U S E R ' S G U I D E

TCAT for Java/Windows

Version 1.2

Test Coverage Analysis Tool
For Java on
Windows

SOFTWARE RESEARCH, INC.

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/home/l1/wu/win-tcjava/tcatJava.wu/tcatwin.cov1.4.book

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Preface

Congratulations!

By choosing the TestWorks suite of testing tools, you have taken the first step in bringing your application to the highest possible level of quality.

Software testing and quality assurance, while increasingly important in today's competitive marketplace, can dominate your resources and delay your product release. By automating the testing process, you can assure the quality of your product without needlessly depleting your resources.

Software Research, Inc. believes strongly in automated software testing. It is our goal to bring your product as close to flawlessness as possible. Our leading-edge testing techniques and coverage assurance methods are designed to give you the greatest insight into your source code.

TCAT for Java/Windows is a quick and easy way to detect weaknesses in your code. Easily accessible click-and-point reports find the segments that need further testing. Digraphs and calltrees visualize the location, allowing you to make immediate improvements to the structure and performance of your software.

TestWorks is the most complete solution available, and the peace of mind it provides our customers is our most valued feature.

Thank you for choosing TestWorks.

Audience

This manual is intended for software testers who are using *TCAT for Java/Windows*. You should be familiar with the Microsoft Windows System and your workstation.

Typefaces

Typographical conventions that are used throughout this manual:

boldface — Introduces or emphasizes a term that refers to **TestWorks'** window, its submenus and its options.

italics — Indicates the names of files, directories, pathnames, variables, and attributes. Italics is also used for manual, chapter, and book titles.

"Double Quotation Marks" — Indicates chapter titles and sections. Words with special meanings can also be set apart with double quotation marks the first time they are used.

`courier` — Indicates system output such as error messages, system hints, file output, and *CAPBAK/MSW*'s keysave file language.

`Boldface Courier` — Indicates any command or data input that you are directed to type. For example, prompts and invocation commands are in this text. (**`stw`**, for instance, invokes *TestWorks*.)

CHAPTER 1

TCAT for Java/Windows Overview

This chapter is a conceptual introduction to coverage tools, and explains how to use them most advantageously.

1.1 The QA Problem

It is a sad fact of the software engineering world that on average, without coverage analysis tools, only around 50% of source code is actually tested before release. With little more than half of the logic covered, many bugs go unnoticed until after release. Worse still, the actual percentage of logic covered is unknown to SQA management, making any informed decisions impossible.

Questions such as when to stop testing or how much more testing is required are answered not on the basis of data, but on ad hoc comments and sketchy impressions. Software developers are forced to gamble with the quality of the released software and to make plans based on inadequate data.

A related problem is that test case development is done in an inefficient manner; that is, many test cases are redundant. Test suites become cluttered with cases that repeatedly test the same logic, to the exclusion of other cases that would examine previously unexplored logic. Often, testers are unsure of which direction to take, and can waste SQA time devising the wrong tests.

1.2 The Solution

The primary purpose of testing is to ensure the reliability of a software program before it is released to the end user. The software should be thoroughly tested with a variety of input to provide statistically verifiable means of demonstrating reliability. In other words, a suite of test cases should in some way cover all the possible situations in which the program will be used.

It is a worthy goal to imagine every possible use, and to develop and run corresponding test data. However, achieving this goal is extremely complicated and time-consuming. A more realistic goal is to test every part of the program. According to industry studies, achieving this goal yields significant improvement in overall software quality. Coverage analysis improves the quality of your software beyond conventional levels.

1.3 SR's Solution

Software Research, Inc. offers a solution: **TCAT for Java/Windows**. This product ensures tests that are more diverse than those chosen by reference to functional specification alone or those based on a programmer's intuition. It ensures that they are as complete as possible by measuring against a range of high-quality test metrics:

- Coverage at the logical branch (or segment) level and the call-graph level, employing the *C1* metric

  You can choose to test a single module, multiple modules, or the entire program using the *C1* metric.

- Coverage at the call-pair level employing the *S1* metric

  After individual modules have been tested, you can test all the interfaces of the system using the *S1* metric.

- Dynamic visualization of test attainment during unit testing and system integration

  This visually demonstrates, in real time, such things as segments and call-pairs hit / not hit.Java.

Below is a **TCAT for Java/Windows** flow chart.

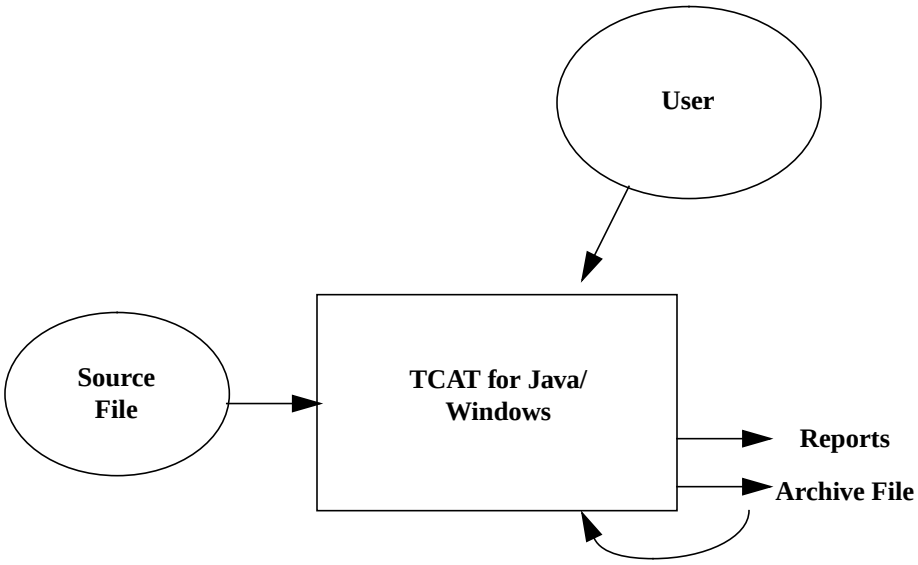


FIGURE 1 TCAT for Java/Windows Dependency Chart

1.4 Testing and TCAT for Java/Windows

TCAT for Java/Windows instruments your program. During instrumentation, **TCAT for Java/Windows** inserts function calls (special markers) at every logical branch (segment) in each program module. Instrumentation also creates a reference listing file, which is a version of your program which has logical branch marking comments added to it in a manner similar to the code added to the instrumented version. Extensive logical branch notation and sequence numbers are also listed.

This instrumented program is then compiled and run. By running it, you are exercising logical branches in the program. The more tests in your test suite, the higher the coverage. This test information is then written to a trace file. From the information stored in the trace file, you can generate coverage reports. In general, the reports give the following information:

- Reports included in the current iteration
- A summary of past coverage runs
- Current and cumulative coverage statistics
- A list of logical branches that have been hit

Recommended coverage is >85%. If reports indicate that you have less than this amount, you can identify unexercised logical branches by studying the coverage reports, and looking at the source code associated with the untested functions. When you identify the troubled areas, you can then create new test cases and re-execute the program.

TCAT for Java/Windows can help you reach your goal of creating the most extensive test cases possible.

1.5 Software Test Methods

Coverage analysis as implemented through **TCAT for Java/Windows** is a powerful testing technique which can save you much money and time, in addition to greatly improving software quality. It is not the only testing technique in existence, and we recommend that you use it along with other techniques.

Testing methods vary from shop to shop, but most successful techniques fall into a few general categories. The most common ones are described below in the sequence they usually occur.

1.5.1 Manual Analysis

Programs are manually inspected for conformance to in-house rules of style, format, and content as well as for correctly producing the anticipated output and results. This process is sometimes called “code inspection,” “structured review,” or “formal inspection.”

1.5.2 Static Analysis

Once a program has passed through manual testing steps, it can be tested more extensively. Automated tools are used to check the design rules applied in a program. Static analysis validates the software allegations about the program's static properties, such as the global properties of its data structures and the application of variable type rules. Such testing can remove 20-30% of the latent software defects in your program. Static analyzers include the following:

- Tools for detecting data element misuse
- Complexity measurement tools, which estimate the difficulty of testing and help identify hard-to-test modules with a statistic
- Conformance measure tools, which flag confusing or inefficient code

1.5.3 Dynamic Analysis

Dynamic analysis tests the dynamic properties of the software under real or simulated operating conditions. The software is executed under controlled circumstances with specific expected results. In this phase, it is important to test as many paths and branches in the program as possible. Doing so ensures that the tests you run have the greatest diversity, hence the best chance of discovering defects.

To obtain statistics on the application under test can be very difficult. Dynamic analysis can uncover 85-90% of the potential remaining software defects. **TCAT for Java/Windows** produces data on what has been validated and what has been left out of your testing.

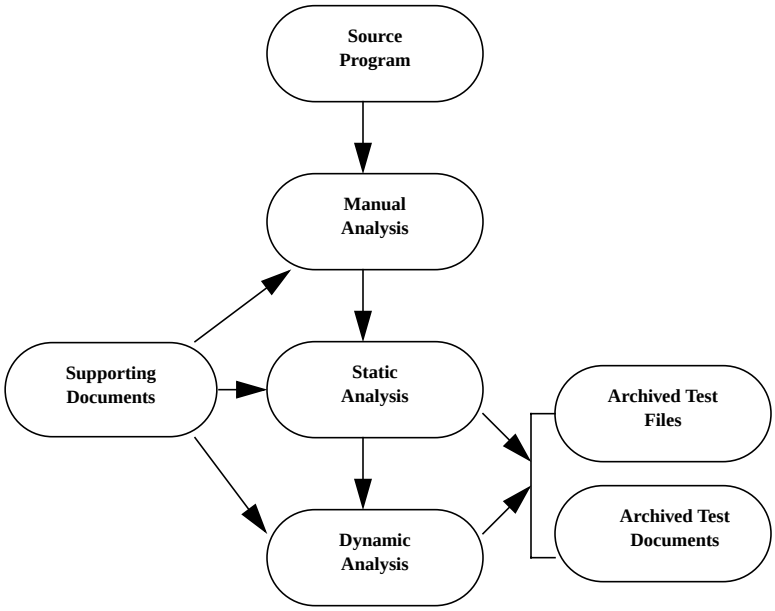


FIGURE 2 Stages in Software Testing

1.6 Single- and Multiple-Module Testing

Another consideration in getting the most out of **TCAT for Java** involves determining the scope of your tests: whether a single program module, multiple modules, or even an entire system should be tested. You can prepare or "instrument" many modules with logical branch markers and run tests on them as a group. **TCAT for Java** keeps track of each module by name.

There are two approaches to multiple-module testing: bottom-up or top-down. Because **TCAT for Java** is able to track many modules simultaneously, it supports either approach. The route you choose depends on your individual needs and testing style.

1.6.1 Bottom-Up

In the bottom-up approach, testing begins at the lowest level in the system hierarchy; that is, modules that invoke no other module. Each bottom-level module is tested individually with special test data. Modules at each subsequent level of the hierarchy are tested using already-tested lower-level modules. The process continues until all modules have been thoroughly exercised. Thus, you can control testing carefully as you progress up the system hierarchy.

1.6.2 Top-Down

In the top-down approach, testing begins at the highest level in the system hierarchy. Sometimes module "stubs"' are used to simulate invoked modules to check the high-level logic of the program. As an alternative to using module stubs, use a complete program with only a few selected modules instrumented. **TCAT for Java** ignores uninstrumented modules as it traces test coverage through the program.

In top-down analysis, the tester is chiefly concerned with the combination of modules to form a larger system. **TCAT for Java** focuses specifically on function calls within the system, so that the tester can verify each interconnection.

1.7 TCAT for Java's Cost Benefits

TCAT for Java will save your organization much time and effort; the economics of coverage analysis are extremely favorable. Here are some ways it can save you money. **TCAT for Java** can save you money in the following ways.

1.7.1 Improved Error Detection

TCAT for Java provides increased error detection. Software Engineering literature indicates that an average error rate is 40 defects per 1,000 lines of code (KLOC). With no coverage analysis, 50% of the code is exercised, leaving the product with 20 defects per KLOC. Assuming a uniform distribution of errors throughout the source code, the simple act of raising the coverage rate can uncover many errors. According to the experience of SR in advanced industrial projects and reports from customers, coverage analysis can eliminate another 75% of the errors.

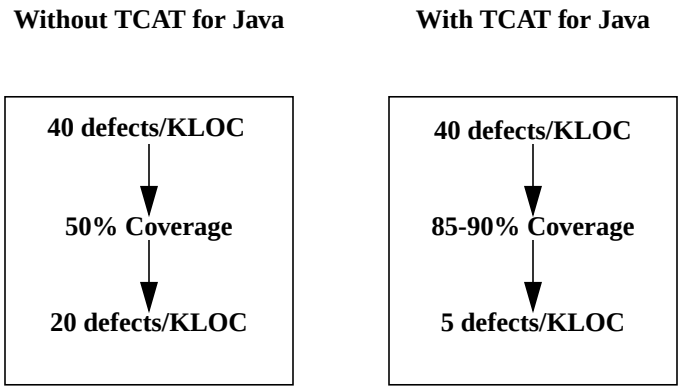


FIGURE 3 Cost Benefit Analysis

The economic value of increased error detection varies from organization to organization. One estimate of the worth of coverage analysis comes from what software consulting firms charge to find and remove errors, a price established in the open market. The software testing industry, sized at $50 million in 1986 by *Fortune* magazine, typically charges $1,000 per error fixed.

Applying this to **TCAT for Java**, you could save $15,000 or more per thousand lines of code. In practical terms, this means that a large project with over 20,000 lines of code might save $300,000.

1.7.2 Earlier Error Detection

Not only are more errors detected with **TCAT for Java**, they are also discovered earlier. The earlier you catch and fix an error, the cheaper. Over and over, managers, vendors and gurus have shown us figures and charts that detail how much less it costs to rectify an early detected defect. The chart below, by Barry Boehm, illustrates this concept.

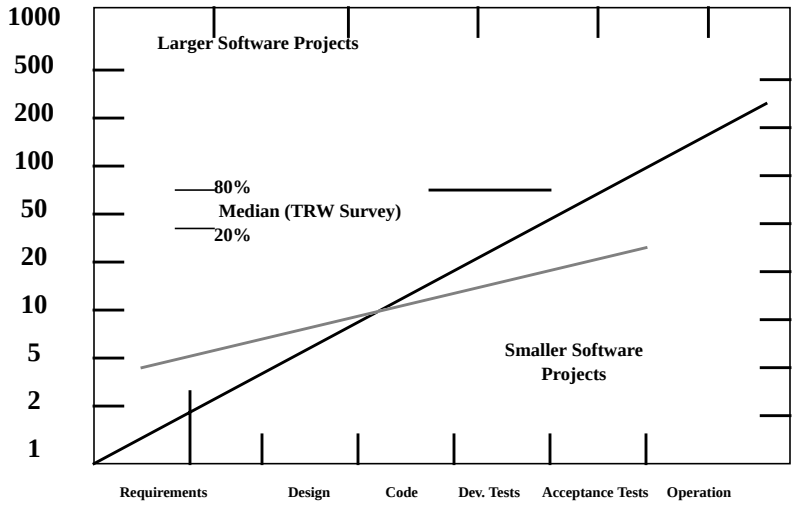


FIGURE 4 Increase in Cost-to-Fix Throughout Life-cycle

Your organization can reduce its cost-to-fix ratio by a factor of ten by using **TCAT for Java** to find errors before system integration. In the diagram, it costs $5,000 to $15,000 to fix errors after they have left the developer. The developer or the Software Quality Engineer (SQE) can identify and fix problems more inexpensively than the beta site or independent testing organization. This is not to say that beta sites or IV&V (independent verification and validation) are not needed; but instead, there is a great cost advantage in letting detailed unit-testing find more errors for less expense.

1.7.3 More Efficient Testing

Using **TCAT for Java**, you can improve test case development. In general, the tool can be used to identify previously untested features. This information can direct the addition of new test cases.

For example, a software test engineer from a super-minicomputer manufacturer used **TCAT for Java** to reduce the time to test by a factor of eight. As detailed in a technical article available from SR, the engineer was in charge of testing a C compiler and used **TCAT for Java** to identify the features missed by commercially-available test suites. The engineer specified the language elements that were not tested to a software engineer, who completed the test suite. Overall, the compiler was fully tested in six weeks rather than the expected one year.

1.7.4 Minimal Test Set

TCAT for Java can be used to develop the minimal covering test suite for a system. It is useful for a tester to have the smallest test suite that exercises all the logic of a system, since test sets require much time and many resources to execute.

We recommend the use of *SMARTS*, *CAPBAK*, and *CBDIFF* (from our *Regression/MSW* tool suite) to automate test suite execution, evaluation, and analysis steps. These tools can significantly reduce the cost of test suite execution and analysis. **TCAT for Java** can be used to identify and eliminate redundant test cases. With the coverage reports described in this manual, it is possible to determine how much each new test case adds to the total coverage of a test suite.

If a new test adds less than a specified amount to the overall coverage (e.g. 5%) it might be reasonable to discard it. Having done so, the tester ends up with more efficient, easier-to-run test suite.

1.7.5 Assessment of Progress

Coverage analysis with **TCAT for Java** can be valuable to important SQA decisions, such as when to ship a product or how much further product testing is needed. A coverage value of C1 > 85% has been the traditional threshold for proper coverage. Generally, one should stop improving test coverage when the marginal cost of adding a new test is greater than the cost to visually and rigorously inspect the associated code passage. Other considerations you can weigh are the added test cost and the risk of defects.

Coverage analysis data are important for reliability modeling and predicting error rates. By tracking error rates and number of errors discovered as a function of overall test effort, it is possible to predict eventual latent defect rates. We encourage SQA managers to keep careful records of errors found and corresponding coverage values.

CHAPTER 2

Installation

This chapter describes the system requirements and the step-by-step installation procedure for TCAT for Java / Windows

2.1 System Requirements

Your computer system must have the following hardware configuration to install and run **TCAT for Java/Windows**.

- Windows 95 or NT
- 486 microprocessor or better
- 7.7 MB free disk space
- 16+ MB RAM recommended

Java compiler must be installed.

2.2 Installation Procedure

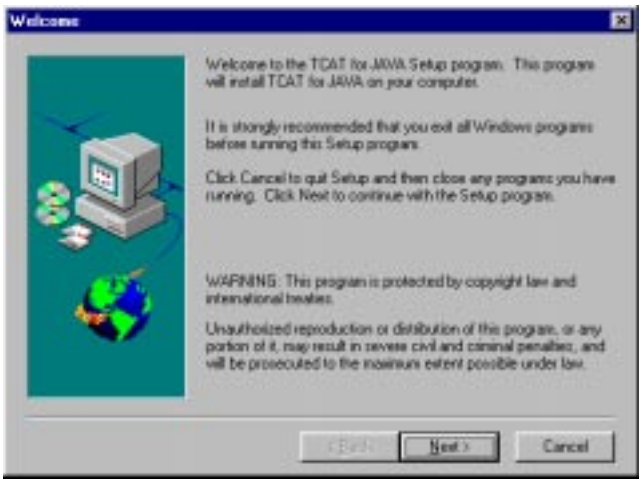
1. Insert the diskette labeled **Disk 1** in your diskette drive (these instructions assume A:).
2. **Activate setup.exe. :**

   In Windows 95, or NT 4.0:

   a. Using either the **My Computer** icon (on the desktop) or **Windows Explorer** (on the **Start** menu, **Programs** submenu), display the contents of the X: drive (X: the floppy dirive or CD-ROM drive).

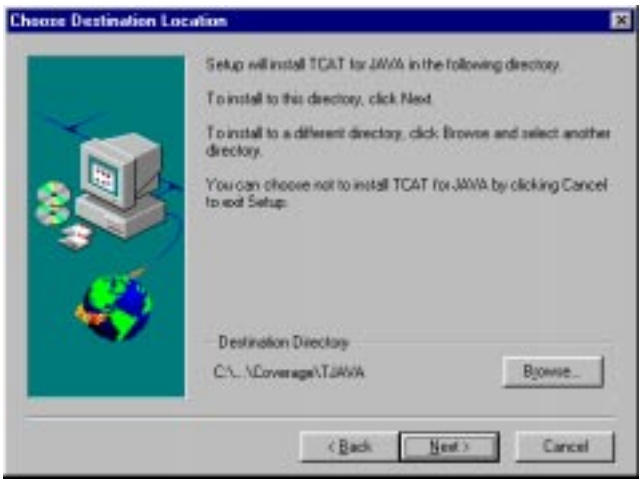
   b. Double-click **setup.exe**.

setup.exe presents you with a series of dialog boxes, beginning with the **Welcome** box shown below. Each box is a step in the installation process, and when you are satisfied with the options offered in a box you should click **Next** to go on to the next step.



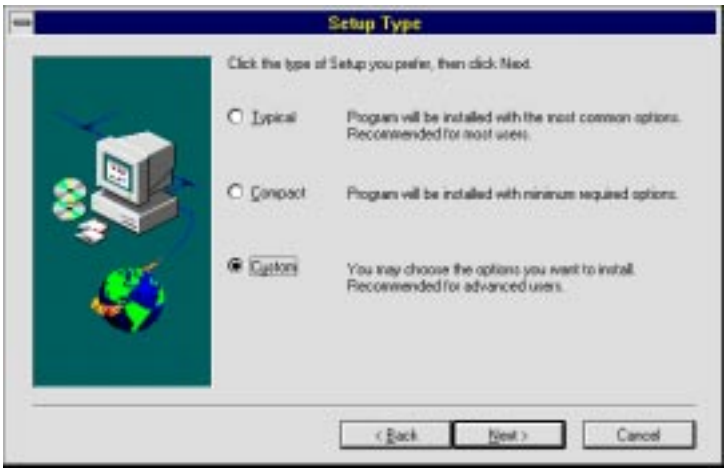
3. Click **Next** in the **Welcome** box.

   The Choose Destination dialog box asks you where you would like to store the executables and the supporting files for **TCAT for Java/ Windows**.

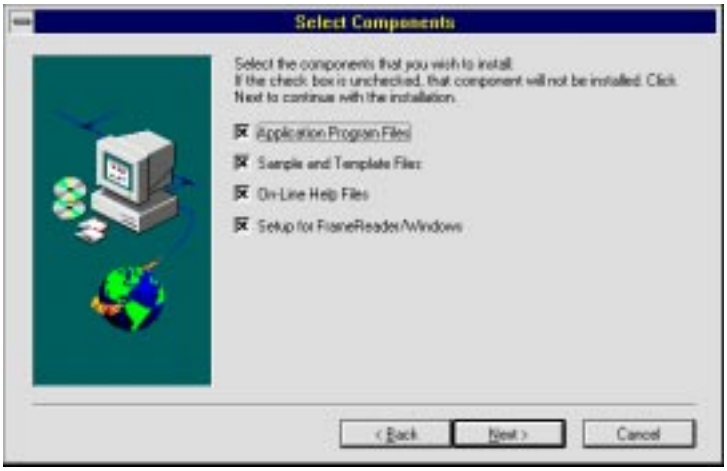


4. To select a path, do one of the following:
   - Click on **Next** if you want to use the **Path** indicated and to continue the installation.
   - Edit the default path to your own path, then click **Next** to continue the installation.
   - Click **Cancel** to end the installation.

After selecting **Next**, the **Setup Type** dialog box pops up and asks you what kind of installation you prefer. It is highly recommended that you select **Custom** installation, which allows you to install the **FrameReader** software that allows you to read the online help that accompanies **TCAT for Java/Windows**. (Be aware that the **FrameReader** software will occupy approximately 9 MB of your computer's memory.)



5. In the **Setup Type** dialog box, do one of the following:
   - Click **Next** if the Setup Type is the one you prefer.
   - Click a different Setup Type, then click **Next** to continue the installation.
   - Click **Back** to review or change previous dialog box queries.
   - Click **Cancel** to end installation.



6. Select the components that you want copied.

   During copying, a bar gauge names the files being copied.

   C:\Program Files\Software Research\Coverage\TCAT-Java directory or the path you indicated is created. **TCAT for Java/Windows** automatically stores your files to this directory unless you selected otherwise.

   The installation script also creates a program group where **TCAT for Java/Windows** and its utilities are installed:

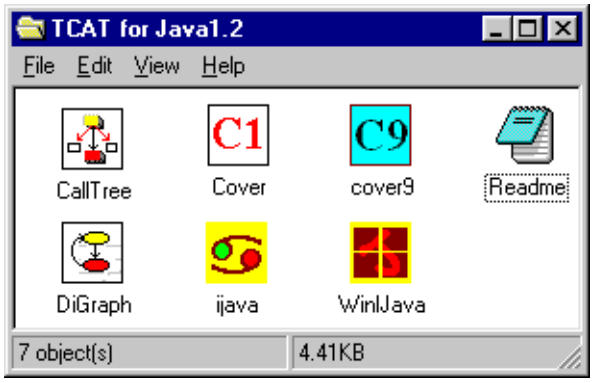


FIGURE 5 Program Group for TCAT for Java/Windows

7. When the installation is complete, include the *Coverage* pathname in your system environment variable.
8. To uninstall, use the following:
    a. Double click the **Add/Remove Programs** icon in the Control Panel.
    b. Click the **Remove** button.

2.3 File List

The following files are written to your computer during the installation. The locations for these files are given for installation to a directory called C:\Program Files\Software Research\Coverage\TCAT-Java.

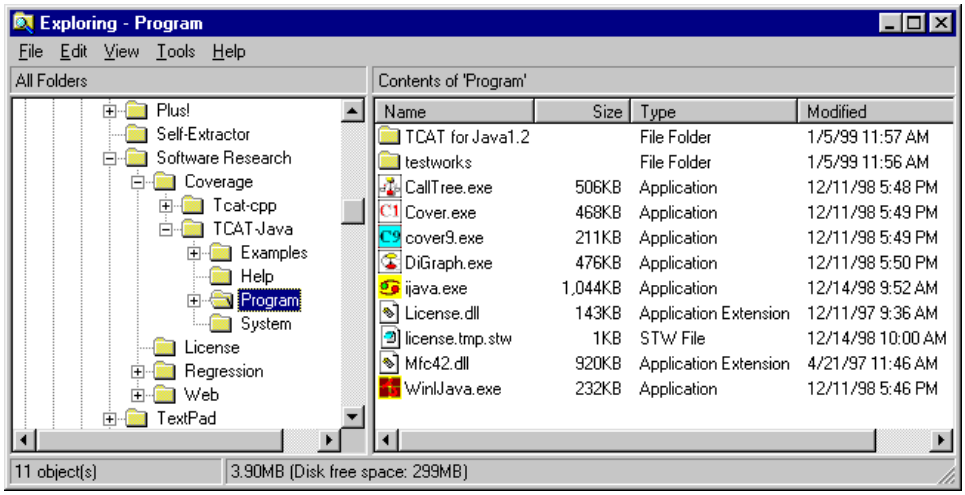


FIGURE 6 Files for TCAT for Java/Windows in Windows 95 / NT

CHAPTER 3

Quick Start

This chapter explains getting started with TCAT for Java / Windows using a demonstration test case. It then describes the main features of the product.

3.1 Getting Acquainted with TCAT for Java/Windows

This section will familiarize you with the main activities involved in using **TCAT for Java/Windows**, including instrumenting, compiling, and running the target program, and finally, looking at the resulting coverage reports, calltree graphs and digraphs.

The applet used to illustrate the operation of **TCAT for Java/Windows** in Windows is *TicTacToe*, which you will prepare and instrument as a test application. You can then exercise various logical branches or segments of *TicTacToe*, creating trace files from which the coverage reports are generated. It is recommended that you complete the *TicTacToe* example before continuing.

If you are using **TCAT for Java/Windows** for the first time, you will benefit most if you refer to chapters 4 through 7 for in-depth operational instructions and detailed explanation of functionality. If you are an intermediate user, you'll only have to refer to those menu definitions which need further explanation.

3.1.1 Step 1 - Preparing and Instrumenting TicTacToe

3.1.1.1 Setup Environment Variables

For the first time user, check your Java manual to see how the environment variables are set. Add $*TCAT-Java_DIR**Program*\ to CLASSPATH.

(e.g. set CLASSPATH=.;C:*jdk1.1.4**lib**classes.zip*; C:*Program Files**Software Research**Coverage**TCAT-Java**Program*))

3.1.1.2 Instrument Using WinIJava

WinIJava instruments the application under test so that any tests can produce trace files.

To instrument the example application:

1. Start up **WinIJava.**

FIGURE 7 WinIJava Window

2. Select TicTacToe.java using the **Select** button.

> **Note**: More than one file can be selected and instrumented, and instrumenting multiple files results in more thorough coverage.

3. Select **Instrument**.

   A copyright box pops up before the instrumentation of each file if the license is invalid. During instrumentation, a command-line window displays messages and warnings. The instrumentor parses the applet's source code, looking for logical branches or segments and inserting markers (function calls).

   Instrumenting a program does not change its functionality. When compiled, and executed, the instrumented application behaves as it normally does, except that it writes coverage data to a trace file. For more information on **TCAT for Java/Windows**' instrumentor, refer to *Chapter 4*.

4. When instrumentation is complete, select **Close** from the **WinIJava** window.

Instrumenting TicTacToe.java produces the following files in the *TicTacToe* directory:

- *TicTacToe.i* — the instrumented version of the source file

  This file is updated during the instrumentation process.

- *TicTacToe.dg* — a Directed Graph Listing file

  Each instrumented file should have its own *.dg* file.

- *TicTacToe.cg* — a Calltree Graph Listing file

  Each instrumented file should have its own *.cg* file.

- *Prj_Name.mdf* — a Module Definition file

  This file contains information about segments and callpairs in all the processed files.

- *mdf.pro* — a profile of the applet for useing on your Web server.

3.1.2 Step 2 - Executing the Instrumented Application

During instrumentation, **TCAT for Java** inserted function calls at each logical branch it found. In order to later determine the C1 coverage, you must run the applet.

By running *TicTacToe* and playing the game, you are exercising segments of the *TicTacToe* program. Because you have instrumented the applet, the exercise will create a trace file and allow you to view coverage information on the exercise.

To run the instrumented applet:

1. Open a **DOS** window. From DOS prompt, CD to *TicTacToe* directory.
2. Type **appletviewer** *TicTacToe*.html.
3. The appletviewer and *TicTacToe* applet will appear. Play the game.
4. When you are finished playing, select the **Applet** and choose “Quit”.

When the *TicTacToe* is running, your display should look like this:

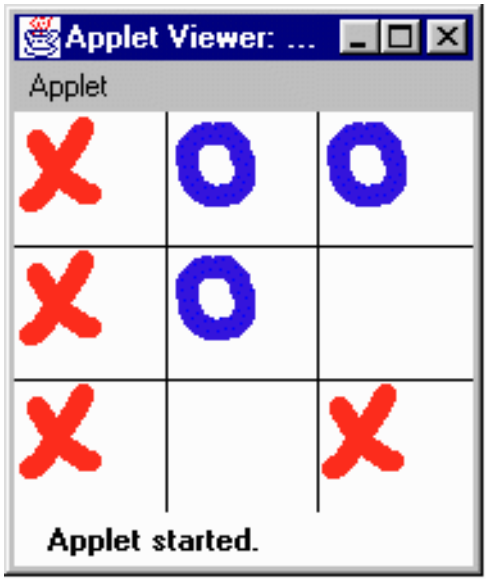


FIGURE 8 Testing TicTacToe

3.1.3 Step 3 - Viewing Coverage Reports Using Cover

1. From the **Program menu**, select **Testworks for Win32** folder.
2. From the resulting window, select **Cover** icon.
3. From the **File** menu, select **Open**.
4. In the **Open** dialogue**,** click on the filename *Trace.trc* from the *tcat_db\Prj_Name* directory.

A coverage report of the test you ran on the example program appears.

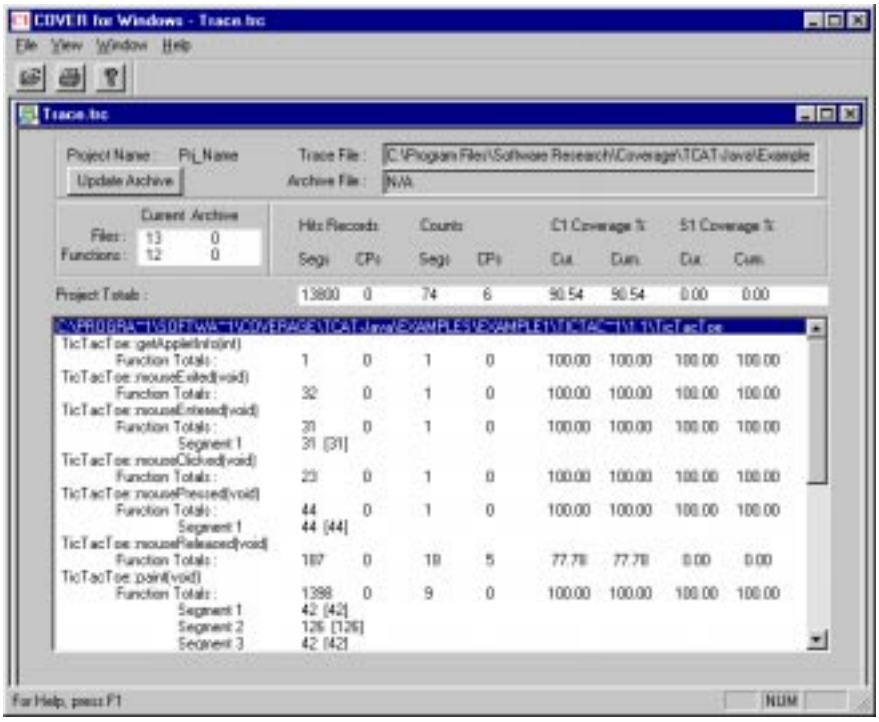


FIGURE 9 Cover Main Window Displaying Coverage Report on TicTacToe

Cover displays trace and coverage information on your development project in a treelike list. Clicking on a branch of the list expands the branch and shows its contents, and also contracts it. The several fields in the report have the following meanings:

Hits	The number of times the segment and call pair were executed during the test
Count	The number of segments and call pairs within the function
C1	The percentage of branch coverage for each function
S1	The percentage of call pair coverage for the function

For detailed information about **Cover**, see *Chapter 5*.

3.1.4 Step 4 - Viewing Directed Graphs with DiGraph

To view a directed graph (digraph) of possible program flows of a function:

1. From the **TCAT Program Group**, select **DiGraph**.
2. Using the **File** menu, select **Open**.
3. A selection box asks for the name of the directed graph to view. For this example, find the *TicTacToe.dg* file under the *tcat_db\Prj_Name\d_graph* directory.

   A selection box asks for the name of the module definition file.
4. Find the *TicTacToe.mdf* file under the *tcat_db\Prj_Name* directory (one level up from the *TicTacToe.dg* file).

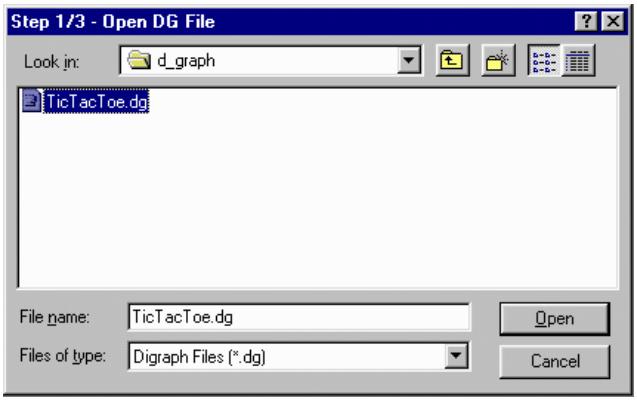


FIGURE 10 DiGraph Open Dialog Box

A selection box asks which function to display.

5. For this example, select ***TicTacToe::status(int)***.

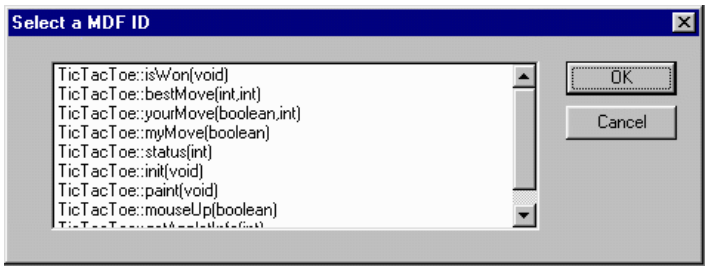


FIGURE 11 Select MDF ID Box

A directed graph depicting possible program flows of the function ***TicTacToe::status(int)*** appears.

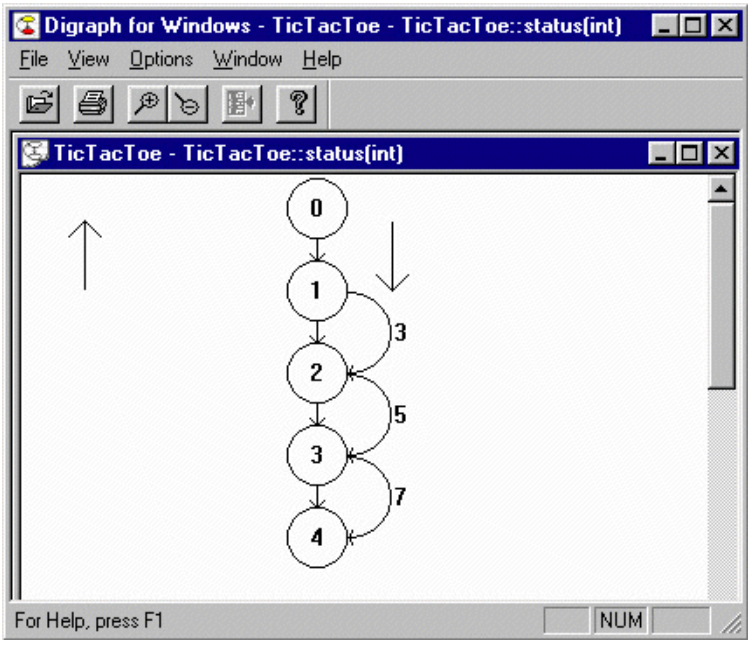


FIGURE 12 Directed Graph of TicTacToe

The digraph shows the set of conditions and paths that make up a function. The next step shows how to look at the code that the digraph displays as numbered segments.

3.1.5 Step 5 - Viewing Source Code from a Digraph

To view the source code represented by a particular segment of the function ***TicTacToe::status(int)***:

1. Click near the number of the segment.
2. From the tool bar, select the **View Source Code** button.

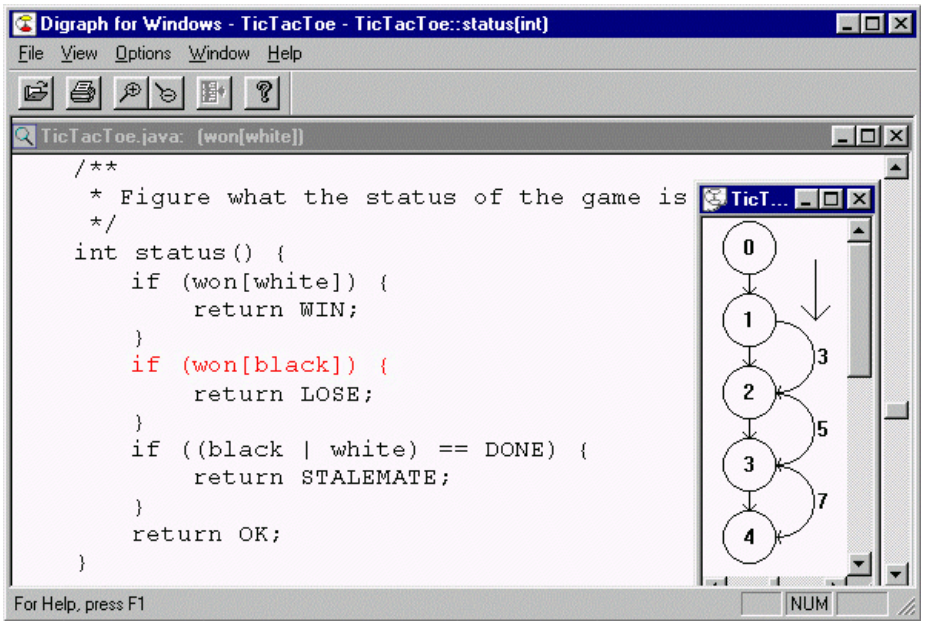


FIGURE 13 Source Code Associated with Segment 3 of Digraph of ***TicTacToe::status(int)***

3.1.6 Step 6 - Viewing a Calltree

To view a calltree of ***TicTacToe***:

1. From the **TCAT Program Group**, select **Calltree**.
2. In the **File** menu, select **Open**.

   You are prompted for the name of the calltree to view.
3. Find *TicTacToe.cg* file under the *tcat_db\Prj_Name\ c_graph* directory.

   You are prompted for the name of the database file.
4. Find the *TicTacToe.mdf* file under the *tcat_db\Prj_Name* directory.

   A window appears asking you which function to display.
5. For this example, select ***TicTacToe::mouseup(boolean)***.

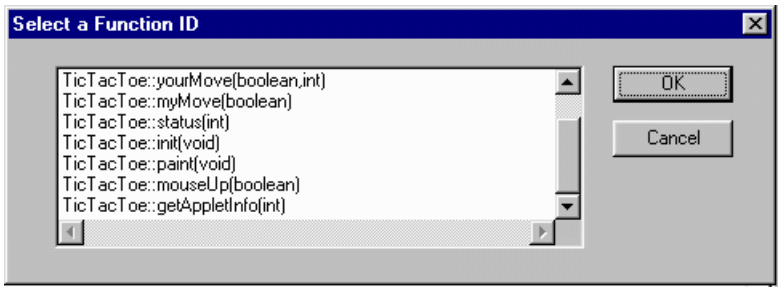


FIGURE 14 Select Function ID Box:

A calltree depicting the selected function appears.

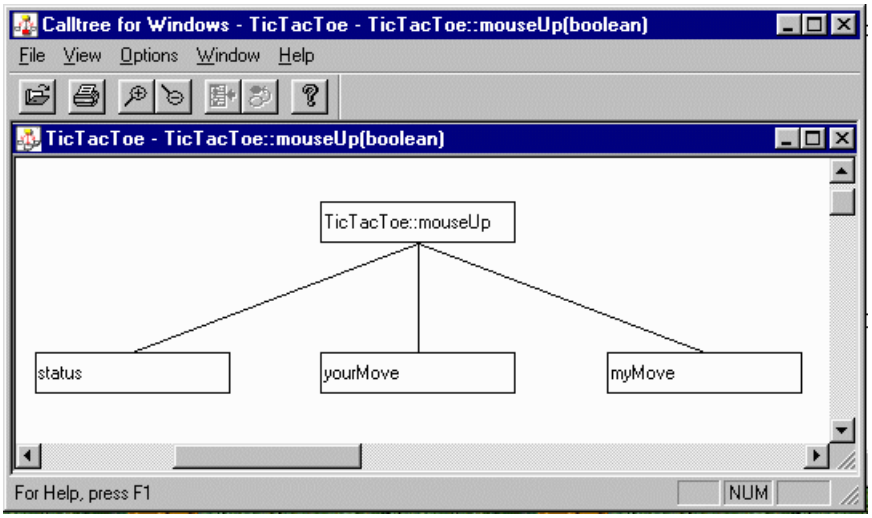


FIGURE 15 Displaying a Calltree

The calltree shows all of the callpairs associated with the function ***TicTacToe::mouseup(boolean)***.

The next step shows how to look at digraphs of the possible program flows belonging to this function.

3.1.7 Step 7 - Viewing the Directed Graph Associated With a Calltree Node

To display a directed graph of any callpair shown in the calltree:

1. Select a node by clicking on it.

   Notice that the **View Digraph** button on the toolbar now has a red arrow, indicating that it is available.

2. To display a directed graph of the selected function, click the View DiGraph button.

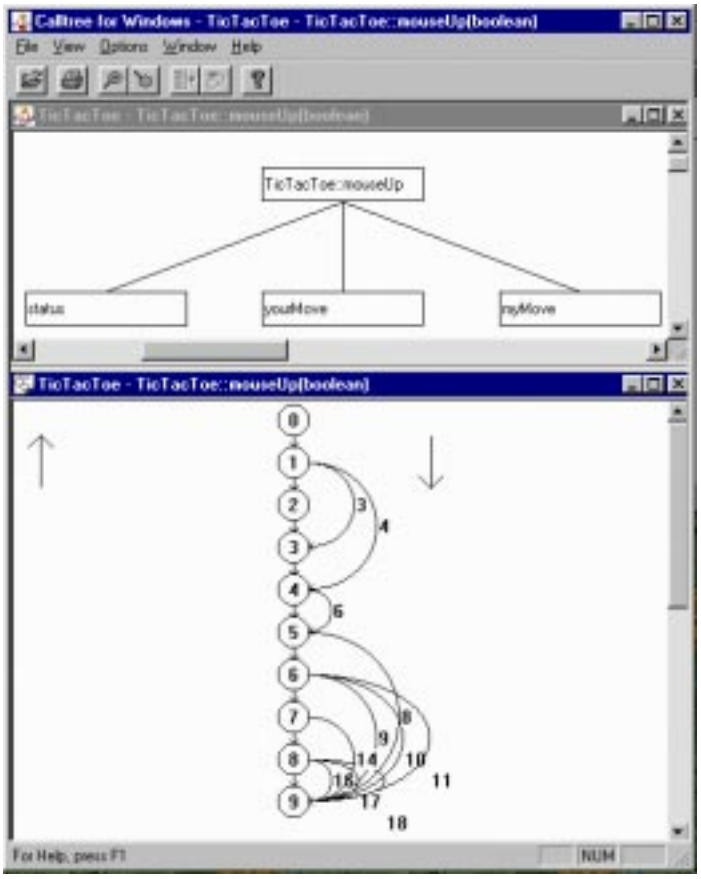


FIGURE 16 Calltree of ***TicTacToe::mouseup(boolean)*** and Digraph of Its Possible Program Flows

3.1.8 Step 8 - Viewing the Source Code Associated With a Calltree

You can view the source code associated with any node in a calltree by clicking on the corresponding edge.

Notice that the **Source Code** button on the Tool Bar has a red arrow.

1. To display the associated source code, click the Source Code button.

   The code is displayed in a separate window with the calling statement highlighted in red.

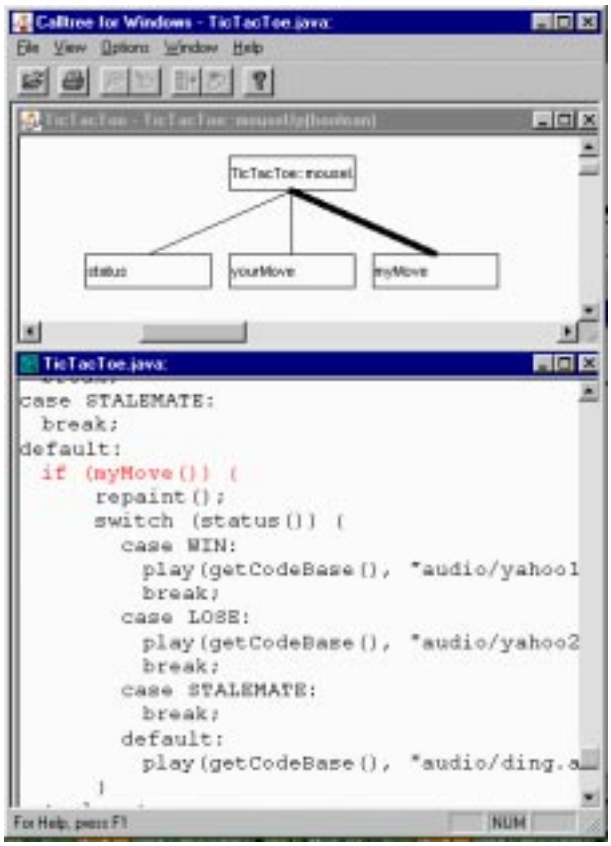


FIGURE 17 Source Code Window Displayed from Calltree

3.1.9 Step 9 - Closing TCAT for Java/Windows

After looking at the source code, select one of the following options to complete the session.

To close **TCAT for Java/Windows:**

- Select **File|Exit** from the menu bar of each open program.
- **In Windows NT:** double-click on the frame window **Close Box** of each program.
- **In Windows 95:** click on the frame window **Close Box** of each program.

You have now seen all the main features of **TCAT for Java/Windows**.

3.2 Summary

If you have completed the proceeding steps successfully, you have seen and practised the basic skills you need to use TCAT for Java / Windows productively. You should have learned how to invoke TCAT for Java / Windows, how to instrument, compile, and run a program, and how to look at the coverage reports.

For best learning you may want to:

- Repeat STEPS 1 - 9 without the manuall and experiment by running the applet several times and looking at the amount of coverage your test input receives.
- Repeat STEPS 1 - 9 with your applet.
- Review the chapters on system operation where you had difficulties. The table of contents can help you locate the topic you want.

CHAPTER 4

Java Instrumentor Engine

This chapter discusses the **TCAT for Java/Windows** integrated Java instrumentor. This chapter applies to all editions of **TCAT for Java/Windows**.

4.1 Instrumentor Description

WinIJava instruments the source code of the application under test by inserting function calls at each logical branch and call pair. The instrumentation does not affect the functionality of the program. When compiled, and executed, the instrumented program will behave normally, but writes coverage data to a trace file.

There is some performance overhead related to the data collection process, but the overhead varies with the choice of the runtime used. The trace files are processed by several kinds of report generators.

There is a single version of the instrumentor engine for Java programs.

4.1.1 Files Generated

In operation, the **WinIJava** instrumentor parses candidate source code looking for logical branches and / or call pairs and generates auxiliary files that are used by other parts of the system. **TCAT for Java/Windows** uses and produces the following files:

Instrumenting TicTacToe.java produces the following files in the Example directory:

- *TicTacToe.i* — the instrumented version of the source file

  This file is updated during the instrumentation process.

- *TicTacToe.dg* — a Directed Graph Listing file

  Each instrumented file should have its own *.dg* file.

- *TicTacToe.cg* — a Calltree Graph Listing file

  Each instrumented file should have its own *.cg* file.

- *Prj_Name.mdf* — a Module Definition file

  This file contains information about segments and callpairs in all the processed files.

- *mdf.pro* — a profile of the applet for useing on your Web server.
- *Trace.trc* — produced when the instrumented application is executed

  This file contains coverage information for the current test.

4.2 WinIJava Main Window

FIGURE 18 WinIJava

WinIJava drives the instrumentor, **IJava,** according to selections made by the user.

Select	Click a file to select it for instrumentation, control-click to select several files, or shift-click to select a series of files.
Instrument	Instruments the selected file(s). During instrumentation, a command-line box gives informational and warning messages.
Options	Selects among code languages and modes of instrumentation.
Close	Exits **WinIJava**.

FIGURE 19 Select File(s) to Instrument

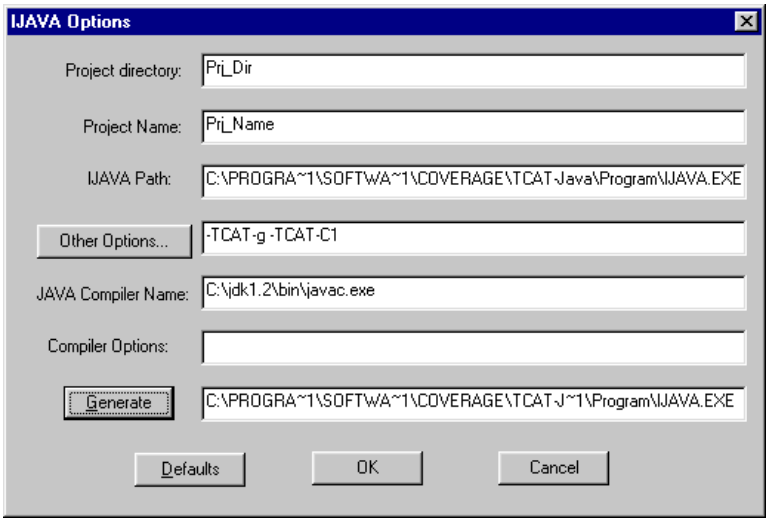


FIGURE 20 IJava Options

Figure 20 shows the default options for **IJava**.

On Windows 95 / NT systems, any alterations generated here are written to the Registry key *HKEY_CURRENT_USER \ Software \ Software Research \ Coverage \ TCAT-Java \ 1.2 \ WinIJava*, from which WinIJava reads them. The Defaults button retrieves the contents of Registry key *HKEY_LOCAL_MACHINE \ SOFTWARE \ Software Research \ Coverage \ TCAT-Java \ 1.2 \ WinIJava* to this box.

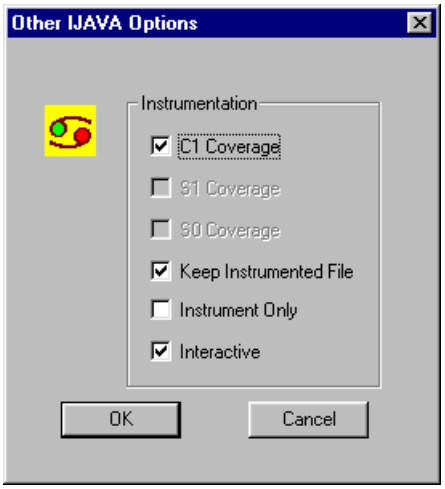


FIGURE 21 Other IJava Options

For the Instrumentation options, the usual assumption is that more coverage is better. Note that S0 coverage requires S1 coverage and cannot be selected unless S1 coverage is also selected.

Selecting the Keep Instrumented File option means that the **.i* file created during instrumentation is retained. Should the instrumentation fail, this file can be debugged for information.

Selecting the Instrument Only option prevents **IJava** from compiling and producing an **.i* file.

The Interactive option makes the instrumentation more visible. The interactivity means that the **IJava** command line window, which is present during instrumentation, waits for the user to exit from it before closing down to begin instrumentation of the next file or to return to **WinIJava**. This ensures that the user can read the messages and warnings in the window.

4.3 Instrumenting the Application Under Test

4.3.1 Options and Parameters

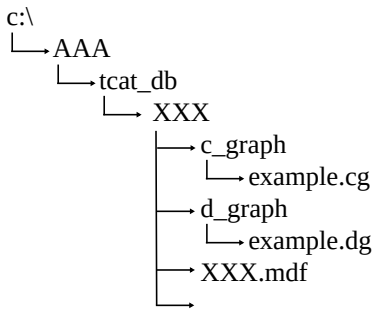
The syntax for command line invocation of **IJava** is as follows:

```
IJava <<option>> file.ext
[-TCAT-A]
[-TCAT-B]
[-TCAT-Cmd driver]
[-TCAT-C1]
[-TCAT-G]
[-TCAT-H]
[-TCAT-PD name]
[-TCAT-PN name]
[-TCAT-S0]
[-TCAT-S1]
```

These commands instrument submitted “Java” language file(s).

The directory specified with the -TCAT-PD switch becomes the project directory for the instrumentation. Within this directory, the t*cat_db* directory is automatically created. The directory name specified with the -TCAT-PN switch is created under the *tcat_db* directory, and contains the trace file, the module definition file, and the *c_graph* and *d_graph* directories. These lowest directories contain the **.cg* and **.dg* files, respectively.

If you invoke **IJava** with the switches `-TCAT-PD c:\AAA` and `-TCAT-PN XXX` on the file *`example.c`*, the directory tree created during instrumentation is as follows:



The following instrumentor switches may be used to vary the processing and reports generated by the instrumentor. The instrumentor switches are listed in alphabetical order. The trace file (trace.tre) will be created in the Java Program directory after execution.

Note that the commands are prefixed with *-TCAT*. This is done because all other switches are passed to the "Java" compiler. The prefix indicates that these switches are for TCAT processing.

file.ext	Instrumented File Specification(s); File(s) to be instrumented The extension is *java*. If there are multiple files, each one is processed in the order presented, and they are treated as if they have been concatenated together.
-TCAT-B	Non-Interactive Instrumentation Switch Instrumentation does not require any input from tested even if more than one file is being instrumented.
-TCAT-Cmd driver	Compiler Driver Command Switch Default driver is **cc.** For Microsoft Visual C, use **cl.exe.**-*TCAT-C1* C1 Instrumentation Switch If this switch is present, then the instrumentor inserts a function call in each segment, or logical branch. This is the preset default.

-TCAT-G	Instrumented File Disposition Switch Normally the instrumentor does not keep the instrumented file, because it has already been used to produce the instrumented output. When this switch is present the instrumented files are retained.
-TCAT-Help	Help Message Switch This switch prints out the set of valid switches.
-TCAT-i	Instrumentation Only Switch **WinIJava** instruments the target application but does not generate an object file. *-TCAT-i* overrides the *-TCAT-cmd* switch.
-TCAT-PD name	Project Directory Switch This switch specifies the location of the "project" directory.
-TCAT-PN name	Project Name Switch This switch specifies the project name.
-TCAT-S0	S0 Instrumentation Switch If this switch is present, then the instrumentor inserts a function call in each module. This tells you which functions are actually called during the invocation of the program, but it does not indicate the callee functions. To do this, you need to use the **-S1** switch.
-TCAT-S1	S1 Instrumentation Switch If this switch is present, then the instrumentor inserts a function call in each call pair.

4.3.2 Instrumentation Function Names

Instrumentation involves inserting function names into the source program. The function names for TCAT-instrumented programs are:

`Testworks.Runtime.SegHit();`	For entry segment, switch segments
`Testworks.Runtime.CprHit();`	For S1 coverage of call pairs
`ExpHit();`	For C1 coverage **if**'s, **while**'s and **for**'s

4.3.3 Instrumentor Inline Directives

It is possible to control instrumentation from within the processed "java" file, using the following instrumentor directives to turn off / on all instrumentation (but keep the segments and call pairs numbered correctly):

```
/* TCAT OFF */
/* TCAT ON */
```

4.4 Database File Formats

For information on the format of **WinIJava** output files, see Appendix A, "Java Instrumentor Engine Database Files."

4.5 Runtime Classes

This section is a guide to TCAT for Java / Windows'™ Runtime Options applies to all editions of the product.

4.5.1 Runtime Support Options

Provided with TCAT for Java / Windows is a package containing the TCAT for Java / Windows runtime classes.

By default, this package is installed into the *$SR/program* directory, where *$SR* is your TCAT for Java / Windows installed directory. The actual classes in the package are installed into *$SR/program/testworks/runtime* directory,

Your instrumented Java classes must be able to find this package. Therefore, during instrumentation and execution your CLASSPATH environmental variable must point to the top of this package. You can either append the program directory to your CLASSPATH or copy the *testworks* directory to one of the CLASSPATH directories.

Inside the *$SR/program/testworks/runtime* directory are several classes that implement various levels of trace buffering.

The default level of buffering is one. This is effectively no buffering, since as each trace hit occurs it is written to the trace file. To increase the size of buffering, replace *jrun.class* by one of the desired class from the chart below before executing your instrumented applet or application.

Class Name	Buffering level
jrun1.class	None
jrun10.class	10 Trace Hits
jrun100.class	100 Trace Hits
jrun10000.class	10000 Trace Hits
jrunInt.class	Infinite, Trace hits are not written to trace file until termination of application.

TABLE 1 **Buffering level for runtime class**

Note: that if your applet or application terminates abnormally that up to one buffer full of trace data will be lost.

4.5.2 Performance Gain With Buffering

The larger the trace buffer the better the performance of your instrumental application. However, it should be noted that the trace records up to the size of a buffer may be lost if the program is terminated abnormally.

CHAPTER 5

Cover

This chapter discusses **Cover**, the **TCAT for Java/Windows** complete TCAT Java analyzer for branch (C1) and callpair (S1) metrics. This chapter applies to all editions of the product.

5.1 Cover

Cover analyzes the trace files created when an instrumented program is executed, and generates reports based on the trace file data.These coverage reports can be tailored to show a variety of data, including:

- segments hit
- segments not-hit
- past-test and cumulative coverage percentages

Cover makes the following assumptions:

- A [possibly empty] archive file and a current [possibly empty] trace file exist.
- There is a file containing the names of the files in the project.
- The actual update of trace + archive --> archive is optional at end of a session.

The package maintains its usual rules for precedence of archive over trace, and displays warning messages when it finds size differences between archive and trace file.

5.2 Trace File and Archive File Formats

For information on the format of trace files and archive files, see Appendix A, “Java Instrumentor Engine Database Files.”

5.3 Cover Main Window

Once you have built an instrumented version of your application and exercised it, follow these steps to display a coverage report:

1. From the **Programs menu**, select **TCAT for Java** folder.
2. From the resulting window, select **Cover** icon.
3. From the **File** menu, select **Open**.
4. In the **Open** dialogue box, click on the filename *Trace.trc* in the *tcat_db* directory.

A coverage report on the application appears.

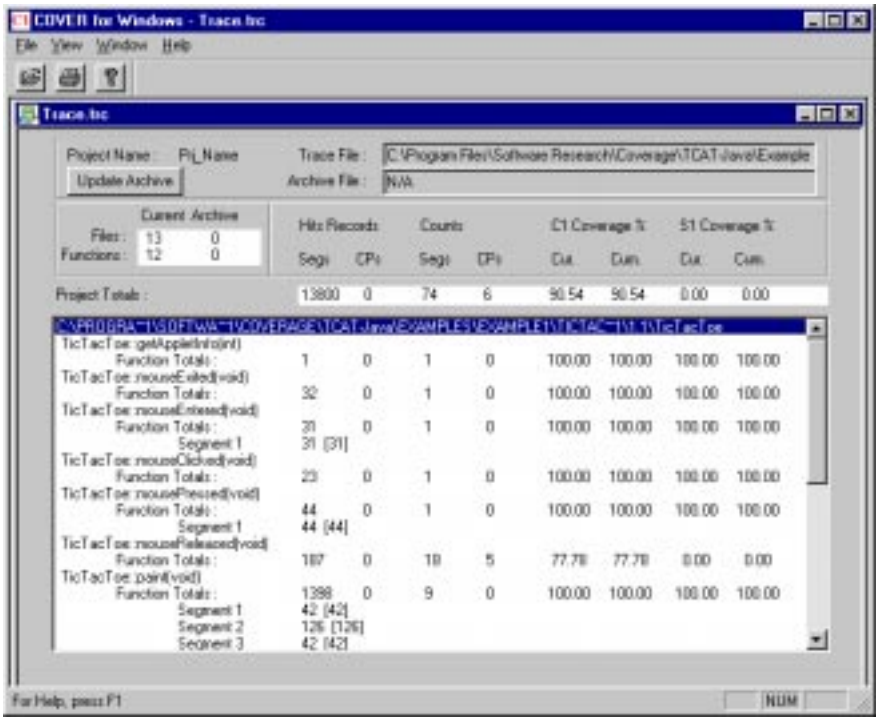


FIGURE 22 Cover Main Window

5.3.1 Tool Bar

The options available from the Tool Bar are the frequently used **Cover** features.

FIGURE 23 Tool Bar

Open	This option brings up the **Open** dialog box.
Print Button	This button brings up the **Print** dialog box.
Help	This button brings up a brief description of **Cover**.

5.3.2 File Menu

This menu displays the file management and printing options that are available in **Cover**.

Open	This option brings up the **Open** dialog box.
Print	This option brings up a the **Print** dialog box.
Print Preview	This option displays an image of what prints when you select the **Print** option.
Print Setup	This option displays a standard Windows printer set-up dialog box.
Exit	To end your **Cover** session, select the **Exit** option.

5.3.3 View Menu

This menu provides two options for configuring the **Cover** display.

Toolbar This toggle allows you to hide the Tool Bar in order to give your report more vertical display space or to re-display it.

Status Bar This toggle allows you to hide or re-display the status bar at the bottom of the **Cover** window.

5.3.4 Window Menu

This menu allows you to manipulate the **Cover** windows using the **Cascade**, **Tile** and **Arrange Icons** options, and the **Window** list box.

5.3.5 Help Menu

The first help option currently offers a brief description of **Cover**. The second option, **About**, displays the program's version number and copyright information.

5.3.6 Status Bar

This section of the window (appearing at the bottom left) displays messages regarding the functionality and operation of the **Cover** options.

5.4 File Menu

This menu is typical of Windows interfaces and provides access to file-manipulation options.

5.4.1 Open

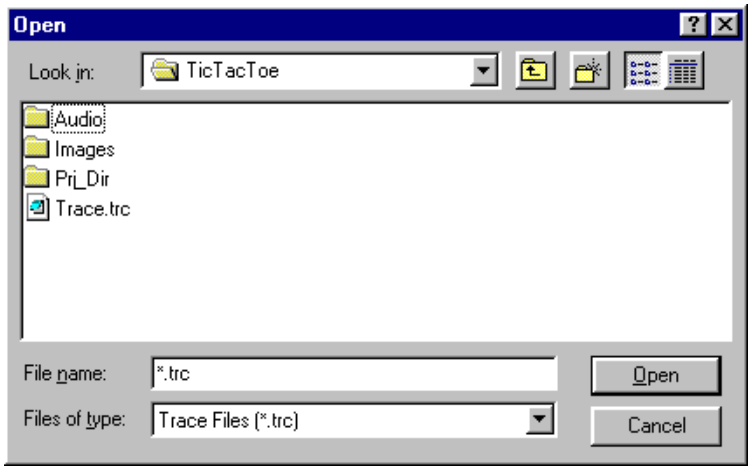


FIGURE 24 Cover Open Dialog Box

This option brings up a file selection dialog box. Typical of Windows interfaces, this dialog allows you to browse the directory tree and select files to open. Since all trace files are usually saved as *trace.trc*, each project has only one trace file.

File Name This box lists the files in the current directory that match the filter.

Directory This box lists the available directories.

When you have found the desired file, click **OK**, and the coverage report is displayed. **Cancel** closes the dialog box without opening a report.

5.4.2 Print

FIGURE 25 Print Dialog Window in Cover

5.5 Window Menu

This menu provides four options to manipulate the **Cover** windows. By default the active window entirely overlaps all others.

5.5.1 Cascade

This option arranges your windows in a cascade, with the active window top-most and highlighted.

5.5.2 Tile

This option arranges the windows so that a portion of each window is displayed. The active window is highlighted.

5.5.3 Arrange Icons

When you have minimized windows, this option arranges them neatly at the bottom of the **Cover** window.

5.5.4 Window List Box

This area of the pull down-menu lists all the windows open in **Cover**. The active window is indicated by a check mark. To activate a new window, especially if the windows are fully overlapping, select it from this list.

5.6 Create/Update an Archive File

If no archive file is loaded, this option creates one by copying the current **.trc* file as an **arh* file. Updating combines the information from the current **.trc* file with that of the selected **.arh* file.

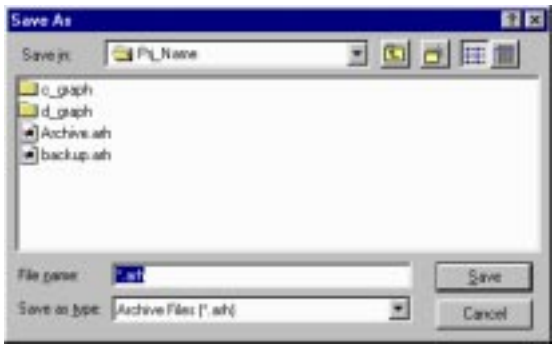


FIGURE 26 Save Archive File

5.7 Analysis of Coverage Reports

In the following analysis, a coverage report shows that a certain function, ***TicTacToe::myMove(boolean)***, has been tested 66.67%.

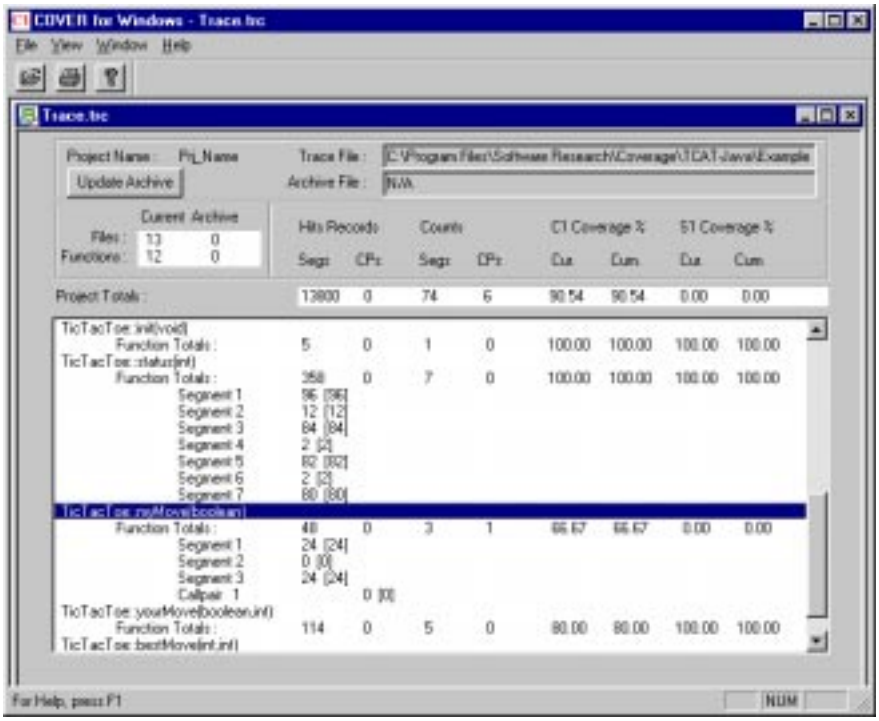


FIGURE 27 Coverage Report Showing C1 Coverage of 66.67% on the Function ***TicTacToe::myMove(boolean)***

The function consists of three segments and one callpair. This coverage report shows that segments 1 and 3 were hit twenty four times each and segment 2 not once. The two callpairs were each exercised twenty seven times.

The following few pages show graphical views of these numerical results.

In Figure 28, **TCAT for Java/Windows** graphs

TicTacToe::myMove(boolean) and its relations. The calltree shows the callpairs in ***TicTacToe::myMove(boolean)***, and the digraph shows possible program flows through ***TicTacToe::myMove(boolean)*** divided into segments.

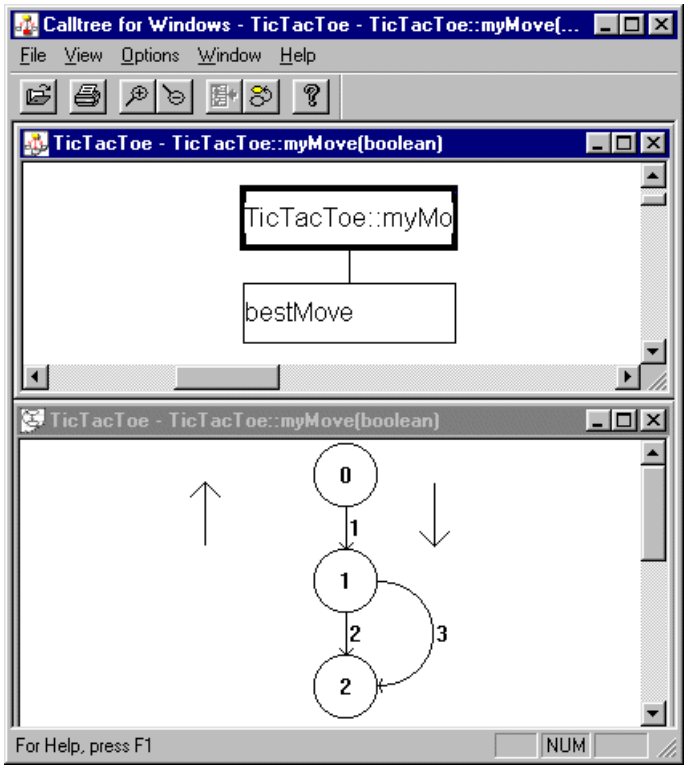


FIGURE 28 Calltree and Digraph of ***TicTacToe::myMove(boolean)***

Note that the calltree shows two callpairs: these are the same two callpairs registered by the coverage report in Figure 15 as having been exercised seven times each by the test of **TicTacToe**. The coverage report shows that the percentage of S1 coverage (coverage of call pairs) was 100% for this function.

Note that the digraph shows three segments. The coverage report shown in Figure 32 registered that the test of **TicTacToe** hit two of these segments seven times each and one of them not once. The coverage report shows that the percentage of C1 coverage (branch coverage) was 66.67%.

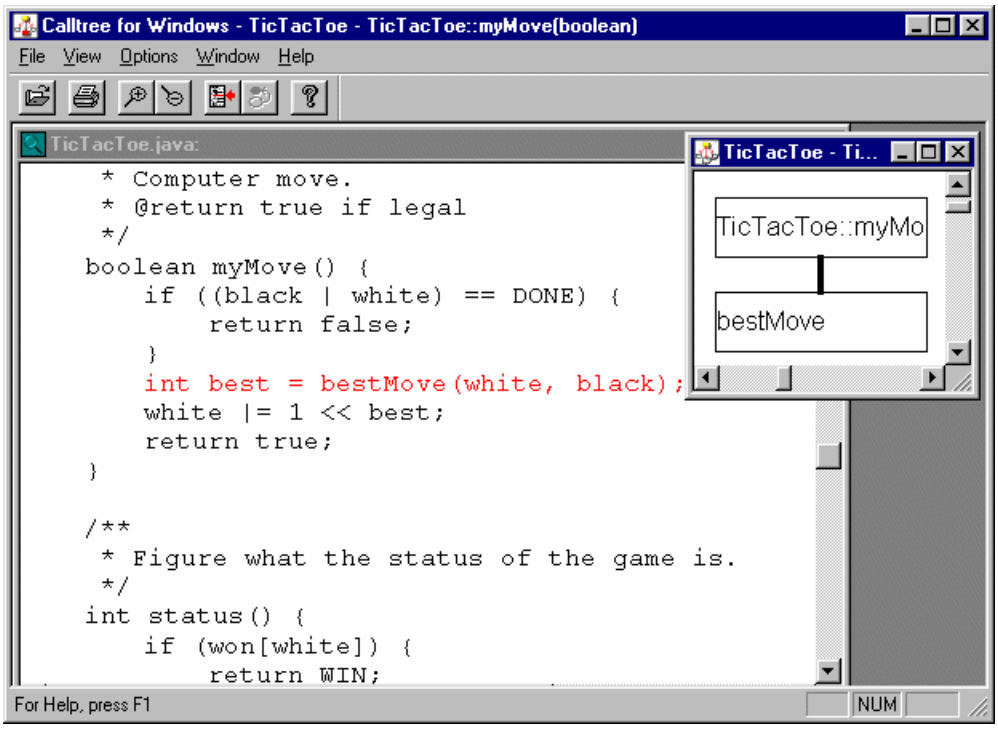


FIGURE 29 Calltree and Source Code Associated with One Callpair

To look at source code associated with callpairs, highlight the graphic lines connecting the functions shown in the calltree.

To look more closely at the segments, highlight one of the graphic lines in the digraph by clicking on it close to the number. Then use the Source Code button to display the associated source code.

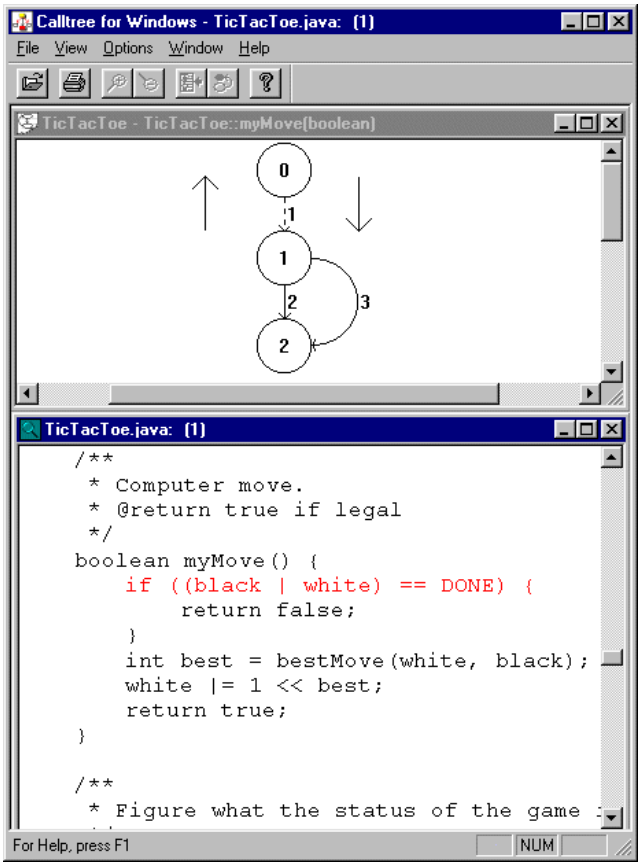


FIGURE 30 Digraph and Source Code Associated with One of Its Segments

CHAPTER 6

DiGraph

This chapter provides details on viewing and using directed graphs in **TCAT for Java/ Windows**.

6.1 Purpose and Overview

Directed graphs (digraphs) graphically display a program's structure and flow to help developers isolate flaws and bottlenecks.

TCAT for Java/Windows draws digraphs based on archive files that are created during instrumentation. Digraphs are composed of **edges** and **nodes**. Edges are derived from segments (also known as logical branches) representing sets of consecutive program statements or a program's "actions" (see Figure 31). Nodes are the places or "states" where the actions occur.

6.2 Directed Graph File Format

For information regarding the format of a directed graph chart file, see Appendix A, "Java Instrumentor Engine Database Files."

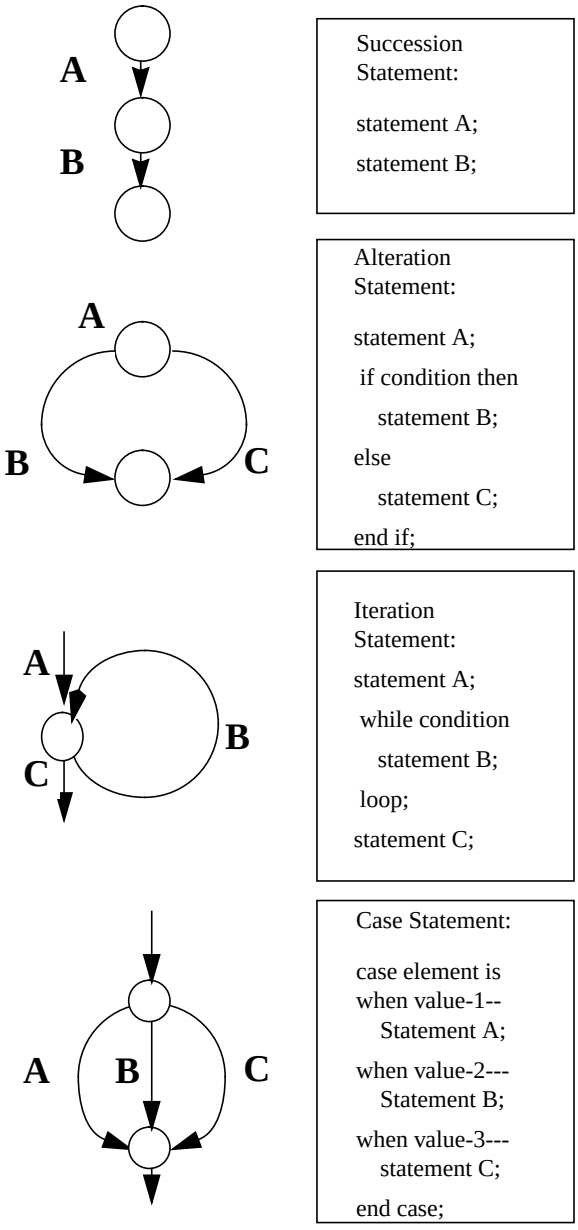


FIGURE 31 Program Edges as Represented in a Digraph

6.3 DiGraph Main Window

In order to explore all the options available, open a directed graph of the example program. In order to do this, you must first instrument the example application, which is discussed in Sections 4.1, 4.2, and 4.3, "Using IJava."

When you have an instrumented executable:

1. From the **Programs menu**, select the **TCAT for Java** folder.
2. Select the Digraph icon from the resulting window.
3. Use the **File** pull down menu and select **Open**.
   You are prompted for the name of the directed graph to view.
4. Find the *TicTacToe.dg* file under the *tcat_db\name\d_graph* directory.
   You are prompted for the name of the database file.
5. Find the *TicTacToe.mdf* file under the *tcat_db\name* directory.
   A window pops up listing the available functions.
6. Select **TicTacToe::status(int)**.

A directed graph depicting the **main[int,int,char*]** function appears.

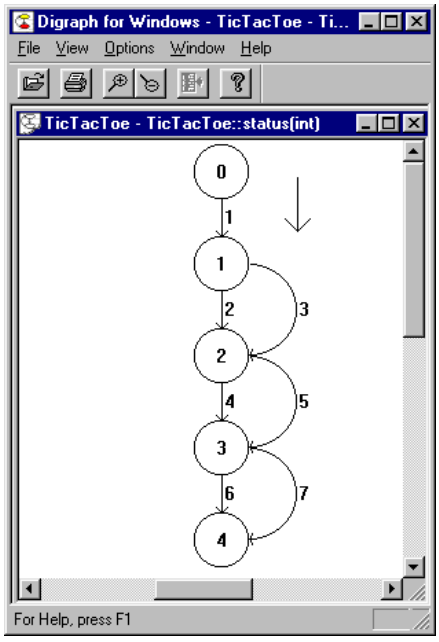


FIGURE 32 Directed Graph of TicTacToe

The following sections discuss the options available in **DiGraph**. Several options are discussed in more detail in later sections.

6.3.1 Tool Bar

The options available from this Tool Bar are the frequently used DiGraph features. When available, they appear highlighted.

FIGURE 33 Tool Bar

Open	This button brings up the **Open** dialog box.
Print	This button brings up the **Print** dialog box.
ZoomIn	This button Zooms in magnification factors of the current open window.
ZoomOut	This button Zooms out magnification factors of the current open window.
Source	This button brings up a window which contains the source code for the currently selected edge.
Help	This button brings up a brief description of DiGraph.

6.3.2 File Menu

This menu displays the file management and printing options that are available in **DiGraph**.

Open	This option brings up the **Open** dialog box.
Print	This option brings up a the **Print** dialog box.
Print Preview	This option displays an image of what will print when you select the **Print** option.
Print Setup	This option displays a standard Windows printer set-up dialog box.
Exit	To end your **DiGraph** session, select the **Exit** option.

6.3.3 Zoom Menu

This menu contains two options for scaling the digraph's display. For information on setting the zoom scale, see Section 6.6.1, "The Digraph Options Dialog Box."

In This option allows you to enlarge a portion of the digraph so that you can see it in more detail. There is a limit to how far you can zoom in, determined by your computer's display resolution.

Out This option allows you to see a wider portion of the digraph at a reduced magnification. Again, limits apply to how far you can zoom out.

6.3.4 View Menu

This menu provides three options for configuring the digraph's display.

Source This option allows you to display the source code for the selected function in the current directed graph.

Tool Bar This toggle allows you to hide the Tool Bar in order to give your digraph more vertical display space or to re-display it.

Status Bar This toggle allows you to hide or re-display the status bar at the bottom of the **DiGraph** window.

6.3.5 Options Menu

This menu provides access to two dialog boxes where you can set global display options for **DiGraph**.

Digraph Options This option displays a dialog box allowing you to choose the characteristics of the nodes and edges displayed in the digraph, as well as the increments for the **Zoom In** and **Zoom Out** options.

6.3.6 Window Menu

This menu allows you to manipulate the **DiGraph** windows using the **Cascade, Tile,** and **Arrange Icons** options, and the **Window** list box.

6.3.7 Help Menu

The first help option currently offers a brief description of **DiGraph**. The second option, **About**, displays the program's version number and copyright information.

6.3.8 Status Bar

This section of the window (appearing at the bottom left) displays messages regarding the functionality and operation of the **DiGraph** options.

6.4 File Menu

This menu is typical of Windows interfaces, and provides access to file-manipulation options.

6.4.1 Open

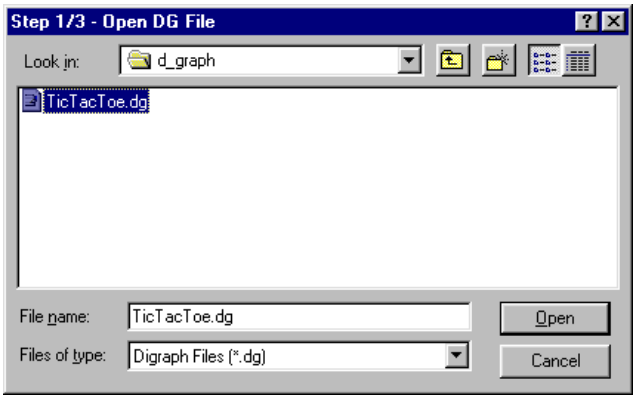


FIGURE 34 DiGraph Open Dialog Box

This option brings up a file selection dialog box. Typical of Windows interfaces, this dialog box allows you to browse the directory tree, and select files to open.

File Name This box lists the files in the current directory that match the filter.

Directory This box lists the available directories.

When you have found the desired file, click **OK**, and the directed graph is displayed. **Cancel** closes the dialog box without opening a graph.

6.4.2 Print

FIGURE 35 Print Dialog Box in DiGraph

6.5 View Menu

The most critical option on this menu is the **View Source** option.

6.5.1 Viewing Associated Source Code

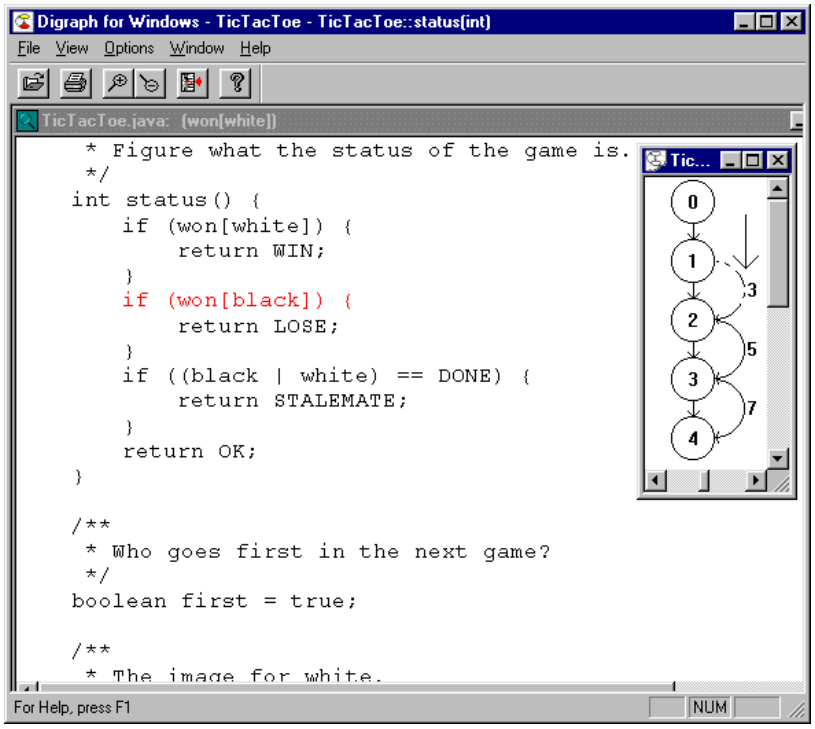


FIGURE 36 View Source Option

This option displays the source code for the program depicted in the digraph. If you click on an edge segment number in the digraph's main window, and the **View Source** option, the source code associated with that edge is displayed.

The arrow (triangle) symbols on the right-hand side (and bottom, when appropriate) of the window are scroll bars, which you can use to move vertically (or horizontally) in this window.

6.6 Options Menu

The options available from this menu allow you to configure certain aspects of the **DiGraph** display.

6.6.1 The Digraph Options Dialog Box

Characteristics

FIGURE 37 Digraph Options Dialog Box

This dialog box allows you to choose the magnification step used for the **Zoom In** and **Zoom Out** commands, the shape and size of the digraph's nodes, and the colors of the digraph's edges.

Zoom Increment This sets the magnification interval for the **Zoom In** and **Zoom Out** options. The default setting is .1 meaning a 10% reduction or enlargement in scale each time these buttons are used. To change the setting, move the slider left or right. Each 0.1 represents 10%, so if you slide the rule to .3, for example, the reduction and enlargement is 30% each time.

Eccentricity This determines the curvature of the generated display. The default value is .3; bigger values make the picture wider, and smaller values narrower.

Node

You can choose different sizes and shapes for the digraph's nodes. In this window, you can change the space between nodes and their height-to-width ratio.

You have four choices for shapes: **Circle**, **Box**, **Oval** or **Outlined** (the circle is drawn but not filled). The default setting is **Circle**.

- You can choose the size of the circle, box or oval. The default size is 1.0.
- You can change the amount of space between nodes. The default setting is 1.0.
- You can change the height-to-width ratio (for ovals or box shapes only). The default setting is 1.0.

Edge This area provides options to change the appearance of edges on your directed graph.

- There are three choices for Unhighlighted Edge: **Fulltone**, **Halftone** (dashes) or **Blank** (no visible lines). The default setting is **Fulltone**.
- Default Color is the basic color of the digraph's edges and nodes. The default setting is **blue**.

OK If you click on the **OK** button, all the current settings in the **Options** window are applied to the digraph.

Cancel If you click on the **Cancel** button, any changes you have made since opening the **Options** window are discarded.

Close If you click on the **Close** button, you exit the **Options** window.

6.7 Window Menu

This menu provides four options to manipulate the **DiGraph** windows. The default arrangement is that the active window entirely overlaps all others.

6.7.1 Cascade

This option arranges your windows in a cascade, with the active window top-most and highlighted.

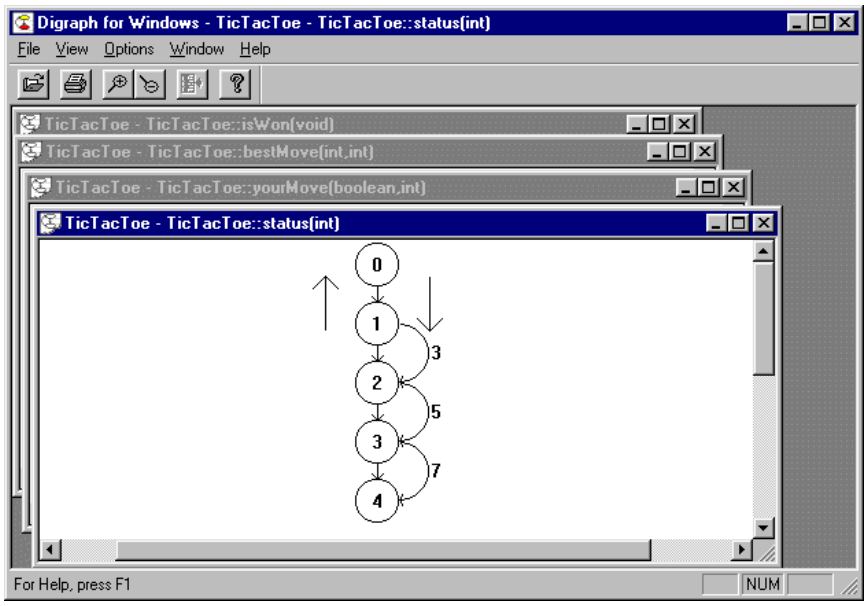


FIGURE 38 Cascading Windows in DiGraph

6.7.2 Tile

This option arranges the windows so that a portion of each window is displayed. The active window is highlighted.

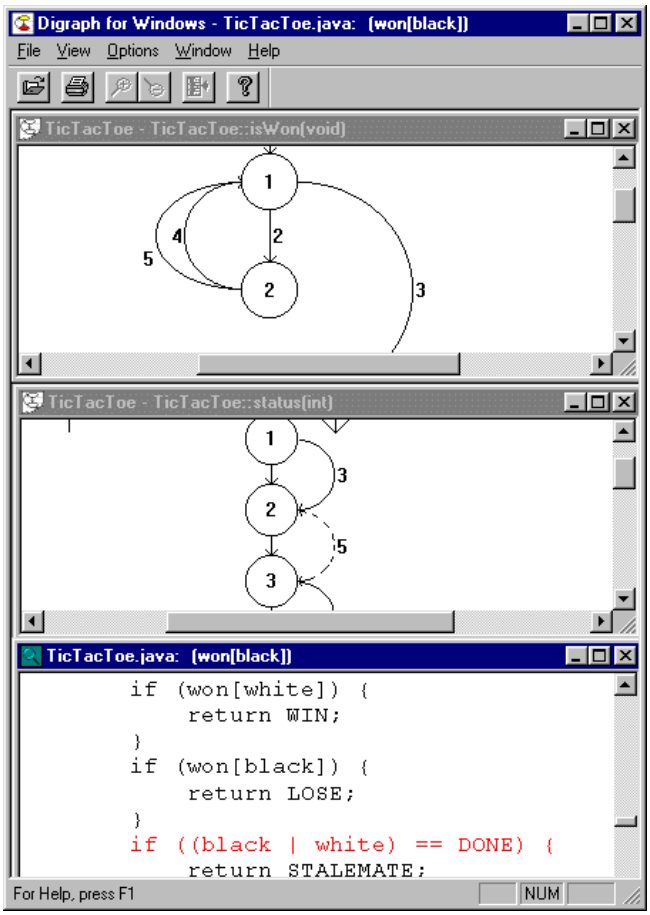


FIGURE 39 Tiled Windows in DiGraph

6.7.3 Arrange Icons

When you have minimized windows, this option arranges them neatly at the bottom of the **DiGraph** window.

6.7.4 Window List Box

This area of the pull down menu lists all the open windows available in **DiGraph**. The active window is indicated by a check mark. To activate a new window, especially if the windows are fully overlapping, select it from this list.

CHAPTER 7

CallTree

This chapter provides details about using calltrees in **TCAT for Java/Windows**.

7.1 Calltree Overview

A calltree displays a program's caller–callee dependency structure. **TCAT for Java/Windows** generates a calltree graph for each segment of your executable during instrumentation and stores it in a separate archive file. Once the instrumented application has been exercised, you can display a calltree window for a specified program segment by opening the target application's ***.cg** file.

7.2 Generating and Viewing Calltrees

You generate calltrees for your application by instrumenting your source-code files, as described in Sections 4.2 and 4.3 .

To Launch CallTree:

1. Select the **TCAT for Java Program Group**.
2. Click **CallTree**.

To View a calltree of the example program:

1. Pull down the **File** menu.
2. Select **Open**.

   You are prompted for the name of the calltree to view.

3. Find the *EXAMPLE.cg* file under the *tcat_db \ name \ c_graph* directory.

   You are prompted for the name of the database file.

4. Find the *Prj_Name.mdf* file under the *tcat_db \ name* directory.
5. Select a function ID from the presented list.

A calltree depicting the selected function appears. This first node of the calltree is called the root, as it is never called from within the program. The second (and lower) tier of nodes are the called functions, as they are called by nodes above them. The final tier of a calltree consists of called functions which never call other functions.

7.3 Calltree File Format

For information on the format of calltree files, see Appendix A, "Java Instrumentor Engine Database Files."

7.4 CallTree Window Overview

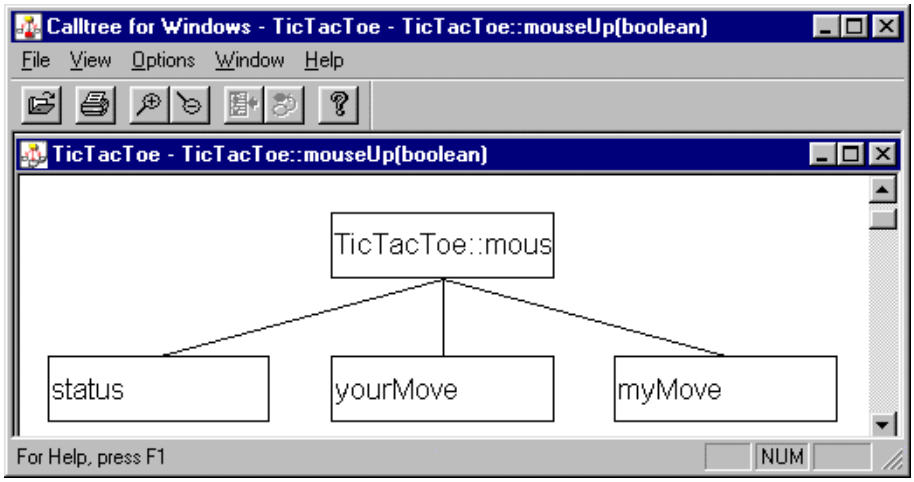


FIGURE 40 CallTree Main Window

This window allows you to view the calltree. This section briefly describes the menus available from **CallTree**. Several of the menus are discussed in more detail in later sections.

7.4.1 Tool Bar

The options available from this Tool Bar are the frequently-used CallTree features. When unavailable, they appear grayed out.

FIGURE 41 Tool Bar

Open	This button brings up the Open dialog box.
Print	This button brings up the Print dialog box.
ZoomIn	This button Zooms in magnification factors of the current open window.
ZoomOut	This button Zooms out magnification factors of the current open window.
Source	This button brings up a window which contains the source code for the currently selected edge.
Digraph	This button brings up a digraph of the associated function.
Help	This button brings up a brief description of CallTree.

7.4.2 File Menu

This menu displays the file management options available for CallTree.

Open	This option calls up the **Open** dialog box.
Close	This option closes the currently selected calltree.
Exit	If you wish to end your **CallTree** session, drag the mouse to **Exit**.
Print	This option brings up a the **Print** dialog box.
Print Preview	This option displays an image of what prints when you select the **Print** option.
Print Setup	This option displays a standard Windows printer set-up dialog box.

7.4.3 View Menu

This menu provides three options (**Select Function, Source** and **Directed Graph**) allowing alternate views of the program segment displayed in the calltree.

7.4.4 Window Menu

This menu allows you to manipulate any open **CallTree** windows using the **Cascade**, **Tile** and **Arrange Icons** options and the **Window** list box.

7.4.5 Options Menu

In this menu, a dialog box pops up where you can set the size, aspect ratio, and vertical spacing of the calltree, as well as the increments for the **Zoom In** and **Zoom Out** options.

7.4.6 Help Menu

This menu currently offers only one option, **About**, which displays the program's version number and copyright information.

7.4.7 Status Bar

This section of the window (appearing at the bottom left) displays messages regarding the functionality and operation of the CallTree.

7.5 File Menu

The File menu is typical of Windows applications.

7.5.1 Open

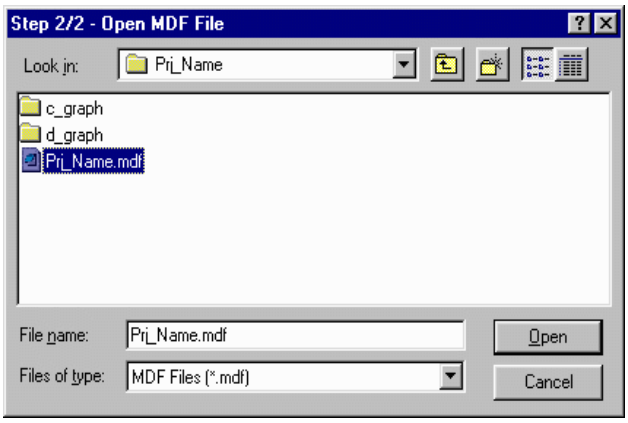


FIGURE 42 CallTree Open Dialog Box

This option brings up a file selection dialog box. It allows you to browse the directory tree and select files to open.

File Name This box lists the files in the current directory that match the filter.

Directory This box lists the available directories. When you have found the desired file, click **OK**, and the calltree is displayed.

Cancel closes the dialog box without opening a calltree.

7.5.2 Print Menu

FIGURE 43 Print Dialog Box in CallTree

7.6 View Menu

From **CallTree**, you can view source code and directed graphs of your program using the options on this menu.

7.6.1 Viewing Associated Source Code

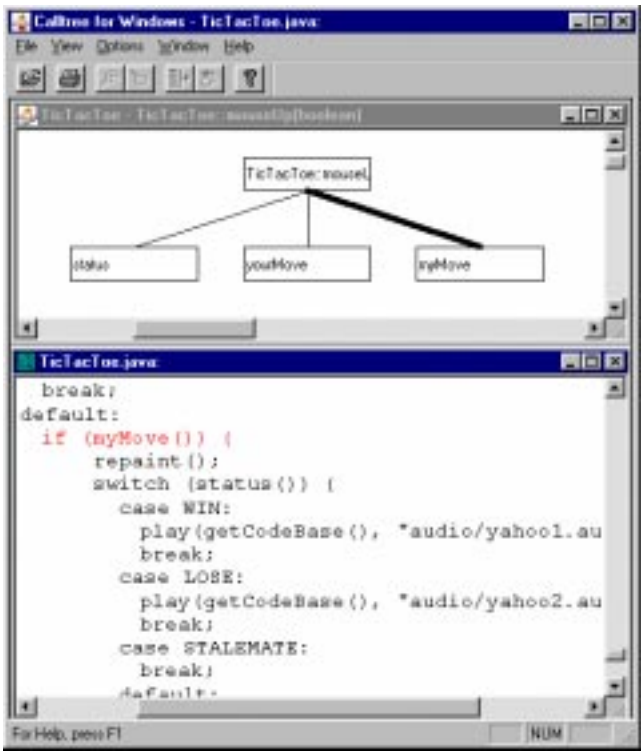


FIGURE 44 View Source Option

This option displays the source code for the program depicted in the calltree. If you click on an edge segment in the calltree's main window, and select the **View Source** option, the source code associated with that edge is displayed. If no call pair was selected, the display is positioned at the first call pair in the module. You can also select the **Source** button on the Tool Bar.

The arrow (triangle) symbols on the right-hand side and bottom of the window are scroll bars, which you can use to move vertically or horizontally in this window.

7.6.2 Viewing a Directed Graph

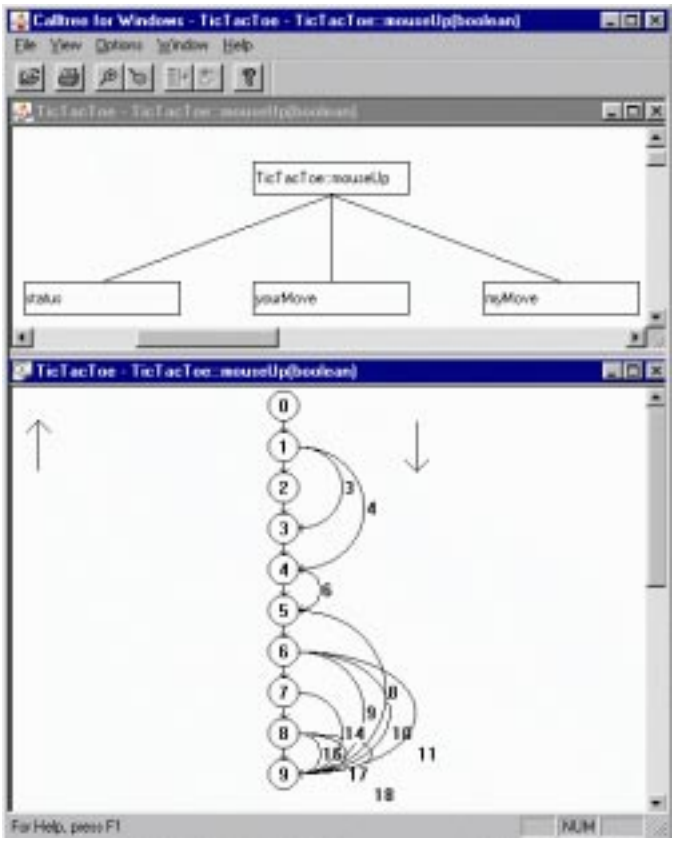


FIGURE 45 Directed Graph Option

This option allows you to view the detailed structure of a function in the current calltree. If you click on a node and select the **Directed Graph** option, a directed graph depicting that node appears. You can also select the **Directed Graph** button on the Tool Bar.

From this new window, you can view the source code in terms of edges and nodes rather than call pairs. To do so, click on an element of the directed graph and select **View Source** either from the **View** menu or from the Tool Bar.

7.7 Window Menu

This menu provides four options used to manipulate the **CallTree** windows.The default arrangement is that the active window entirely overlaps all others.

7.7.1 Cascade

This option arranges your windows in a cascade, with the active window top-most and highlighted.

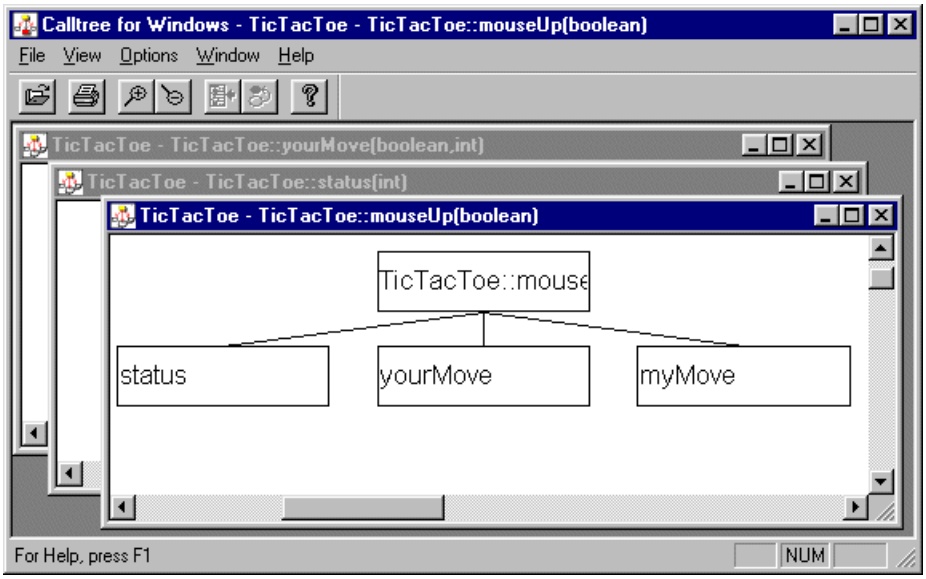


FIGURE 46 Cascading Windows in CallTree

7.7.2 Tile

This option arranges the windows so that a portion of each window is displayed. The active window is highlighted.

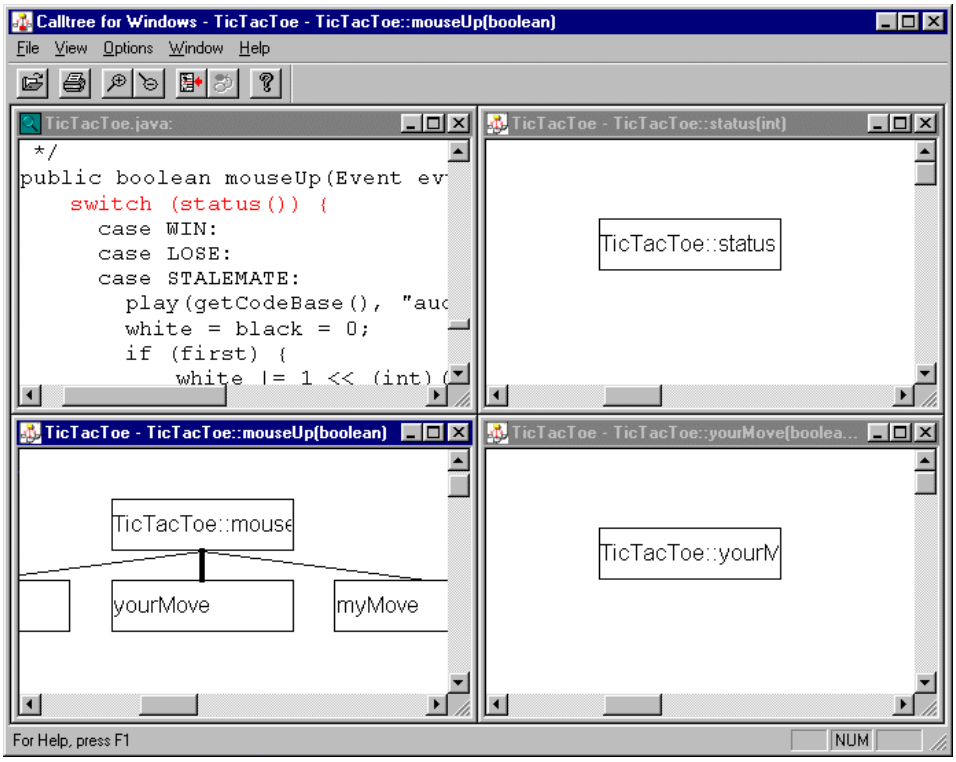


FIGURE 47 Tiled Windows in CallTree

7.7.3 Arrange Icons

When you have minimized windows, this option arranges them neatly at the bottom of the **CallTree** window.

7.7.4 Window List Box

This area of the pull-down menu lists all the open windows available in **CallTree**. The active window is indicated by a check mark. To activate a new window, especially if the windows are fully overlapping, select it from this list.

7.8 Options Menu

This menu brings up a dialog box from which several display options are available.

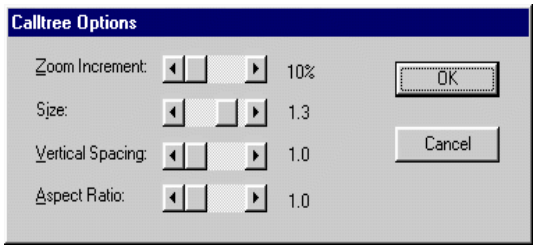


FIGURE 48 CallTree Options Dialog Box

This dialog box allows you to choose the magnification step used for the **Zoom In** and **Zoom Out** commands, the shape and size of the digraph's nodes, and the colors of the digraph's edges.

Zoom Increment This sets the magnification interval for the **Zoom In** and **Zoom Out** options. The default setting is .1 meaning a 10% reduction or enlargement in scale each time these buttons are used. To change the setting, move the slider left or right. Each 0.1 represents 10%, so if you slide the rule to .3, for example, the reduction and enlargement is 30% each time.

Vertical Spacing This alters the vertical distance between members of callpairs.

Aspect Ratio This alters the distance between and the width of the boxes.

OK If you click on the **OK** button, all the current settings in the **Options** window are applied to the calltree.

Cancel If you click on the **Cancel** button, any changes you have made since opening the **Options** window are discarded.

APPENDIX A

Java Instrumentor Engine Database Files

This file lists examples of **WinIC9**'s output files. This appendix applies to all editions of **Coverage for Windows**.

A.1 Instrumentation Database Definitions

This section outlines the files that are used in the instrumentation database stored in the *tcat_db* directory. This information is used throughout **Coverage for Windows**.

A.1.1 d_graph Files

The digraphs for each function are put into files which are named with the same basename as the file from which they originated, with any file-name suffix stripped off.

The format of each d_graph file is a set of blank delimited (white space delimited) lines composed as follows:

```
tail  head  edge  fun_id  type  filename
lbeg  lend  byte_beg  byte_end  string
result  [byte1  byte2]
```

where the fields have the following meanings:

tail	The tail node number (string)
head	The head node number (string)
edge	The **IJava** assigned edge number (string), also known as the seg ID
fun_id	The number of the function, whose name is found in the **mdf** file
type	The type of statement which gave rise to the edge
filename	The filename where the original text of the program was found
lbeg	The beginning line number, in the named file, where the tail node is found
lend	The ending line number, in the named file, where the head node is found
byte_beg	The beginning byte number, in the named file, where the tail node is found
byte_end	The ending byte number, in the named file, where the head node is found
string	The text string associated with the logical expression that headed the segment
result	The result corresponding to this edge, e.g. **T** or **F** or **36** (for switch outcome)
[byte1 byte2]	Currently “0 0”; reserved for expansion

A sample *d_graph* file is listed in Section A.2.1

A.1.2 c_graph Files

The calltrees for each processed file are put into files which are named with the same basename as the file from which they originated, with any filename suffix stripped off.

The format of each ***c_graph*** file is as a set of blank delimited (white space delimited) lines composed as follows:

```
file.caller callee callpair_id module_id
   source_file line 0 0 Segment_id
```

where the fields have the following meanings:

file.caller	The file name (given as a prefix up to the rightmost "." in the token, and the name of the calling function (the "caller")
callee	The name of the called function
callpair_id	The assigned identification number of the call pair
module_id	The assigned identification number of the module. This number points into the **mdf** file
source_file	The name of the source file that gave rise to the call pair
line	The line number of the source file where the call pair exists
0 0	These two fields are pre-set to be "0 0"
segment_id	(Reserved for future releases)

An example *c_graph* file is given in Section A.2.2.

A.1.3 Module Definition Files (mdf)

The *mdf* file contains basic information about the location of text fragments for every segment and every call pair in all processed files.

The ***mdf*** file has the following format:

```
project-name #segs #CPs [#rels]
file.name.function_id type #segs #CPs
[#rels]
file.name.function_id type #segs #CPs
[#rels]
file.name.function_id type #segs #CPs
[#rels]
...
```

where the first line identifies:

project-name	This is the name of the "project" from which the data is taken.
#segs	This is the total number of segments in the project.
#CPs	This is the total number of call pairs in the project.

The subsequent lines' fields have the following meanings:

file.name	This token contains, first, the name of the file in which the function name was found, and second, after the rightmost ".", the name of the function.
function_id	This is the unique numeric identifier for that function, as found in the filename, which prefixes the function name.
type	This is the type of function that was processed according to the key: 84 = static function; 111 = member function. Note: These numbers are implementation specific. Additional function types and different codes will be added in the future. At present this function type information is not used.
#segs	This is the number of segments in the function.
#CPs	This is the number of call pairs in the function.

An example *mdf* file is given in Section A.2.3.

A.1.4 Trace Files and Archive Files

The format described is the Type 3.0 variation that produces trace files that are “self describing" and need no other files to be processed correctly. The assumption is that the assignment of numbers to modules is done by a runtime lookup of each module's name.

The format for an Archive File is identical except that the records are arranged in the “natural” order.

The trace file format is universal for all types of runtimes used and for either trace files or archive files. The record definitions have the following meanings:

#Format number	Trace file Format Type Record Defines the type of the current trace file. This line MUST appear as the first line of the trace file: #Format 3.0 If it does not then this trace file is assumed to be one using a prior set of definitions.
# comment	Comment Line Record The entire line is treated as a comment. Any blank line in the trace file is ignored. Tabs and extra spaces are treated as singleton blanks (i.e. as white space). The trace file line can be any length (subject to system constraints).
@ date	Creation Date Record This is the time and date stamp for the trace file, output taken from date.
p filename F X	The Project The first argument is project name. The first number represents the number of functions.

n"M N nsegments Module Definition Record. The module name M has been entered, and it has been assigned run-time identification number N for the duration of this trace file. The module has *nsegments* segments and *ncallpairs* call pairs. The function name is listed with the pathname and file name preceding it.

This line is written out only the first time that the module was executed in the current test. (Second instances of this record can be ignored by the coverage analyzer.)

c "N M [ntimes]" Call Pair Hit Record

Call pair M in module N has been hit [*ntimes times*]. This record is used to support S1 coverage measurements.

In an archive file the *ntimes* show the total number of times this call pair was hit. If a call pair was not hit, the record need not appear for that segment.

s "N M [ntimes]" Logical Segment Hit Record. Segment M in module N has been hit [*ntimes times*]. This record is used to support C1 coverage measurements, and also is used to support S0 coverage measurements.

In an archive file the *ntimes* show the total number of times this segment was hit. If a segment was not hit the record need not appear for that segment.

A sample trace file is listed in Section A.2.4.

APPENDIX B

Example Instrumentation Database Files

Here are some examples of database files:

A.2.1 Id_graph File

This is a typical *d_graph* file:

```
0 1 1 0 0 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 82 0 0 0 (1) 0 0 0
1 2 2 0 2 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 82 0 0 0 <DONE 0 0 0
2 1 4 0 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 83 0 0 0 ((i&pos)==pos) 0 0 0
2 1 5 0 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 86 0 0 0 ((i&pos)==pos) 0 0 0
1 3 3 0 2 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 87 0 0 0 <DONE 0 0 0
0 1 1 1 0 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 109 0 0 0 (1) 0 0 0
1 2 2 1 2 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 112 0 0 0 <9 0 0 0
2 3 4 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 114 0 0 0 (((white&(1<<mw))==0)&&((black&(1<<mw))==0)) 0 0 0
3 4 6 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 116 0 0 0 (won[pw]) 0 0 0
3 4 7 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 120 0 0 0 (won[pw]) 0 0 0
4 5 8 1 2 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 120 0 0 0 <9 0 0 0
5 6 10 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 121 0 0 0 (((pw&(1<<mb))==0)&&((black&(1<<mb))==0)) 0 0 0
6 4 12 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 123 0 0 0 (won[pb]) 0 0 0
6 4 13 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 127 0 0 0 (won[pb]) 0 0 0
5 4 11 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 128 0 0 0 (((pw&(1<<mb))==0)&&((black&(1<<mb))==0)) 0 0 0
4 7 9 1 2 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 130 0 0 0 <9 0 0 0
7 1 14 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 130 0 0 0 (bestmove==-1) 0 0 0
7 1 15 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 133 0 0 0 (bestmove==-1) 0 0 0
2 1 5 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 134 0 0 0 (((white&(1<<mw))==0)&&((black&(1<<mw))==0)) 0 0 0
1 8 3 1 2 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 135 0 0 0 <9 0 0 0
8 9 16 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 135 0 0 0 (bestmove!=-1) 0 0 0
8 9 17 1 1 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 140 0 0 0 (bestmove!=-1) 0 0 0
9 10 18 1 2 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 140 0 0 0 <9 0 0 0
```

B.1.1 c_graph Files

This is a typical *c_graph* file:

```
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::myMove(boolean) bestMove(int,int,int) 1 3 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 174 0 0 3
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::mouseUp(boolean) status(int,TicTacToe&) 1 7 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 249 0 0 1
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::mouseUp(boolean) yourMove(boolean,TicTacToe&,int) 2 7 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 267 0 0 6
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::mouseUp(boolean) status(int,TicTacToe&) 3 7 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 270 0 0 7
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::mouseUp(boolean) myMove(boolean,TicTacToe&) 4 7 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 280 0 0 12
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::mouseUp(boolean) status(int,TicTacToe&) 5 7 C:\JAVA\TEST\TICTAC~1\TicTacToe.java 282 0 0 13
```

B.1.2 mdf Files

This is a typical mdf file:

```
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::isWon(void) 0 111 5 0
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::bestMove(int,int) 1 111 21 0
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::yourMove(boolean,int) 2 111 5 0
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::myMove(boolean) 3 111 3 1
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::status(int) 4 111 7 0
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::init(void) 5 111 1 0
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::paint(void) 6 111 9 0
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::mouseUp(boolean) 7 111 18 5
C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::getAppletInfo(int) 8 111 1 0
```

B.1.3 Trace Files and Archive Files

This is a typical trace file or archive file:

```
#Format 3.0
# TCAT for Java (tm) Version 1.2
# Copyright 1997 by Software Research, Inc.
# 11-18-1997
# Profile for project 'Prj_Name':
p Prj_Name 9 8
n C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::isWon(void) 0 111 5 0
n C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::bestMove(int,int) 1 111 21 0
n C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::yourMove(boolean,int) 2 111 5 0
n C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::myMove(boolean) 3 111 3 1
n C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::status(int) 4 111 7 0
n C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::init(void) 5 111 1 0
n C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::paint(void) 6 111 9 0
n C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::mouseUp(boolean) 7 111 18 5
n C:\JAVA\TEST\TICTAC~1\TicTacToe.TicTacToe::getAppletInfo(int) 8 111 1 0
# End of profile for project 'Prj_Name'.
s 0 1 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 4 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
s 0 2 1
s 0 5 1
```

cover9 —TCAT for Java's Coverage Analyzer

This notes explains options for invoking and customizing the "cover9" coverage analyzer. This notes applies to all editions of TCAT C / C+ and TCAT for Java.

These are the options on how to invoke **cover9**. This command, used inside the **TCAT for Java** graphical user interface, is used to produce a coverage report which, optionally, can report results in a Reference Listing. The Reference Listing report allows you to look up a segment in order to identify the actual unexecuted code, and plan new test cases.

C.1 Command Line Invocation

The complete syntax for calls to **cover9** is listed below. Items enclosed in [brackets] are to be included zero or more times.

```
cover9 [tracefile [tracefile]]
         [-a old-archive]
         [-b file]
         [-c]
         [-C1]
         [-d name [name]]
         [-DI deinst-file]
         [-DL]
         [-f new-archive]
         [-h | -h name [name]]
         [-html | -html filename]
         [-H]
         [-N]
         [-n]
         [-nl namefile]
         [-NH]
         [-m]
         [-l | -l name]
         [-p]
```

```
[-P0]
[-P1]
[-q]
[-r report]
[-S0]
[-S1]
[-s]
[-SU]
[-T [threshold]]
[-w width]]
```

C.2 Cover9 Switch Definitions

The options may be used to vary the processing and reports generated by **cover9**. The options are listed in alphabetical order.

[tracefile [tracefile]] These are the names of the trace files that you wish to process. If there are no trace files then **cover9** looks for data in the default trace file name **Trace.trc**.

If there are no names given, and **Trace.trc** is not present then an error message is issued.

If there are multiple trace files, each trace file is processed in the order presented.

Caution: *The list of trace files must be the first set of arguments. The list is ended by the first symbol that appears with a '-', i.e. by the first optional switch.*

-a *old-archive* *Old Archive File Name Switch.*You can include data from an old archive file in your reports. On the standard cumulative coverage report, this data will be included in the "Cumulative Summary" test results, but not under the column "Test". To test iteratively, progressing through a structured series of tests towards higher C1 values, each run of **cover** should include the cumulative archive file from the previous test.

If you do not include an archive file, the "Cumulative Summary" figures will be the same as those for "Test". Alternatively, if no -a option is given, the file Archive is used by default.

The **-a** option interacts with the other report options discussed below.

-b *file*

Banner File Name Switch. This allows you to include specific text, taken from the first line of the file named *title* as a title for your reports. A maximum of 80 characters is allowed for titles.

-c

Cumulative Report Switch. This option prints the Cumulative report only.

-C1

Branch Coverage Reporting Switch. Turns on reporting of C1 or branch coverage.

Note: *Unless at least one of* ***-C1****,* ***-S1****, or* ***-S0*** *is turned on, no coverage report will be generated.*

-d *name*

Module Name Delete Switch. If this switch is present then the named modules, if found in the current execution, are deleted from the generated Archive file. Subsequently, **cover9** will never have heard about these names. This switch is useful in updating an extensive test record that would otherwise be lost due to the complexity of editing the Archive file.

-DI *deinst-file*

De-instrument Switch. Allows the user to specify a list of modules that are to be excluded from coverage reporting. Only the list of module names found in the specified `deinst-file` is to be excluded from coverage reporting. The module names can be specified in any format. White space (such as tabs, spaces) is ignored. `deinst-file` is also the file where new modules that pass the coverage threshold value (see the **-T** switch) will be written.

-DL

De-instrument Module List Switch. Allows the user to see which modules are excluded from coverage reporting. This switch is used along with the **-DI** switch. The list of excluded modules is printed at the end of the coverage report

-f *new-archive*

New Archive File Name Switch. Newly accumulated test coverage data will be placed in this file. If you do not include a different name with this switch, the accumulated test data will be placed in the default name Archive.

Caution: Each time you run **cover9**, you will write over the contents of the Archive file unless you use the -f switch to direct the Archive file to another place. You may wish to remove the filename before starting a new test sequence.

-h | -h [name] Linear Histogram Report Switch (**-h**).

-html *[filename]* *HTML Switch.* If present, the current coverage report in html format will be generated. Normally the report is written to the file Coverage.htm (the default name), but you can rename the file with this switch. CAUTION: You will overwrite any file you name with this switch.

-l | -l [name] Logarithmic Histogram Report Switch **(-l)**.

These two options produce two "histogram" reports that graph the frequency distribution of the segments exercised in a single module. The histograms provide a module-by-module analysis of testing coverage, combining current trace file data with archive date included through the -a option or using the default Archive file. If the optional name argument is present, then the corresponding histogram for only the named module is produced; otherwise, **cover9** produces histograms for all modules found. There can be multiple names in the argument if you want histograms of several modules. Also, the names can be mixed between linear and logarithmic histograms.

-H *Hit Report Switch.* Lists the segments that have been hit one or more times in current or past tests. This report analyzes the cumulative effect of the current trace file and any archive data included through the use of the **-a** option or using the default Archive file.

-m *Minimal Output Switch.* When present, **cover9** suppresses banner information, list of current options and trace file descriptions. The coverage report contains only the reports requested.

-N, **-n** *Not Hit Report Switch.* This option produces the "Not Hit" report which lists segments that have not been exercised. This report analyzes the cumulative effect of the current trace file and any archive data included through the use of the **-a** option or using the default Archive file.

-NH *Newly Hit Report Switch.* Shows the segments by module that were hit in the current execution that were not hit previously. Thus this gives the user an assessment of the value of the most-recently added test(s). This shows what the current test "gained". Output is the complement of the "Newly Missed" report.

-nl *namefile*

Name List Switch. This switch specifies that only the list of module names found in the specified *namefile* file is to be reported on in the current coverage report. Coverage on other module names that may appear in the archive or supplied trace files are ignored; however, the data is accumulated in the archive file.

The names used must be specified one name per line. White space (tabs, spaces, etc.) on the line is ignored.

The following reports are affected by the existence of a namefile:

- Cumulative Report
- Past Report
- Not Hit Report
- Hit Report
- Newly Hit Report
- Newly Missed Report.

The histogram outputs are not affected. There is a separate name mechanism that can be used to produce individual histogram reports.

-NM

Newly Missed Report Switch. This option produces the Newly Missed report. Shows which segments, by module, hit in any prior test that were not hit in the current test. This shows what the current test "lost". This output is the complement of the Newly Hit report.

-p

Past Report Switch. Print only the Past Test report; this option should be used in conjunction with the -a option when you want to analyze the overall performance of a set of past tests.

-q

Quiet Output Switch. Suppress printout of current version and release information (this can be used to facilitate running **cover9** in batch mode).

-r *report*

Coverage Report File Name Switch. Normally the report is written to the file Coverage (the default name), but you can rename the file with this switch. CAUTION: You will overwrite any file you name with this switch.

-S1

Call-Pair Coverage Switch. If present, the report will show call pair coverage.

-S0 — *Module Coverage Switch.* If present, the report will show module coverage.

NOTE: Unless at least one of **-C1**, **-S1**, or **-S0** is turned on, no coverage report will be generated. However, not both **-S1** and **-S0** can be present; if they are then only **-S1** is assumed.

-s — *Sort Switch.* This option produces output reports with module names sorted alphabetically.

-SU — *Suppress Update Switch.* During processing, **cover9** will suppress updating of the archive file, either the default Archive or the file named by the **-f** switch. **cover9** will read the data in the archive file to form the basis for the "past test" information.

-T *threshold* — *Coverage Threshold Switch.* Threshold is a real number that specifies threshold value. Any module with a coverage percentage greater than or equal to this threshold value will be written to the de-instrumented file (see the **-DI** `deinst-file` switch). If no threshold is specified, then the default value of 85 percent is assumed.

-w *width* — *Report Width Switch.* Normally the reports generated by **cover9** are wide enough to accommodate module names up to 21 characters in length. The internal limit on name length is, however, 128 characters. You can use this switch to force **cover9** system to generate reports that are wide enough to accommodate the full 128 character module names.

The width factor is the number of additional characters to be added to the report. The default value is zero. Maximum width is 128 - 21 = 107. **WARNING**: Reports with high values for the -w option may contain long lines and may not be suitable for printing directly.

C.3 Error Processing

In case there is an error, **cover9** gives a response line (usage line) indicating the set of switches and options. This response is the same as the **-help** response.

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