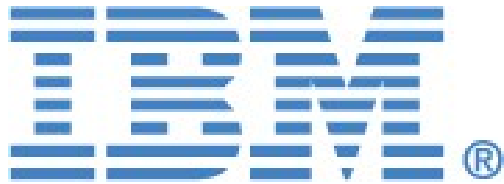


Tutorial for TestConductor for Rhapsody in Ada



Rational. Rhapsody

Rhapsody in Ada Tutorial

for

IBM[®] Rational[®] Rhapsody[®]
TestConductor Add On

Rational. Rhapsody

IBM



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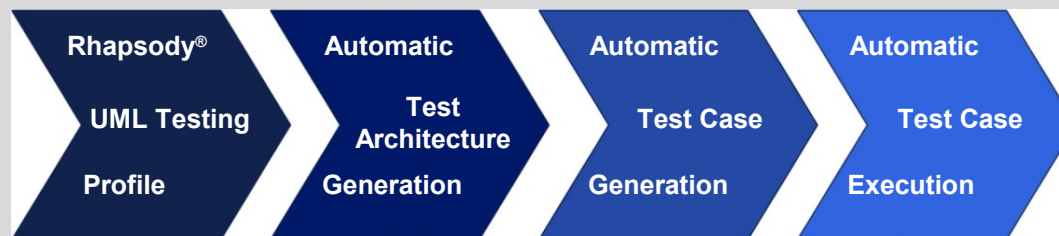
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TestConductor for Rhapsody for Ada

In this tutorial we would like to give you an impression of the Rhapsody Testing Environment, which goes beyond current embedded software testing technologies; it ensures that the system can be continuously tested throughout the design process. The Testing Environment and its parts seamlessly integrate in Rhapsody UML and guide the user through the complex process of test preparation, execution and result analysis.

TestConductor is the test execution and verification engine in the Rhapsody Testing Environment. It executes test cases defined by sequence diagrams, statecharts, and source code. During execution TestConductor verifies the results against the defined requirements.



IBM® Rational® Rhapsody® Testing Environment

StopWatch Application

4

Events

Object:

Event:

Arguments:

Name	Type	Value
KeyVal	int	

History:

myStopWatch[0]->

```
0 0
0:0
0 0
0:1
0 1
0:2
0 2
0:3
0 3
0:4
0 4
0:5
0 5
```

The [StopWatch application](#), the example Ada application for this tutorial, models a simple stopwatch. Make yourself familiar with the use cases of the application. Open the project „AdaStopWatch“ from the folder „Samples/AdaSamples/TestConductor“ in your Rhapsody installation, run the component «StopWatchComp», and use the following input:

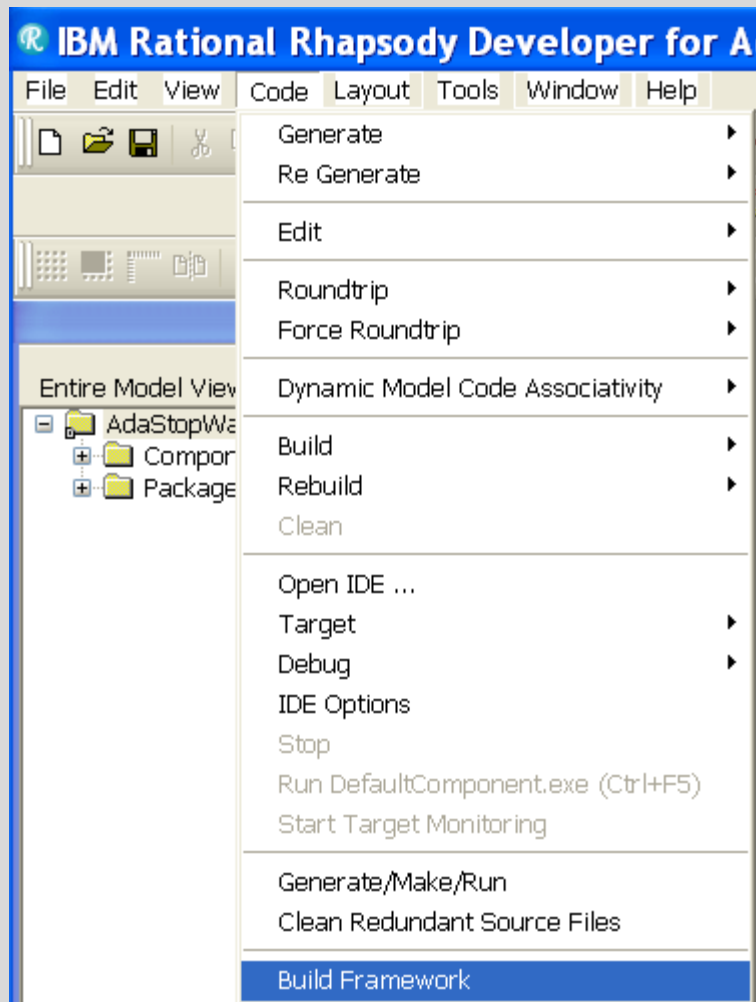
To start the application, press “Go” in Rhapsody’s animation toolbar.

To start the stopwatch, generate event “evKey(1)” using the animation toolbar.

To stop the stopwatch, generate event “evKey(1)” again using the animation toolbar.

When running, the stopwatch outputs the elapsed time in minutes and seconds to the console. Each second is printed twice, one time with a colon and 0.5 seconds later without a colon, similar to a stopwatch with blinking colon.

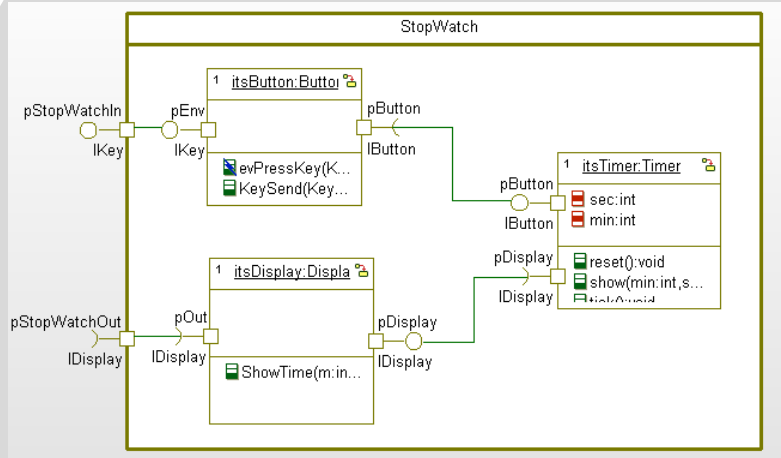
Before testing the model



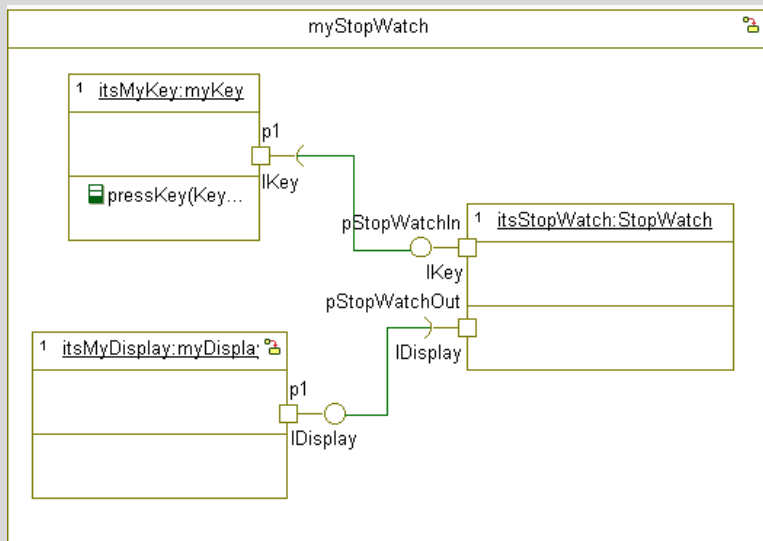
Before testing the tutorial model, one has to rebuild the Rhapsody Ada framework. In order to do this, go to Rhapsody's Code menu and select "Build framework". This rebuilds Rhapsody's framework which is needed before we can test the tutorial model. Please note that this is only needed once, you don't have to rebuild the framework again if you want to test other models.

StopWatch Model

6



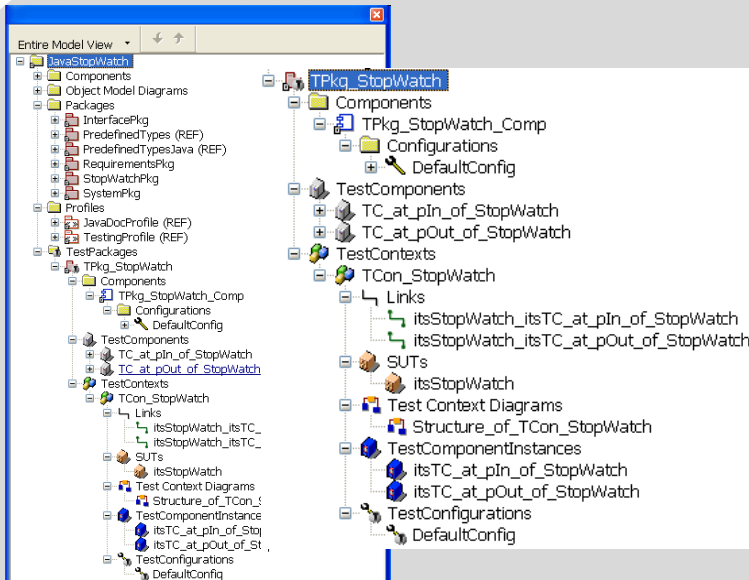
The **StopWatch model** contains the `StopWatch` class and its three parts. The first part is a button that can be used to start and stop the stopwatch. The second part is the timer that is used in order to count the elapsed time. The third part is the display that displays the elapsed time. Within the stopwatch the different components are connected via ports and links. Additionally, the stopwatch class itself relays both the start/stop button and the display to its boundaries in order to be able to connect an external start/stop button and an external display .



The **myStopWatch class** represents a sample instantiation of the `StopWatch` class. It connects a stopwatch to an external key “myKey” that can be used as a start/stop button. Additionally, it connects the stopwatch to an external display “myDisplay” that displays the elapsed time.

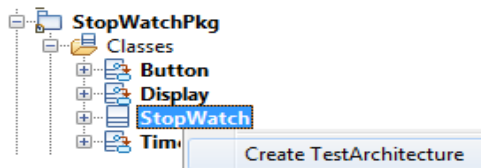
System Under Test

7

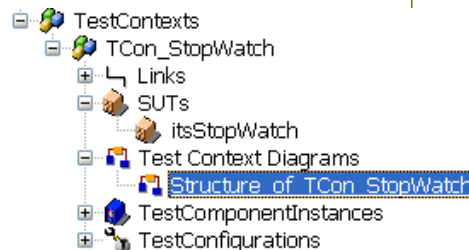


Defining the System Under Test (SUT) is the first step in the test workflow. This tutorial will focus on the StopWatch class. To define StopWatch to be the SUT, we have to create a test architecture. The needed administrative framework will be placed in the folder „TestPackages“.

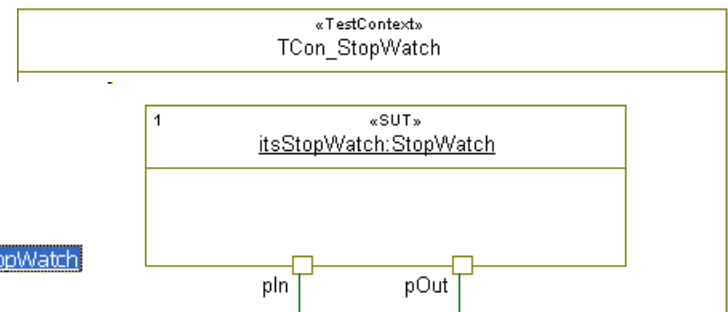
The System Under Test (SUT) is a part and is the component being tested. A SUT can consist of several objects. The SUT is exercised via its public interface operations and events by the test components.



1 Select the class „StopWatch“ in the browser and choose from context menu „Create TestArchitecture“.

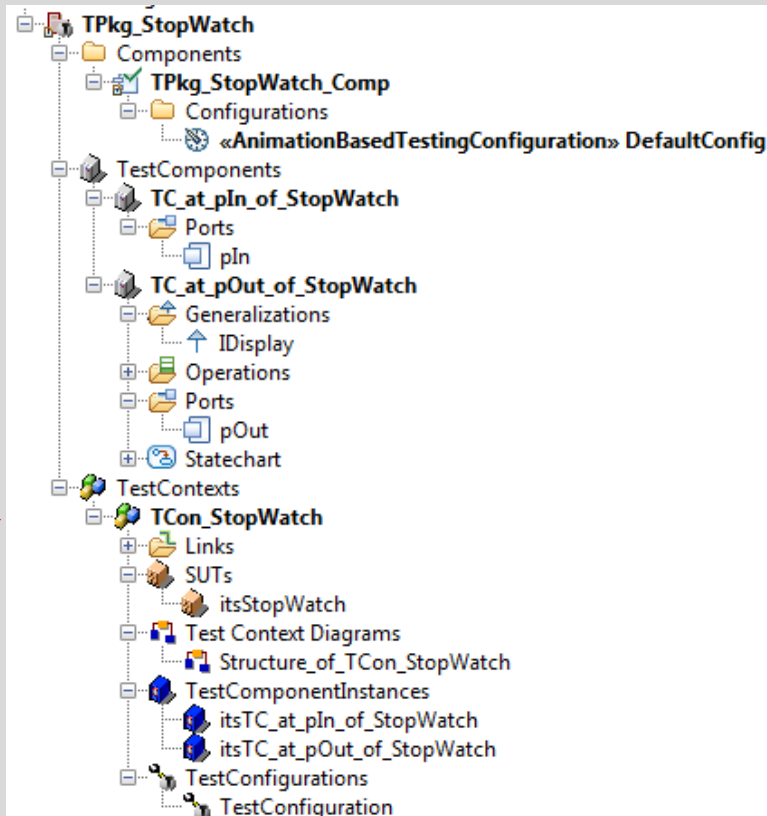


2 Have a look on the newly created Test Context Diagram „Structure_of_TCon_StopWatch“, and view the resulting parts in the composite class „TCon_StopWatch“ of our test context.



Test Architecture

The automatically created test architecture is completely represented in the browser and seamlessly integrates into Rhapsody; think of it as an independent test model besides the design model. After creation the following elements are visible:



The new configuration under the component „TPkg_StopWatch_Comp“ describes the collection of test components and SUT objects and their interconnections when a test case is started.

A test component is a class of a test system. Test component objects (test component instances) realize partially the behavior of a test case. A test component might have a set of interfaces via which it might communicate via connections with other test components or with SUT objects.

A test context describes the context in which test cases are executed. It is responsible for defining the structure of the test system. The test components and SUT objects are normally parts of a test context.

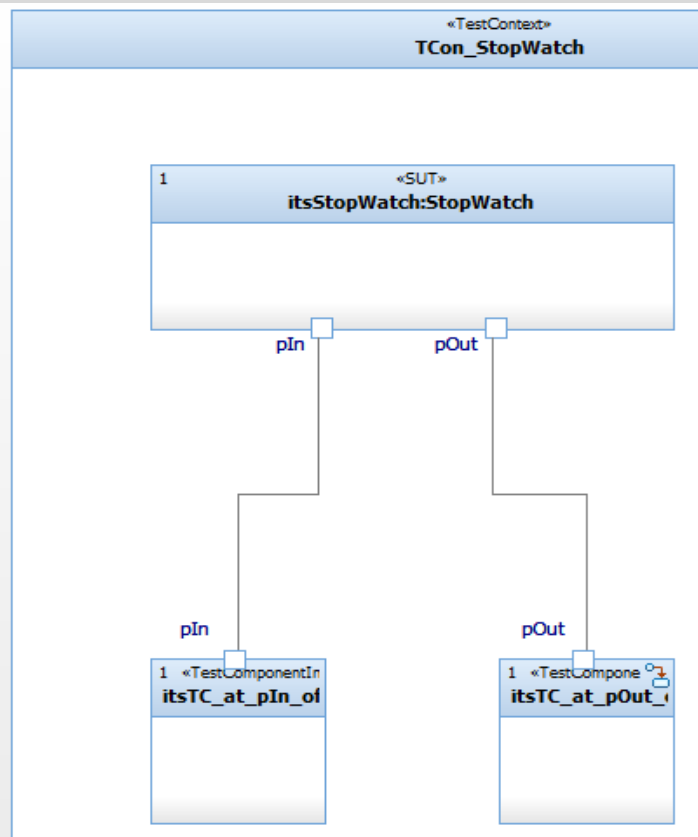
Test Context

The automatically created test context represents the formal structure of the test system. TestConductor analyzed the model structure in consideration of the selected SUT and proposed a test structure, which is visualized in the test context diagram inside the test context. TestConductor generated corresponding test components for ports and associations of the SUT.

The composite class „TCon_StopWatch“ is the part container for the SUT object and the created test component objects.

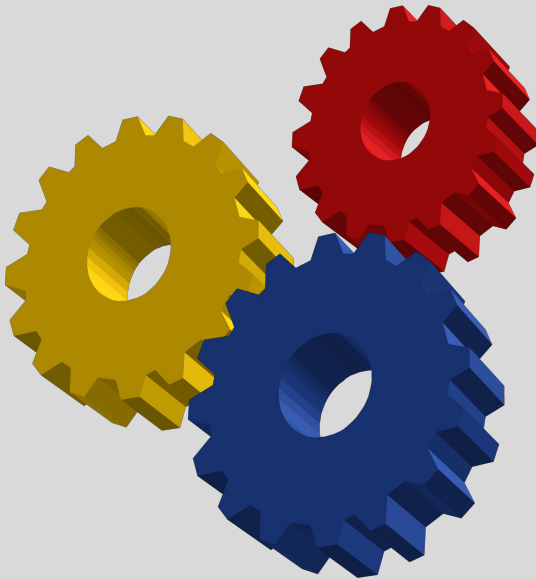
The class „TC_at_pIn_of_StopWatch“ realizes the required interface „IKey“ and thus can be connected to the “pIn” port of the stopwatch class that provides this interface.

The class „TC_at_pOut_of_StopWatch“ provides realizations for the interface “IDisplay” and thus can be connected to the “pOut” port of the stopwatch class.



Test Cases

Test cases are the soul of a test system. Until now we created a complete test architecture around the SUT with a few mouse clicks in less than a minute. The established and reviewed test system is linkable and runnable. Well, the body works, let's have a look at the test cases. A test case ...



is a specification of one case to test the system including what to test, with which inputs, and what the expected outcomes are. It is defined in terms of stimuli injected to SUT objects and observations coming from SUT objects.

is an operation of a test context that specifies how a set of cooperating test components interact with the SUT.

can be specified as sequence diagrams, statecharts, and source code.

can be generated automatically by using TestConductor's test case wizard.

can be recorded as animated sequence diagrams.

can be created by hand.

Test Case Specification

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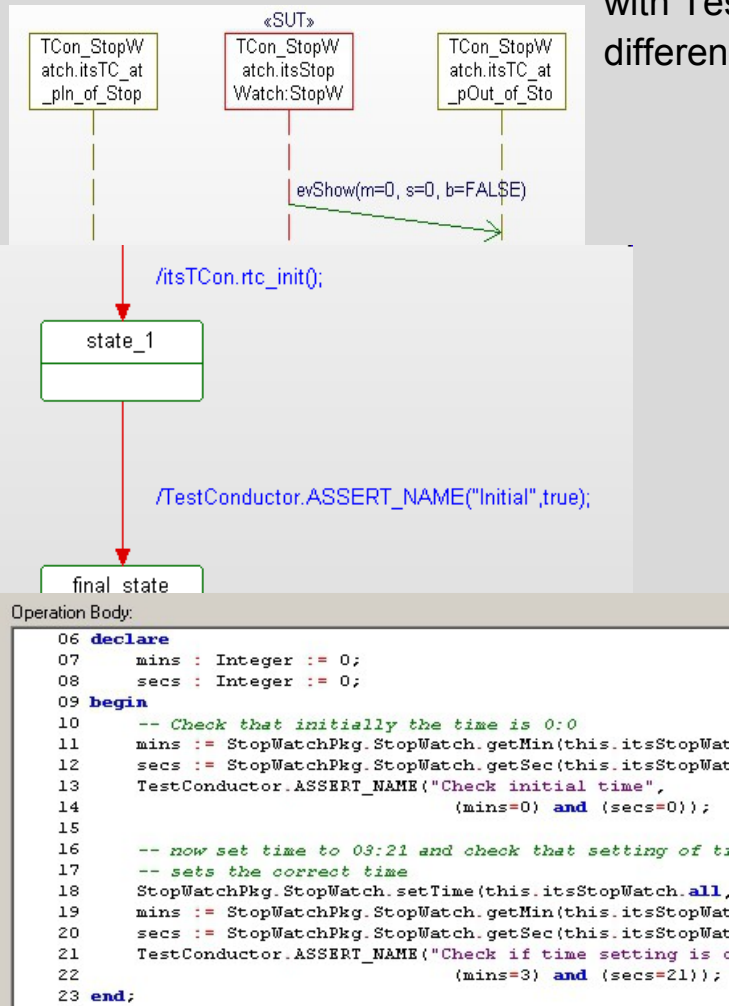
How to manually create test cases and how to execute them with TestConductor will be discussed in the following sections. The different kinds of definitions have their own strengths:

Sequence diagram test cases can be recorded automatically or created by hand. In some cases they have already been specified during the analysis phase of the project, and define the actions and reactions of the SUT. The graphical formalism boosts the readability and understanding.

Statechart test cases are a well known and convenient means to specify behavior based on states and modes.

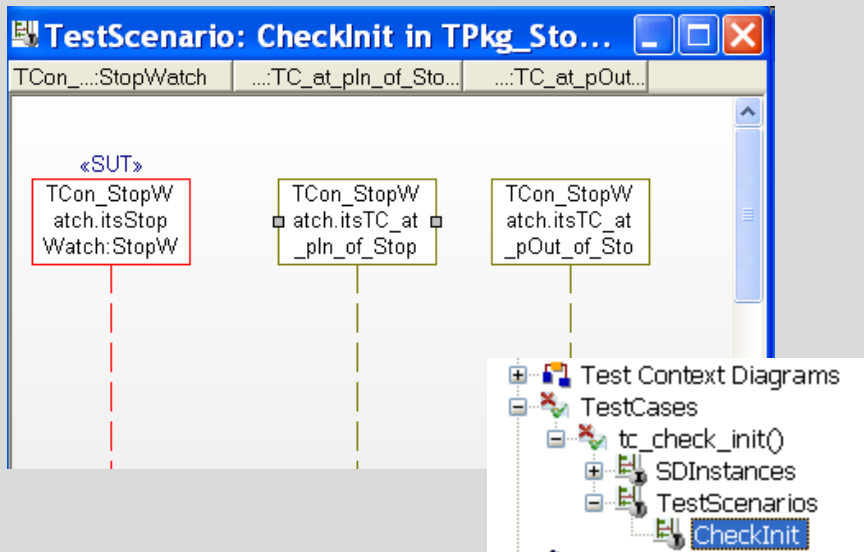
Source code test cases are often preferred by experienced programmers.

In summary TestConductor, the Rhapsody test case execution engine, works with all kinds and combinations of test case definitions.



Test Case: Sequence Diagram I

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To manually create a sequence diagram test case we have to define a test scenario which is represented as a sequence diagram and link it to a test case. TestConductor simplifies this process with a single command.



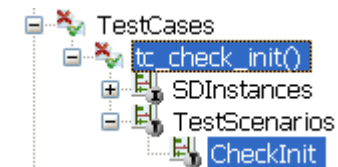
1

Select the test context „TCon_StopWatch“ in the Rhapsody-Browser ...

2

Create SD TestCase
Create Flowchart TestCase
Create Code TestCase
Create Statechart TestCase

... and choose from the context menu „Create SD TestCase“..

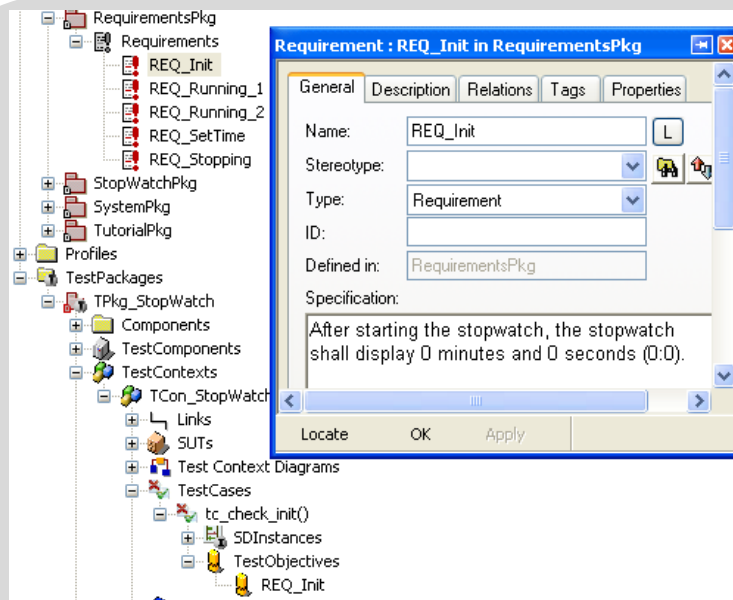


3

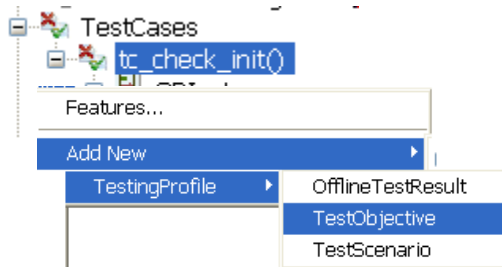
Rename the test case to „tc_check_init“. Rename the test scenario to „CheckInit“ and open it.

Test Case: Sequence Diagram II

13

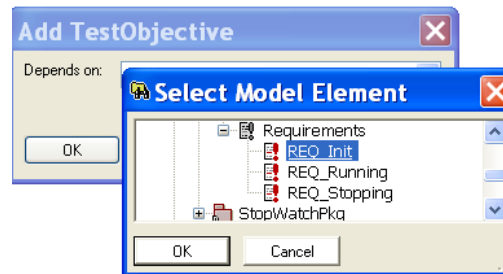


Determine the test objective of the test case: the SD test case should check that requirement “REQ_Init” is indeed fulfilled by the stopwatch class. To make explicit that the SD test case shall verify this particular requirement, a test objective is added to the test case.



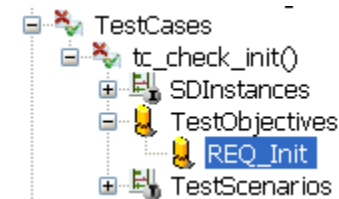
1

Select the test case and select “Add New -> TestingProfile -> TestObjective”



2

Select requirement “REQ_Init” as target of the test objective

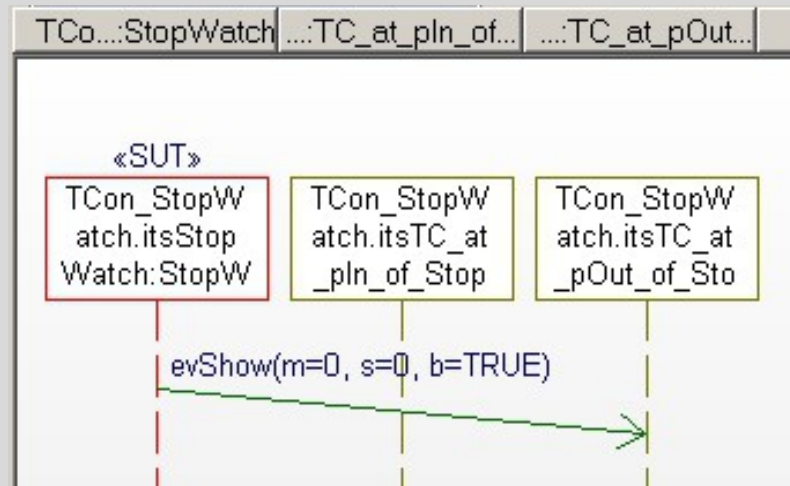


3

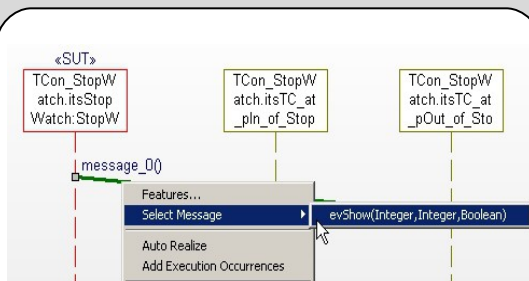
The test objective now links the test case to the requirement “REQ_Init”.

Test Case: Sequence Diagram III

14

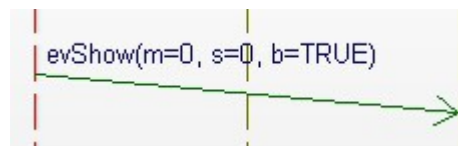


Define action and reaction of the system under test. We will specify the „CheckInit“ scenario, where the SUT shall emit event “evShow” with current time 0:0 after starting the SUT. This output shall be generated automatically by the SUT, since no further input is needed for that.



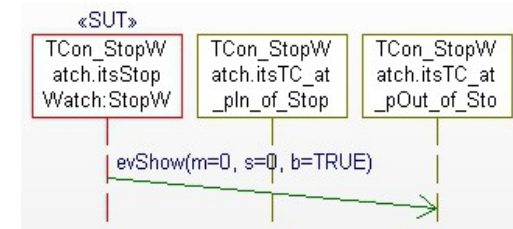
1

Draw the message “evShow” from the SUT to the test component “TCon_StopWatch.itsTC_at_pOut_of_StopWatch”.



2

Specify argument values $m = 0$, $s = 0$, $b = \text{TRUE}$ for the message.



3

That's it already. The test case specification is complete.

Test Case Execution I

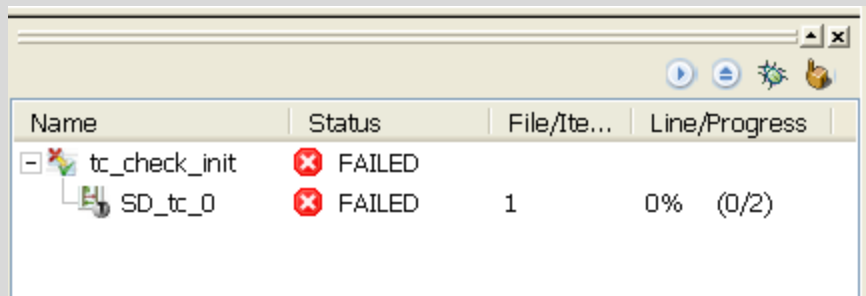
15

Execute the test case with Rhapsody TestConductor. The execute dialog lists all executed test scenarios, their progress and status.

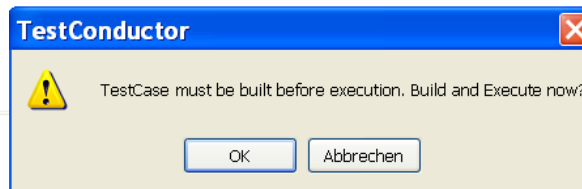
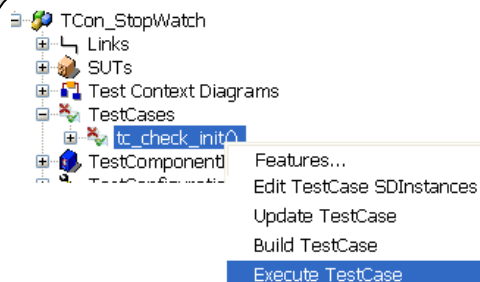
The status, the final result can be either „PASSED“ or „FAILED“.

The progress displays how many steps are finished yet. In case of a passed test 100% have to be achieved.

The buttons in the top right corner of the execution dialog can be used to control actual test case execution and will be explained later.

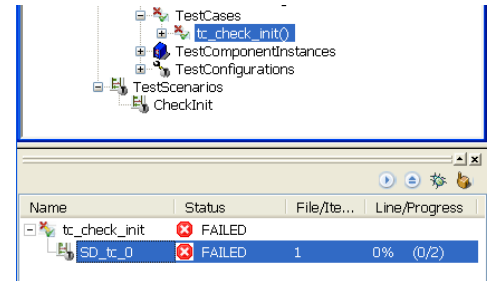


Name	Status	File/Item...	Line/Progress
tc_check_init	FAILED		
SD_tc_0	FAILED	1	0% (0/2)



1

To execute a test case, simply right-click the test case and select “Execute TestCase” from the context menu. In case the test model needs to be updated and/or the tested executable needs to be compiled, a popup window appears in order to update the test case and/or build the executable.

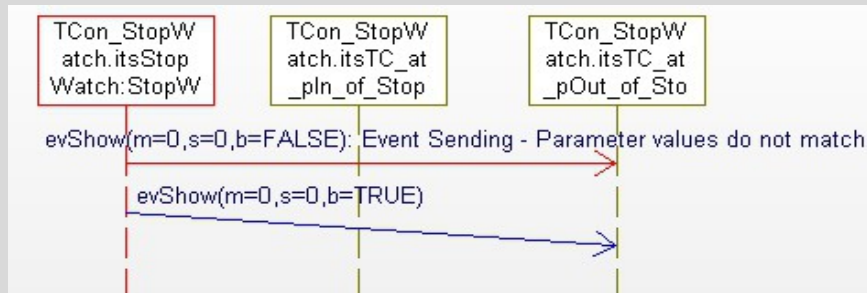


2

The test case execution dialog is a dockable dialog that can be placed e.g. underneath the main browser window

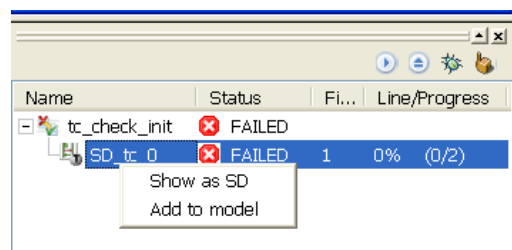
Test Case Execution II

16



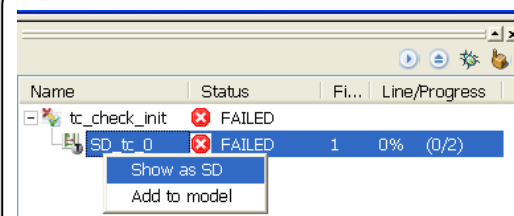
Summary Info	
Total number of SDs used:	1
Total number of SD instances in test:	1
Total number of executed SD instances:	0

The test case execution **FAILED** with Rhapsody TestConductor. To analyze the reason TestConductor offers two kind of views. The HTML-report displays a textual summary and can be found directly under the test case in the Rhapsody-Browser. TestConductor created a witness sequence diagram to display the error. The red arrow visualizes the faulty step and the reason. TestConductor expects the parameter value „TRUE“ for argument “b”, but observes the value „FALSE“ during actual test execution. The expected value was not specified correctly... by accident.



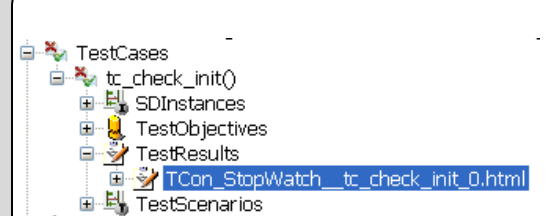
1

To open the witness sequence diagram right click the item SD_tc_0 in the TestConductor execution dialog...



2

... and select “Show as SD”

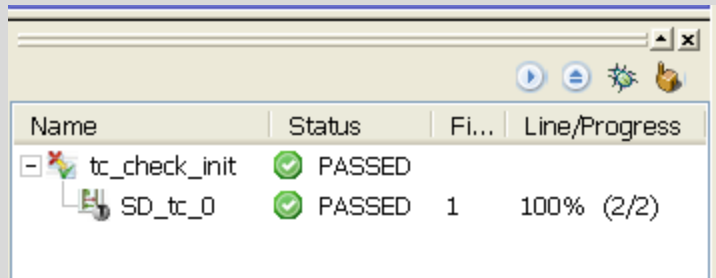


3

In the browser, underneath the test case, you can find the generated html report. Double click the report to open it.

Test Case Execution III

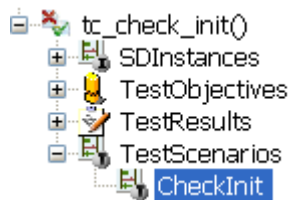
17



Name	Status	Fi...	Line/Progress
tc_check_init	✓ PASSED		
SD_tc_0	✓ PASSED	1	100% (2/2)

The test execution **PASSED** with Rhapsody TestConductor after we corrected the expected parameter value for argument “b” from “true” to “false” in the test scenario „CheckInit“. After changing the scenario and re-executing the test case, the test case is passed.

Refer to the [user guide](#) to get familiar with the extended functionality of TestConductor.

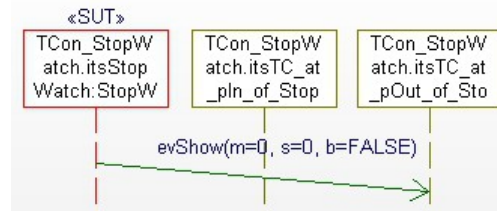


1

To correct the test case open the test scenario „CheckInit“.

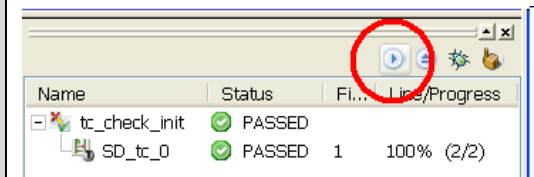
2

For argument “b”, change the expected value from “TRUE” to “FALSE”.



3

Re-execute the test case by pressing the “Start” button in the top right corner of the execution dialog.



Test Case: Source Code I

18

Operation Body:

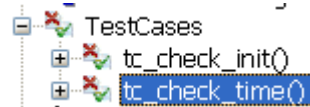
```
06 declare
07     mins : Integer := 0;
08     secs : Integer := 0;
09 begin
10     -- Check that initially the time is 0:0
11     mins := StopwatchPkg.StopWatch.getMin(this.itsStopWatch.all);
12     secs := StopwatchPkg.StopWatch.getSec(this.itsStopWatch.all);
13     TestConductor.ASSERT_NAME("Check initial time",
14                               {mins=0} and {secs=0});
15
16     -- now set time to 03:21 and check that setting of time indeed
17     -- sets the correct time
18     StopwatchPkg.StopWatch.setTime(this.itsStopWatch.all,3,21);
19     mins := StopwatchPkg.StopWatch.getMin(this.itsStopWatch.all);
20     secs := StopwatchPkg.StopWatch.getSec(this.itsStopWatch.all);
21     TestConductor.ASSERT_NAME("Check if time setting is correct",
22                               {mins=3} and {secs=21});
23 end;
24
```

To manually create a source code test case create a code test case and write the test code into the edit field under the implementation tab of the test case. TestConductor provides a set of functions like e.g.

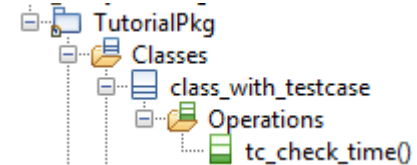
„TestConductor.ASSERT_NAME“ that can be used to execute checks during test case execution. If the function “setTime” (line 08) of the stopwatch works as expected, the test case passes.



- 1 Select the test context „TCon_StopWatch“ and choose from the context menu „Create Code TestCase“.



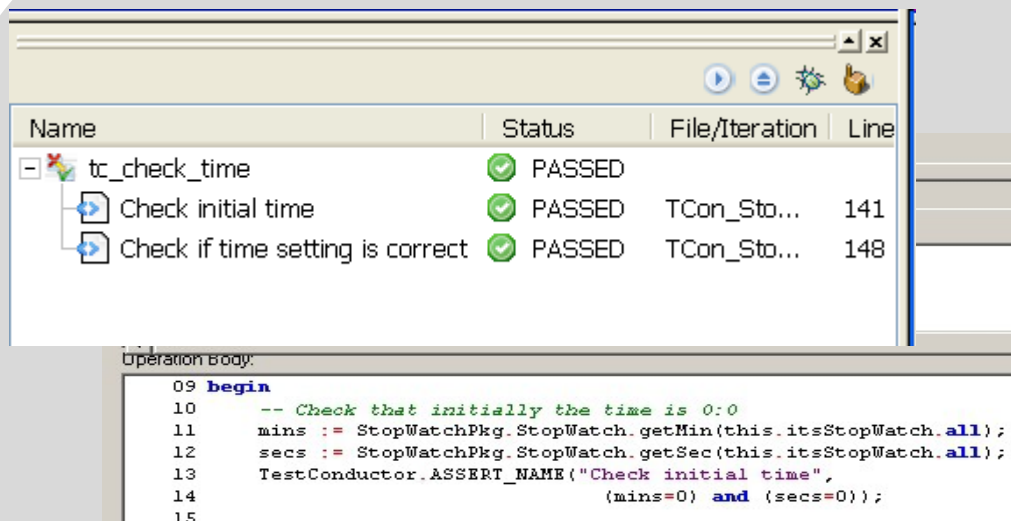
- 2 Rename the created test case to „tc_check_time“ and open the features dialog.



- 3 Replace the content of the edit field under the implementation tab of the test case with the content from the “tc_check_time” operation in the Tutorial package.

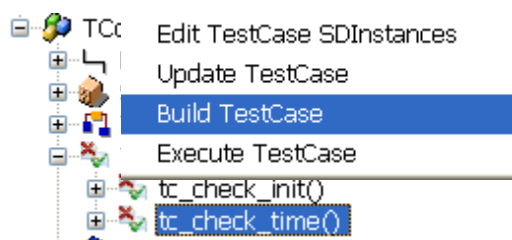
Source Code Test Case: Execution

19

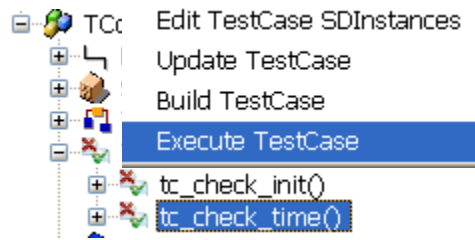


Execute the test case with Rhapsody TestConductor.

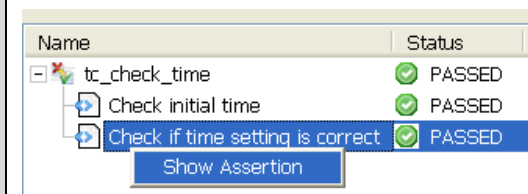
Both assertions evaluate to true and the test case passes. Double-clicking an evaluated assertion in the execution window highlights the assertion in the test model.



- 1 Select test case "tc_check_time" and then select "Build TestCase" from the context menu.



- 2 Select test case "tc_check_time" and select "Execute TestCase" from the context menu.

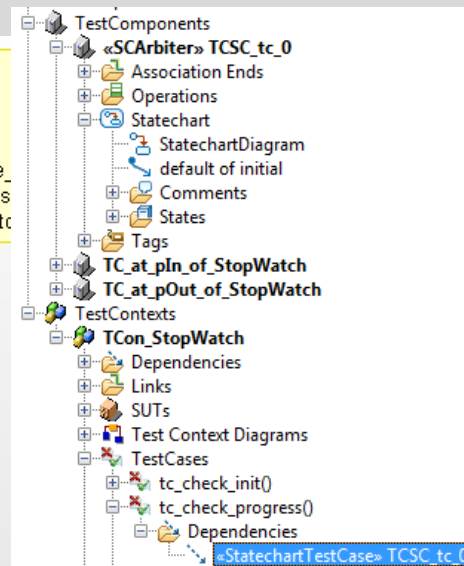
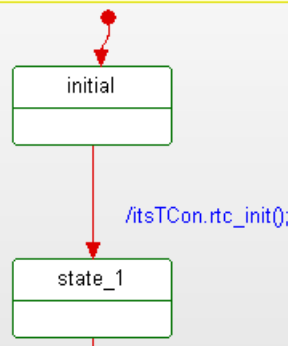


- 3 In the execution window, select the assertion and click "Show Assertion" in order to highlight the assertion in the model.

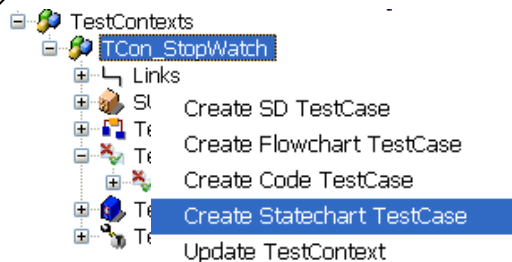
Test Case: Statecharts I

20

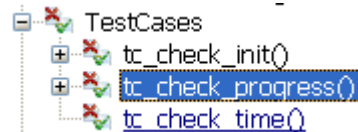
This is a statechart defining TestCase behavior
In Statechart TestCases you can use ASSERT macros like :
TestConductor ASSERT_NAME(n,e), e.g.
TestConductor ASSERT_NAME("Check_1", attribute_
For the list of available macros see TestConductor Us
or the TestConductor.java file in the installation direct



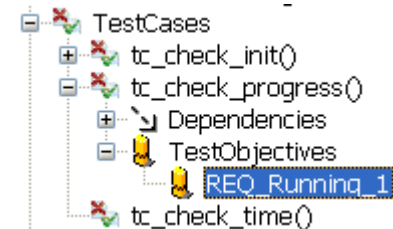
To manually create a **statechart test case** we have to define a test scenario which is represented as a statechart and link it to a test case. Technically, the test case has a dependency to a TestComponent that contains the statechart. TestConductor simplifies this process with a single command.



1 Select the test context „TCon_StopWatch“ and select “Create Statechart TestCase”.



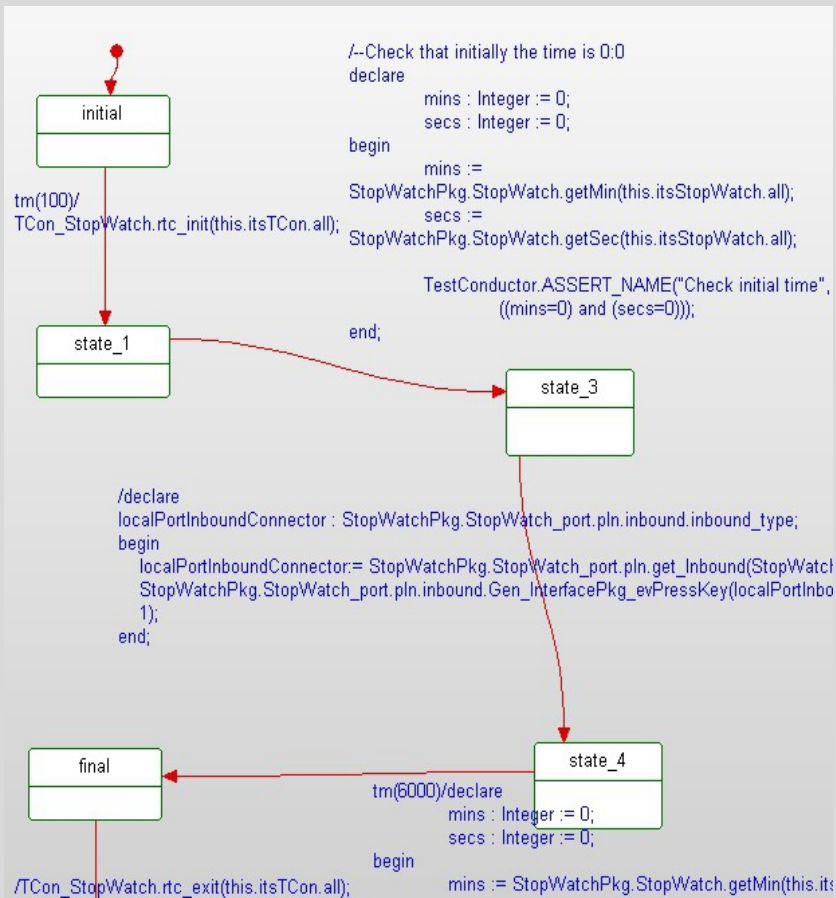
2 Rename the test case to “tc_check_progress”



3 Add a test objective (using “Add New -> TestingProfile -> TestObjective”) to requirement REQ_Running_1

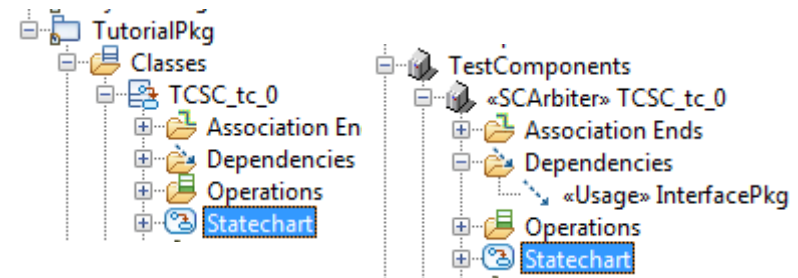
Test Case: Statecharts II

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Vitalize the statechart in order to execute it with TestConductor. The statechart test case first checks that initially the stopwatch's time is indeed 0:0. After starting the stopwatch, the statechart test case waits 6 seconds, and then checks that indeed more than 3 seconds have been counted by the stopwatch during that period. To execute the checks the statechart test case uses the Rhapsody TestConductor function

„TestConductor.ASSERT_NAME()“. This function was already used for the code test case in order to perform code based checks. If both checks are passed, the complete test case is passed.



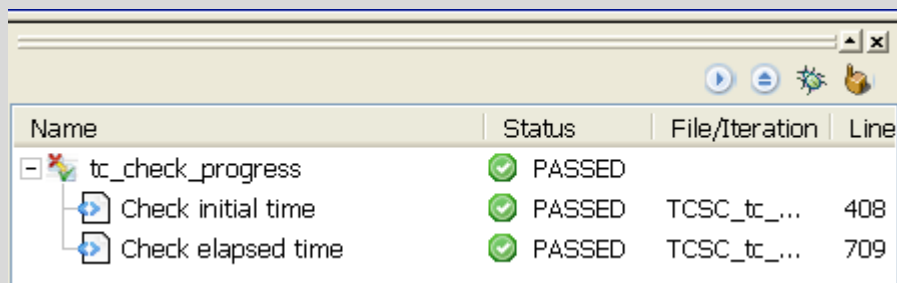
1

Replace the content of the test component statechart associated with this test case with the statechart of the Tutorial package.

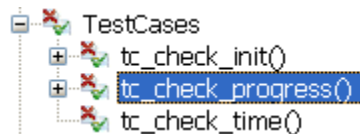
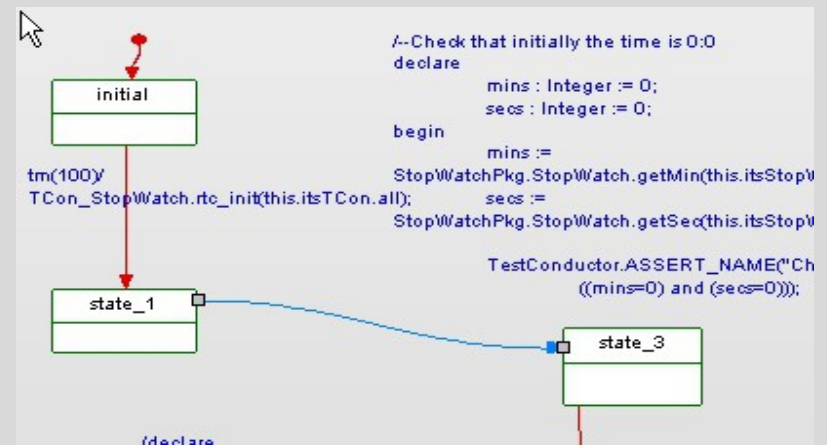
Statechart Test Execution

22

Execute the test case with Rhapsody TestConductor. Both assertions evaluate to true and the test case passes.

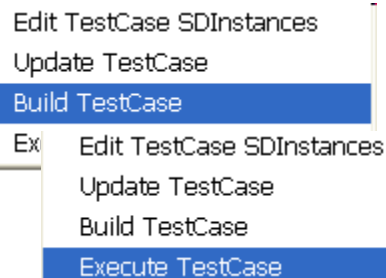


Name	Status	File/Iteration	Line
tc_check_progress	✓ PASSED		
Check initial time	✓ PASSED	TCSC_tc_...	408
Check elapsed time	✓ PASSED	TCSC_tc_...	709



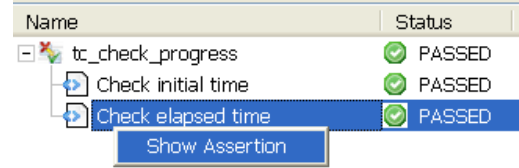
1

Select the test case „tc_check_progress“ ...



2

... and choose from context menu the items „Build TestCase“ and „Execute TestCase“.

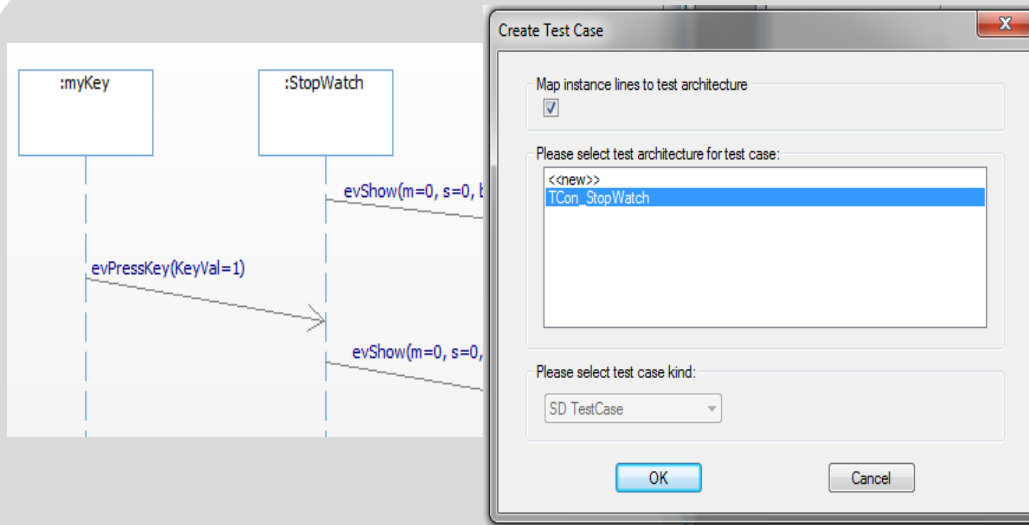


3

In the execution window, select the assertion and click “Show Assertion” in order to highlight the assertion in the model.

Create Test Cases Using Test Case Wizard - SDs

23



To create a test case based on existing sequence diagrams, operations or requirements, you can use the TestConductor test case wizard. For an existing sequence diagram, the test case wizard creates an analogue test case with the same message structure as the original sequence diagram. For a requirement the test case wizard creates a test case with the chosen requirement as the test objective.

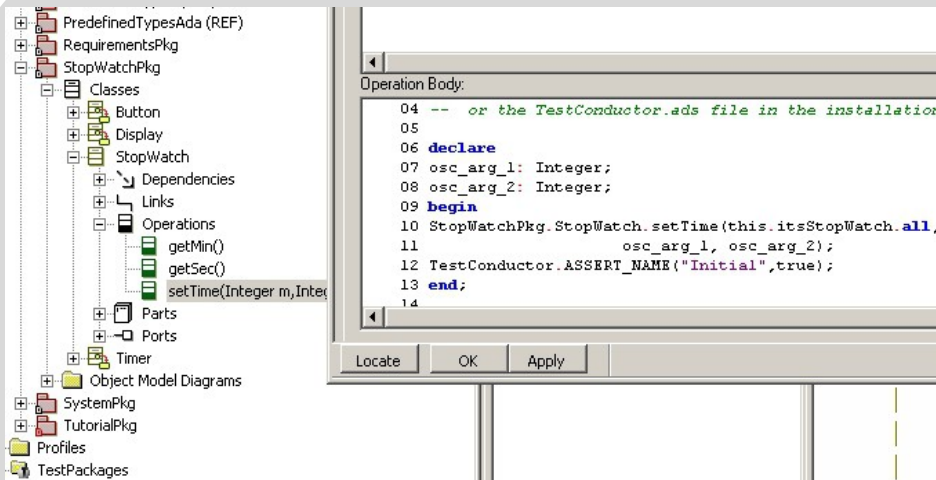
1 Select the sequence diagram "StopWatchRunning" in the tutorial package and select "Create Test Case..."

2 In the test case wizard dialog, the test context "TCon_StopWatch" is already highlighted. Press OK to proceed.

3 As a result, a new testcase "SD_tc_0" has been created which is based on a new test scenario containing the same messages as the original SD, but life lines adapted to the test context structure.

Create Test Cases Using Test Case Wizard - Operations

24



The test case wizard can also be used to **test operations** that are defined in the model. The wizard allows to create three different kinds of test cases: sequence diagram test cases, statechart test cases or code test cases. Independent of the chosen kind of test case, the created test case calls the selected operation. Additionally, the test case already contains a check that can be refined by the user in order to check the out values of the operation.

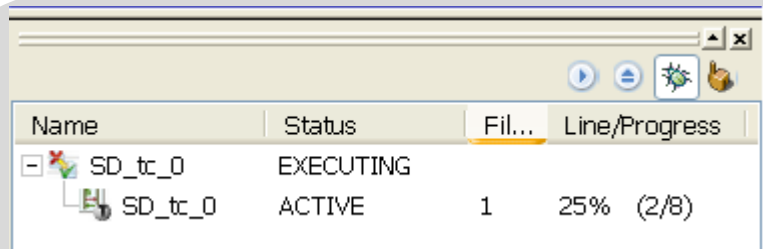
1 Select operation "setTime" of class StopWatch in the browser and select "Create TestCase..."

2 In the test case wizard dialog, select "Code TestCase" as test case kind and press OK.

3 As a result, a new code test case has been created that contains a call to operation "setTime" and also a dummy assertion that can be refined.

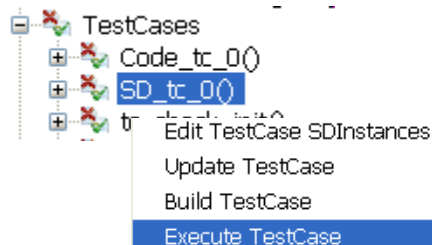
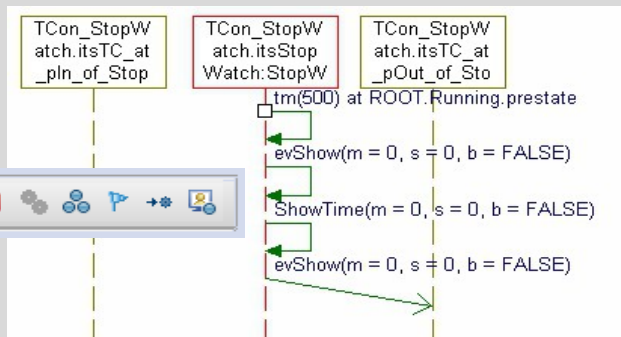
Debugging Test Cases

25

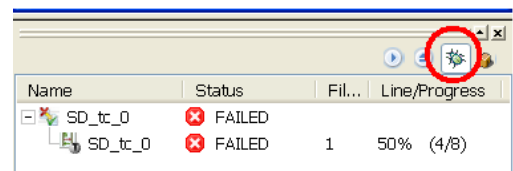


Name	Status	File...	Line/Progress
SD_tc_0	EXECUTING		
SD_tc_0	ACTIVE	1	25% (2/8)

Debugging failed test cases can also be done with TestConductor. When a test case fails, one can turn on debug execution mode in TestConductor's execution window. After switching on debug mode, when executing the test case one can step through it by using the "Go Step", "Go Idle", etc. buttons of Rhapsody's animation toolbar. Additionally, when stepping through the test case, one can use Rhapsody's animation features to inspect animated statecharts, animated SDs, etc. in order to find the reason why the test case fails.

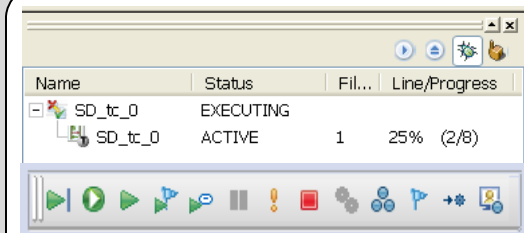


- 1 Select test case "SD_tc_0" and select "Execute TestCase".



Name	Status	File...	Line/Progress
SD_tc_0	FAILED		
SD_tc_0	FAILED	1	50% (4/8)

- 2 After the test case has failed, turn on debug execution mode by clicking the debug button in the execution dialog.

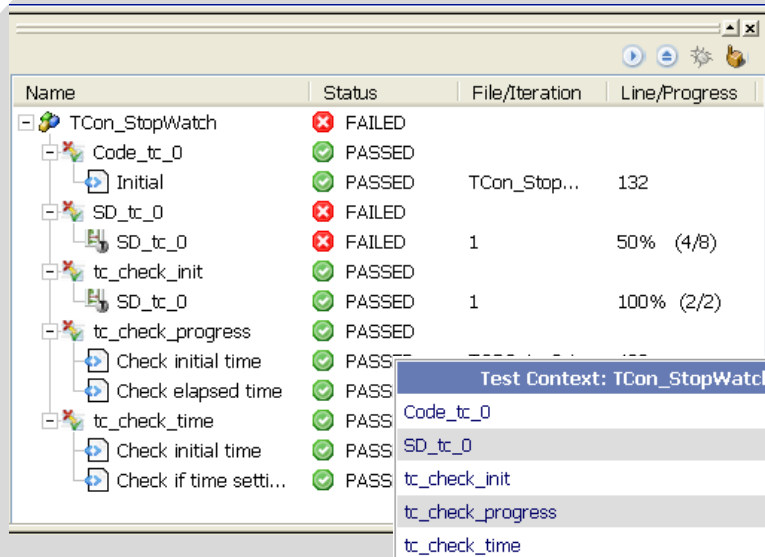


- 3 Execute the test case again by pressing the "Start" button in the execution dialog. Now you can step through the test case by using Rhapsody's animation toolbar.

Executing Multiple Test Cases

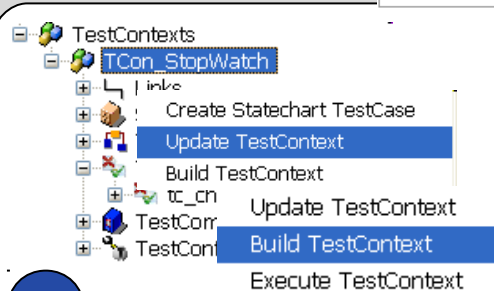
26

Executing multiple test cases can be done by executing a complete test context or a complete test package. When a test context or a test package is executed, all test cases within the context or test package are executed. After all test cases have been executed, TestConductor computes an overall test result for the test context or the test package.



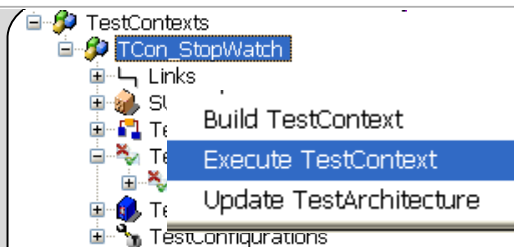
Name	Status	File/Iteration	Line/Progress
TCon_StopWatch	FAILED		
Code_tc_0	PASSED		
Initial	PASSED	TCon_Stop...	132
SD_tc_0	FAILED		
SD_tc_0	FAILED	1	50% (4/8)
tc_check_init	PASSED		
SD_tc_0	PASSED	1	100% (2/2)
tc_check_progress	PASSED		
Check initial time	PASSED		
Check elapsed time	PASSED		
tc_check_time	PASSED		
Check initial time	PASSED		
Check if time setti...	PASSED		

Test Context: TCon_StopWatch	Summary: FAILED
Code_tc_0	PASSED
SD_tc_0	FAILED
tc_check_init	PASSED
tc_check_progress	PASSED
tc_check_time	PASSED



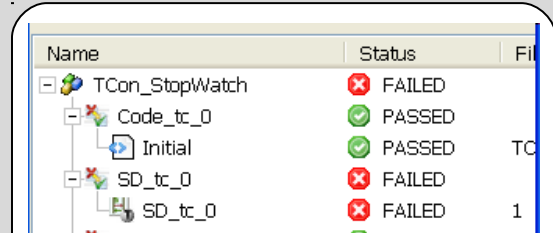
1

Select the test context "TCon_StopWatch" and select "Update TestContext". After that, select "Build TestContext".



2

Select the test context again and press "Execute TestContext". All test cases will be executed one after the other.



Name	Status	File
TCon_StopWatch	FAILED	
Code_tc_0	PASSED	
Initial	PASSED	TC
SD_tc_0	FAILED	
SD_tc_0	FAILED	1

3

The results are shown in the execution window. As always, "Show as SD" resp. "Show assertion" can be used to show the reasons of failed test cases.

Assessing Test Case Requirement Coverage I

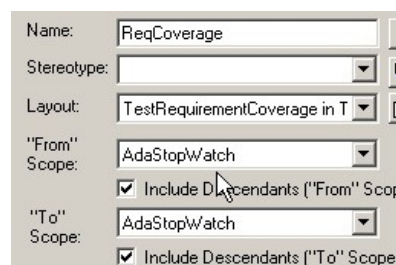
27

Which requirements are covered by my test cases? This important question can be answered either by using a test case requirements matrix or by generating a requirements coverage test report. A test case requirements matrix shows the relationship between test cases and requirements in a matrix view. A requirements coverage test report shows the same information, but presented as a textual report. It can be generated by Rational Publishing Engine or by ReporterPlus using a predefined template.

To: Requirement		Scope: JavaStopWatch				
From: Test Case		REQ_Init	REQ_Running_2	REQ_Stopping	REQ_Running_1	REQ_SetTime
	tc_check_init	REQ_Init				
	tc_check_time					
	tc_check_progress				REQ_Running_1	
	SD_tc_0					
	Code_tc_0					



- 1 Select the test package "TPkg_StopWatch" and select "Add New -> TestingProfile -> TestRequirementMatrix".



- 2 Open the features dialog of the matrix, rename it to "ReqCoverage", and set the "from" scope and the "to" scope to the complete model "AdaStopWatch".

To: Requirement		Scope: AdaStopWatch		
From: Test Case		REQ_Init	REQ_Running_1	
	tc_check_init	REQ_Init		
	tc_check_time			
	tc_check_progress		REQ_Running_1	
	SD_tc_0			
	Code_tc_0			

- 3 When double clicking the matrix in the browser, the matrix view shows the relationship between the test cases and the requirements.

Assessing Test Case Requirement Coverage II

28

All Requirements

Name	ID	Covered By Test Case
REQ_Init	no id	<ul style="list-style-type: none">• tc_check_init in TPkg_StopWatch::TCon_StopW PASSED for CG Configuration TPkg_StopWatch::TCon_StopWat
REQ_Running_1	no id	<ul style="list-style-type: none">• tc_check_progress in TPkg_StopWatch::TCon_StopW not executed
REQ_Running_2	no id	<ul style="list-style-type: none">• not covered

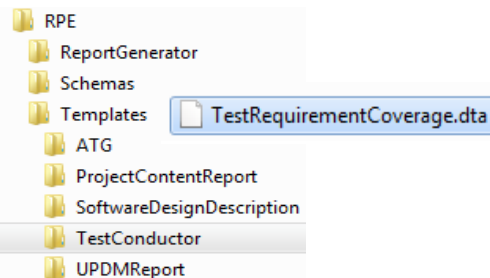
Test Case Reports can be used as an alternative in order to figure out coverage of requirements with the test cases. With Rational Publishing Engine a requirement coverage report can be generated in different formats like Word, Html, etc. The requirements coverage report shows the list of requirements, their coverage by test cases and the outcome of the test case execution. The report also contains information about the specification of the test cases.

Rational Publishing Engine

Generate report...

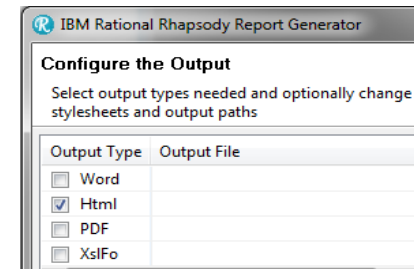
1

From Rhapsody's tools menu, select "Rational Publishing Engine"
-> "Generate Report..."



2

Select the "TestRequirementCoverage.dta" as template for the report to generate and click Next in the following dialogs.



3

Select the desired output format, html for example, and click on Finish. After generating the report, the report can be viewed with any browser that can display Html files.

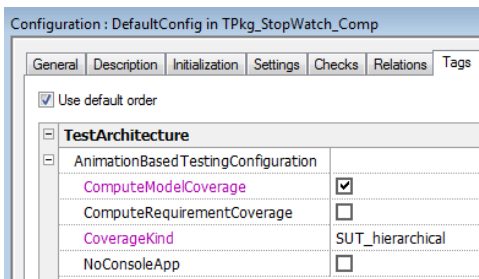
Assessing Test Case Model Coverage

29

Detailed Coverage Summary of Button (5/5)		
Operations		
covered	KeySend	
EventReceptions		
covered	evPressKey	
Statechart: StatechartOfButton		
covered	ROOT.Running	State
covered	0	Transition
covered	1	Transition

Detailed Coverage Summary of Display (5/5)		
Operations		
covered	ShowTime	
EventReceptions		
covered	evShow	
Statechart: StatechartOfDisplay		
covered	ROOT.running	State
covered	0	Transition
covered	1	Transition

Besides coverage of the requirements, an important orthogonal information is which parts of the model are executed by the test cases, i.e, what is the achieved **Model Coverage** when executing the test cases. TestConductor can compute this information during test case execution. When model coverage computation is turned on, after test case execution TestConductor adds a model coverage report to the test cases, test contexts etc. that shows the achieved model coverage.



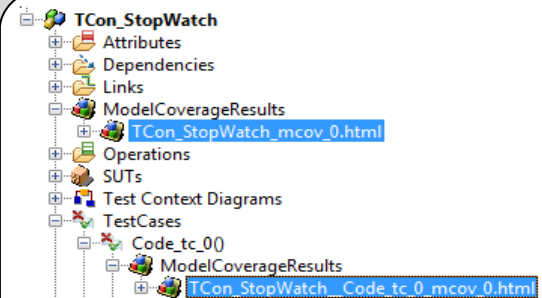
1

Open the features dialog of the code generation configuration and turn on tag "ComputeModelCoverage" and set tag "CoverageKind" to "SUT_hierarchical".



2

Execute the test context "TCon_StopWatch".



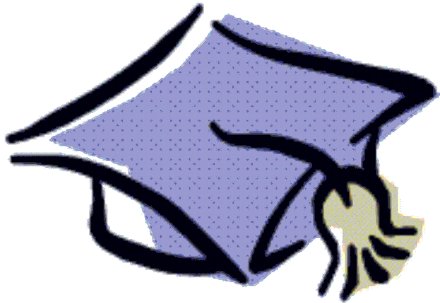
3

After execution has finished, model coverage reports can be found both for individual test cases as well as a cumulative coverage report for the test context.

Conclusion

The high-grade automation in the Rhapsody Testing Environment with TestConductor

- /// generates complete, immediately executable test architectures in shortest time with a few mouse clicks.
- /// makes it for the first time possible to implement cyclically quality assurance measures in early phases of the development.
- /// increases substantially the planning reliability for projects, because design errors and subsequent errors will be recognized very early.
- /// makes statements about the coverage rates for both the model elements and model code. Developers can easily and fast analyze reasons for not covered elements.
- /// highly automates the testing process and **can save test development time** compared to traditional approaches.



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- What software versions were you running when the problem occurred?
- Do you have logs, traces, or messages that are related to the problem?
- Can you reproduce the problem? If so, what steps do you take to reproduce it?
- Is there a workaround for the problem? If so, be prepared to describe the workaround.