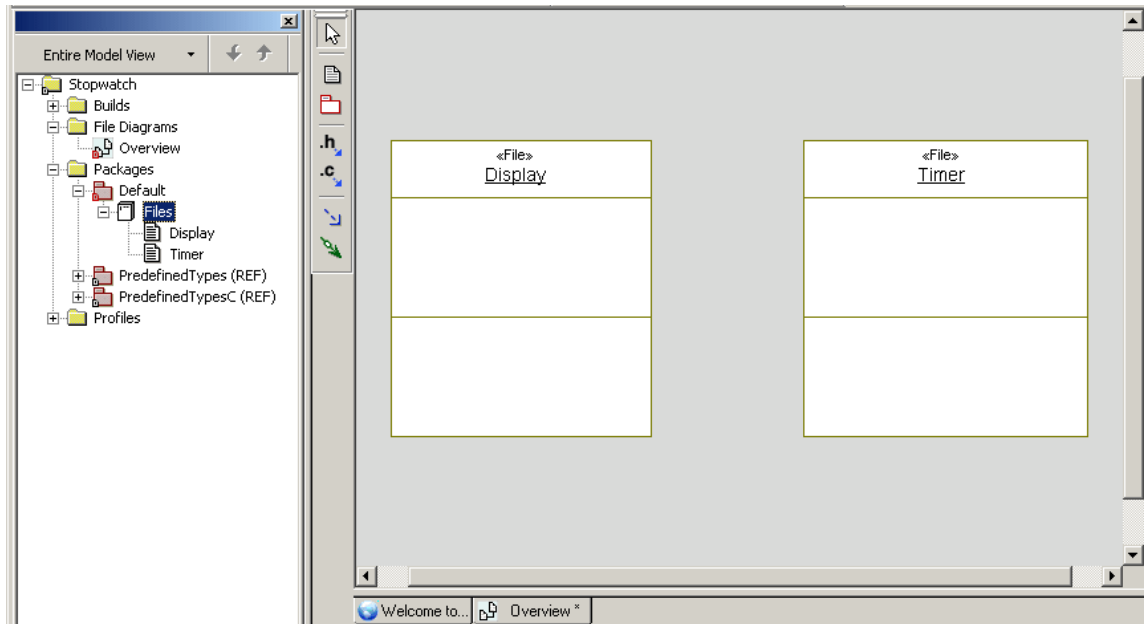
In this task, you draw files for your Overview file diagram. The stopwatch model must have a display to show the time and a timer to perform its function as a stopwatch. You add these elements as files on your file diagram. A file is a graphical representation of a specification (.h) or implementation (.c) source file. For more information about files, refer to the *IBM Rational Rhapsody User Guide*.

Use the [Overview File Diagram](#) figure as a reference

To add a file, follow these steps:

1. Select the **File** button  on the **Drawing** toolbar.
2. On the Drawing area, click and drag the pointer to create a rectangle.
3. Type `Display` and then press **Enter**.
4. Repeat the above steps, but this time name the file `Timer`.

5. Expand the **Packages** category in the browser, then **Default**, and then **Files**. Notice that the **Display** and **Timer** files also appear in the Rational Rhapsody browser, as shown the following figure.

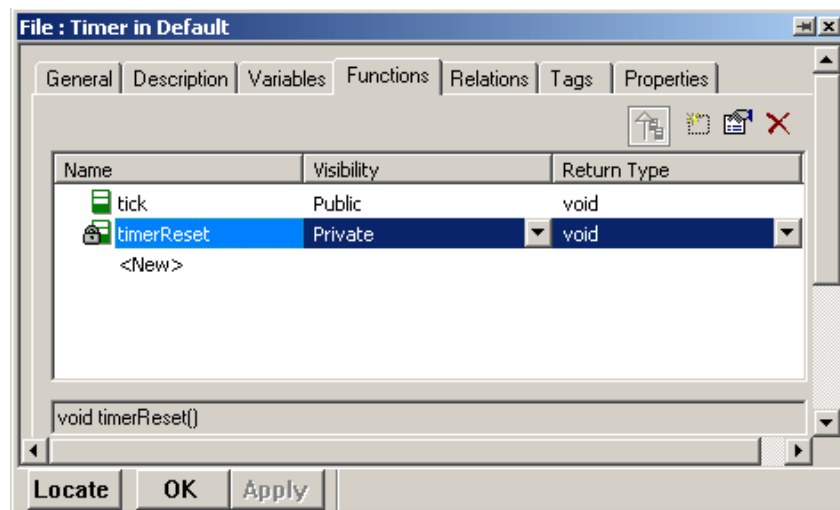


Task 1c: Adding Functions for Timer

In this task, you add a `tick` function to the **Timer** file for your Overview file diagram. Use the [Overview File Diagram](#) figure as a reference.

To add a function, follow these steps:

1. Double-click the **Timer** file in the Rational Rhapsody browser or on the drawing area to open the Features dialog box.
2. On the **Functions** tab, click **<New>** and select **Function**.
3. Type `tick` as the name of this function and then press **Enter**.
4. Repeat the above steps to create a function named `timerReset`, and select **Private** from the **Visibility** drop-down list box and then click **Apply**. Because the visibility is set to **Private**, a lock symbol appears for **timerReset**, as shown in the following figure.



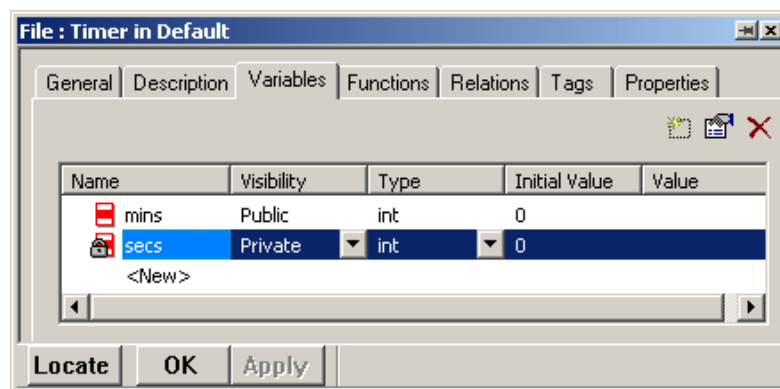
5. Click **OK**.

Task 1d: Adding Variables for Timer

In this task, you add variables to the **Timer** file for your Overview file diagram. To control the timer, you need variables. A *variable* is a storage place within a file for a data element. The data element can be a data type such as a date or number, or a reference to another file. Use the [Overview File Diagram](#) figure as a reference.

To add variables, follow these steps:

1. Double-click the **Timer** file in the browser or on the drawing area to open the Features dialog box.
2. On the **Variables** tab, click **<New>** and for the first variable, make these settings in the following columns and then press **Enter**:
 - a. **Name:** Type `mins`
 - b. **Type:** Select **int** from the drop-down list box if not already set to this choice
 - c. **Initial Value:** Type `0` (zero)
3. Click **<New>** again and create a second variable with these settings:
 - a. **Name:** Type `secs`
 - b. **Visibility:** Select **Private** from the drop-down list box
 - c. **Type:** Select **int** if not already set to this choice
 - d. **Initial Value:** Type `0` (zero)
4. Click **Apply**. Because the `secs` variable has its visibility set to **Private**, a lock symbol appears for `secs`, as shown in the following figure.




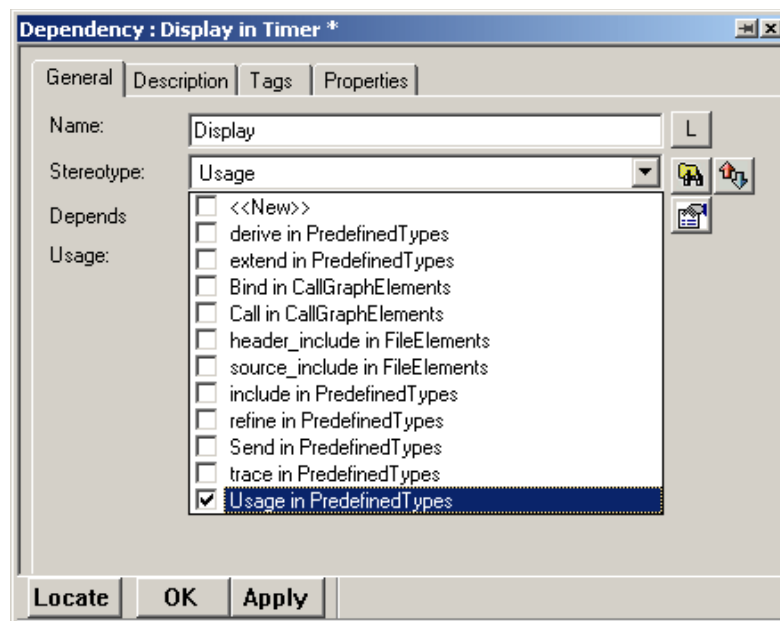
5. Click **OK**.

Task 1e: Adding a Dependency

In this task, you draw a dependency between **Display** and **Timer**. A *dependency* is a direct relationship in which the function of an element requires the presence of and might change another element.

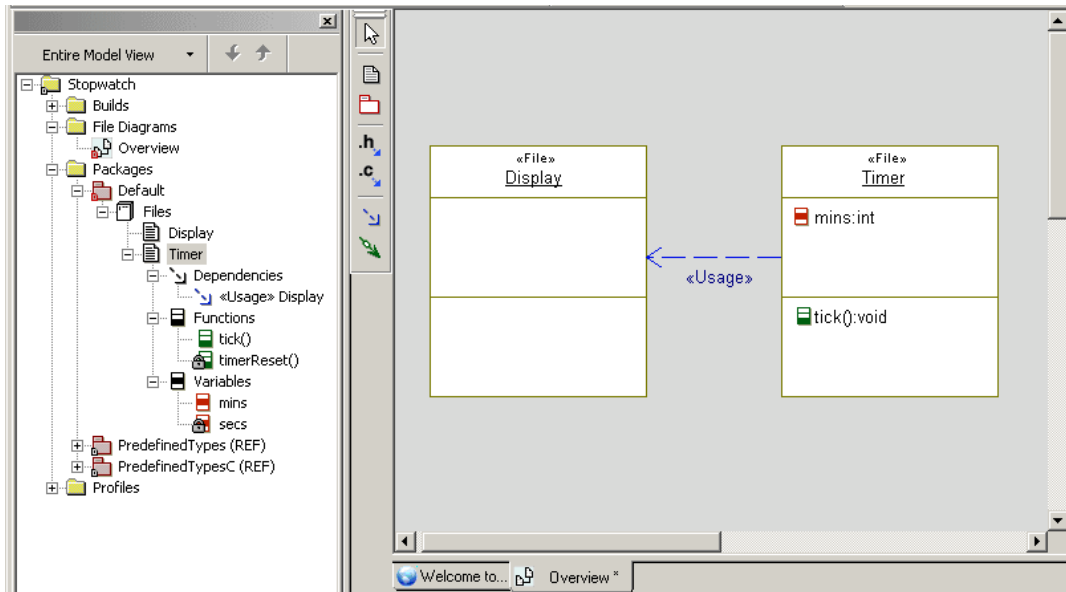
To draw a dependency, follow these steps:

1. Click the **Dependency** button  on the **Drawing** toolbar.
2. Click the left edge of **Timer** in the diagram and then click the right edge of **Display**. The arrowhead of the Dependency line should be pointing at **Display**.
3. Double-click the dependency line to open the Features dialog box.
4. On the General tab, in the **Stereotype** box, select the **Usage in PredefinedTypes** checkbox from the drop-down list box, as shown in the following figure.



5. Click **Apply** and then **OK**. This adds the `display.h` include into `timer.h`.

At this point, your Rational Rhapsody browser and file diagram should resemble the following figure.

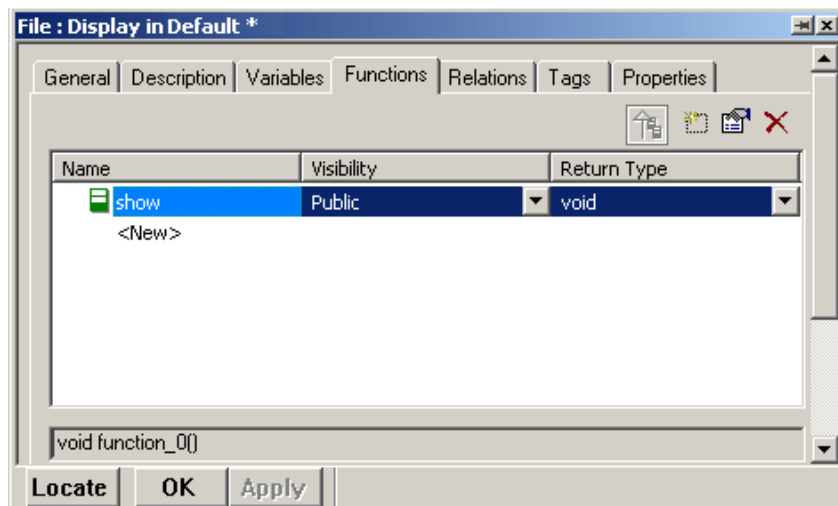


Task 1f: Adding a Function and Arguments for Display

In this task, you add a function with arguments to **Display**. Use the [Overview File Diagram](#) figure as a reference.

To add a function and arguments to **Display**, follow these steps:

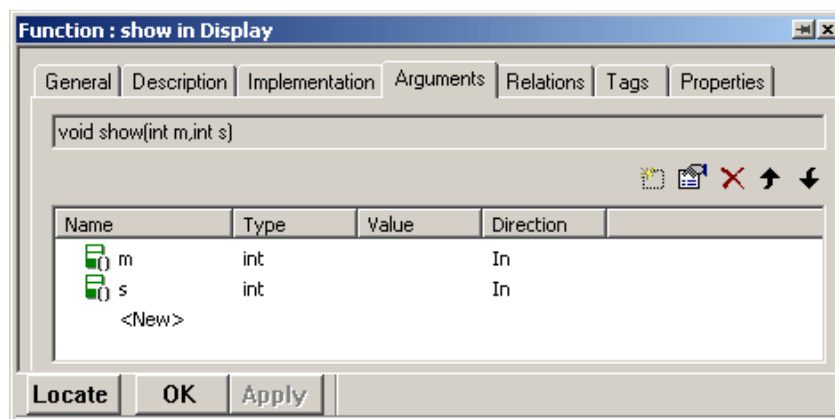
1. Double-click the **Display** file in the Rational Rhapsody browser or on the diagram to open the Features dialog box.
2. On the **Functions** tab, click **<New>** and select **Function**.
3. Type `show` for the function name, as shown in the following figure, and press **Enter**.



4. Click **OK**.
5. In the browser or on the diagram, double-click **show** to open the Features dialog box.

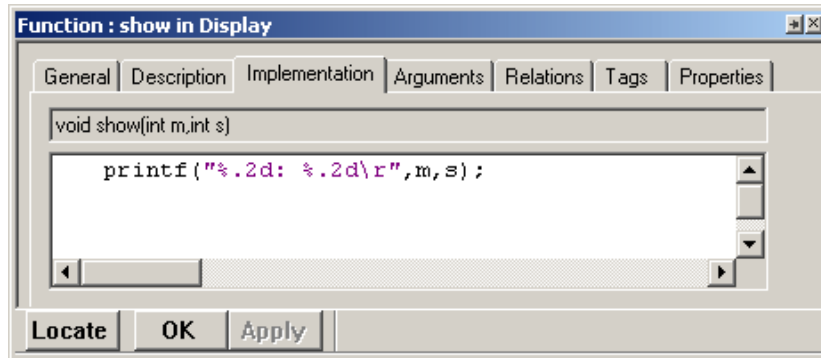
6. On the **Arguments** tab, click **<New>** to create the following argument and then press **Enter**:
 - a. **Name:** m
 - b. **Type:** int
 - c. **Direction:** In
7. Create another argument with these settings:
 - a. **Name:** s
 - b. **Type:** int
 - c. **Direction:** In

Your **Arguments** tab should resemble the following figure.



8. Select the **Implementation** tab and enter this code, as shown in the following figure.

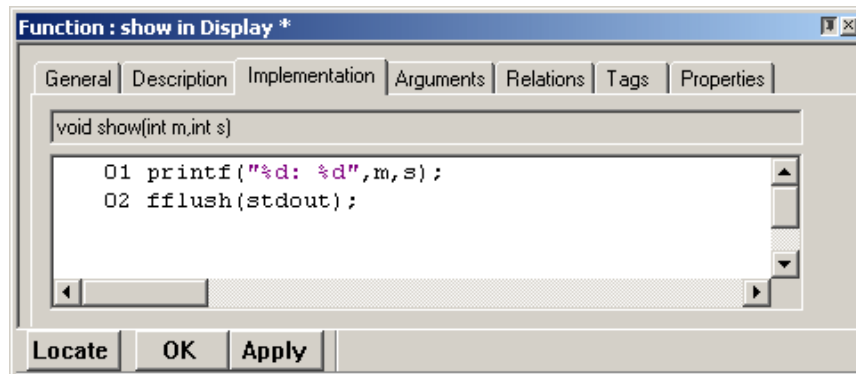
```
printf("%.2d: %.2d\r",m,s);
```



Note that if you are using Linux, you should enter this code, as shown in the following figure.

```
printf("%.2d: %.2d\r",m,s);  
fflush(stdout);
```

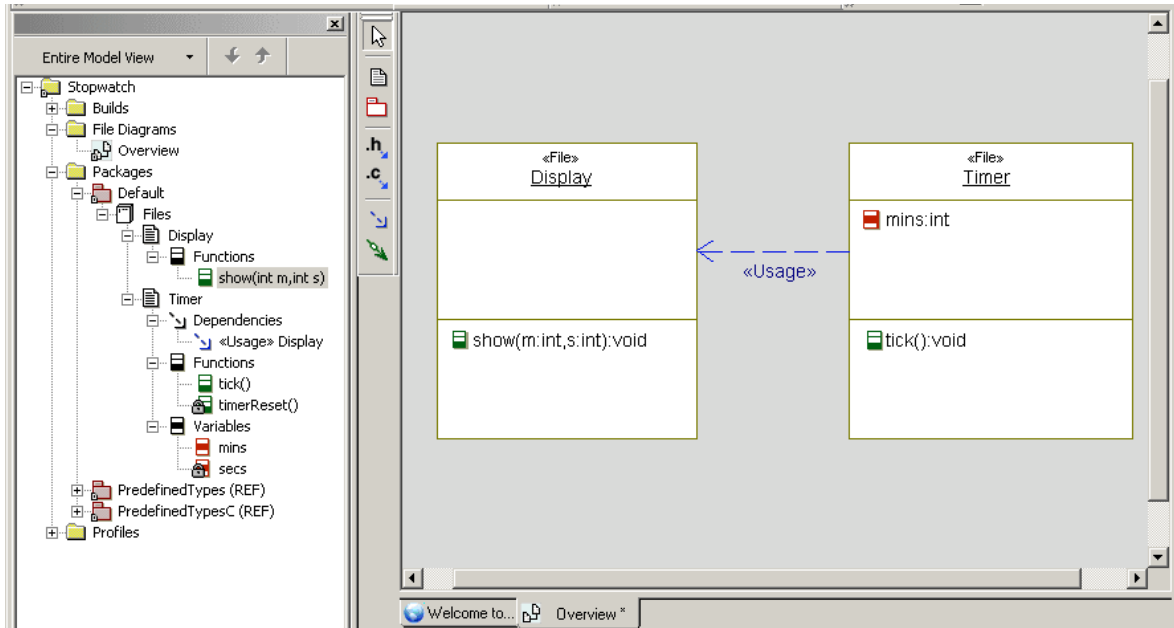
Note: The `fflush(stdout)` code resolves a buffering issue in Linux so that the time updates on your screen correctly.



Note: If you have Line Numbering turned on, each line of code will have a number preceding it, as shown in the above figure.

9. Click **OK**.

At this point, your browser and file diagram should resemble the following figure.



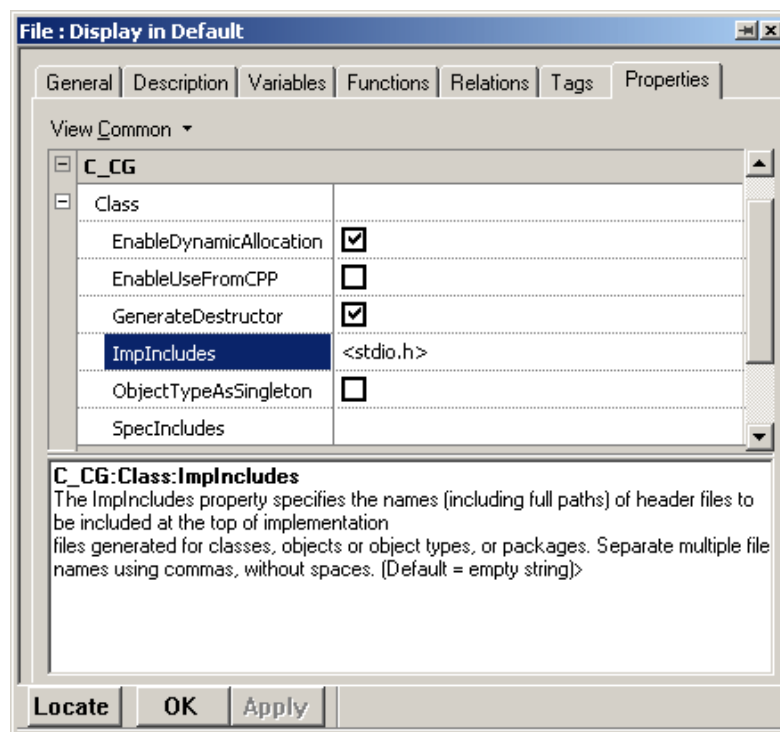
Task 1g: Adding an Include File for Display

In the previous task, you added implementation code for the **Display** file that uses `printf()`. To complete the implementation, you must add the `<stdio.h>` include file to **Display**. Follow these steps:

1. In the Rational Rhapsody browser or the file diagram, double-click the **Display** file to open the Features dialog box.
2. On the **Properties** tab, click the drop-down arrow and select **Common** to list only the common properties.
3. Expand the **C_CG** subject, then expand the **Class** metaclass, and then select the **ImpIncludes** property.

The **ImpIncludes** property defines the Implementation include files. The **C_CG** subject means C Code Generation.

4. Enter `<stdio.h>`, as shown in the following figure.




5. Click **OK**.

Task 1h: Adding a Diagram Title

Each diagram has its name in the diagram table and in the title bar of the window that displays the diagram. However, it is also useful to add a title onto the diagram itself to help other members of your team understand the content and purpose of a diagram.

To add an optional title to your diagram, follow these steps:

1. With the diagram displayed in the drawing area, click the **Text** button .
2. Click above the items in the diagram and type the title of the diagram. For example, you can name this diagram `Overview File Diagram`.
3. Make the following changes if you want:
 - a. Reposition the title by dragging it into another location.
 - b. Use the tools on the **Format** toolbar to change the font styles.
4. Save your model.

You have completed drawing the Overview file diagram. It should resemble the [Overview File Diagram](#) figure.

Summary

In this lesson, you created a file, which shows how the system components are interconnected. You became familiar with the parts of a file diagram and you added the following elements:

- ◆ Files
- ◆ Functions
- ◆ Variables
- ◆ Dependencies
- ◆ Arguments
- ◆ Implementation code

You are now ready to proceed to the next lesson, where you create a flow chart.

Lesson 2: Creating Flow Charts

Flow charts describe a function or class operation. They show algorithmic flow.

In the previous lesson, you entered code directly for the **Display** function, see [Task 1f: Adding a Function and Arguments for Display](#). As it does for file diagrams, the Rational Rhapsody code generator also directly translates the elements modeled in flow charts of the function you want to implement into C source code.

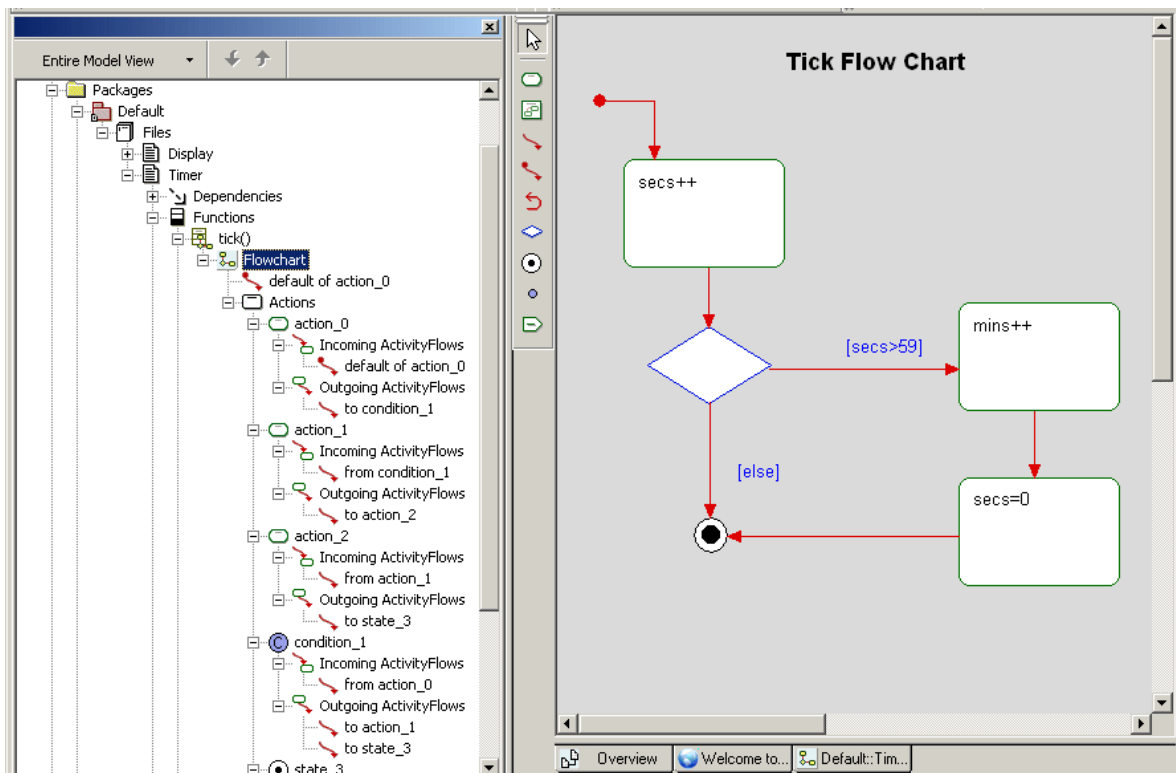
Goals for this Lesson

In this lesson, you create a flow chart called `TICK`. In this tutorial, Tick is a timing function that increments in minutes and seconds.

Exercise 1: Creating a Flow Chart for the Tick Function

The elements in a flow chart describe a function or class operation. The following diagram shows the Tick flow chart that you create in this exercise.

Tick Flow Chart



Task 1a: Creating the Flow Chart

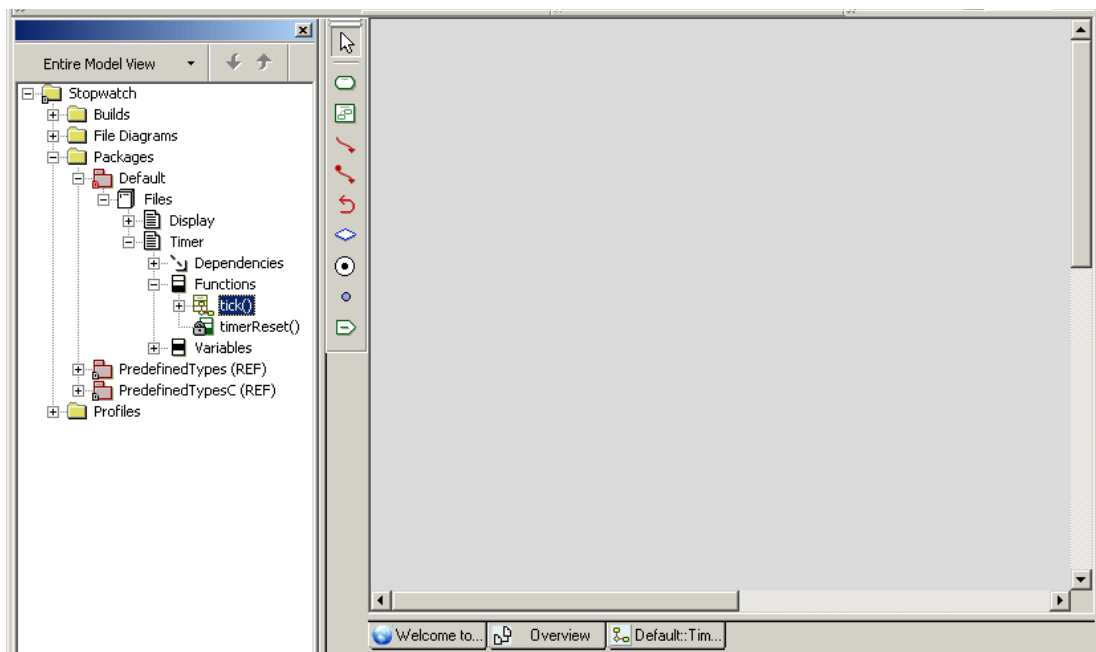
You draw a flow chart using the following general steps:

1. Draw actions
2. Add default flows, activity flows, condition connectors, and termination states

The following tasks describe each of these steps in detail. Use the [Tick Flow Chart](#) figure as a reference.

To create a flow chart, follow these steps:


1. Start Rational Rhapsody and open the stopwatch model if they are not already open.
2. In the Rational Rhapsody browser, expand **Packages, Default, Files, Timer, and Functions**.
3. Right-click the **tick()** function and select **Add New > Flowchart**.
Notice the new diagram tab in the drawing area, as shown in the following figure.

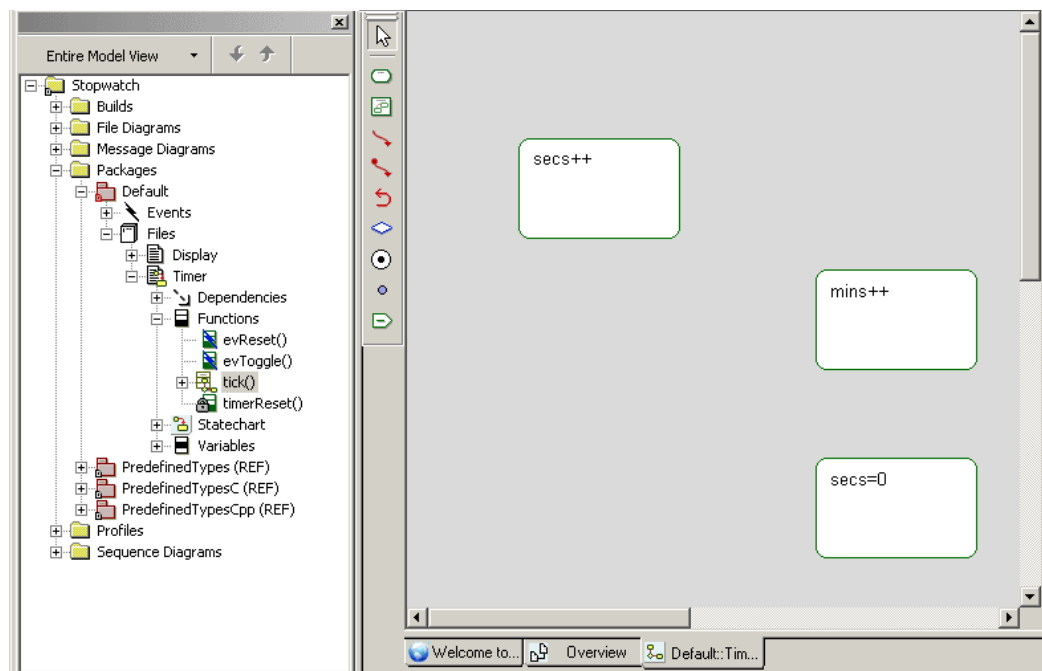


Task 1b: Drawing Action Elements

In this task, you draw the *action elements* that represent the functional processes.

To draw action elements, follow these steps. Use the [Tick Flow Chart](#) figure as a reference for the placement of the action elements.

1. Click the **Action** button  on the **Drawing** toolbar.
2. Near the top left corner of the drawing area, click and draw an action element, type `secs++` and then press **Ctrl+Enter**.
3. Click the **Action** button and draw another action element below and to the right of the `secs++` action element, type `mins++`, and then press **Ctrl+Enter**.
4. Draw another action element below the `mins++` action element, type `secs=0`, and then press **Ctrl+Enter**. Your flow chart should resemble the following figure.




5. Click the **Save** button  to save your work

Task 1c: Drawing a Default Flow

In this task, you draw a *default flow*. One of the action elements must be the default action element. The flow chart flow originates from the element pointed to by the default flow.


To draw a default flow, follow these steps. Use the [Tick Flow Chart](#) figure as a reference.

1. Click the **Default Flow** button  on the **Drawing** toolbar.
2. Click above and to the left of the **secs++** action element, then click its edge, and then click the mouse button again (this is the same as pressing **Enter**); or press **Ctrl+Enter**.

Task 1d: Drawing a Termination State

A *termination state* provides local termination semantics. The flow chart returns at this point to the operation/function that invoked it.


To draw a termination state, follow these steps. Use the [Tick Flow Chart](#) figure as a reference.

1. Click the **Termination State** button  on the **Drawing** toolbar.
2. Click below the **secs++** action element and to the left of the **secs=0** action element.

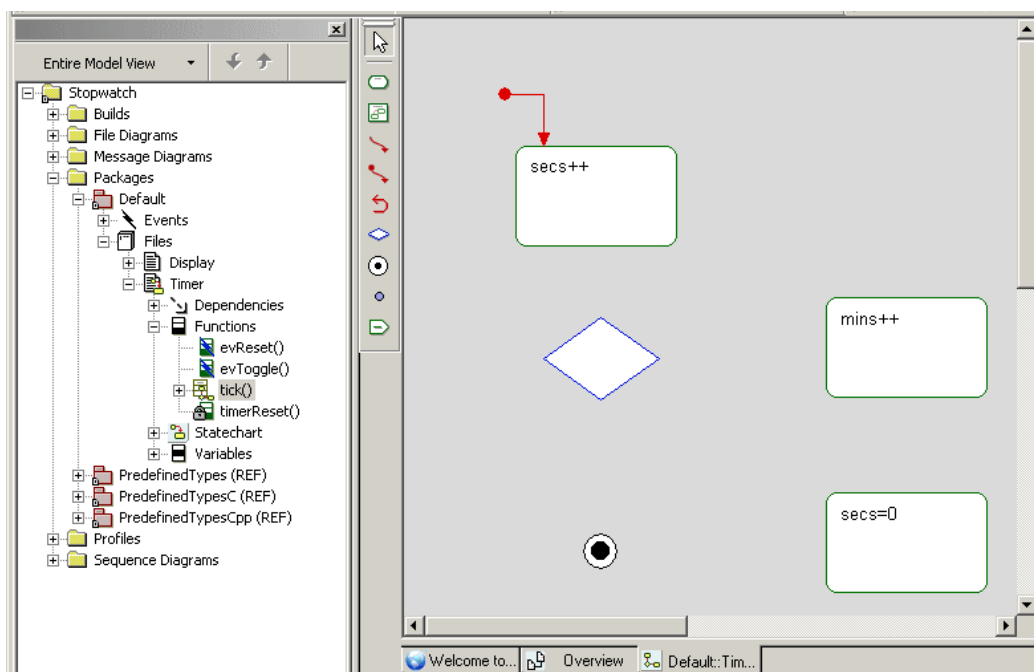
Task 1e: Drawing Condition Connector

A *condition connector* shows a branching condition. A condition connector can have only one incoming action flow and two or more outgoing action flows. The outgoing flows are labeled with a distinct guard condition. A predefined guard, denoted `[else]`, can be used for no more than one outgoing flow.

To draw a condition connector, follow these steps:

1. Click the **Condition Connector** button  on the **Drawing** toolbar.
2. Click below the `secs++` action element and to the left of the `mins++` action element, and then press **Ctrl+Enter**.
3. Save your work.


Your flow chart should resemble the following figure.

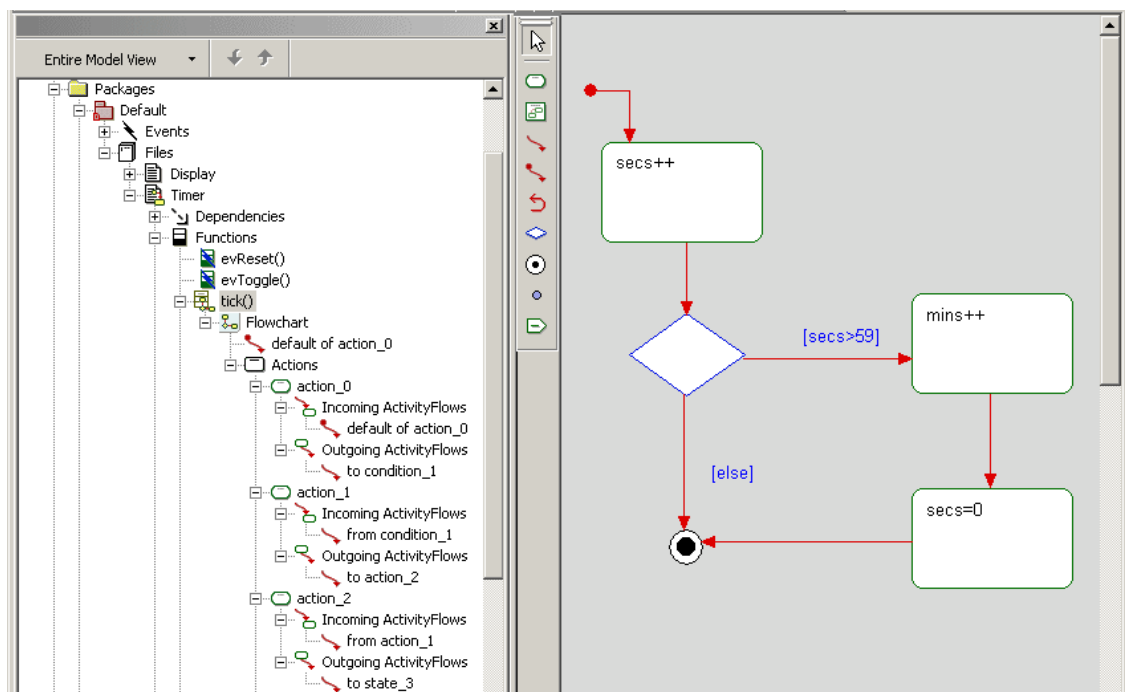


Task 1f: Drawing Activity Flows

Activity flows represent the response to a message in a given action element. They show what the next action element will be.

To draw activity flows between actions, follow these steps. Use the [Tick Flow Chart](#) figure as a reference.


1. Click the **Activity Flow** button  on the **Drawing** toolbar and draw a flow from the **secs++** action element to the **Condition Connector**, and then click the mouse button again (this is the same as pressing **Enter**); or press **Ctrl+Enter**.
2. Click the **Activity Flow** button and draw a flow from the **Condition Connector** to the **mins++** action element, type `[secs>59]`, and then press **Ctrl+Enter**.
3. Draw a flow from the **mins++** action element to the **secs=0** action element and then click the mouse button again or press **Ctrl+Enter**.
4. Draw a flow from the **secs=0** action element to the **Termination State** and then click the mouse button again or press **Ctrl+Enter**.
5. Draw a flow from the **Condition Connector** to the **Termination State**, type `[else]` and then press **Ctrl+Enter**.
6. Save your work. Your model should resemble the following figure.



Task 1g: Adding a Diagram Title

Each diagram has its name in the diagram table and in the title bar of the window that displays the diagram. However, it is also useful to add a title onto the diagram itself to help other members of your team understand the content and purpose of a diagram.

To add an optional title to your diagram, follow these steps:

1. With the diagram displayed in the drawing area, click the **Text** button .
2. Click above the items in the diagram and type the title of the diagram. For example, you can name this diagram `Tick Flow Chart`.
3. Make the following changes if you want:
 - a. Reposition the title by dragging it into another location.
 - b. Change the font styles.
4. Save your work.

You have completed drawing the Tick flow chart. It should resemble the [Tick Flow Chart](#) figure.

The flow chart you have drawn will generate code, as shown in the following figure. The generating code function is covered in [Lesson 5: Generating Code and More](#).

```
345 void tick() {
346     /*#[ state tick().ROOT.action_0.(Entry) */
347     secs++;
348     /*#]*/
349     if ( secs>59 )
350     {
351         /*#[ state tick().ROOT.action_1.(Entry) */
352         mins++;
353         /*#]*/
354         /*#[ state tick().ROOT.action_2.(Entry) */
355         secs=0;
356         /*#]*/
357     }
358     return;
359 }
```

Summary

In this lesson, you created a flow chart, which shows actions and implementation code, and which will be used for code generation later. You became familiar with the parts of a flow chart and you added the following elements:

- ◆ Action elements
- ◆ Default flow
- ◆ Activity flows
- ◆ Condition connector
- ◆ Termination state

You are now ready to proceed to the next lesson, where you identify the action element-based behavior for the stopwatch model using a statechart.

Lesson 3: Creating Statecharts

Statecharts define the behavior of classifiers (actors, files, use cases, or classes), objects, including the states that they can enter over their lifetime and the messages, events, or operations functions that cause them to transition from state to state.

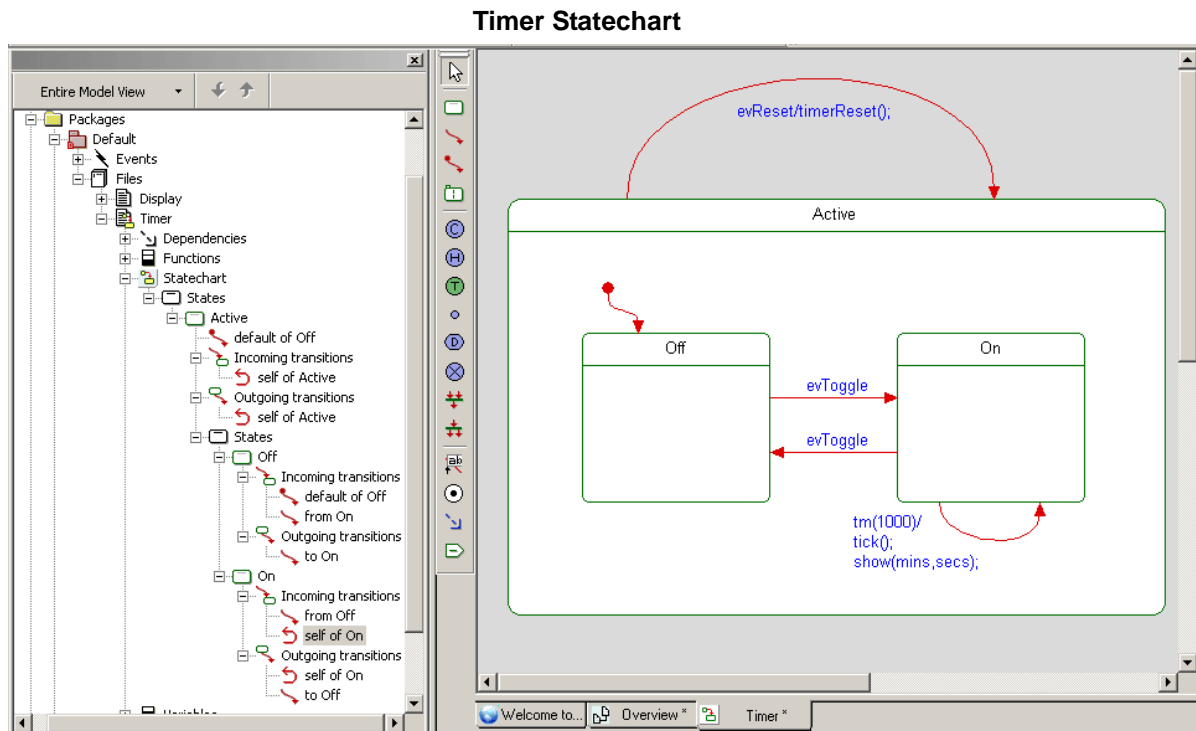
Statecharts are a key animation tool used to verify the functional flow and modeling. Statecharts can be animated to view the design level of abstraction and graphically show dynamic behavior.

Goals for this Lesson

In this lesson, you create the Timer statechart.

Exercise 1: Creating a Statechart for the Timer

Statecharts define state-based behavior. The following figure shows the Timer statechart that you create in this lesson.

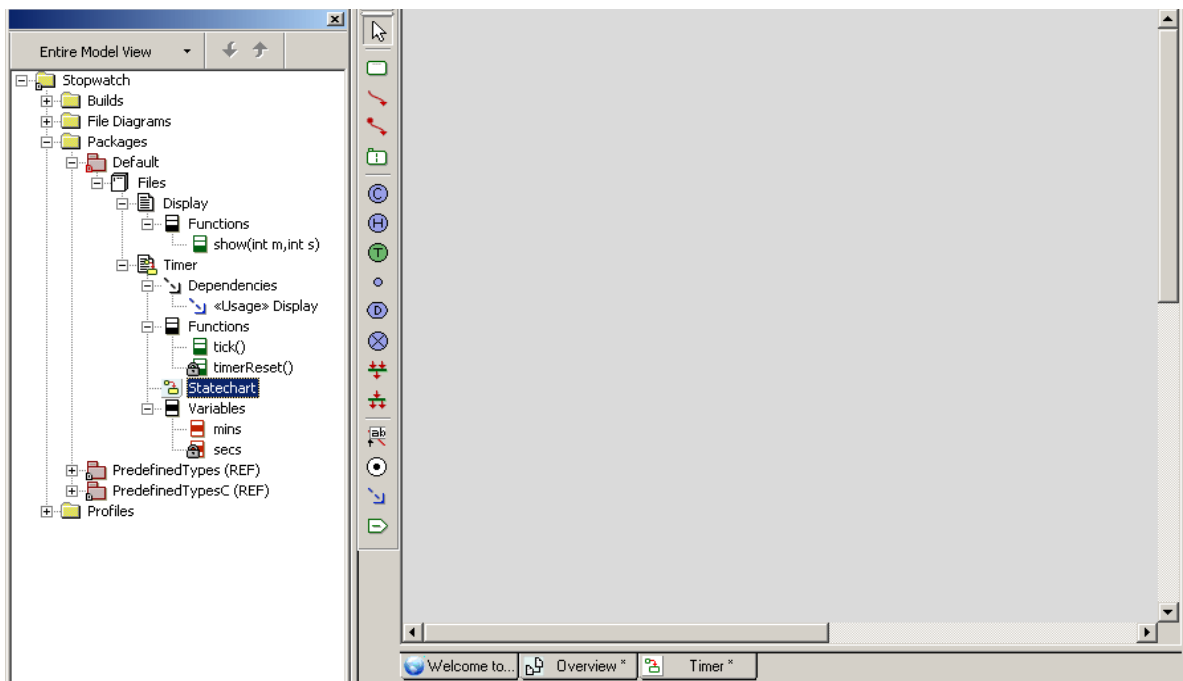



Task 1a: Creating the Statechart


In this task, you create a statechart. In order to describe the behavior of the timer, you need to add a statechart. Use the [Timer Statechart](#) figure as a reference.

To create a statechart, follow these steps:

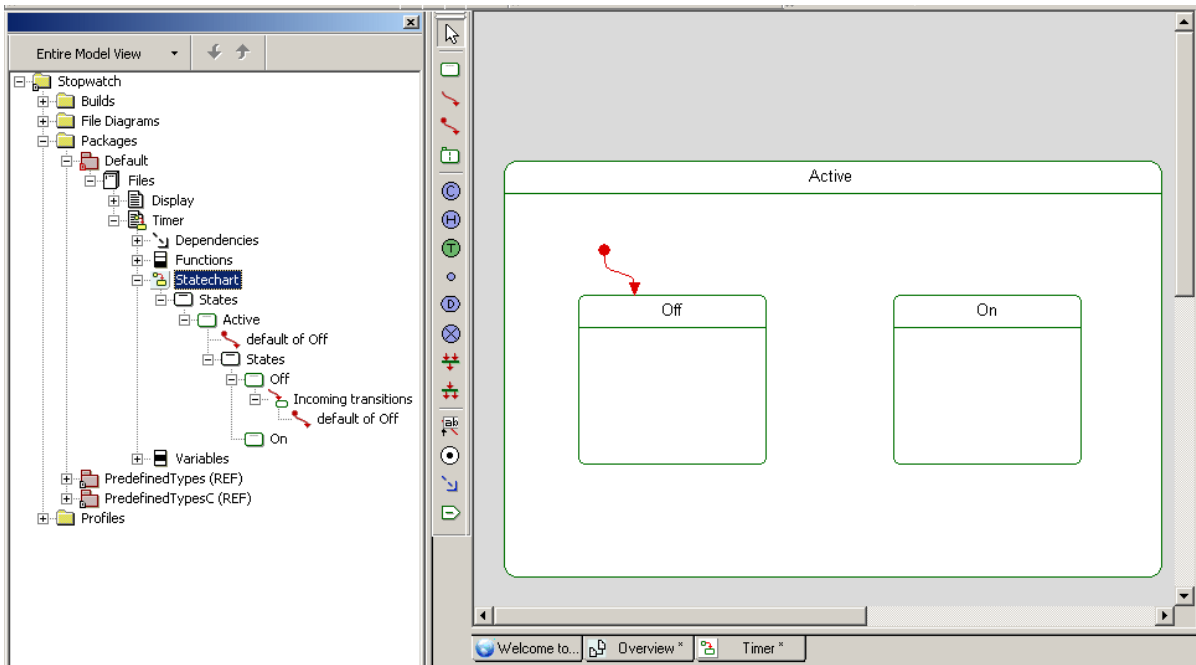
1. Start Rational Rhapsody and open the stopwatch model if they are not already open.
2. In the Rational Rhapsody browser, expand **Packages, Default, and Files**.
3. Right-click the **Timer** file in the Rational Rhapsody browser and select **Add New > Statechart**. The system adds a **Statechart** element to the Rational Rhapsody browser and creates a drawing area named **Timer**, as shown in the following figure.



4. Click the **State** button  on the **Drawing** toolbar.
5. Draw a large rectangle by clicking near the upper left hand corner of the drawing area and dragging to the lower right hand corner.
6. Replace the default name with `Active`, and then press **Enter**.
7. Draw two states inside the `Active` state and name them `off` and `on`.

- Click the **Default Connector** button  and draw a connector to the **Off** state and then click the mouse button again (this is the same as pressing **Enter**) or press **Ctrl+Enter**.

At this point, your diagram should resemble the following figure.




- Click the **Save** button  to save your work.

Task 1b: Adding Transitions Between States

To build a functioning statechart, the states must have connections (transitions) to indicate the workflow. Rational Rhapsody provides a timer, **tm(1000)**, that you can use within statecharts. The timer **tm(1000)** acts as an event to be taken one second after the state has been entered. Therefore, when entering into a state, the timer starts, and it stops when exiting the state.

Use the [Timer Statechart](#) figure as a reference.

To create transitions for the states, follow these steps:

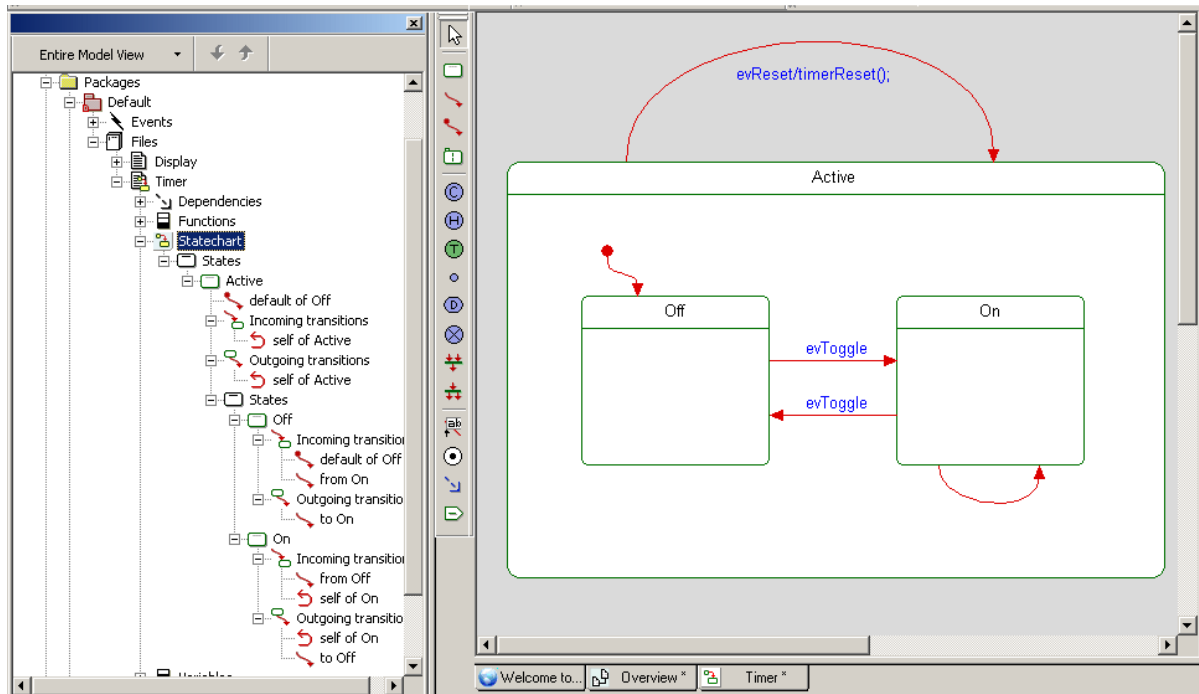
1. Click the **Transition** button , then click the right border of the **Off** state, and then draw a transition to the **On** state.
2. Name the transition `evToggle` and then press **Ctrl+Enter**.
3. Draw another transition from **On** to **Off** and name it `evToggle`.
4. Draw another transition line from `Active` state back to itself, type the following code, and press **Ctrl+Enter**:

```
evReset/timerReset();
```

5. Draw another transition line from the **On** state back to itself and press **Ctrl+Enter**.

Lesson 3: Creating Statecharts

Your statechart should resemble the following figure.



Task 1c: Using the Rational Rhapsody Timer

Rational Rhapsody provides a timer, **tm(1000)**, that can be used within the statecharts. This timer uses the OS Tick and only generates timeouts that are a multiple of ticks. For example, if a system tick is 20ms and a timeout of 65ms is requested, then the resulting timeout is actually between 80ms and 100ms, depending on when the timeout is started relative to the system tick.

Note

If precise timeouts are required, then it is better to use a hardware timer in combination with triggered operations.

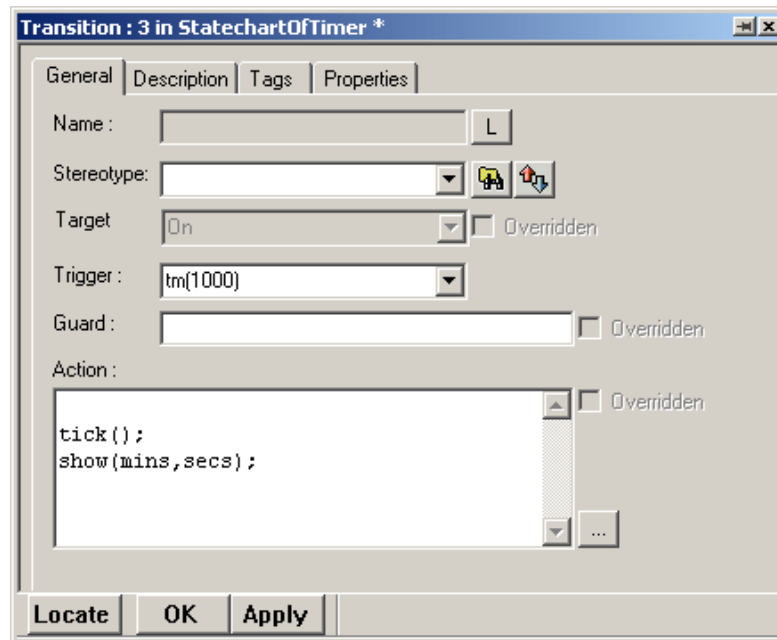
To enter a definition for a timer, follow these steps:

1. Double-click the unlabeled transition line located at the bottom of the **On** state in the statechart diagram to open the Features dialog box.
2. Type `tm(1000)` in the **Trigger** box.

3. In the **Action** box, press **Enter** and then type the following code below that blank line as shown in the following figure.

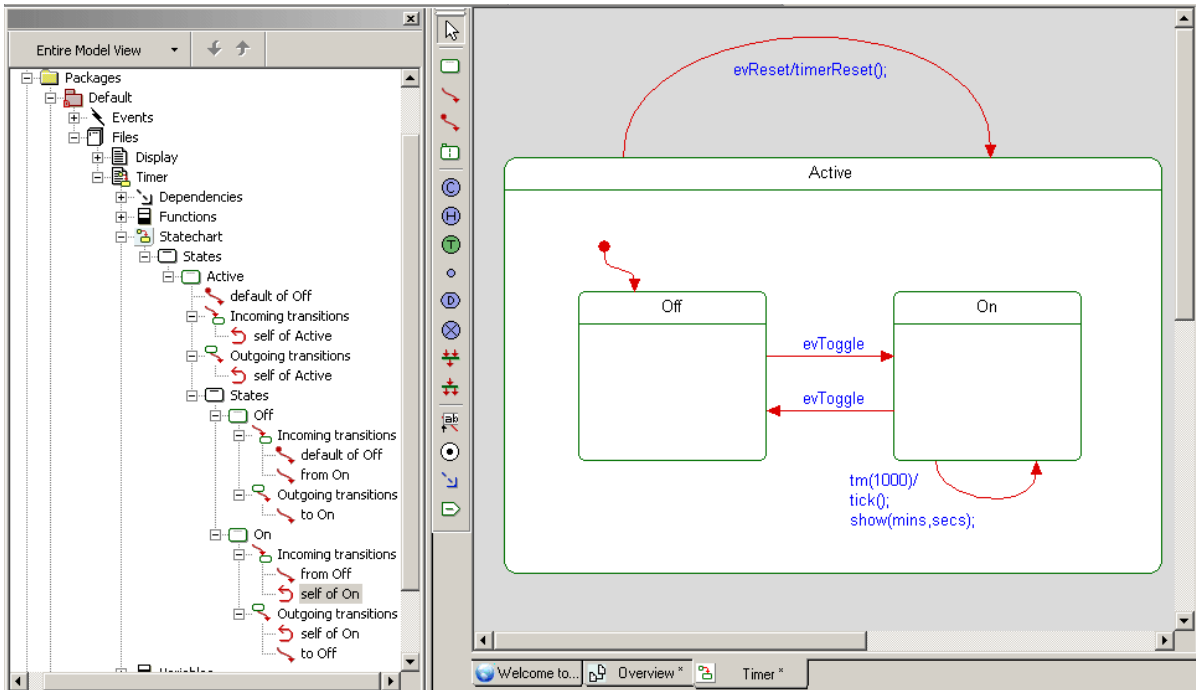
```
tick();  
show(mins,secs);
```

Note: The blank line before the code forces the action to appear on a new line.



- Click **OK**.

At this point, your statechart should resemble the following figure.



- Click the Save button  and save your model.

Exercise 2: Animating a Statechart

As the model gets more and more complicated, it is a good practice to stop and validate the model periodically and provide design-level debugging. One of the primary methods the Rational Rhapsody product uses to simulate a model is animation.

Animation is the execution of behaviors and associated definitions in the model. Rational Rhapsody animates the model by executing the code generated with instrumentation for classes/files, operations/functions, and associations. Once you animate the model, you can open animated diagrams, which let you observe the model as it is running and perform design-level debugging. You can step through the model, set and clear breakpoints, inject events, and generate an output trace.

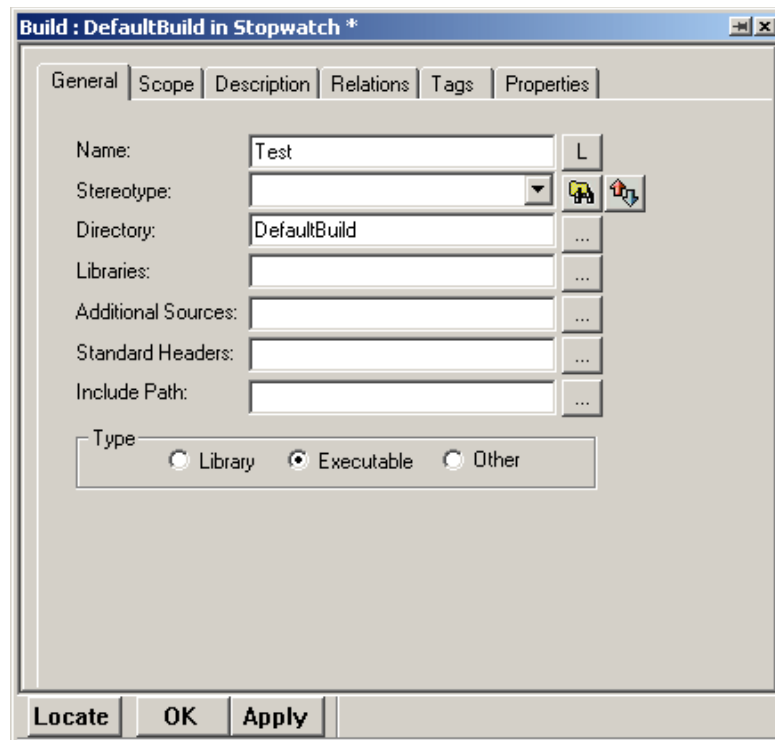
Note

As part of this exercise, you generate code. However, this exercise focuses on animation, and specifically for a statechart. In later lessons you learn more about generating code and animating.

Task 2a: Defining a Test Component and Configuration

In this task, you define the execution code for this animation. To do this, you must first define a test component and a configuration to use for animation. Follow these steps:

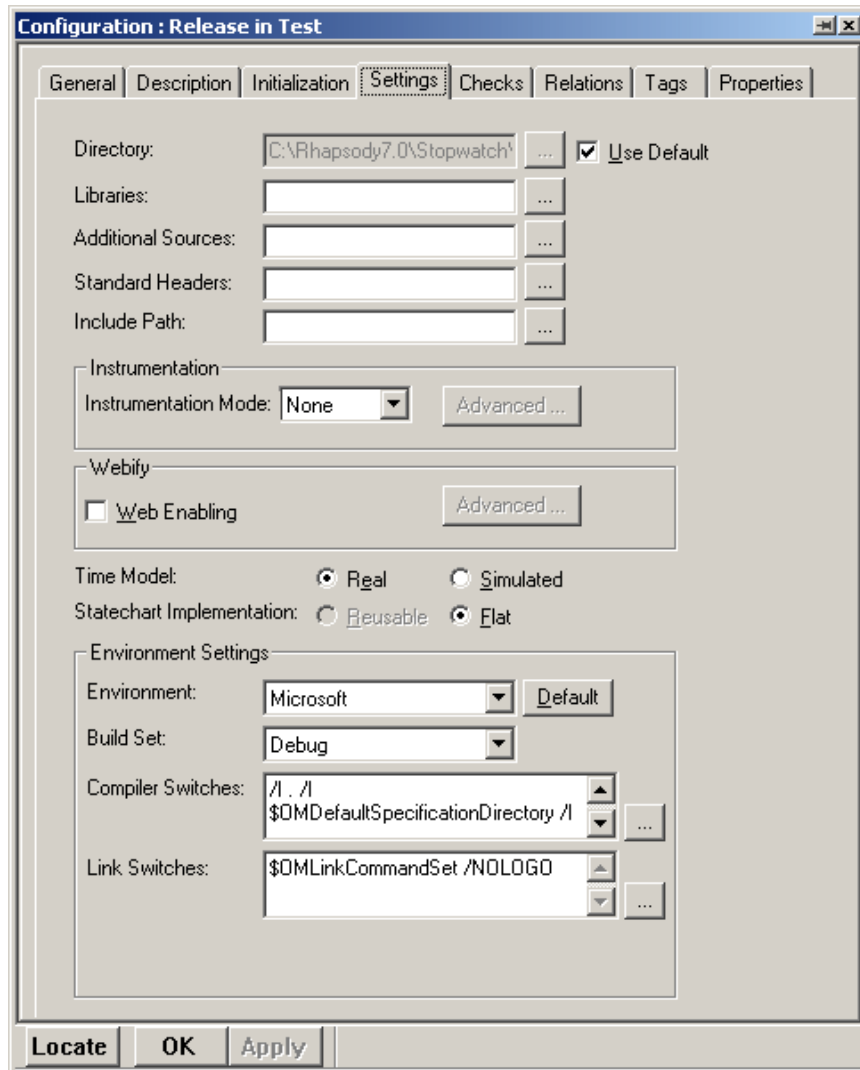
1. In the Rational Rhapsody browser, expand **Builds**.
2. Double-click **DefaultBuild** to open the Features dialog box.
3. Replace the default name with `Test`, as shown in the following figure, and then click **OK**.



4. Expand **Test** and then expand **Configurations**.
5. Double-click **DefaultConfig** to open the Features dialog box.
6. On the **General** tab, replace the default name with `Release`.

7. On the **Settings** tab, define the environment so that Rational Rhapsody knows how to create an appropriate makefile. Rational Rhapsody sets the values in the **Environment Settings** group based on the compiler settings you configured during installation. If you want to use a different compiler, select a system compiler from the drop-down menu in the **Environment** box.

Note: This example uses a system with the Microsoft compiler, as shown in the following figure. Your environment might use a different compiler.



8. Click **OK**.

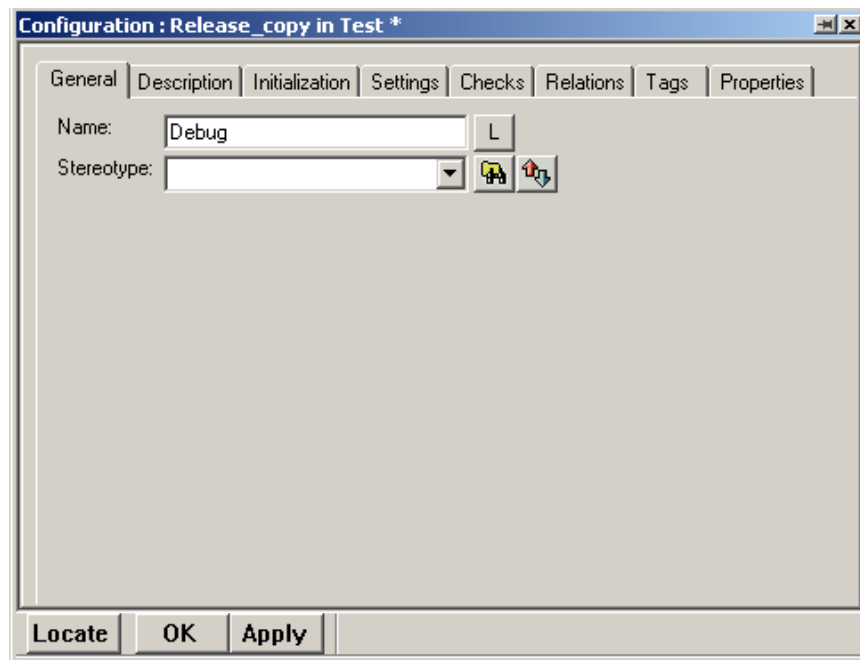
Task 2b: Creating a Debug Configuration

In this task, for animation purposes, you create a Debug configuration. Follow these steps:

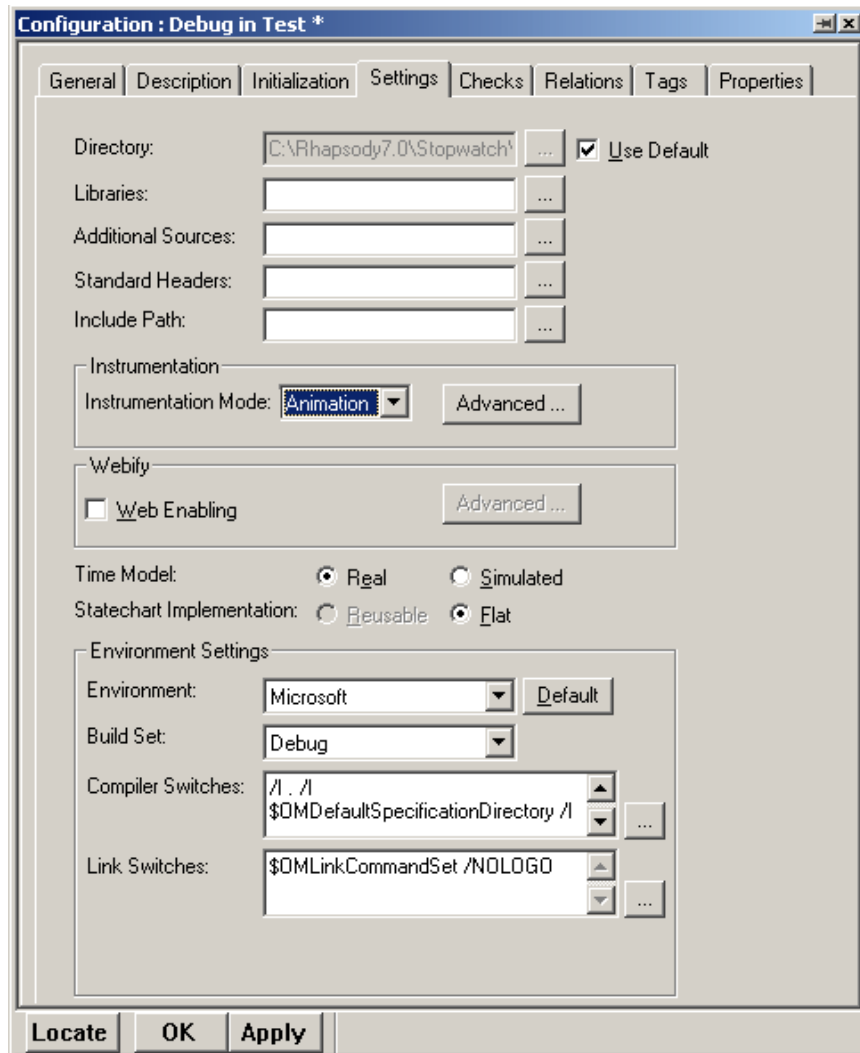
1. In the Rational Rhapsody browser, highlight the **Release** configuration you created in the previous task.
2. Hold the **Ctrl** key and use the mouse to drag the **Release** configuration in to **Test**.

This creates a copy of the configuration named `Release_copy`.

3. Double-click **Release_copy** to open the Features dialog box.
4. On the **General** tab, replace the default name with `Debug`, as shown in the following figure.



5. On the **Settings** tab, in the **Instrumentation** group, from the **Instrumentation Mode** drop-down list box, select **Animation**, as shown in the following figure. This adds instrumentation code to this configuration, which makes it possible to animate the model.




6. Click **OK**.

Task 2c: Starting Animation

In this task, you validate the model by animating the statechart. Follow these steps:

1. On the **Code** toolbar, select **Test** and **Debug** as shown in the following figure. Doing this sets **Debug** as the active configuration for what you are about to do.

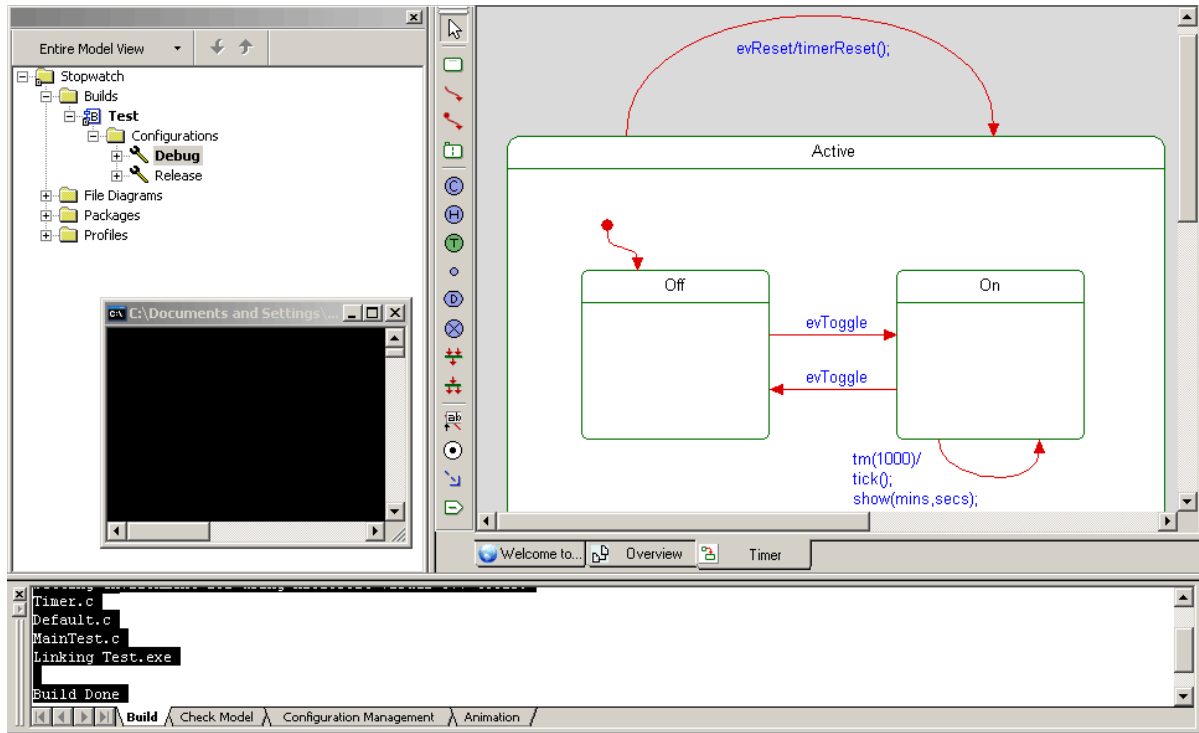


2. Save the project.
3. Click the **Generate/Make/Run** button .

Note: Click **Yes** to create the Debug subfolder, if necessary.

Lesson 3: Creating Statecharts

4. If the build is successful, the Output window lists the messages and states `Build Done`. In addition, when the animation starts successfully, the Animation toolbar becomes active and a blank Display window opens. The following figure shows these windows.




Note: If error messages appear in the Output window indicating that the model did not build, check the diagrams for typographical errors and examine the code by clicking on the errors in the Output window to display the generated code in the drawing area.

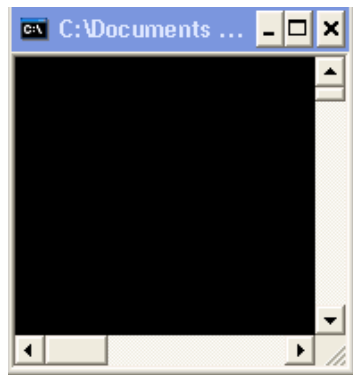
5. If you make changes to correct any problems you discover, save the model and choose **Code > Re Generate > Debug**.

Task 2d: Creating the Timer Instance

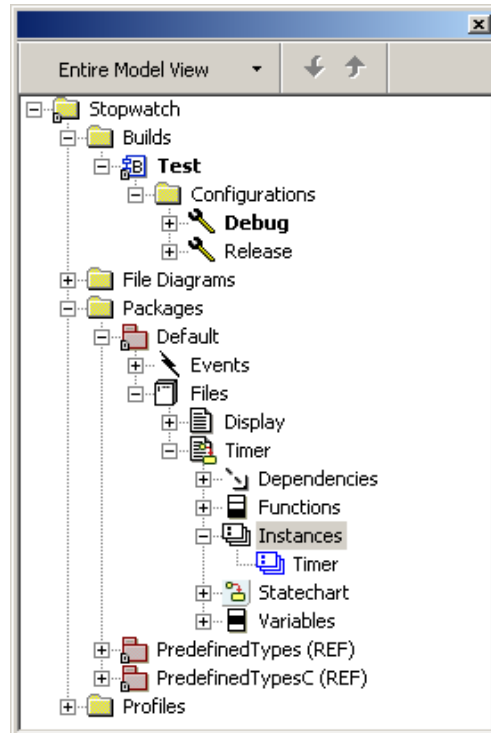
In this task, after the model builds without errors and the executable has been run, you can run the animation. Follow these steps:

1. On the **Animation** toolbar, click the **Go** button  to trigger the statechart animation.

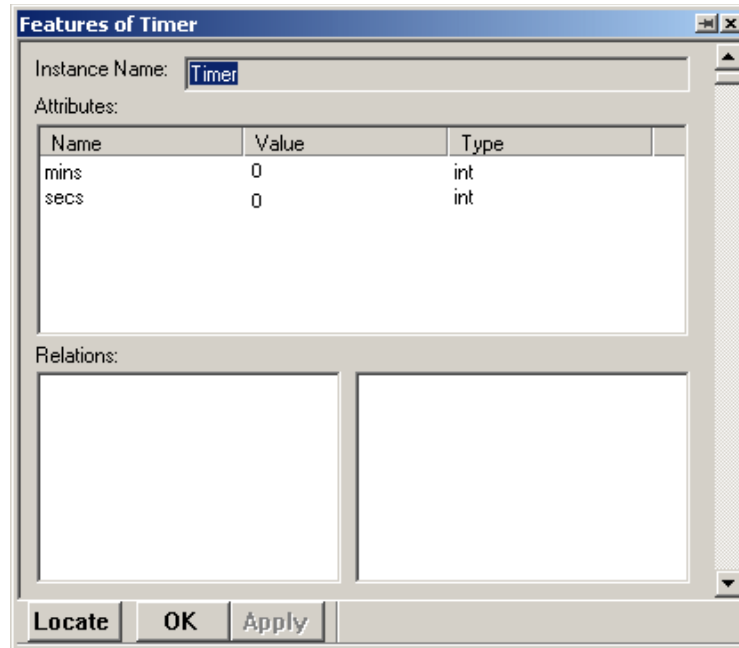
You can resize or move the Display window, as shown in the following figure, to be able to observe the animation of the diagram and the display at the same time.



2. On the Rational Rhapsody browser, expand **Timer** and notice that there is now an **Instances** category, as shown in the following figure.

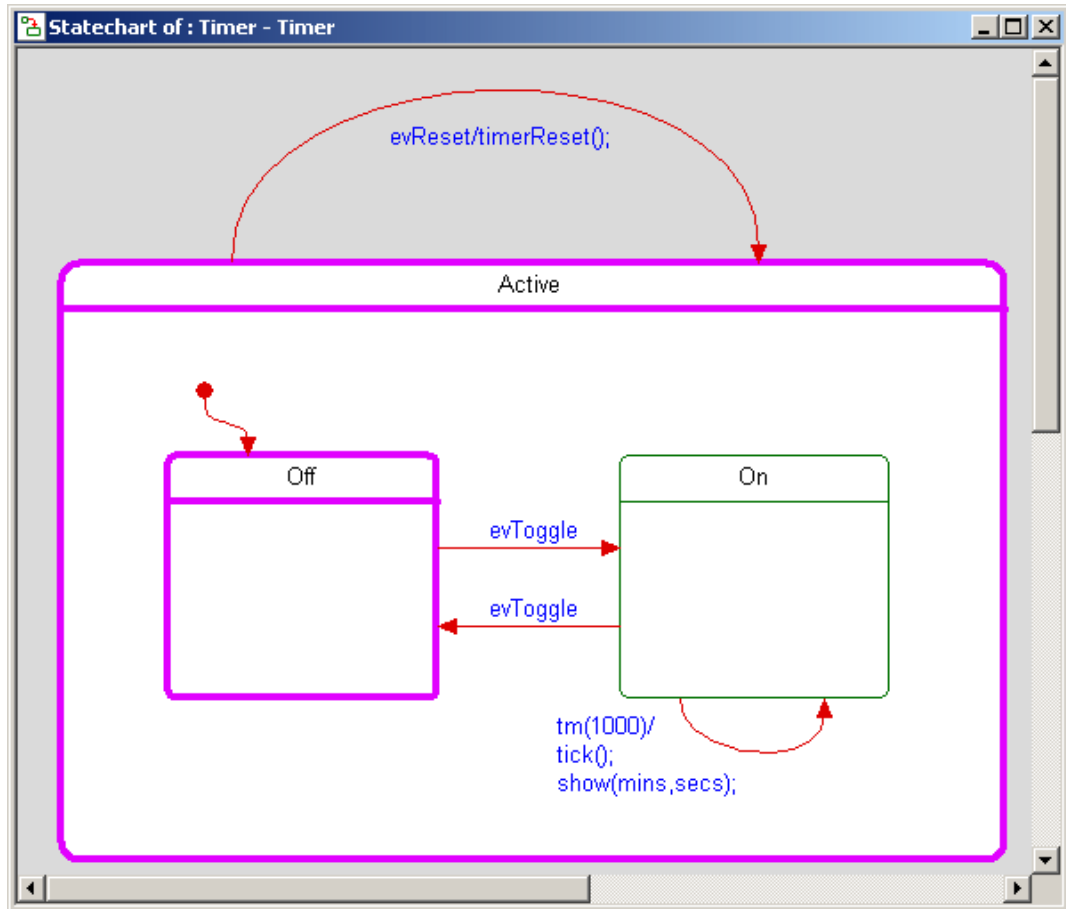


3. Double-click the **Timer** instance to open the Features dialog box. Notice that the attributes `mins` and `secs` are now initialized to 0, as shown in the following figure.



4. Click **OK**.
5. Right-click the **Timer** instance and select **Open Instance Statechart**.

- The animated statechart displays, as shown in the following figure, with **Off** as the active state (magenta).

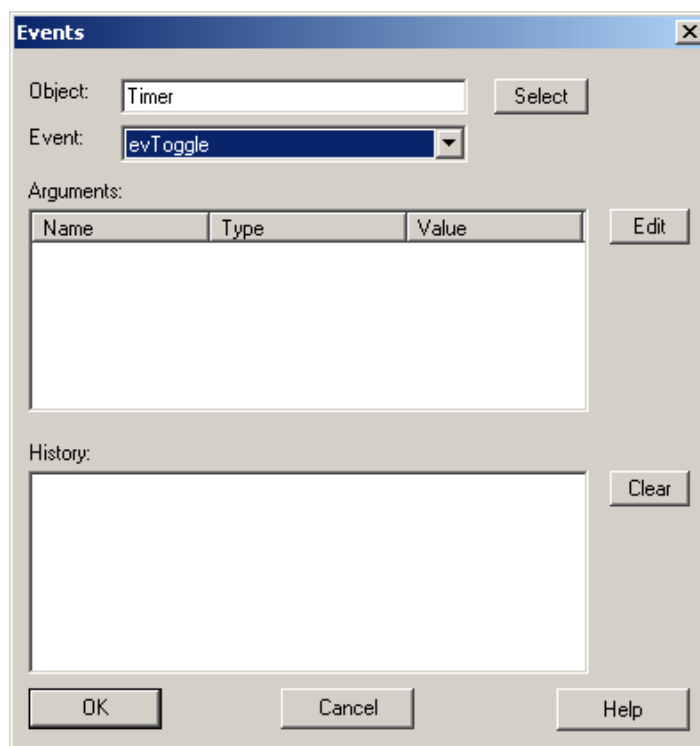


Task 2e: Generating Events to Run the Animation

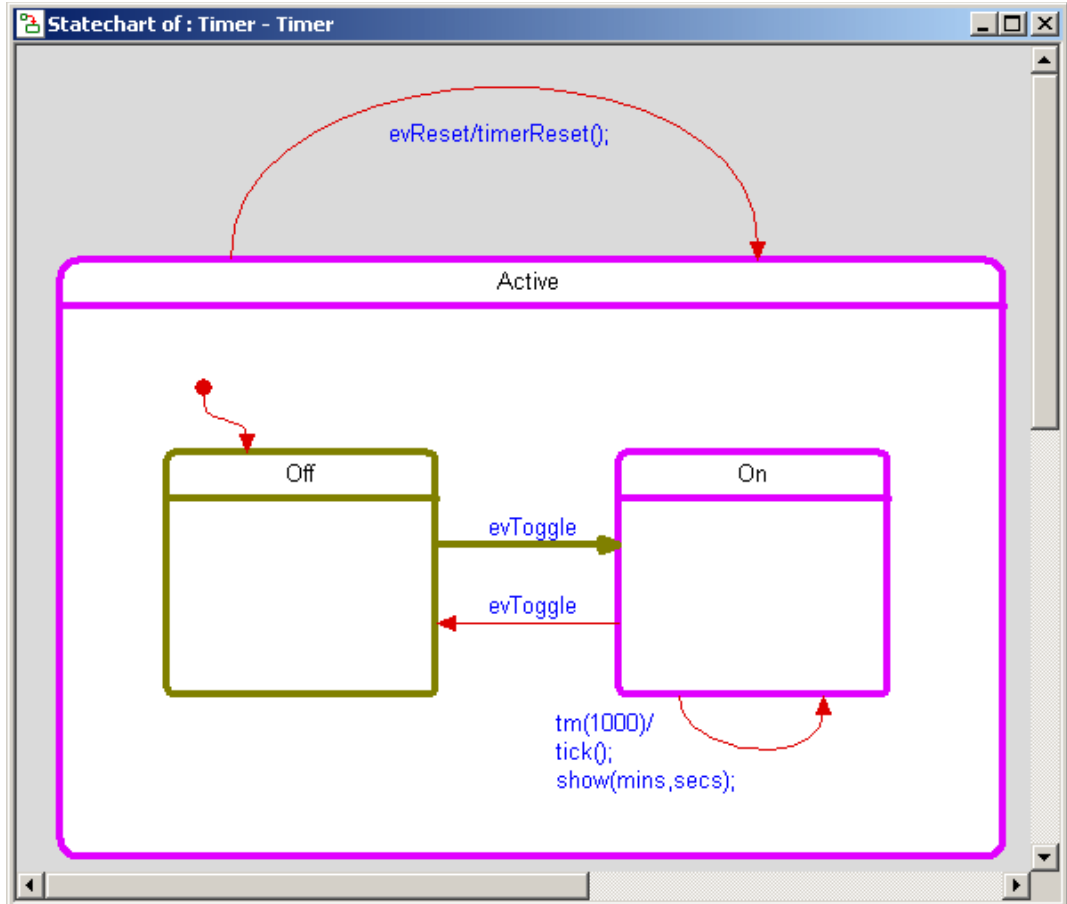
In this task, you generate events to run the animation. You inject events in an animated diagram to see how the model reacts.

To generate events, follow these steps:

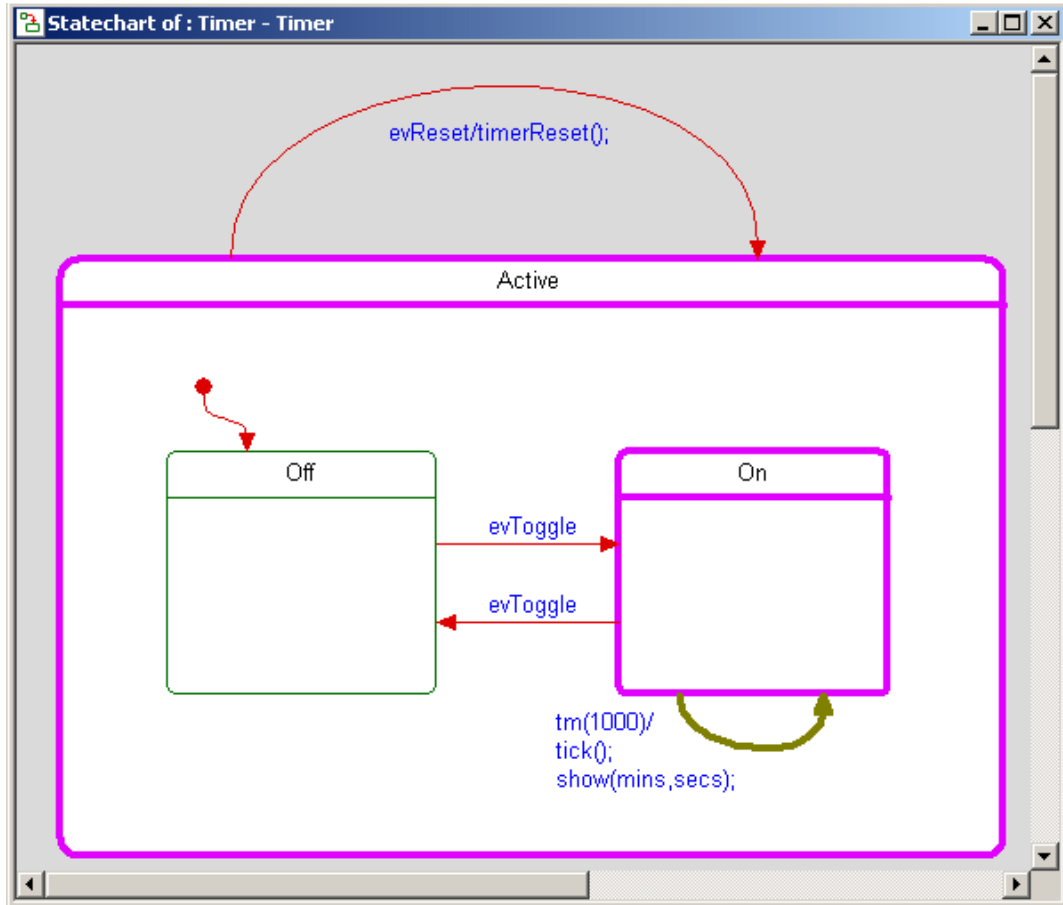
1. Right-click the **Off** state in the animated statechart and select **Generate Event** to open the Events dialog box.
2. From the **Event** drop-down list box, select **evToggle**, as show in the following figure.



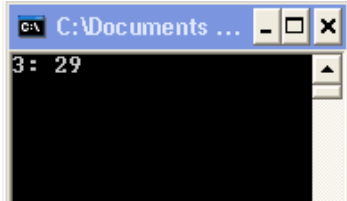
3. Click **OK**. The **evToggle** transitions to the **On** state is briefly highlighted, as shown in the following figure.



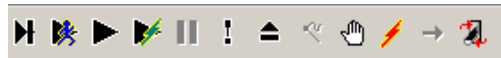
Then the $t_m(1000)$ transition line on the model highlights the **On** state and the timer arrow to show the animation, as shown in the following figure.



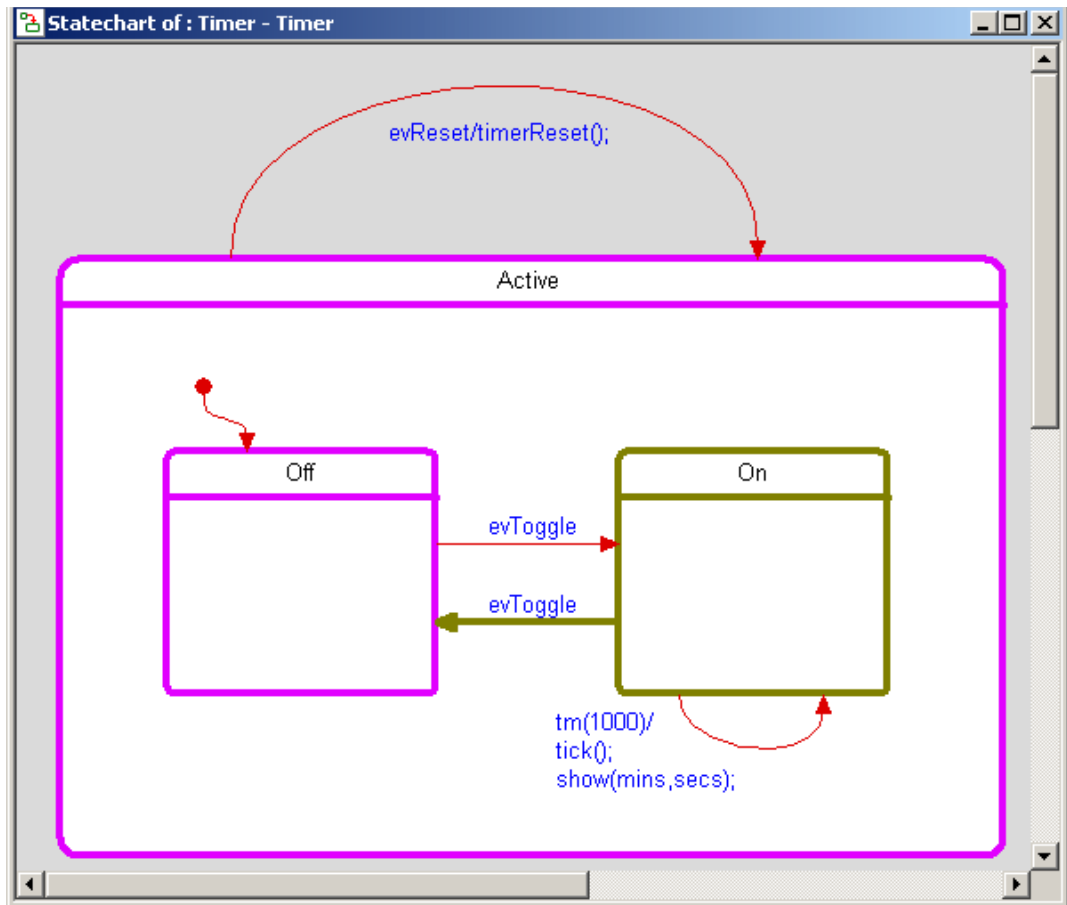
4. Examine the Display window. The stopwatch timer displays elapsed minutes and seconds, as shown in the following figure.



5. Examine the **Timer** instance in the browser and notice that it is blinking.
6. Use the other animation buttons, as shown in the following figure, to stop and start the animation and perform other actions. For more information about the Animation toolbar, refer to the *IBM Rational Rhapsody User Guide*.





- Right-click the **On** state on the diagram, select **Generate Event** to open the Generate Events dialog box and then click **OK**. The animation toggles back to the **Off** state to complete the statechart animation, as shown in the following figure.





Task 2f: Quitting Animation

To end the animation session, follow these steps:

1. Click the **Animation Break** button  on the **Animation** toolbar and then click the **Quit Animation** button .
2. Click **Yes** to confirm ending the animation session.
3. Save your model.

The Display window closes, and the Animation tab on the Output window displays the message `Animation session terminated`.

Note

To animate the statechart again, on the **Code** toolbar, click the **Run executable** button  and then, from the **Animation** toolbar, click the **Go** button  to trigger the statechart animation.

Summary

In this lesson, you created a statechart for the timer for the stopwatch model. You became familiar with the parts of a statechart and did the following:

- ◆ Added transitions and timeout transitions
- ◆ Added the Rational Rhapsody time
- ◆ Animated a statechart and saw it progress through states
- ◆ Created a timer instance
- ◆ Generated an event for a statechart

You are now ready to proceed to the next lesson, where you define the message exchange for the stopwatch model by using a message diagram.

Lesson 4: Creating Message Diagrams

Message diagrams show how the files functionality can interact through messaging (through synchronous function calls or asynchronous communication). Message diagrams can be used at different levels of abstraction. At higher levels of abstractions, message diagrams show the interactions between actors, files, use cases, and objects. At lower levels of abstraction and for implementation, message diagrams show the communication between classes, files, and objects.

Message diagrams have an executable aspect and are a key animation tool. When you animate a model, Rational Rhapsody dynamically builds message diagrams that record the object-to-object messaging.

Goals for this Lesson

In this lesson, you create the Execution message diagram, which captures what happens when the stopwatch model runs.

For the stopwatch model, only one message diagram is needed. You can have more than one message diagram for the models you create, depending on their complexity and need.

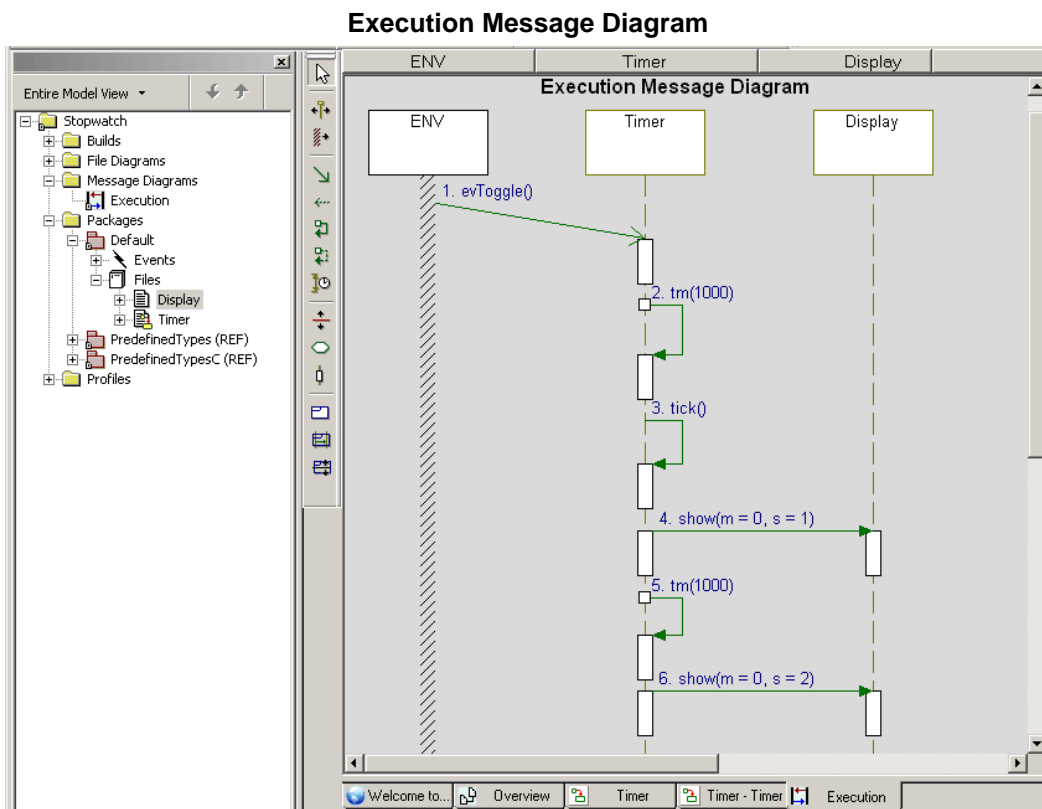
Exercise 1: Creating a Message Diagram

In this task, you create a message diagram. You draw a message diagram using the following general steps:

1. Draw classifier roles
2. Draw messages
3. Draw timeouts

This exercise describes each of these steps in detail.

The following figure shows the Execution message diagram that you create in this lesson.



Task 1a: Creating a Message Diagram

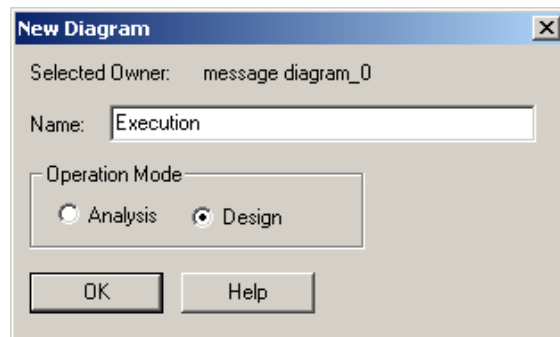
In this task, you create a message diagram. The model needs a message diagram to capture what happens when the stopwatch model runs.

To create a message diagram, follow these steps:

1. Start Rational Rhapsody and open the stopwatch model if they are not already open.
2. In the Rational Rhapsody browser, right-click **Stopwatch** and select **Add New > Message Diagram** to open the New Diagram dialog box.

Note: If **Message Diagram** is not enabled on the pop-up menu, you can choose **File > Message Diagram** and click the **New** button on the dialog box that opens.

3. Type `Execution`, as shown in the following figure.



4. In the **Operation Mode** area, select the **Design** option button if it is not already selected.

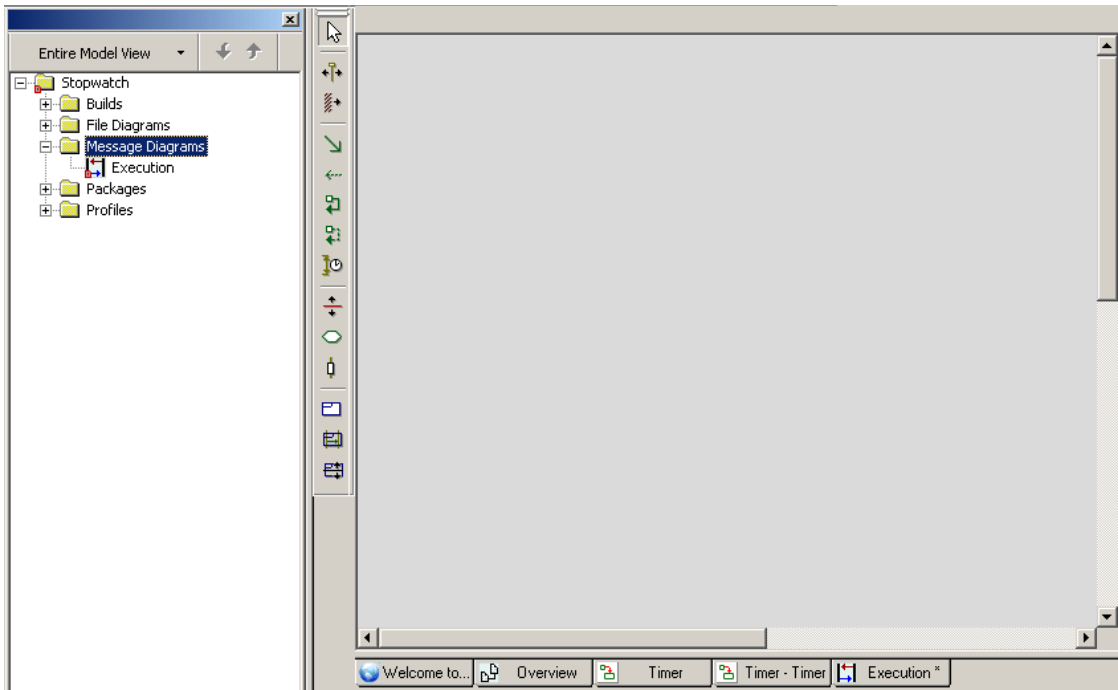
Rational Rhapsody lets you create message diagrams in two modes:

- a. In *analysis mode*, you draw message sequences without adding elements to the model. This means you can brainstorm your analysis and design without affecting the generated source code.
- b. In *design mode*, which is the default, every instance line and message you create or rename can be realized as an element (class/file, object, operation/function, or event) that appears in the Rational Rhapsody browser, and for which code can be generated. When you draw a message, Rational Rhapsody might ask if you want to realize it. If asked by the system, click **Yes** to realize the message.

5. Click **OK**.

Lesson 4: Creating Message Diagrams

Rational Rhapsody automatically creates the **Message Diagrams** category in the browser and adds the name of the new message diagram. In addition, Rational Rhapsody opens the new diagram in the drawing area, as shown in the following figure.



Note

You can also create a message diagram using the Tools menu or the **Diagrams** toolbar. Refer to the *IBM Rational Rhapsody User Guide* for more information about creating diagrams.

Task 1b: Adding Instances to the Message Diagram

In this task, you create the basic items in the message diagram. For placement of the items, use the [Execution Message Diagram](#) figure as a reference.

To add instances to the message diagram, follow these steps:

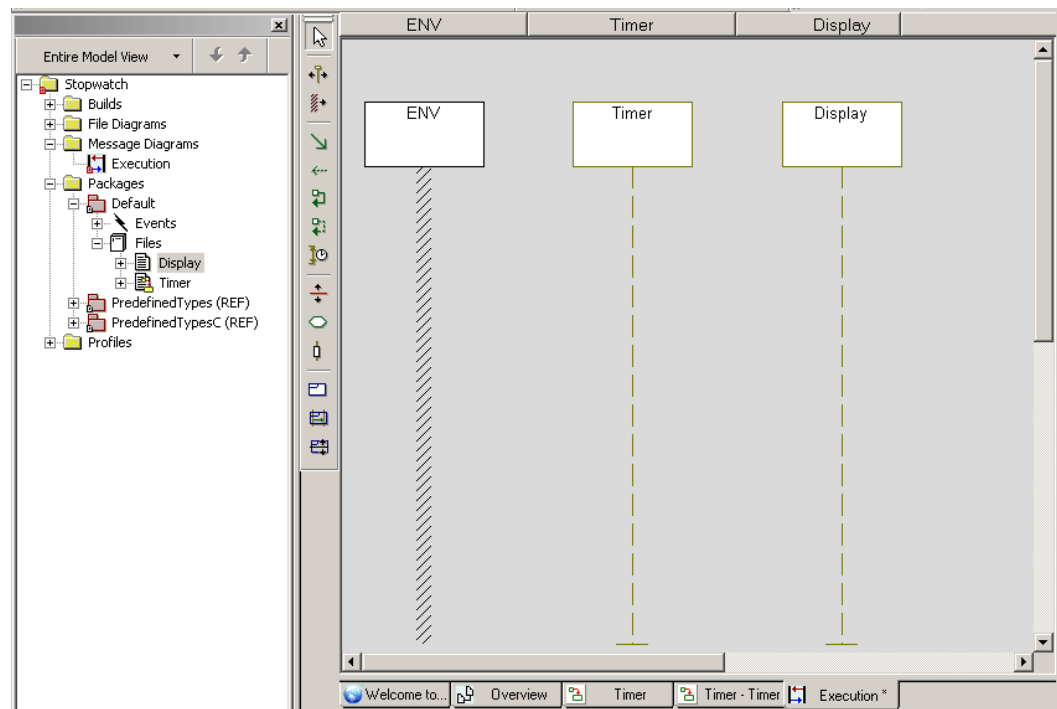
1. In the Rational Rhapsody browser, expand **Packages**, and then **Default** and **Files**.
2. Click the **Timer** file and drag-and-drop it onto the message diagram.

3. Click the **System Border** button  and click to the left of the **Timer** item.

This creates the environment boundary of the message diagram.

4. In the browser, click the **Display** file and drag-and-drop it to the right of the **Timer** item.

At this point, your diagram should resemble the following figure.



Task 1c: Drawing Messages to Define the Stopwatch Communication

To show the model's scenario, a message diagram defines the communication between parts of the model. To show these messages, you draw communication lines.

A *message* represents an interaction between objects/files, or between an object/a file and the environment. A message can be an event, a triggered operation, or a primitive operation.



Depending on the shape of the line, Rational Rhapsody interprets the message as follows:


- ◆ If the message line is horizontal, the message is interpreted as a triggered operation if the target is a reactive class, or a primitive operation if the target is a nonreactive class. A message line that is horizontal indicates that the operations are synchronous.
- ◆ If the message line is slanted, the message is interpreted as an event if the target is a reactive class, or as a primitive operation if the target is a nonreactive class. A message line that is slanted emphasizes that time passes between the sending and receiving of messages. Message lines that are slanted can cross each other.
- ◆ If the message line returns to itself, the message is interpreted as a primitive operation if the arrow folds back to a nonreactive class or if the arrow folds back immediately; or it is interpreted as an event if the arrow folds back sometime later. The arrow can be on either side of the instance line.

Note

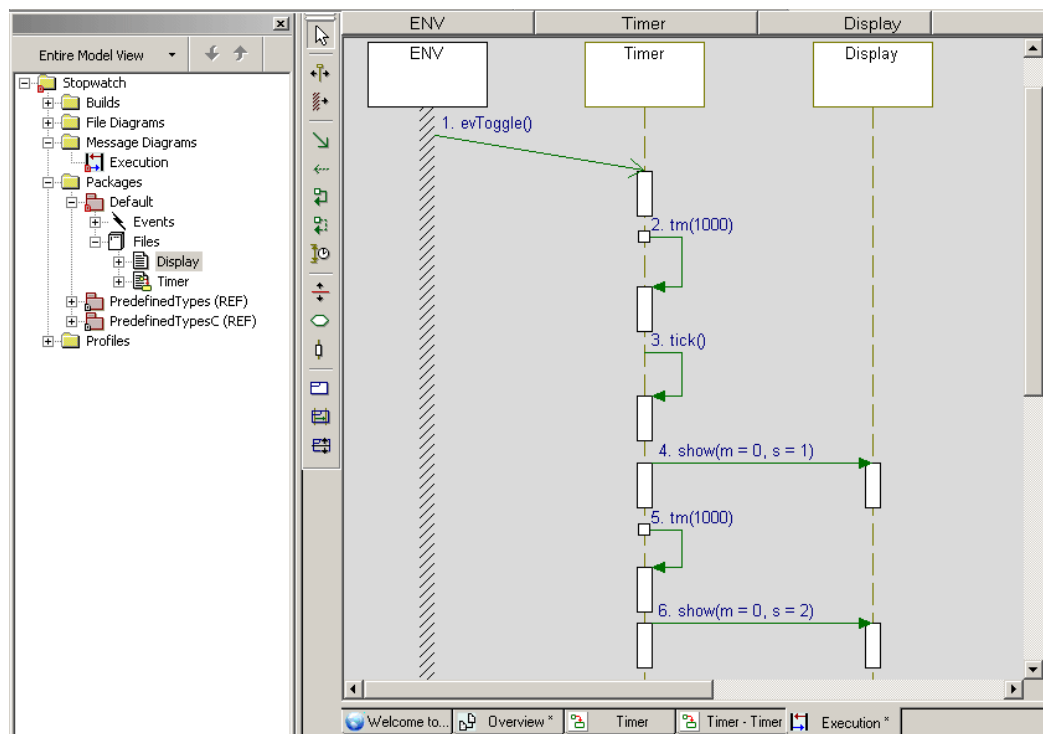
Reactive classes can receive events, triggered operations, and primitive operations.
Non-reactive classes can receive only messages that are calls to primitive operations.

To draw messages, follow these steps:

1. Click the **Message** button  on the **Drawing** toolbar.
2. Click the **ENV** system boundary line and click the **Timer** to create a downward-slanted diagonal line. Rational Rhapsody creates a message with a default value name of **#function_n()**, where **n** is an incremental integer starting with 0.
3. Rename the message `evToggle()` and then press **Enter**.
4. Click the **Timeout** button  and draw a timeout on the **Timer** line that goes back to itself and which is below the `evToggle()` message line, then type `tm(1000)`, and then press **Enter**.

5. Click the **Message** button and draw a message from the **Timer** line back to itself, then type `tick()`, and then press **Enter**.
6. Click the **Message** button and draw a straight message line from **Timer** to **Display**, then type `show(m = 0, s = 1)`, and then press **Enter**.
7. Click the **Timeout** button  and draw a timeout on **Timer** that goes back to itself, then type `tm(1000)`, and then press **Enter**.
8. Click the **Message** button and draw a straight message line from **Timer** to **Display**, then type `show(m = 0, s = 2)`, and then press **Enter**.

Your message diagram should resemble the following figure. Notice that each item is numbered and appears with execution occurrence bars by default. Refer to the *IBM Rational Rhapsody User Guide* to learn how to make them not appear if you want.




9. Click the **Save** button  and save your model.

Task 1d: Adding a Diagram Title

Each diagram has its name in the diagram table and in the title bar of the window that displays the diagram. However, it is also useful to add a title to a diagram to help other members of your team understand the content and purpose of a diagram.

To add an optional title to your message diagram, follow these steps:

1. With the diagram displayed in the drawing area, click the **Text** button .
2. Click above the items in the diagram and type `Execution Message Diagram`.
3. Make the following changes if you want:
 - a. Reposition the title by dragging it into a new location.
 - b. Change the font styles.
4. Save your work.

You have completed drawing the Execution SD. It should resemble the [Execution Message Diagram](#) figure.

Summary

In this lesson, you created the Execution message diagram, which captures what happens when the stopwatch model runs. You became familiar with the parts of a message diagram and created the following:

- ◆ System border
- ◆ Classifier roles
- ◆ Messages
- ◆ Time intervals
- ◆ Timeouts

You are now ready to proceed to the next lesson, where you are going to generate code.

Lesson 5: Generating Code and More

Rational Rhapsody uses the following sources to generate code for the model:

- ◆ Project Type or profile selected when you created the project. Refer to [Creating a Project](#).
- ◆ Component definition described in the [Task 2a: Defining a Test Component and Configuration](#).
- ◆ Compiler and instrumentation mode selections made when defining the configuration.
- ◆ Code you entered for functions, as in the [Task 1f: Adding a Function and Arguments for Display](#).
- ◆ Flow charts as described in [Lesson 2: Creating Flow Charts](#).
- ◆ C code that Rational Rhapsody automatically generates to support the design you created in the diagrams.

You must generate or regenerate code before you can run animation.

Goals for this Lesson

In this lesson, you learn about the following:

- ◆ Generating code
- ◆ Viewing code
- ◆ Locating code
- ◆ Manually adding code

Exercise 1: Managing Multiple Configurations

With more than one configuration, you must select which one you want to use. There are two ways to do this. You can do either of the following:

- ◆ Select the configuration from the **Code** toolbar, as shown in the following figure.



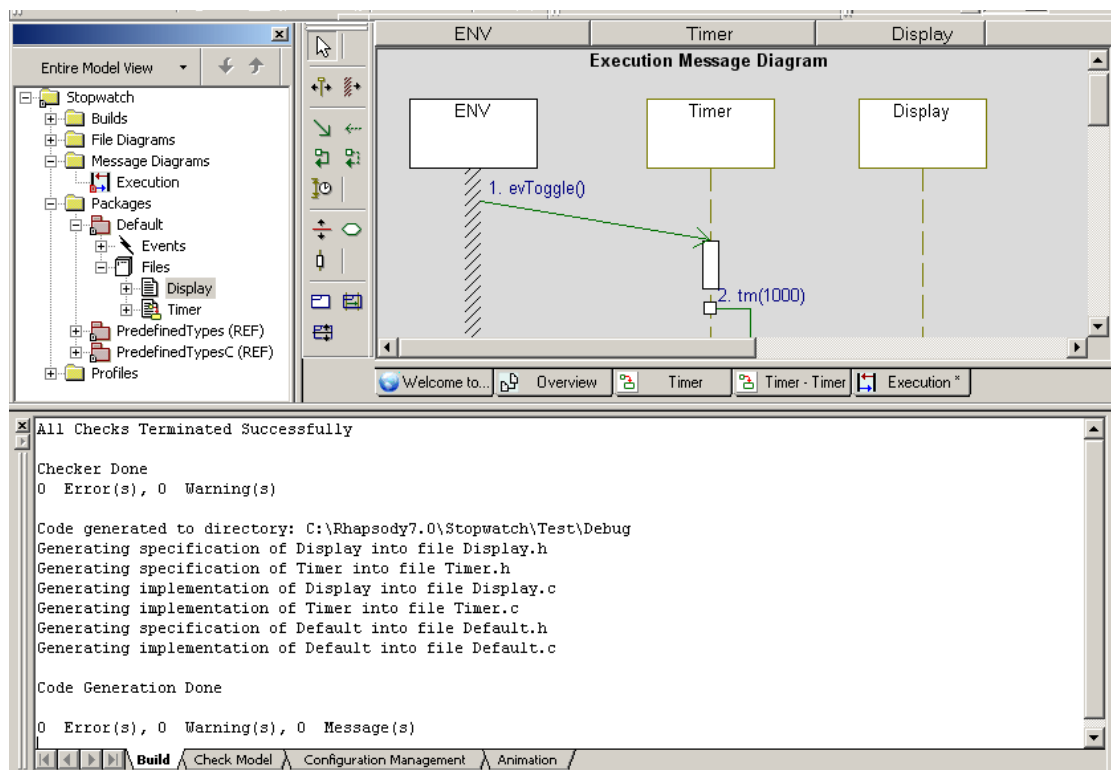
or

- ◆ Right-click the configuration in the Rational Rhapsody browser and select **Set as Active Configuration**.

Exercise 2: Generating Code

With the component, configuration, and environment defined, you can generate code for the stopwatch model. Follow these steps:

1. From the menu bar, choose **Code > Generate > Debug**.
2. Wait while Rational Rhapsody generates code. Rational Rhapsody generates the code for your application along with the Microsoft makefiles. See the Output window, as shown in the following figure.



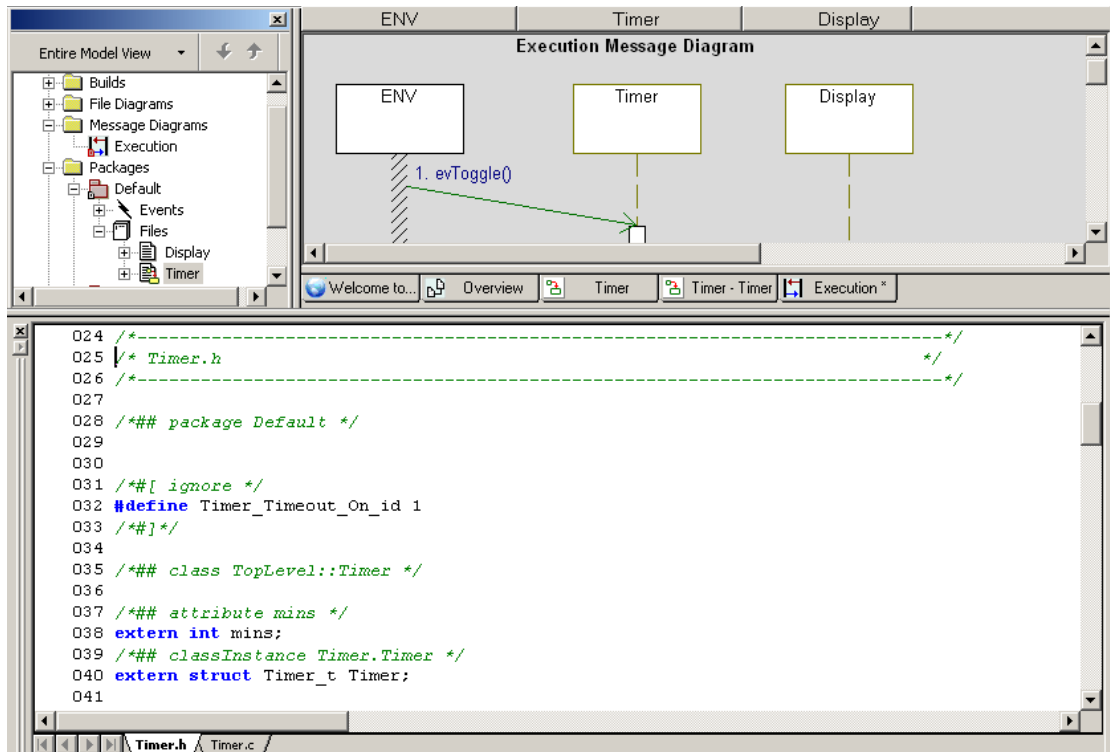
Exercise 3: Viewing and Editing the Generated Code


In this exercise, you view and edit the generated code. You also learn how to use the Rational Rhapsody browser to locate code, how to manually add code, and how to update the model with small changes by roundtripping.

Task 3a: Viewing the Generated Code

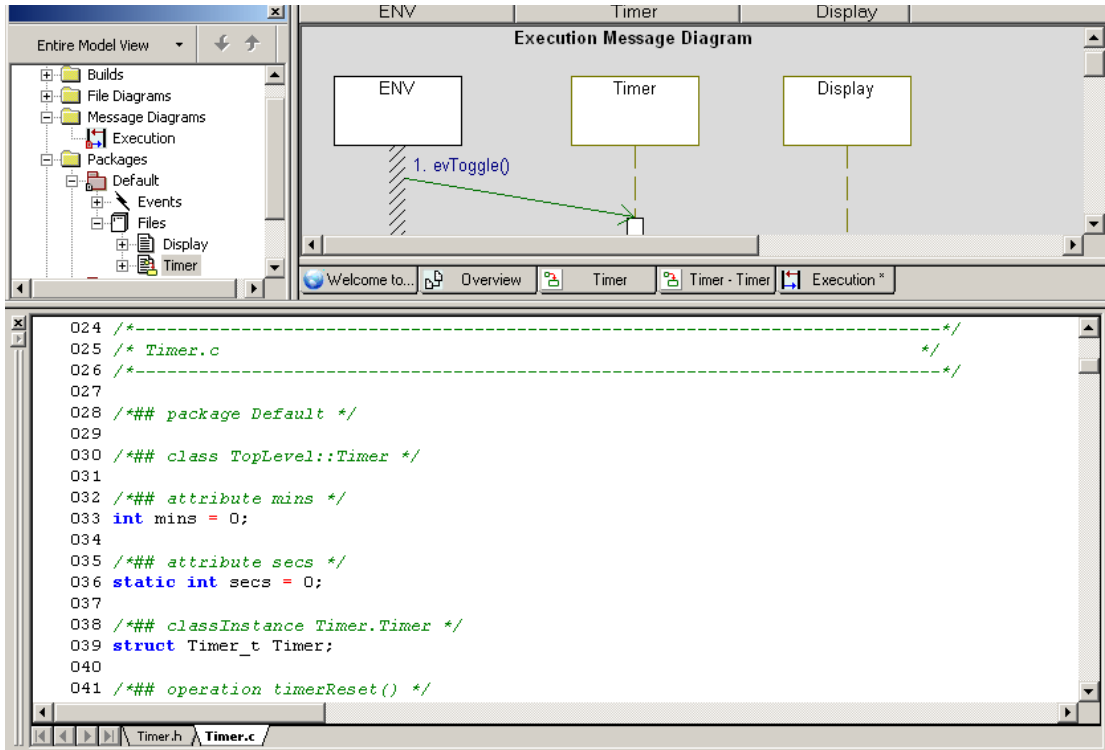
In this task, you view the generated code. Follow these steps:

1. Select the **Timer** file in the Rational Rhapsody browser.
2. From the menu bar, choose **View > Active Code View**. Rational Rhapsody displays the generated code in the Code window, as shown in the following figure.



Note: If your Output window is still open, click the **Hide docked window** button  for it so that you can expand the Code window. Note that in the above figure, the **Drawing** toolbar is also closed.

The **Timer.h** tab displays the *header file*, as shown in the previous figure. The **Timer.c** tab shows the C code, as shown in the following figure.



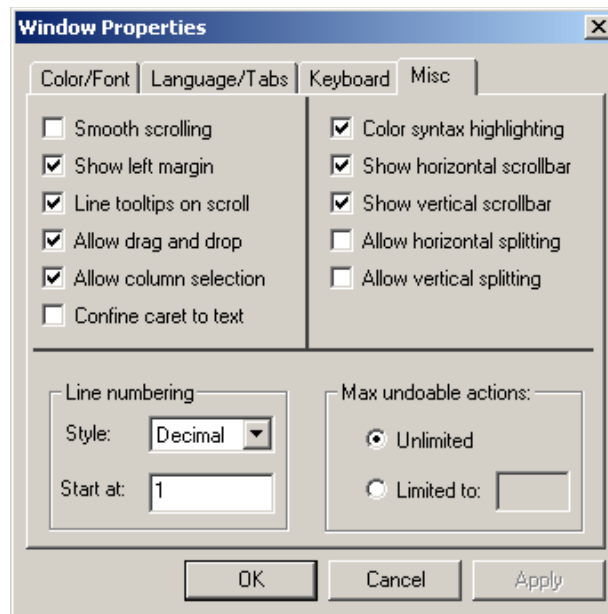
Note

You can scroll through the code and edit any code you want to change.

Task 3b: Adding Line Numbers

By default, line numbers should appear in the Code window. If they do not appear, and you would like them to appear, follow these steps.

1. Right-click in the Code window and select **Properties** to open the Window Properties dialog box.
2. On the **Misc** tab, in the **Line Numbering** area, from the **Style** drop-down list box, select **Decimal**, and in the **Start at** box, enter 1, as shown in the following figure.

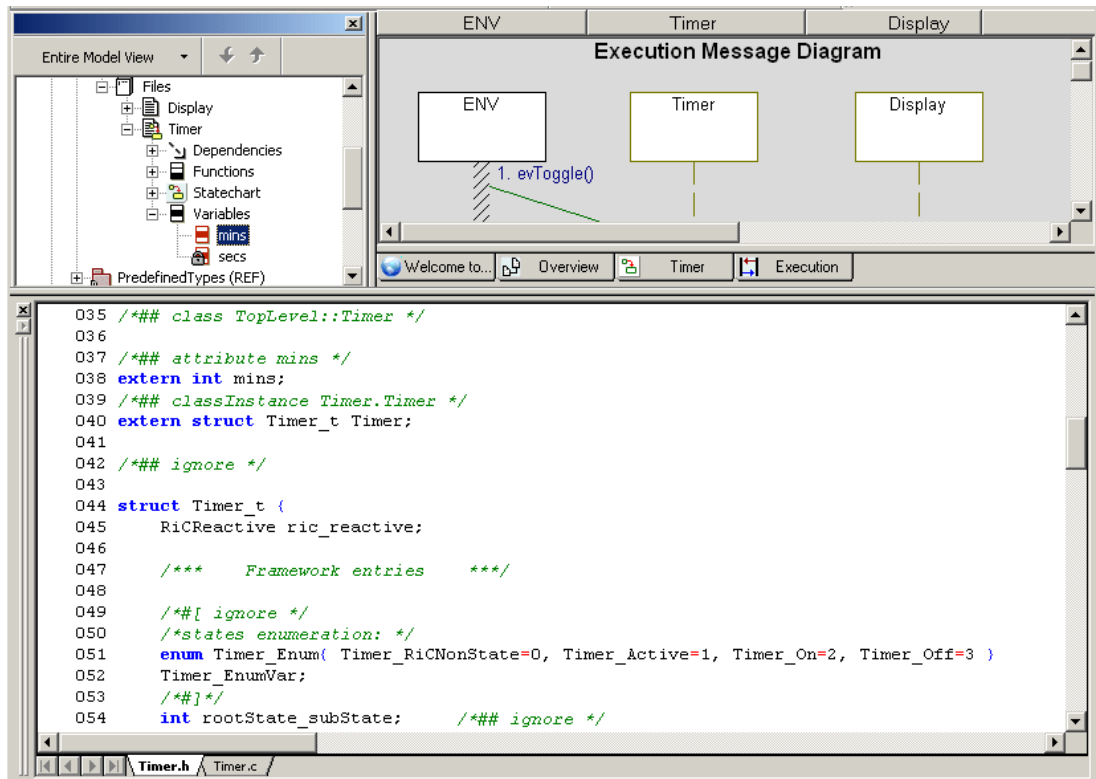


3. Click **OK**.

Task 3c: Using the Browser to Locate Code

In this task, you use the Rational Rhapsody browser to locate code. Follow these steps:

1. In the browser, click the **mins** variable.
2. Wait for the header and C code files to display in the Code window, as shown in the following figure.



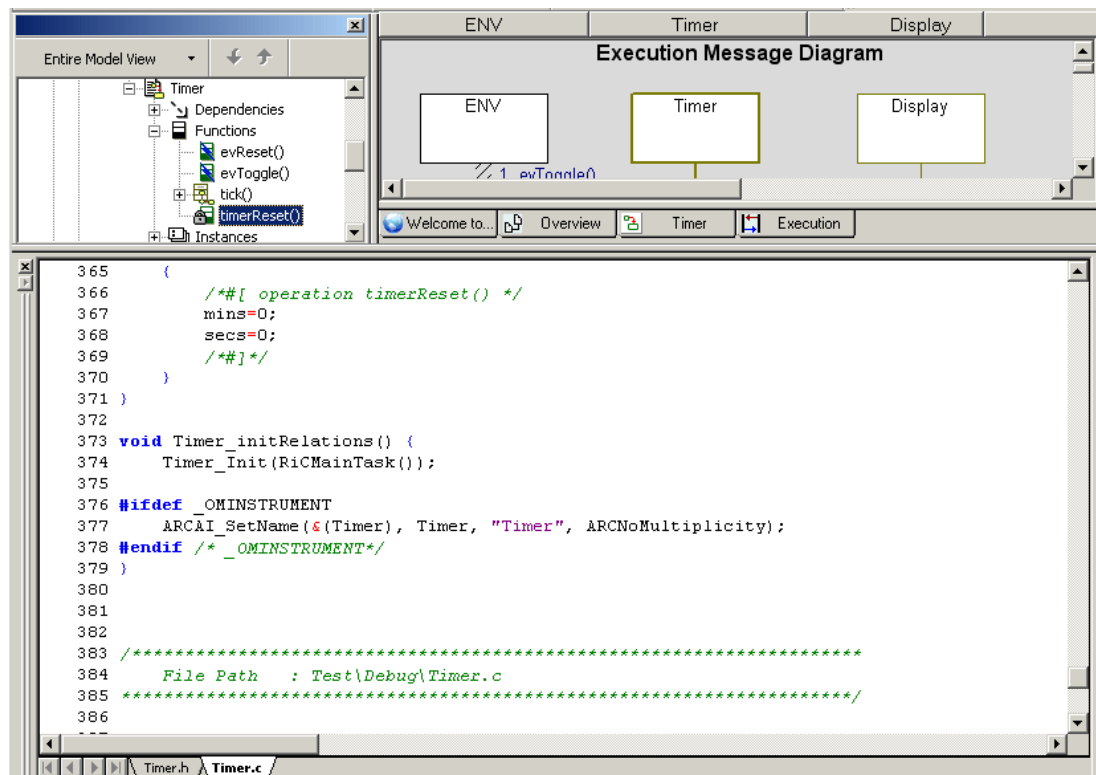
Task 3d: Adding Code for the timerReset Function

In this task, you add code for the `timerReset` function. While you have defined the `tick` function in the model, you have not yet done so for the `timerReset` function that was included in the statechart.

To manually add code for the `timerReset` function directly into the previously generated code, follow these steps:

1. If it is not already displayed, click the **Timer.c** tab in the Code window.
2. Locate the `timerReset` section of the code as shown in the following figure and type these missing instructions:

```
mins=0;
secs=0;
```





3. Save the model.

Because you have changed the generated code, you must update the model with the change. To do this, you use the roundtripping, which is described in the next task.

Task 3e: Roundtripping

In this task, you use roundtripping. *Roundtripping* is an on-the-fly method used to update the model quickly with small changes entered to previously generated code. You can set Rational Rhapsody to automatically roundtrip changed code using one of these methods:

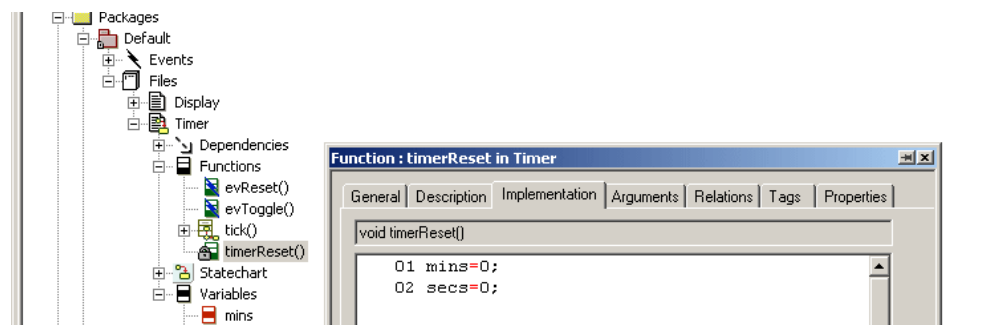
- ◆ Select **Code >Dynamic Model Code Associativity > Roundtrip**.
- ◆ Click the **Enable Dynamic Code Associativity** button  if the button has a red x and look disabled (gray). This changes the button to be active .

In order to compile the new code you manually entered for the `timerReset` function in the previous task into the model's generated code and check to be certain it was added to the model, follow these steps:

1. If Rational Rhapsody was not set to automatically roundtrip the code, from the file menu, choose **Code > Roundtrip > Debug**.

See what message appears in the Output window.

2. To check that the code has been added to the model, double-click the **timerReset** function in the Rational Rhapsody browser to open the Features dialog box.
3. On the **Implementation** tab, and see if the code is now listed, as shown in the following figure.



Note

Roundtripping should not be used for major changes in the model that would require the entire model to be rebuilt.

Summary

In this lesson, you generated code. You became familiar with the following:

- ◆ Managing multiple configurations
- ◆ Generating, viewing, locating, editing, and manually adding code
- ◆ Roundtripping

You have completed creating the stopwatch model. You are now ready to proceed to the next lesson, where you animate the message diagram and compare message diagrams.

Lesson 6: Animating and Comparing Message Diagrams

Animation executes the behaviors and associated definitions in the model. Rational Rhapsody animates the model using the code generated with instrumentation for the components to simulate the behaviors. After animating a diagram, you can open the animated versions of the diagrams to observe the model as it is running. This facilitates design-level debugging and troubleshooting. Using the animation approach, you can step through the model, set and clear breakpoints, inject events, and generate an output trace.

It is good practice to test the model incrementally using model execution. You can animate pieces of the model as it is developed. This gives you the opportunity to determine whether the model meets the requirements and find defects early on. Then you can test the entire model. In this way, you iteratively build the model, and then with each iteration perform an entire model validation.

Goals for this Lesson

Previously you animated the Timer statechart. In this lesson, you animate the message diagram for the stopwatch model by:


- ◆ Preparing for animation
- ◆ Animating the message diagram
- ◆ Viewing the animated message diagram
- ◆ Comparing the non-animated and animated message diagrams

Exercise 1: Animating Message Diagrams


Message diagrams are a key animation tool. When animating a model, Rational Rhapsody dynamically builds message diagrams to record the block-to-block messaging.

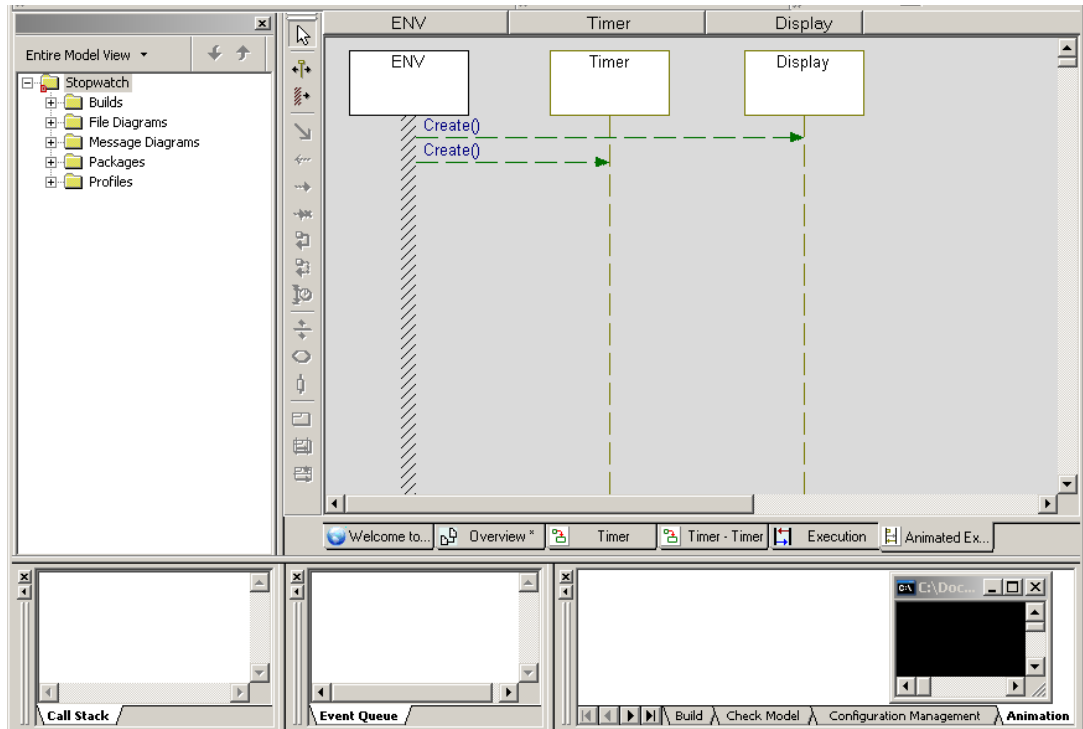
Task 1a: Running the Executable

To be certain that all of the previous changes are incorporated in the model, it is a good practice to generate the model again. Follow these steps:

1. Click the **Run Executable** button . The following happens:
 - ◆ The Display window opens. Do not close the Display window, though you might want to minimize, resize, and/or move the it so that you have a better view of the message diagram.
 - ◆ A copy of the message diagram (without the message lines) displays on an Animated Execution tab on the Drawing area.
 - ◆ The Call Stack, Event Queue, and Output (with the Animation tab active) windows open. The Call Stack and Event Queue windows provide supporting information to help you understand what is happening in the animated views.

Note: If these windows are not displayed, from the menu bar, choose **View > Call Stack**, **View > Event Queue**, and/or **View > Output Window**. The windows are dockable, so you can move them out of the Rational Rhapsody GUI to increase the viewable area for animations. To move a window, click-and-drag it to another location.

- Click the **Go** button  and watch as the system adds `Create()` message lines to the copy of the message diagram, as shown in the following figure.

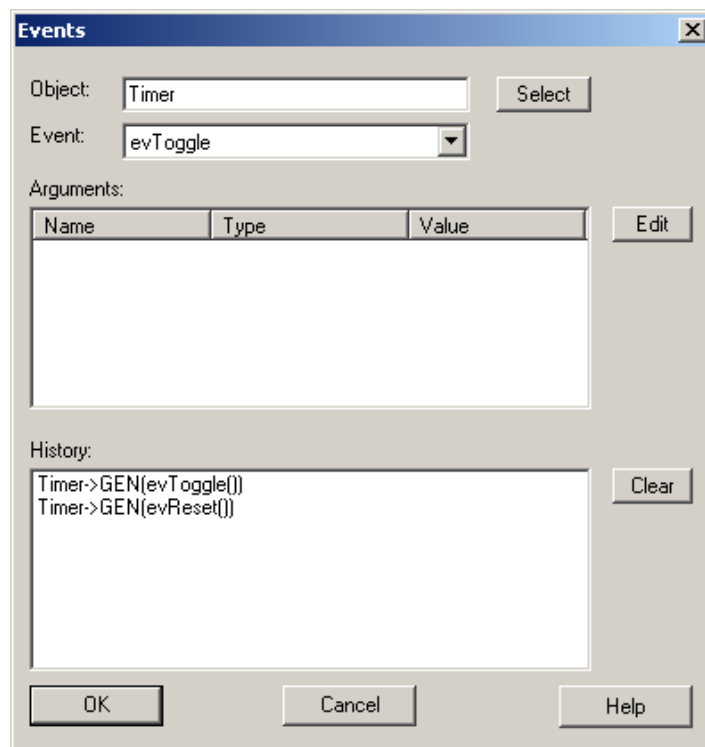


Task 1b: Generating an Event

In this task, you start the animation of the messages defined in the original message diagram by generating an event to start the communication.

To inject a previously defined event into the message diagram, follow these steps:

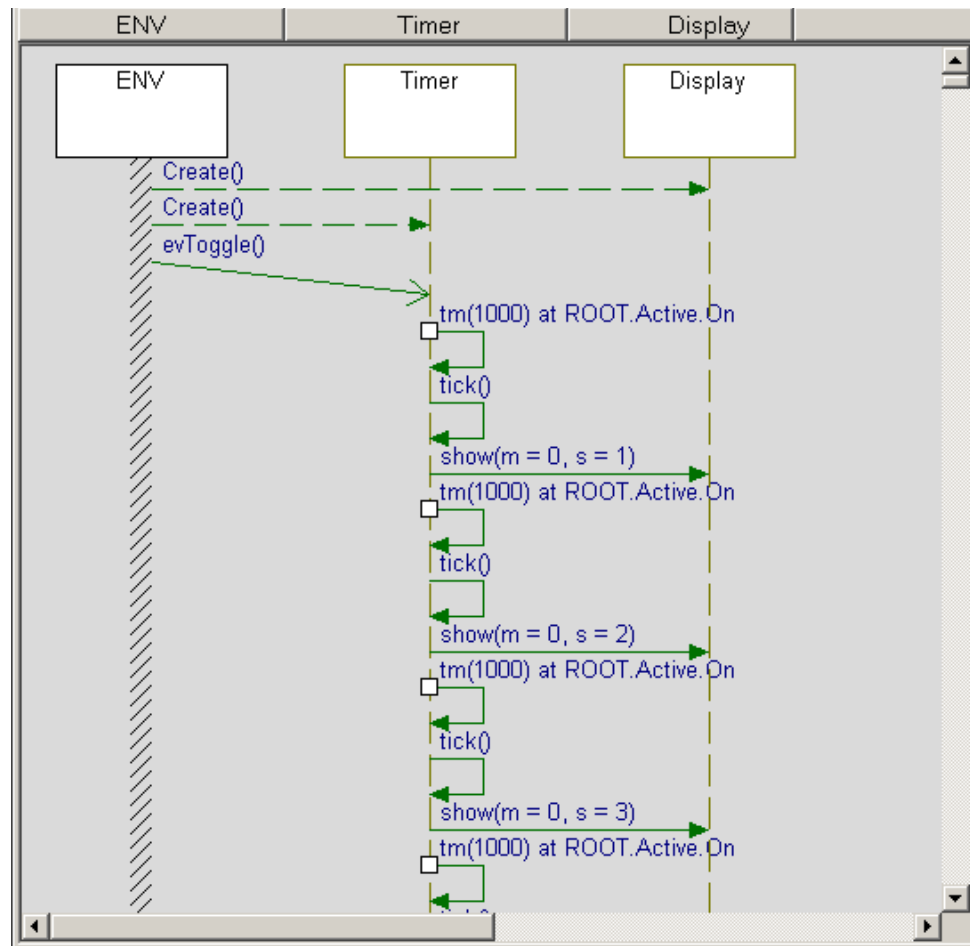
1. Right-click the **Timer** on the message diagram and select **Generate Event** to open the Events dialog box, as shown in the following figure.



2. In the **Event** box, select **evToggle** if it is not already selected.



3. Click **OK**.

The display begins the timer by displaying seconds with each tick. The file chart begins to generate timer tick message lines. At this point your animating diagram should resemble the following figure.





Task 1c: Pausing Animation

You can pause the animation and restart it.

- ◆ Click the **Pause** button  to pause the animation.
- ◆ Click the **Go** button  to restart animation.

Task 1d: Stopping Animation

To stop the animation when you are done with observing the animated messages, follow these steps:


1. Click the **Pause** button  to pause the animation.
2. Click the **Quit Animation** button . The system asks if you want to exit the animation session.
3. Click **Yes**.

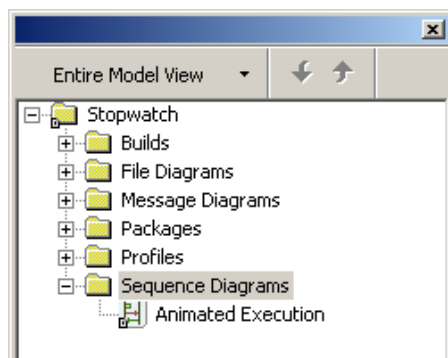
Notice that in the Output window, the `Animation session terminated` message appears.

Task 1e: Saving the Animated Diagram

You need to save the animated version of the message diagram in order to compare it to your original version.

To save the animated message diagram, follow these steps:

1. Click the **Save** button  or choose **File > Save**. The system asks if you want to save the animated diagram.
2. Click **Yes**. The animated diagram appears in the browser, as shown in the following figure.



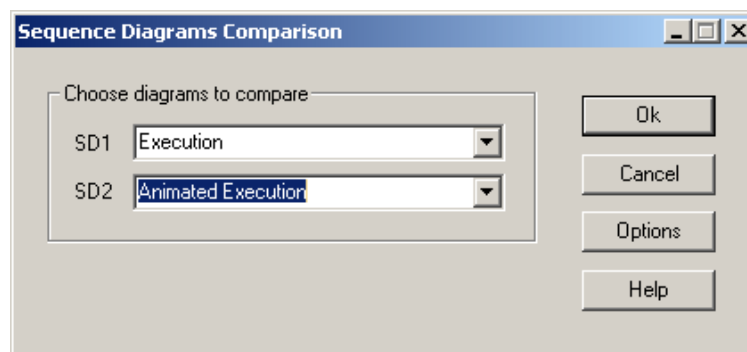
Task 1f: Comparing the Message Diagrams

Once you have saved the two message diagrams, you can do file comparison.

To compare the message diagrams, follow these steps:

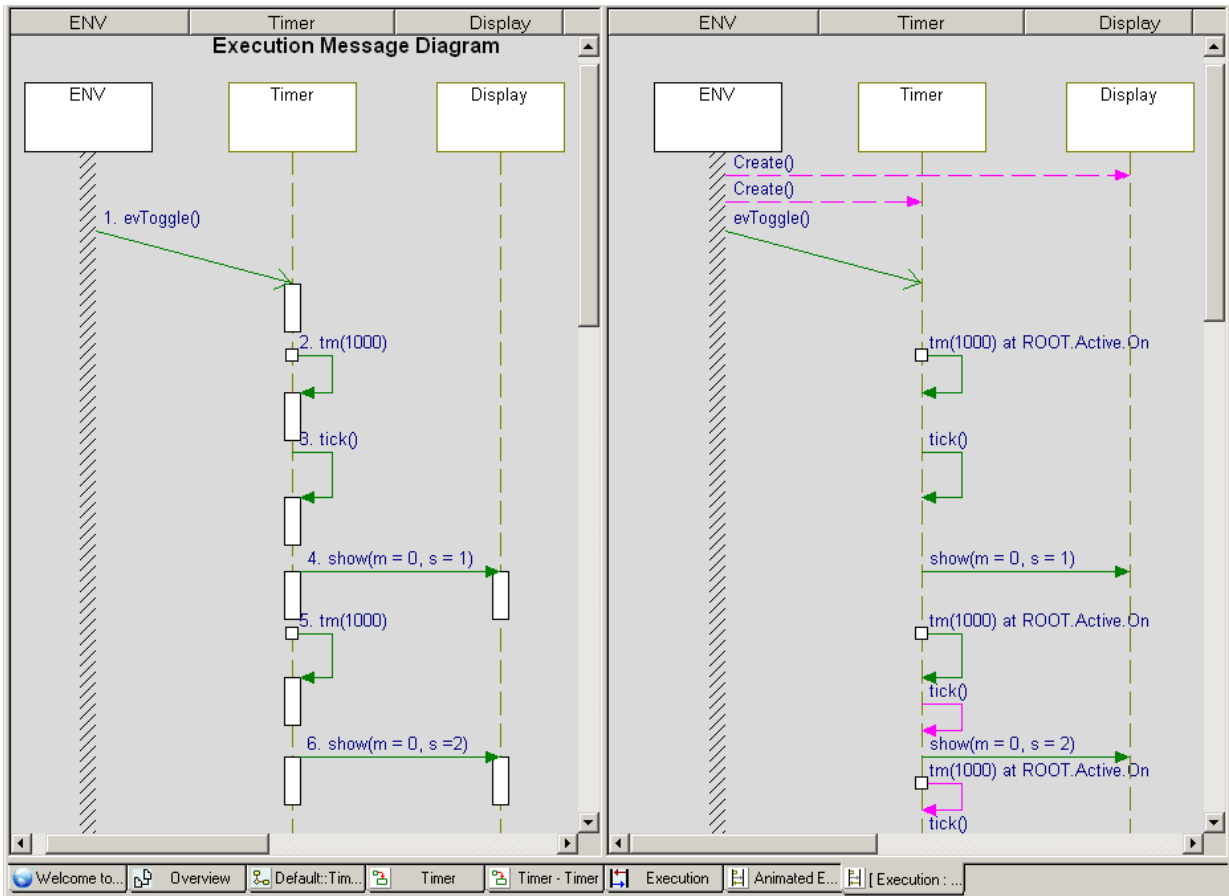
1. Choose **Tools > Sequence Diagram Compare** to open the Sequence Diagrams Comparison dialog box.
2. In the **SD1** box, select the Execution message diagram.
3. In the **SD2** box, select the animated Execution message diagram.

Your Sequence Diagrams Comparison dialog box should resemble the following figure.



4. Click **OK**.

Your comparison results should resemble the following figure.



Task 1g: Examining the Comparison Results

The displayed messages are color-coded on the comparison results to easily show the differences.

- ◆ Green means the message matches in both message diagrams.
- ◆ Pink means the message is missing in the other message diagram.

Notice that the animation added the `create()` messages as expected. However, it also added a `tick()` after the second timer that was missing from the original. Then it generated the expected timer results.

To correct the problem found in this comparison, open the original file diagram and add the missing `tick()` as shown in the animated version.

Summary

In this lesson, you animated the message diagram for the stopwatch model. You become more familiar with animation and you performed the following:

- ◆ Ran the component
- ◆ Animated the message diagram
- ◆ Sent events to the model and saw it pass messages
- ◆ Compared the message diagram with the animated message diagram

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