

**SigTest**  
User's Guide  
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This guide describes how to install and run the SigTest collection of tools. This collection includes the Signature Test tool and the API Coverage tool. Signature Test tool includes utilities used to develop signature test components that can be used to compare API test signatures. API Coverage tool is used to estimate the test coverage a test suite provides for an implementation of a specified API.

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# Preface

This guide describes how to install and run the SigTest collection of tools. This collection includes the Signature Test tool and the API Coverage tool. Signature Test tool includes utilities used to develop signature test components that can be used to compare API test signatures. API Coverage tool is used to estimate the test coverage a test suite provides for an implementation of a specified API.

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**Note:** For simplicity, this user's guide refers to the test harness as the *JavaTest harness*. Note that the open source version of the harness, called *JT harness*, can be used in its place. The JT harness software can be downloaded from: <http://jtharness.dev.java.net/>

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## Who Should Use This Guide

This guide is for developers of quality assurance test suites and developers of compatibility test suites — TCKs for a Java platform API as part of the Java Community Process (JCP) program.

## Before You Read This Guide

Before reading this guide, it is best to be familiar with the Java programming language. A good resource for the Java programming language is the Oracle Technical Network web site, located at <http://www.oracle.com/technetwork/java/index.html>.

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**Note:** Web URLs provided are subject to change.

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# How This Guide Is Organized

**Introduction** describes the SigTest collection of tools.

**Part I** describes how you can use the *Signature Test tool* to easily compare the signatures of two different implementations of the same API.

**Part II** describes how you can use the *API Coverage tool* to estimate the test coverage a test suite provides for an implementation of a specified API.

**Part III** describes how you can use the *API Check tool* to track API changes and roughly check for source and binary compatibility.

**Part IV** contains an appendix that includes step-by-step examples that show how to use Signature Test tool.

## Related Documentation

For details about the Java programming language, see the following documents:

- *The Java Programming Language, Third Edition*
- *The Java Language Specification, Second Edition*
- *The Java Virtual Machine Specification, Second Edition*

These documents are available at

<http://www.oracle.com/technetwork/java/index-jsp-142903.html#documentation>.

## Typographic Conventions

Typeface	Meaning	Examples
AaBbCc123	The names of commands, files, and directories, or on-screen computer output	Edit your <code>.login</code> file. Use <code>ls -a</code> to list all files. % You have mail.
AaBbCc123	Book titles, new words or terms, words to be emphasized	Read Chapter 6 in the <i>User's Guide</i> . These are called <i>class</i> options. You <i>must</i> be superuser to do this.
	Command-line variable or placeholder. Replace with a real name or value	To delete a file, type <code>rm filename</code> .
		SigTest-Directory <sup>1</sup>
\ or ^	A backslash at the end of a line indicates that a long code line has been broken in two on a UNIX® system, typically to improve legibility in code. The caret character (^) indicates this on a Microsoft Windows system.	<code>java classname \ [classname_arguments]</code> <code>java classname ^ [classname_arguments]</code>
Indented code or command line	Indicates a wrapped continuation from a previous line with no carriage return or return character in the actual code.	<code>java classname [classname_arguments]</code>

<sup>1</sup> The top-most SigTest Tool collection installation directory is referred to as *SigTest-Directory* throughout the SigTest Tool collection documentation.



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# Introduction

The SigTest product is a collection of tools that can be used to compare APIs and to measure the test coverage of an API. The tools were originally created to assist in the creation of Java technology compatibility test suites (TCKs), but are also useful in the creation of other types of test suites and in the software development process. The SigTest product consists of the following tools.

**Signature Test tool** makes it easy to compare the signatures of two different implementations or different versions of the same API. When it compares different implementations of the same API, the tool verifies that all of the members are present, reports when new members are added, and checks the specified behavior of each API member. When it compares different versions of the same API, the tool checks that the old version can be replaced by the new one without adversely affecting existing clients of the API.

**API Coverage tool** can be used to estimate the test coverage a test suite provides for an implementation of a specified API. It does this by determining how many public class members the test suite references within the API specification. The tool uses a signature file representation of the API specification as the source of specification analysis. It does not process a formal specification in any form.

**API Check tool** tracks API changes and roughly checks for source and binary compatibility. Much like Signature Test tool, it compares the reference implementation of an API recorded as golden signature file with a tested implementation. Unlike Signature Test tool, which requires that all classes (and the classes they depend on) be specified to the tool, API Check tool does not require dependencies to be specified. For that reason, API Check tool is faster than Signature Test tool, but less rigorous.

Part I of this manual describes how to use the Signature Test Tool, Part II describes how to use the API Coverage tool, Part III describes how to use the API Check tool, and Part IV contains two appendices that include step-by-step examples that show how to use the Signature Test tool and the rules used in the Signature Test API migration feature.

## 1.1 Global Functionality

This section describes functionality that is available to all the tools and their commands.

### 1.1.1 Option File

All of the tools accept options from a option file as well as from the command line. Option files allow you to create complex command lines in a text editor and then reuse them.

The option file is specified on the tool command line using the “@” character as shown in the following example.

```
java -jar sigtest.jar test @file
```

In this case, *file* is the path to a option file. You can use a combination of option files and command-line options as shown in the following example.

```
java -jar sigtest.jar test @file -package com.acme.api.printing.color
```

### 1.1.1.1 Option File Format

In addition to options and their arguments, option files can also contain “set” commands that you can use to set variables for use within the option file. The option file syntax is demonstrated in [Example 1-1](#).

#### **Example 1-1 Option File**

```
-----
#This option file checks the API against JRE 1.6
-----

set HOME=/home/ersh
set JRE=/opt/java/jre16
set AMCE_HOME=${HOME}/projects/release
set API=${AMCE_HOME}/lib/ams.jar

static
backward
classpath=${JRE}/lib/rt.jar:${API}
filename=${AMCE_HOME}/misc/reference.sig
```

This option file is equivalent to the following command line.

```
java -jar sigtest.jar test -static -backward -classpath
/opt/java/jre16/lib/rt.jar:/home/ersh/projects/release/lib/ams.jar
-filename /home/ersh/projects/acmesystem/msc/reference.sig
-package com.acme.api.printing.color
```

### 1.1.2 The -version Option

All of the tools and commands support the `-version` option as a way to display information about the tools and will list which signature files they are compatible with. In addition, you can specify the `-version` option as an argument directly to the JAR file as well as shown here.

```
java -jar sigtest.jar -version
```

# Part I

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## Signature Test Tool

This part describes how you can use the Signature Test Tool to easily compare the signatures of two different implementations or different versions of the same API.

This part includes the following chapters:

- [Chapter 2, "Introduction to Signature Test Tool"](#)
- [Chapter 3, "Using the Signature Test Tool"](#)



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## Introduction to Signature Test Tool

You can use the Signature Test tool to easily compare the signatures of two different implementations of the same API. It verifies that all of the members are present, reports when new members are added, and checks the specified behavior of each API member.

### 2.1 Signature Test Basics

A signature test compares two implementations of an API and reports the differences. The Signature Test tool compares the signatures of two implementations or versions of the same API and can do the following:

- Create and run a test that verifies that all of the members are present
- Report when new members are added
- Check the specified behavior of each API member
- Determine whether the old version of the API can be replaced with the newer one without adversely affecting existing clients of the API

The signature test created by the Signature Test tool can be run independently at the command line, or under the control of the JavaTest™ harness.

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**Note:** For simplicity, this user's guide refers to the test harness as the *JavaTest harness*. Note that the open source version of the harness, called *JT harness*, can be used in its place. The JT harness software can be downloaded from this URL:

<http://jtharness.dev.java.net/>

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The Signature Test tool was originally created to assist in the creation of Java technology compatibility test suites (TCKs). It simplified the process of verifying that the API signature of a new implementation of a Java technology matched the signature of a reference implementation of that API.

When used in a software development environment, the Signature Test tool can be used to track and control changes to an API throughout the development process.

### 2.2 What is Tested

The signature test algorithm compares the API implementation under test with a signature file created from the API you are comparing it to — often referred to as a *reference implementation*. The signature test checks for compatibility by verifying the

equality of API member sets. By checking for mutual compatibility of API member sets, the test verifies that the following conditions are true:

- If an API item is defined in the reference implementation of the API, then that item is implemented in the API under test, and vice versa.
- Attributes chosen for comparison are identical in both implementations of the API. The tool chooses attributes for comparison according to the type of check being processed. This is described more in [Section 2.2.1, "Mutual Binary Compatibility Check"](#) and [Section 2.2.2, "Mutual Source Compatibility Check"](#).

By checking for migration compatibility of API member sets, the test verifies that the following conditions are true:

- If an API item is defined in the previous version of the API, then that item is implemented in the API version under test
- If an API item is not defined in the previous version of the API, but added to the API version under test, the added item does not break backward compatibility. This is described more in [Section 2.2.3, "Migration Binary and Source Code Check"](#).
- Attributes chosen for comparison are identical in both versions of the API or their change does not break backward compatibility. The tool chooses attributes for comparison according to the type of check being processed. This is described more in [Section 2.2.3, "Migration Binary and Source Code Check"](#).

## 2.2.1 Mutual Binary Compatibility Check

The signature test binary compatibility check mode verifies that a Java technology implementation undergoing compatibility testing and its referenced APIs are mutually binary compatible as defined in Chapter 13, "Binary Compatibility," of *The Java Language Specification*. This assures that any application runs with any compatible API without any linkage errors.

This check is less strict than the default source compatibility check, described next. It is for use primarily in the special case of when a technology is developed for Java technology environments that are purely runtime. Such an environment does not provide a Java technology-based compiler (Java compiler), nor does it include class files that could be used to compile applications for that environment. Because of the limited use of such an environment, the API requirements are slightly relaxed compared to environments that support application development.

Java application environments can contain several Java technologies. Not all Java technologies can be combined with each other, and in particular, their sets of API signatures might be incompatible with each other. Relaxing signature checks to the level of mutual binary compatibility allows the developer to combine technologies in a purely runtime environment that cannot be combined otherwise.

## 2.2.2 Mutual Source Compatibility Check

While binary compatibility is important, it cannot guarantee that an application in binary form as a set of class files can be *recompiled* without error.

The signature test source compatibility check mode verifies that any application that compiles without error with a compatible API, compiles without error with all other source compatible APIs.

Mutual source compatibility is a stricter check than the mutual binary compatibility and the Signature Test tool performs it by default.

### 2.2.3 Migration Binary and Source Code Check

Mutual compatibility is generally used in certification processes where the goal is to ensure that an alternative or third-party implementation of an API conforms to a reference implementation. Application developers have a different concern, they must ensure that evolving library APIs that their applications link to continue to work with customers' applications. The Signature Test tool can be used to check APIs as they evolve and ensure both binary and source code migration compatibility.

Migration binary compatibility checking ensures that there will be no linkage errors between pre-existing client binaries and the new version. This determination is based on the Chapter 13, "Binary Compatibility," of The Java Language Specification.

Migration source code compatibility means that pre-existing client source code can be recompiled with the new version without compilation errors.

### 2.2.4 Class and Class Member Attributes Checked

A Java platform API consists of classes, and interfaces, and their member fields, methods, and constructors, and documented annotations. In turn, all of these API items can have various attributes such as names, modifiers, a list of parameters, a list of interfaces, exceptions, nested classes, and so forth. A signature test checks that certain members and attributes belonging to the API under test are the same as those defined by the API to which it is being compared. Signature test only checks public and protected API items and in the most cases ignores private and package access items. Members with private and package visibility are taken into account when the tool calculates hiding for more visible members.

The tool checks the following attributes when comparing items in the API implementation under test:

- Classes and interfaces, including nested classes and interfaces:
  - Set of modifiers except `strictfp`
  - Name of the superclass
  - Names of all superinterfaces, direct plus indirect, where order is insignificant
- Constructors:
  - Set of modifiers
  - List of argument types
  - In source compatibility mode only, the normalized list of thrown exceptions where order is insignificant
- Methods:
  - The set of modifiers, except `strictfp`, `synchronized`, and `native`
  - The return type
  - The list of argument types
  - In source mode only, the normalized list of thrown exceptions, described earlier, where order is insignificant
- Fields:

- Set of modifiers, except transient
  - Field type
- Documented annotations with SOURCE and RUNTIME retention of the following types:
  - Classes and interfaces
  - Fields, methods and constructors
  - Parameters and annotation types

The tool performs the check in the following order:

1. For all top-level public and protected classes and interfaces, it compares the attributes of any classes and interfaces with the same fully qualified name.
2. Taking into account all declared and inherited members, it compares all public and protected members of the same kind and same simple name, treating constructors as class members for convenience sake.

## 2.3 Source and Binary Compatibility Modes

Earlier Signature Test tool versions performed a comparison of all exceptions declared in throws clauses for methods and constructors. Certain variations in this area caused an error message during the signature test. Despite these error messages, the source files compiled successfully together. Successful compilation is the basic criteria for source compatibility with the current Signature Test tool, while successful linking as the basic criteria for binary compatibility.

Changes to the throws clause of methods or constructors do not break compatibility with existing binaries because these clauses are checked only at compile time, causing no linkage error. For the purpose of signature testing, this relates directly to binary compatibility as described earlier in [Section 2.2.1, "Mutual Binary Compatibility Check"](#).

The adaptation of JSR 68, *The Java ME Platform Specification*, formalized the use of building blocks in API development. A building block is a subset of an existing API that is approved for reuse in the construction of profiles or optional packages. The building block concept enables a developer to duplicate the functionality provided by another API without having to redefine an entirely new API. For further details see JSR 68 at <http://www.jcp.org/en/jsr/detail?id=68>.

The use of building blocks created a need for more lenient checking of exception throw lists compared to earlier Signature Test tool versions. Consequently, Signature Test tool 2.2 provides both a source and a binary compatibility mode of operation. This retains compatibility with earlier signature files while adding support for building blocks and eliminating the unnecessary error messages.

The `SignatureTest` command recognizes the `-mode` option that takes the values "src" or "bin" as arguments for choosing source mode or binary mode. The choice of which mode to use depends on the type of signature file being used in the test. This is described in more detail later in these sections:

- [Section 3.3, "Setup Command"](#) describes how to generate a signature file
- [Section 3.4, "SignatureTest Command"](#) describes how to specify the mode when running a signature test
- [Section 3.6, "Merge Command"](#) describes how to generate a combined signature file from set of signature files

The difference between the binary and source compatibility modes is how the tool handles the throws list for constructors and methods (as described in [Section 2.2.4, "Class and Class Member Attributes Checked"](#)). Constant checking behavior is also different in binary and source compatibility modes. Although constant checking can be applied to binary compatibility, it is a necessary prerequisite for source code compatibility. [Section 3.1.2, "Constant Checking in Differing Run Modes"](#) describes these differences in more detail.

## 2.4 Using Custom Signature Loaders

The signature test has a requirement for the Java Platform, Standard Edition (Java SE platform) runtime environment version 1.4 or later. This requirement might prevent use of the tool on limited or nonstandard environments such as some Java Platform, Micro Edition (Java ME platform) or Java Platform, Enterprise Edition (Java EE platform) configurations.

To overcome this, the tool provides support for custom signature loaders that can be implemented as plug-ins. These plug-ins gather signatures from a runtime environment when the `SignatureTest` command cannot be run directly. For example, you might create a light-weight remote JavaTest harness agent and run the signature loader on a remote Connected Device Configuration (CDC) compatible device. Another example is using a wrapped J2EE platform bean as a signature loader inside a J2EE platform container where any direct file I/O operations are prohibited.

As an aid in developing such an extension, the Signature Test tool distribution includes a class library that contains a signature serializer and some related utility classes in the *SigTest-Directory/lib/remote.jar* file. This file contains a subset of the Signature Test tool classes that are necessary to develop a custom plug-in. All of these library classes are CDC 1.0 compatible and have minimal memory requirements. The source code for these classes is distributed in the *SigTest-Directory/redistributables/sigtest\_src.zip* file. The code is designed for running a plug-in with the JavaTest harness using the Java ME Framework. The server and client source code and the HTML test descriptions for an actual plug-in example are located in the *SigTest-Directory/examples/remote* directory.

---

**Note:** The open source version of the ME Framework is available at:  
<http://cqme.dev.java.net/framework.html>.

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## Using the Signature Test Tool

This chapter provides a synopsis of each of the Signature Test tool commands along with their available options and arguments. It contains these sections:

- [Signature Test Tool Basics](#)
- [Setup Command](#)
- [SignatureTest Command](#)
- [SetupAndTest Command](#)
- [Merge Command](#)
- [Report Formats](#)

---

**Note:** [Appendix A](#) includes examples of each command.

---

### 3.1 Signature Test Tool Basics

The Signature Test tool operates from the command line to generate or manipulate signature files. A signature file is a text representation of the set of public and protected features provided by an API. Test suite developers include it in a finished test suite as a signature reference for comparison to the technology implementation under test. The following list shows the commands that are available.

- **Setup** - Creates a signature file from either an API defined by a specification or a reference API implementation.
- **SignatureTest** - Compares the reference API represented in the signature file to the API under test and produces a report. This is the test that becomes part of a finished test suite.
- **SetupAndTest** - Executes the **Setup** and **SignatureTest** commands in one operation.
- **Merge** - Creates a combined signature file from several signature files representing different Java APIs in one Java runtime environment according to the JSR 68 rules.

The Signature Test tool distribution includes a Java Archive (JAR) file used for developing a signature test and one for distribution within a finished test suite to run its signature test. The description of each follows:

- **sigtestdev.jar** - Contains classes for running the commands used during signature test development.
- **sigtest.jar** - Contains only the classes for running the **SignatureTest** command. This file is distributed in a finished test suite.

Test suite developers perform these operations while using `sigtestdev.jar` to develop a signature test.

1. Run the `Setup` command to create a signature file from either an API defined by a specification or a reference API implementation.
2. Include the files required to run the signature test in the finished test suite distribution.

### 3.1.1 Reflection and Static Run Modes

Two run modes are available during command execution. These modes determine how the class descriptions are examined and retrieved, as follows:

- **Reflection Mode** - Uses reflection to examine API classes and retrieve information about them. The reflection mode is of greatest advantage when the API to be analyzed has no external class files.
- **Static Mode** - Specified with the `-static` flag, the tool parses only the class files listed in the `-classpath` command-line option.

---

**Note:** In static mode you can test specified classes in another runtime environment. For example, this can be useful to analyze APIs that are part of a Java SE platform 1.4.2 environment when the `SignatureTest` command is run on a Java SE platform version 5.0.

---

### 3.1.2 Constant Checking in Differing Run Modes

The requirements related to constant checking differ in binary and source compatibility testing. Although constant checking can be applied to binary compatibility, it is a necessary prerequisite for source code compatibility. Use the `-static` mode to enforce strict constant checking in source code compatibility testing.

When running a signature test in source compatibility mode and using the static mode, constant checking is strict and two way. This means that all the constant fields specified in the reference API must exist and have the same values in the API under test. Likewise, all the constant fields and their related values specified in the API under test must exist and have the same values in the reference API.

In binary compatibility mode, the requirements related to constant checking are less strict. The signature test verifies that all the constant fields and associated values contained in the reference API are also available in the API under test. If any field values are missing or different, it reports an error. However, the signature test does not report an error if constant values are found in the API under test that are not available in the reference API.

### 3.1.3 Generics Checking in Binary Mode

The information related to generics is not used by the Java Virtual Machine<sup>1</sup> at runtime. This information is used only by the compiler at compile time. Because the information does not effect the runtime linkage process, it cannot cause binary incompatibility.

In binary mode the `SignatureTest` command compares the signatures of parameterized types after omitting the type parameters and arguments from both the signature file and the analyzed API (termed “type erasure”). This is to ensure that they

---

<sup>1</sup> The terms “Java Virtual Machine” and “JVM” mean a Virtual Machine for the Java platform

are compatible at runtime. See *The Java Language Specification, Third Edition*, for a detailed description of type erasure.

The bridge methods that are generated by the compiler during type erasure are not a part of the API and so they are ignored by the Signature Test tool.

### 3.1.4 CLASSPATH and -classpath Settings

**Table 3-1** lists the requirements for setting the CLASSPATH environment variable and the -classpath option when running either the `Setup` or `SignatureTest` commands. The table uses the following terms to describe the classes that must be included:

- **Required classes** - All superclasses and superinterfaces of the classes under test
- **Classes under test** - The set of classes specified by a combination of the following options:
  - package
  - PackageWithoutSubpackages
  - exclude

---

**Note:** The `Setup` command can only be run in static mode.

---

**Table 3-1 Settings for the `Setup` and `SignatureTest` Commands**

Variable or Option	In Reflection Mode	In Static Mode
CLASSPATH environment variable	Required. Must contain the following: <ul style="list-style-type: none"> <li>■ <code>sigtestdev.jar</code> or <code>sigtest.jar</code></li> <li>■ Classes under test</li> <li>■ Other required classes, except for bootstrap and extension classes described in <a href="#">Section 3.1.4.1, "Bootstrap and Extension Classes"</a></li> </ul>	Required. Must contain either <code>sigtestdev.jar</code> or <code>sigtest.jar</code> .
-classpath <i>argument</i>	N/A	Required. Must contain the following: <ul style="list-style-type: none"> <li>■ Classes under test</li> <li>■ All required classes</li> </ul>

#### 3.1.4.1 Bootstrap and Extension Classes

Bootstrap and extension classes are those located in `rt.jar` and several other JAR files under the `Java-Home/jre/lib/` directory, where `Java-Home` is the base directory of the Java platform runtime installation. For example, classes from the `java` package such as `java.lang.Object` are bootstrap classes. Their location is already available to the Java Virtual Machine environment. Because of this, they do not need to be specified in the CLASSPATH environment variable when reflection mode is used. Furthermore, bootstrap and extension classes are always loaded from JAR files located in the `Java-Home/jre/lib/` directory, regardless of whether they were specified in the class path or not. This is an important feature of the reflection mode.

## 3.2 Signature File Merge Rules

The `-Files` option of the `SignatureTest` command accepts values to specify one or more signature files that are combined to represent an API configuration that is used as input for testing. This resulting API-set can also be combined into a single signature file for testing purposes.

By default the API combination is assumed to be constructed according to the JSR 68 rules. This can be overridden during a Signature Test tool test run by specifying the `-NoMerge` option to run the signature test. The `-NoMerge` option forces the Signature Test tool to use the first class description it encounters if more than one class with the same name is found in the set of signature files specified by the `-Files` option. In this case it uses the class from the left-most signature file that is specified with `-Files`.

---

**Note:** The operative merging principles used by the Signature Test tool are described in [Appendix D](#).

---

### 3.2.1 JSR 68-Based Merge

The Java ME platform architecture specified by JSR 68<sup>1</sup> allows for the inclusion of several Java platform APIs in one conforming Java platform runtime environment. The condition for combining these APIs is that any application written for the resulting runtime environment must execute successfully on the combination.

If such a combination exists, it is defined on the basis of the combined sets of APIs with semantics, and the semantics must be compatible with those of all the included components.

The only means of verifying the semantics of the combination is to run the applicable test suite for each API. However, it is possible to automate the creation of a combined set of API signatures, and it is also possible to detect when a combined set cannot be built.

The `Merge` command functionality combines (merges) several input signature files into one resulting signature file, as follows: If A, B, and C are signature files, then A + B yields signature file C, and each of the three signature files represent the corresponding classes of their respective APIs. The `Merge` process constructs the resulting API C out of the two input APIs A and B.

## 3.3 Setup Command

The `Setup` command has the following synopsis:

```
java -jar sigtestdev.jar Setup [options]
```

or

```
java com.sun.tdk.signaturetest.Setup [options]
```

[Table 3-2](#) describes the available command options and the values that they accept. Before running the command, also see these sections: [Section 3.3.2, "Case Sensitivity of Option Arguments"](#) and [Section 3.1.4, "CLASSPATH and -classpath Settings"](#).

---

<sup>1</sup> <http://jcp.org/en/jsr/detail?id=68>

### 3.3.1 Command Description

The Setup command accepts a reference implementation of an API as input. The command processes the API input to generate a signature file that represents the API to be used as a reference of comparison for the purpose of signature testing.

Setup processes the API input in the static mode by parsing the set of classes specified with the `-classpath` options.

Also see [Appendix A](#) for an example of the command that you can run.

---

**Note:** Arguments to options marked with an asterisk (\*) in [Table 3–2](#) can be specified multiple times. For example, if you want to specify filtering for the `java.awt`, `java.lang`, and `java.math` packages, you can specify the three arguments separated by a file separator character as shown in the following example: `-Package java.awt:java.lang:java.math` On Unix operating systems the separator character is ":" and on Microsoft Windows it is ";".

---

**Table 3–2** Setup **Command Options**

Option	Description
<code>-help</code>	Optional. Displays usage information for available command options and exits.
<code>-debug</code>	Optional. Enables printing of the stack trace for debugging purposes if Setup fails.
<code>-classpath path</code>	Required. Specifies the path to one or more APIs that generate the signature file. Can contain multiple directories or ZIP or JAR files. The <code>-package</code> option further refines the set of classes specified in <code>-classpath</code> (see <a href="#">Section 3.1.4, "CLASSPATH and -classpath Settings"</a> ). There is no default <code>-classpath</code> . Use the path separator appropriate for the platform (identified by <code>java.io.File.pathSeparator</code> ).
<code>-TestURL path</code>	Optional. Specifies the directory location in which to create the signature file as a file protocol URL: <code>file://path</code> Must end in a trailing slash on a UNIX system or a backslash on a Microsoft Windows or DOS system. Setup does not support the HTTP protocol.
<code>-FileName file_name</code>	Required. Specifies the name of the signature file to be created.
<code>-ClosedFile</code>	Optional. The default if not specified. Specifies to include in the signature file all direct and indirect superclasses for all required classes (tested classes), even if these superclasses are non-public or from untested packages.
<code>-NonClosedFile</code>	Optional. Declines the default <code>-ClosedFile</code> mode previously described. Does not include all direct and indirect superclasses and superinterfaces of tested classes in the signature file

**Table 3–2 (Cont.) Setup Command Options**

Option	Description
<code>-package package_or_class_name*</code>	Optional. Specifies a class or package to be included in the signature file, including its subpackages if a package is specified. The <code>-package</code> value acts as a filter on the set of classes specified in <code>-classpath</code> . The default is all classes. Repeat the option to specify multiple entries.
<code>-PackageWithoutSubpackages package*</code>	Optional. Similar to the <code>-package</code> option, this specifies a package to be included but without its subpackages. Repeat the option to specify multiple entries.
<code>-exclude package_or_class_name*</code>	Optional. Specifies a package or class to be excluded from the signature file, including its subpackages. Repeat the option for multiple entries. Excludes duplicate entries specified by the <code>-package</code> or the <code>-PackageWithoutSubpackages</code> option.
<code>-verbose</code>	Optional. Enables error diagnostics for inherited class members.
<code>-version</code>	Optional. Displays version information.
<code>-apiVersion version_string</code>	Optional. Specifies the API version string to be recorded in the second line of the signature file, as described in <a href="#">Section 3.3.4, "Signature File Contents"</a> .
<code>-CopyRight copyright_string</code>	Optional. Writes the specified copyright string to the signature file.
<code>-static</code>	Deprecated. The <code>Setup</code> command now runs only in static mode.

### 3.3.2 Case Sensitivity of Option Arguments

The specification of each argument option at the command line is not case sensitive, but the input value entered immediately after the option is case sensitive.

The following two command lines produce identical results for the `-FileName` flag:

```
% java -jar sigtestdev.jar Setup -FileName name.sig
% java -jar sigtestdev.jar Setup -filename name.sig
```

However, these two might not produce identical results if the host operating system is case sensitive to the file name values entered:

```
% java -jar sigtestdev.jar Setup -FileName name.sig
% java -jar sigtestdev.jar Setup -FileName NAME.sig
```

### 3.3.3 Signature File Formats

The Signature Test tool has changed signature file formats through progressive versions. [Table 3–3](#) lists the existing signature file formats and describes how each relates to a specific Signature Test tool version. In Signature Test tool 2.2, the `SignatureTest` and `Merge` commands read v2.1 and later signature files, and output only v4.1.

**Table 3–3 Signature File Format Compatibility**

Format	Description
v0	Generates a signature file with simple class member names. This was the default format in Signature Test tool 1.0, but is not supported by <code>SignatureTest</code> command in Signature Test tool 1.3 and later.
v1	Generates a signature file with fully qualified class member names. This was the default format in Signature Test tool 1.1. This format includes <i>non-normalized</i> exception throw lists for constructors and methods. Normalizing the throw list involves removing all superfluous exception classes. A class is superfluous if it is a subclass of either the <code>java.lang.RuntimeException</code> class, or the <code>java.lang.Error</code> class, or another class from the same list. This format is not supported by <code>SignatureTest</code> command in Signature Test tool 1.3 and later.
v2	This is the default format for Signature Test tool 1.2. Generates a signature file with fully qualified class member names and modified <code>supr</code> statements. This format includes <i>normalized</i> exception throw lists for constructors and methods. This format is not supported by <code>SignatureTest</code> command in Signature Test tool 1.3 and later.
v2.1	This version extends the v2 format to indicate whether an interface is inherited directly or indirectly. It is read by <code>SignatureTest</code> command in Signature Test tool 1.3 and later.
v3.1	Generates data for JDK™ software version 5.0 such as generics, annotations, and enums.
v4.0	Inherited members are not written to the signature file. Private and default visibility fields and nested classes that can potentially hide visible API elements are tracked. In Signature Test tool 2.2, all output files are of this version.
v4.1	Non-static constants are written to the signature file. References to outer classes are stored for the inner classes. Constructor names are changed to <code>&lt;init&gt;</code> . This has been the case since SigTest 2.2.

Also see [Section 2.3, "Source and Binary Compatibility Modes"](#).

### 3.3.4 Signature File Contents

Setup generates each signature file with a mandatory header in the first two lines, followed by the body of the signature file.

---

**Note:** Comment lines start with the pound (#) character and can be inserted anywhere after the first two mandatory header lines.

---

#### 3.3.4.1 Signature File Header

Setup generates the first two mandatory header lines of each signature file as follows:

```
#Signature file format
#Version version-string
```

With the following variable replacement values:

- *format* is either one of the values described in [Table 3–3](#), or empty, that indicates v0.
- *version-string* is a value taken directly from the argument given at the startup command line to the `-apiVersion` option (see [Table 3–2](#)).

Note that the header can also contain an optional copyright string.

### 3.3.4.2 Signature File Body

The remaining body of a signature file immediately follows the header. It contains the following information, which is further clarified in [Table 3-4](#):

- For each `public` or `protected` class:
  - All modifiers except `strictfp`
  - The fully qualified name of any superclass or interfaces implemented
  - Generic type parameters, and annotations.
- For each `public` or `protected` interface:
  - All modifiers except `strictfp`
  - The fully qualified name of any superinterfaces implemented,
  - Generic type parameters
  - Annotations
- For each `public` or `protected` field:
  - All modifiers except `transient`
  - The fully qualified name of the field's type and its fully qualified name
  - If the field is a primitive or string constant, the value of the field is included
- For each `public` or `protected` method:
  - All modifiers (except `native`, `synchronized`, and `strictfp`)
  - The fully qualified name of the type of returned value, the method's fully qualified name
  - Types of all parameters
  - The names of exceptions declared in a `throws` clause
- For each `public` or `protected` constructor:
  - All modifiers
  - The fully qualified name of the constructor
  - Types of all parameters
  - Any exceptions declared in a `throws` clause

---

**Note:** All `private` types that are used in the definition of a `public` or `protected` item are substituted by their `public` or `protected` equivalent if possible, otherwise an error is generated. All types included in a signature file are either `public` or `protected` and not `private` or `package local`.

---

[Table 3-4](#) further summarizes the contents of a generated signature file. A plus (+) indicates a class modifier is included in a generated signature file and a minus (-) indicates it is ignored for that particular element. A blank cell indicates that the condition does not apply to a cell, for example, a class does not have a `transient` modifier so it is blank.

**Table 3–4 Signature File Content Summary**

Modifier	Class or Interface	Field	Method	Constructor	Nested Class or Interface
public	+	+	+	+	+
protected		+	+	+	+
abstract	+		+		+
static		+	+		+
final	+	+	+		+
strictfp	-		-		-
transient		-			
volatile		+			
synchronized			-		
native			-		

## 3.4 SignatureTest Command

The SignatureTest command has the following synopsis:

`java -jar sigtest.jar Test [options]`

or

`java com.sun.tdk.signaturetest.SignatureTest [options]`

The second alternative assumes that `sigtest.jar` is on the class path. The rules described in [Section 3.3.2, "Case Sensitivity of Option Arguments"](#) apply. [Table 3–5](#) lists the available options.

---

**Note:** SignatureTest command settings for the CLASSPATH environment variable and the `-classpath` option are the same as those listed for the Setup command in [Table 3–1](#).

---

### 3.4.1 Command Description

The SignatureTest command compares the reference API represented in a signature file to the API under test and produces a report. Depending on the command-line options specified, it uses either the reflection or static mode. If the `-classpath` option is specified, the SignatureTest command checks if any extra classes are contained in the APIs it specifies.

See [Section 3.3.3, "Signature File Formats"](#) for details about supported versions of signature file formats.

---

**Note:** Arguments to options marked with an asterisk (\*) in [Table 3–5](#) can be specified multiple times. For example, if you want to specify filtering for the `java.awt`, `java.lang`, and `java.math` packages, you can specify the three arguments separated by a file separator character as shown in the following example: `--Package java.awt:java.lang:java.math` On Unix operating systems the separator character is ":" and on Microsoft Windows it is ";".

---

**Table 3-5** SignatureTest **Command Options**

Option	Description
<code>-help</code>	Optional. Displays usage information for available command options and exits.
<code>-debug</code>	Optional. Enables printing of the stack trace for debugging purposes if SignatureTest fails.
<code>-static</code>	Optional. Specifies to run in static mode without using reflection and reports on only the class files specified in the <code>-classpath</code> option.
<code>-mode [bin   src]</code>	Optional. Specifies the compatibility mode to use during the signature test, either binary or source, respectively. Defaults to <code>src</code> . <a href="#">Section 2.3, "Source and Binary Compatibility Modes"</a> describes each mode.
<code>-CheckValue</code>	Specifies to check the values of primitive and string constants. This option generates an error if a signature file does not contain the data necessary for constant checking.
<code>-NoCheckValue</code>	Specifies not to check the values of primitive and string constants.
<code>-ClassCacheSize <i>size_of_cache</i></code>	Optional. Used in static mode only. Default is 1024. Specifies the size of the class cache as a number of classes to be held in memory to reduce execution time. Increasing this value dedicates more memory to this function.
<code>-classpath <i>path</i></code>	Optional. Specifies the path to one or more APIs to be tested. Defaults to the classes contained in the signature file under test. Can contain multiple directories or ZIP or JAR files. The <code>-package</code> option filters the set of classes specified in <code>-classpath</code> (see <a href="#">Section 3.1.4, "CLASSPATH and -classpath Settings"</a> ). Uses the path separator appropriate for the platform (identified by <code>java.io.File.pathSeparator</code> ).
<code>-TestURL <i>URL</i></code>	Optional. Specifies the directory location of the signature file as a <code>file</code> protocol URL: <code>file://path</code> Must end in a trailing forward slash on a UNIX system or a backslash on a Microsoft Windows or DOS system.
<code>-FileName <i>file_name</i></code>	Required if <code>-Files</code> is not specified. Specifies the name of a signature file to be used.
<code>-Files <i>file_names</i></code>	Required if <code>-FileName</code> is not specified. Use this option for testing a combination of APIs represented by corresponding signature files. Specifies the names of the signature files to be used delimited by a file separator. The file separator on UNIX systems is a colon (:) character, and on Microsoft Windows systems it is a semicolon (;). See <a href="#">Section 3.2, "Signature File Merge Rules"</a> for details about the rules used for merging.

**Table 3–5 (Cont.)** SignatureTest **Command Options**

Option	Description
<code>-NoMerge</code>	Optional. Forces using the first encountered class description if more than one class with the same name is found in the input set of signature files specified by <code>-Files</code> option. In this case it uses the class from the left-most signature file that is specified with <code>-Files</code> . This option prevents the test from using the default merging behavior according to the JSR 68 rules. See <a href="#">Section 3.2, "Signature File Merge Rules"</a> for details about the rules used for merging.
<code>-Package package_or_class_name*</code>	Optional. Specifies a class or package to be reported on, including its subpackages if a package is specified. The default is all classes and packages in the signature file. This option acts as a filter on the set of classes or packages optionally specified in <code>-classpath</code> . Repeat the option to specify multiple entries.
<code>-PackageWithoutSubpackages package*</code>	Optional. Similar to the <code>-package</code> option, specifies a package to be reported on without its subpackages. Repeat the option to specify multiple entries.
<code>-Exclude package_or_class_name*</code>	Optional. A package or class to be excluded from the report, including its subpackages. Repeat the option for multiple entries. Excludes duplicate entries specified by the <code>-package</code> or the <code>-PackageWithoutSubpackages</code> option.
<code>-out file_name</code>	Optional. Prints report messages to a specified file instead of standard output.
<code>-FormatPlain</code>	Optional. Specifies not to sort report messages, but output them immediately. Allows a decrease in memory consumption compared to the default sorted format of message reporting.
<code>-FormatHuman</code>	Optional. Specifies the human-readable report output format. Simple API changes are presented not as pair of errors ("missing element" and "added element"), but as a single API change.
<code>-H</code>	
<code>-Backward</code>	Optional. Specifies migration compatibility check mode.
<code>-B</code>	
<code>-apiVersion version_string</code>	Optional. Specifies the API version number of the implementation under test to be recorded in the report.
<code>-verbose</code>	Optional. Prints all error messages for inherited class members. Default is to remove all these error messages.
<code>-version</code>	Optional. Displays version information.
<code>-ErrorAll</code>	Optional. Specifies to make the signature test more strict by upgrading certain warnings to errors.
<code>-Update file_name</code>	Optional. Specifies the name of an update file. See <a href="#">Section 3.4.2, "Using Update Files"</a> .

### 3.4.2 Using Update Files

An update file is an XML file that contains API changes that can be applied to a signature file before tests are performed. An update can have an ID and corresponding comments. [Example 3-1](#) shows an example of an update file that removes and adds a class before test execution.

#### **Example 3-1 Update File Example**

```
<updateset>
    <update type="removeclass" id="Change #12" comments="Fixing bug #1234"
            classname="com.acme.Elefant" />
    <update type="addclass" id="Change #13" commens="Approved by the committee"
            classname="com.acme.Tiger"
            CLSS public com.acme.Tier">
        cons public Tiger()
        cons public Tiger(java.lang.String)
        supr java.lang.Object
    </update>
</updateset>
```

The XML file is enclosed within the `<updateset>` element and each change is specified in an `<update>` element. Each `<change>` element consists of a type and a set of attributes. The types and their attributes are described in [Table 3-6](#).

**Table 3-6 Update Types and Attributes**

Update Types	Description
removeclass	<p>Removes a class.</p> <p>Required attributes:</p> <ul style="list-style-type: none"> <li>■ classname - the name of the class to remove</li> </ul> <p>Optional attributes:</p> <ul style="list-style-type: none"> <li>■ id - change ID</li> <li>■ comments - a comment that describes the change</li> </ul> <p>Example:</p> <pre>&lt;update type="removeclass" classname="com.acme.Zoo"         id="Issue #1717" comments="Bug fixing" /&gt;</pre>
removepackage	<p>Removes all classes belonging to a specified package.</p> <p>Required attributes:</p> <ul style="list-style-type: none"> <li>■ packagename - the name of the package to remove</li> </ul> <p>Optional attributes:</p> <ul style="list-style-type: none"> <li>■ id - change ID</li> <li>■ comments - a comment that describes the change</li> </ul> <p>Example:</p> <pre>&lt;update type="removepackage"         packagename="com.acme.animals" id="CR 4657"         comments="Removing incorrectly introduced package,         approved" /&gt;</pre>

**Table 3–6 (Cont.) Update Types and Attributes**

Update Types	Description
addclass	<p>Adds a class.</p> <p>Required attributes:</p> <ul style="list-style-type: none"> <li>▪ classname - the name of the class to remove</li> <li>▪ Definition of the new class in the element body</li> </ul> <p>Optional attributes:</p> <ul style="list-style-type: none"> <li>▪ id - change ID</li> <li>▪ comments - a comment that describes the change</li> </ul> <p>Example:</p> <pre>&lt;update type="addclass" classname="com.acme.zoo.Rabbit"&gt; CLSS public com.acme.zoo.Rabbit cons public com.acme.zoo.Rabbit() cons public com.acme.zoo.Rabbit(java.lang.String) supr com.acme.zoo.Animal &lt;/update&gt;</pre>
removemember	<p>Removes a class member.</p> <p>Required attributes:</p> <ul style="list-style-type: none"> <li>▪ classname - the name of the class to change</li> <li>▪ member - the name of the member signature to remove</li> </ul> <p>Optional attributes:</p> <ul style="list-style-type: none"> <li>▪ id - change ID</li> <li>▪ comments - a comment that describes the change</li> </ul> <p>Example:</p> <pre>&lt;update type="removemember" classname="com.acme.zoo.donkey" member="meth public final com.acme.Tail getTail()"/&gt;</pre>
addmember	<p>Adds a class member.</p> <p>Required attributes:</p> <ul style="list-style-type: none"> <li>▪ classname - the name of the class to change</li> <li>▪ member - the member signature add</li> </ul> <p>Optional attributes:</p> <ul style="list-style-type: none"> <li>▪ id - change ID</li> <li>▪ comments - a comment that describes the change</li> </ul> <p>Example:</p> <pre>&lt;update type="addmember" classname="com.acme.zoo.donkey" comments="See wiki for details" member="meth public com.acme.Ear[] getEars()"/&gt;</pre>

**Table 3–6 (Cont.) Update Types and Attributes**

Update Types	Description
changemember	<p>Changes a class member</p> <p>Required attributes:</p> <ul style="list-style-type: none"> <li>■ classname - the name of the class to change</li> <li>■ member - the member signature to change</li> <li>■ newmember -the new member signature</li> </ul> <p>Optional attributes:</p> <ul style="list-style-type: none"> <li>■ id - change ID</li> <li>■ comments - a comment that describes the change</li> </ul> <p>Example:</p> <pre>&lt;update type="changemember" classname="com.acme.zoo.donkey" member="meth public Ear[] getEars()" newmember="meth public java.util.List&lt;com.acme.Ear&gt; getEars()"/&gt;</pre>

### 3.4.3 Report Formats

You can cause SignatureTest command report messages to be sorted (default), or unsorted by specifying the `-FormatPlain` flag at the command line. See Step 8 of the procedure [Section A.2.2, "Using the SetupAndTest Command"](#) to see a sorted report that was generated into a plain text file with the `-out` option. Report messages contain the following types of information:

- The versions of both the reference API and the API under test
- The total number of errors found
- The differences such as added or missing classes, superclasses, fields, or methods
- The fully qualified name of the enclosing class related to any missing or added description
- Two errors for any modified item, one for a missing item and another for an added item
- A description of any incompatibility in the API implementation under test

#### 3.4.3.1 Sorted Report

Report messages are sorted by default. Unlike the unsorted format, duplicate messages are removed. To accurately compare the error totals between formats, the sorted report prints two error counts: the total number of errors and the total number of duplicates.

The sorted report groups error messages by category of difference with classes within each category ordered alphabetically by name, and empty categories are ignored. This is the category ordering sequence:

- Missing Classes
- Missing Class Descriptions (Modified classes and nested classes)
- Missing Superclasses or Superinterfaces
- Missing Fields
- Missing Constructors

- Missing Methods
- Added Classes
- Added Class Descriptions (Modified classes and nested classes)
- Added Superclasses or Superinterfaces
- Added Fields
- Added Constructors
- Added Methods
- Linkage Errors

Linkage errors occur during testing if the API implementation under test is corrupted, for example, if a superclass or superinterface of a class under test cannot be loaded.

See the sorted report in [Example A-4](#).

### 3.4.3.2 Unsorted Report

The `-FormatPlain` option specifies an unsorted report. The unsorted format reports messages immediately during execution and duplicate messages are included.

[Example 3-2](#) shows an unsorted report that corresponds to the sorted report in [Example A-4](#).

#### ***Example 3-2 Unsorted Report Example***

```
Definition required but not found in example.test
    method public int get(int)
Definition found but not permitted in example.test
    method public java.lang.String get(int)
Definition found but not permitted in example.test
    method public void put()
SignatureTest report
Tested version: 2.0
STATUS: Failed. 3 errors
```

### 3.4.3.3 Human-Readable Report

The human-readable report format is similar to the sorted report format. Unlike the sorted report format where some changes in the API are presented as pairs of messages (“added element” and “missed element”), the human-readable report format presents these changes as a single message that describes the difference between the APIs. This report recognizes the following cases:

- Modifiers were changed
- Return type was changed
- Parameter types were changed
- Normalized throw list was changed
- Constant value was changed
- Annotation was changed

Unlike the sorted report format, all messages are grouped by class first, rather than message type. The code example below shows the output for an class:

```
Class tests.human.many.E1
    Changed
        method public abstract void tests.human.many.E1.foo() throws
```

```
java.io.IOException
  - Throws: [java.io.IOException]
    method public abstract void tests.human.many.E1.foo() throws
java.io.IOException
  - [public, abstract]
  + [protected]
    field public final static int tests.human.many.E1.i = 0
    - type: int
    + type: char
    field public final static int tests.human.many.E1.i = 0
    - value: 0
```

## 3.5 SetupAndTest Command

The SetupAndTest command has the following synopsis:

```
java -jar sigtestdev.jar SetupAndTest [options]
```

or

```
java com.sun.tdk.signaturetest.SetupAndTest [options]
```

The second alternative assumes that `sigtestdev.jar` is on the class path. The rules described in [Section 3.3.2, "Case Sensitivity of Option Arguments"](#) apply. [Table 3-7](#) lists the available options.

### 3.5.1 Command Description

`SetupAndTest` is a wrapper command that runs only in static mode to execute the `Setup` and `SignatureTest` commands in one operation. It performs these functions:

1. Calls the `Setup` command to create a signature file from the reference API specified as input. It creates a temporary signature file if no name is specified for it with the `-FileName` option.
2. Calls the `SignatureTest` command to make the comparison and produce a report.

---

**Note:** Arguments to options marked with an asterisk in [Table 3-7](#) can be specified multiple times. For example, if you want to specify filtering for the `java.awt`, `java.lang`, and `java.math` packages, you can specify the three arguments separated by a file separator character as shown in the following example:-Package `java.awt:java.lang:java.math` On Unix operating systems the separator character is ":" and on Microsoft Windows it is ";".

---

**Table 3-7** *SetupAndTest Command Options*

XXX Must have a Heading Row	XXX
<code>-help</code>	Optional. Displays usage information for available command options and exits.
<code>-reference path</code>	Required. Specifies the path to the classes to be used for creating the signature file.
<code>-test path</code>	Required. Path to the packages being tested.
<code>-FileName file</code>	Optional. Specifies the signature file name. The command execution uses a temporary file if not specified.

**Table 3-7 (Cont.)** SetupAndTest **Command Options**

XXX Must have a Heading Row	XXX
<code>-mode [bin   src]</code>	Optional. Specifies the compatibility mode to use during the signature test, either binary or source, respectively. Defaults to <code>src</code> . <a href="#">Section 2.3, "Source and Binary Compatibility Modes"</a> describes each mode.
<code>-package package_or_class_name*</code>	Optional. Specifies a class or package to be reported on, including its subpackages if a package is specified. This option acts as a filter on the set of classes or packages that are tested and reported on. The default is all classes and packages. Repeat the option to specify multiple entries.
<code>-PackageWithoutSubpackages name*</code>	Optional. Specifies package to be tested excluding subpackages.
<code>-exclude name*</code>	Optional. A package or class to be excluded from testing, including its subpackages. Repeat the option for multiple entries. Excludes duplicate entries specified by the <code>-package</code> or the <code>-PackageWithoutSubpackages</code> option.
<code>-ClassCacheSize size_of_cache</code>	Optional. Specifies the size of the class cache as a number of classes to be held in memory to reduce execution time. Increasing this value dedicates more memory to this function. Defaults to 100.
<code>-CheckValue</code>	Optional. Specifies to check the values of primitive and string constants. This option generates an error if a signature file does not contain the data necessary for constant checking.
<code>-NoCheckValue</code>	Optional. Specifies not to check the values of primitive and string constants.
<code>-verbose</code>	Optional. Enables error diagnostics for inherited class members.
<code>-version</code>	Optional. Displays version information.
<code>-apiVersion version_string</code>	Optional. Specifies the API version number of the implementation under test to be recorded in the generated report.
<code>-out file_name</code>	Optional. Prints report messages to a specified file instead of standard output.
<code>-FormatPlain</code>	Optional. Specifies not to sort report messages, but output them immediately. Allows a decrease in memory consumption compared to the default sorted format of message reporting.
<code>-FormatHuman</code> <code>-H</code>	Optional. Specifies the human-readable report output format. Simple API changes are presented not as pair of errors ("missing element" and "added element"), but as a single API change.
<code>-Backward</code> <code>-B</code>	Optional. Specifies migration compatibility check mode.

## 3.6 Merge Command

The Merge command has the following synopsis:

```
java -jar sigtest.jar Merge [options]
```

or

```
java com.sun.tdk.signaturetest.Merge [options]
```

The second alternative assumes that `sigtest.jar` is on the class path. The rules described in [Section 3.3.2, "Case Sensitivity of Option Arguments"](#) apply. [Table 3-8](#) lists the available options.

### 3.6.1 Command Description

The Merge command combines (merges) a number of input signature files into one resulting signature file. See [Section 3.2, "Signature File Merge Rules"](#) for details about the rules used for merging, and [Section 3.3.3, "Signature File Formats"](#) for details about supported versions of signature file formats. [Table 3-8](#) lists the `Merge` command options.

**Table 3-8** Merge *Command Options*

Option	Description
<code>-help</code>	Optional. Displays usage information for available command options and exits.
<code>-Files</code>	Required. Specifies the names of the signature files to be merged delimited by a file separator. The file separator on UNIX systems is a colon (:) character, and on Microsoft Windows systems it is a semicolon (;). See <a href="#">Section 3.2, "Signature File Merge Rules"</a> for details about the rules used for merging.
<code>-Write</code>	Required. Specifies the resulting output signature file.
<code>-Binary</code>	Optional. Specifies to use the binary merge mode. See <a href="#">Section 2.3, "Source and Binary Compatibility Modes"</a> .

# Part II

---

## API Coverage Tool

Describes how you can use the API Coverage tool to estimate the test coverage a test suite provides for an implementation of a specified API. It does this by determining how many public class members the test suite references within the API specification. The tool uses a signature file representation of the API specification as the source of specification analysis. It does not process a formal specification in any form.

This part includes the following chapters:

- [Chapter 4, "Introduction to API Coverage Tool"](#)
- [Chapter 5, "Using the API Coverage Tool"](#)



---

## Introduction to API Coverage Tool

The API Coverage tool is used to estimate the test coverage that a test suite under development affords to implementations of its related API specification. It does this by determining how many public class members the test suite references within the API specification that it is designed to test against. The tool uses a signature file representation of the API specification as the source of specification analysis. It does not process a formal specification in any form.

The API Coverage tool code is contained in both the `sigtestdev.jar` and `sigtest.jar` files. Additional installation is not required. See [Chapter 5](#) for details about running API Coverage tool.

### 4.1 Static API Coverage Analysis

The tool operates on the principle that a reference to an API member from within a test class indicates a test of that member by the test suite. The ratio of referenced class members to the total number of class members calculated for an API yields a percentage of test coverage for the API.

This method is called *static* API coverage analysis because it does not actually run any tests from the test suite. Since it does not dynamically determine which API members are actually accessed by the tests, the coverage calculation expresses only an estimated percentage of test coverage.

#### 4.1.1 Major Source of Error

Static analysis cannot correctly predict the outcome of virtual calls to overridden methods that are resolved at runtime through dynamic method dispatch. The frequency of this type of overridden method can vary between differing implementations of the same API specification. This makes it difficult to formulate an exact percentage of test suite coverage when using static analysis (in spite of the fact that the implementations may all be binary compatible and correctly implement the specification).

Tests that make dynamic calls to API members are not recognized by API Coverage tool. This may cause some test calls to not be accurately measured and may result in test coverage being underreported.

#### 4.1.2 Advantages of Static Coverage Analysis

Static API coverage testing provides the following advantages over dynamic coverage methods.

- Static testing is more lightweight. Testing is easier to setup and quicker to run than dynamic methods.
- Static testing is easier to automate and provides more consistent results because it is not affected by external conditions such as machine load, or network traffic.
- Static testing is more practical for gathering results for very large APIs. A test suite and its associated API might include many thousands of tests and associated API class members making it very cumbersome to instrument dynamic tests.
- Static testing allows you to quickly *estimate* the quality of test coverage for all APIs, especially APIs that are difficult to test dynamically.

## 4.2 How It Works

The static API coverage algorithms examine precompiled test suite test classes to determine the members that they reference. This includes inner classes and fields as well as constructors, although constructors cannot be inherited.

The algorithms are based on the fact that the constant pool of any class file holds all of its external class references. This constant pool consists of the following related records:

```
CONSTANT_Fieldref
CONSTANT_Methodref
CONSTANT_InterfaceMethodref
```

Each of these records contains the fully qualified name of an external class and the name of the class member referenced. For a method, this includes the signature of the method and its return type.

### 4.2.1 Level of Accuracy During Analysis

[Table 4-1](#) lists example scenarios encountered during static coverage analysis and their related potential for error. The table references the following objects:

- $Q.m$  is a method referenced by the test suite.  
Where  $Q$  is the fully qualified class name, and  $m$  is the descriptor of the called method (including the name, list of arguments, and return type).
- $SubQ$  is a subclass of, and  $SupQ$  is a superclass of class  $Q$ .

$x$  is an object on the stack referenced by either the `invokevirtual` or `invokeinterface` instruction.

The main potential for an inaccurate coverage measurement exists when a great many members are overridden in subclasses of an implementation (as described in condition #2 of [Table 4-1](#)).

**Table 4-1 Example Scenarios and Potential Errors**

Condition	Scenario	Result
#1: Object $x$ is of type $Q$	Class $Q$ declares method $m$ and $Q.m$ is the method called	$Q.m$ is correctly marked as covered
	Method $m$ is inherited from superclass $SupQ$ and is not declared in $Q$ ; method $SupQ.m$ is called	Correctly marks either $Q.m$ or $SupQ.m$ as covered, depending on the calculation mode in use (described later in <a href="#">Section 4.2.2, "Coverage Analysis Modes"</a> )

**Table 4-1 (Cont.) Example Scenarios and Potential Errors**

Condition	Scenario	Result
#2: Object x is of type SubQ, a subclass of Q	No subclass or superclass of Q overrides method m; Q.m is called  A subclass of Q <i>does</i> override method m and the overriding method is called; if there are multiple inherited subclasses, exactly which method is called cannot be correctly identified before runtime	Correctly marks Q.m as covered  Q.m is incorrectly marked as covered; this scenario is the main source of analysis errors
#3: A method is called by means of reflection	Uses: Method.invoke(Object, Object[])	No method is marked as covered, assuming that java.lang.reflect is not in the API under test; this case cannot be correctly resolved

## 4.2.2 Coverage Analysis Modes

The API Coverage tool uses these two modes of analysis:

- **Real World Mode:** Returns a fairly accurate estimate based on input from one specific API implementation, such as a reference implementation. You can then compare the real world results to those of the worst case mode.
- **Worst Case Mode:** Returns an estimate based on a hypothetical API in which every class overrides or hides all members from its superclass. This scenario is highly unlikely to occur in actual practice. You use this mode by extrapolating its results into those of the real world case to estimate the possible range in test coverage that a test suite will provide in the field over a number of differing implementations.

[Chapter 5](#) describes how to set up and use the API Coverage tool.

## 4.2.3 Filtering Coverage By Marking Up Signature Files

Typically, API Coverage tool measures coverage for an entire API or package(s). However, in some use cases it is convenient to track the coverage of a particular feature that spreads throughout multiple packages and classes.

For example, you might want to track a new feature that adds a few methods or fields to preexisting classes, or you might want to track a feature that adds an extra interface implemented by a preexisting class. You will want to know which of those newly added methods are tested.

The way to get this information is to mark up a signature file with directives that indicate which API members belong to the feature that you want reported in the API Coverage tool report. A fragment of a signature file with filtering directives (in bold) is shown in [Example 4-1](#).

### Example 4-1 Signature File Mark-Up

```
#APICover file v4.1

CLSS public final java.awt.SplashScreen
meth public boolean isVisible()
#coverage on
meth public java.awt.Dimension getSize()
meth public java.awt.Graphics2D createGraphics()
```

```
#coverage off
meth public java.awt.Rectangle getBounds()
meth public java.net.URL getImageURL()
meth public static java.awt.SplashScreen getSplashScreen()
meth public void close()
meth public void setImageURL(java.net.URL) throws java.io.IOException
meth public void update()
supr java.lang.Object
hdfs image,imageURL,log,splashPtr,theInstance,wasClosed
```

#### 4.2.3.1 Filtering Markup Format

The following steps describe how to mark up a signature file to designate classes and members you want to track.

1. Copy the signature file.
2. In a text editor, change the first line of the copy of the signature file from `#Signature file v4.1` to `#APICover file v4.1`.
3. Use the `#coverage on` and `#coverage off` directives to mark the classes and members.

Classes or members between the `#coverage on` and `#coverage off` directives are tracked during coverage calculation. All the other classes and members are excluded.

---

## Using the API Coverage Tool

API Coverage tool requires these environmental settings and components:

- A properly configured certified Java Platform, Standard Edition (“Java SE platform”) runtime version 1.4 or later
- One of the following JAR files in your class path:
  - sigtestdev.jar
  - sigtest.jar

The API Coverage tool `Main` class is contained in both JAR files.

The API Coverage tool is a command-line utility that executes in a Java application environment. It generates static API test coverage reports in either plain text or XML format based on the following two input items:

- The test suite being tested for its coverage, represented by a set of test class files
- A signature file that forms a text representation of the public members of an API that must be tested by the test suite

You can use the `Setup` command of the Signature Test tool to create the appropriate signature file for use by the API Coverage tool. The `Setup` command is described in [Chapter 3](#).

### 5.1 Running API Coverage Tool

API Coverage tool command synopsis:

```
% java -jar apicover.jar [options]  
or  
% java com.sun.tdk.apicover.Main [options]
```

The second alternative assumes that `apicover.jar` is on the class path. The rules described in [Section 3.3.2, "Case Sensitivity of Option Arguments"](#) apply. [Table 5-1](#) lists the available options.

---

**Note:** Arguments to options marked with an asterisk (\*) in [Table 5-1](#) can be specified multiple times. For example, if you want to specify filtering for the `java.awt`, `java.lang`, and `java.math` packages, you can specify the three arguments separated by a file separator character as shown in the following example: `-tsInclude java.awt:java.lang:java.math` On Unix operating systems the separator character is ":" and on Microsoft Windows it is ";".

---

**Table 5–1 API Coverage Tool Command Options**

Options	Description
<code>-help</code>	Optional. Displays usage information for available command options and exits.
<code>-ts path</code>	Required. Cannot be repeated. Path to the test suite classes to be analyzed. Also accepts a JAR file.
<code>-tsInclude package_name*</code>	Optional. Can be repeated. Recursively include classes from the specified test suite package.
<code>-tsIncludeW package_name*</code>	Optional. Can be repeated. Include classes from the specified test suite package without subpackages.
<code>-tsExclude package_name*</code>	Optional. Can be repeated. Recursively exclude classes from the specified test suite package.
<code>-excludeList filename</code>	Optional. Can be repeated. Specifies the file name of an exclude list which contains API elements to be excluded from the coverage calculation. <a href="#">Section 5.1.2, "Exclude List"</a> describes the exclude list format.
<code>-excludeInterfaces</code>	Optional. Exclude all interface classes. This option is superfluous if used with <code>-excludeAbstractClasses</code> .
<code>-excludeAbstractClasses</code>	Optional. Exclude all abstract classes including interfaces.
<code>-excludeAbstractMethods</code>	Optional. Exclude all abstract methods from all classes and interfaces
<code>-excludeFields</code>	Optional. Exclude all fields from all classes and interfaces. cannot be used with the <code>-includeConstantFields</code> option.
<code>-includeConstantFields</code>	Optional. Specifies to include all final fields of any type in the coverage calculation. cannot be used with the <code>-excludeFields</code> option. The default, without this option, is to remove from the coverage calculation all final fields of primitive types and type <code>java.lang.String</code> .  Constant fields such as final fields of primitive and String types are initialized at compile-time with a constant expression. The Java technology-based compiler usually optimizes them and replaces them with their values. In such cases, test suite classes does not contain a reference to the field, even if the field were used/referenced in the test suite. For this reason, the tool removes all constant fields from the calculation by default to make coverage calculations more consistent. The <code>-includeConstantFields</code> option provides a means for changing this behavior.
<code>-api path/filename</code>	Required. Cannot be repeated. Specifies the location of the signature file representing the API under examination. The <code>path</code> defaults to the working directory. Accepts v1 and v2 format signature files generated by the Signature Test Tool Setup command, and rejects v0. See the <code>-FileFormat</code> option description in <a href="#">Chapter 3</a> .
<code>-apiInclude package_name*</code>	Optional. Can be repeated. Recursively include classes from the specified API package.
<code>-apiIncludeW package_name*</code>	Optional. Can be repeated. Include classes from the specified API package without subpackages.
<code>-apiExclude package_name*</code>	Optional. Can be repeated. Recursively excludes classes from the specified API package.

**Table 5–1 (Cont.) API Coverage Tool Command Options**

Options	Description
<code>-mode [w   r]</code>	Optional. Specifies the mode of coverage calculation as <code>w</code> for worst case or <code>r</code> for real world. Defaults to worst case.
<code>-detail [0   1   2   3   4]</code>	Optional. Specifies the level of report detail as an integer from 0–4. Defaults to 2. See <a href="#">Table 5–2</a> .
<code>-format [plain   xml]</code>	Optional. Specifies the report format as plain text or XML. Defaults to <code>plain</code> . Note that an example of the XML output is available in <code>SIGTEST_HOME/msc</code> .
<code>-report path/filename</code>	Optional. Where to place the generated report file. The <code>path</code> argument defaults to the working directory when only a file name is specified; otherwise, defaults to standard out.
<code>-version</code>	Optional. Displays version information.

[Table 5–2](#) describes the reporting levels resulting from the five settings available with the `-detail` option.

**Table 5–2 Report File Contents for Levels of Detail**

Detail Setting	Package Summary	Class Summary	Members Not Covered	Covered Members
0	X			
1	X	X		
2	X	X	X	
3	X	X		X
4	X	X	X	X

### 5.1.1 Special Report File

The special report file specified with the `-out` option contains the same coverage data that the standard report file contains. The main difference is that this format is easier for other applications to parse.

The special report file is essentially a table with these two columns delimited by a tab character:

- The left column provides the coverage counter value which can be zero.
- The right column provides the fully qualified name of the corresponding API member: a class, constructor, method, or field.

The `-mode` option affects the special report file, while the `-detail` setting has no effect on it.

### 5.1.2 Exclude List

In some cases a test suite either cannot or should not test certain elements of an API, whether they be a class, a method, or field. In this case you can use the `-excludeList filename` option (described in [Table 5–1](#)) to make the coverage calculation more accurate by excluding the elements listed in the specified exclude list file(s).

The exclude list is a text file that specifies each entry for exclusion on a separate line, as follows:

- *Package name* specified to recursively exclude all classes of the package
- *Class name* specified as a fully qualified class name
- *Field name* specified using a fully qualified class name: *classname.fieldname*
- *Method name* specified using a fully qualified class name: *classname.methodname(parameters)*

Exclude list processing follows these rules:

- Regards a line starting with the # character as a comment.
- Ignores empty lines.
- Silently ignores an entry if it is not found in the API.

---

**Note:** Each entry specified for exclusion should match its appearance in a report file. For example, you must specify an inner class with the \$ character prepended to its name, like this: *Outer\$Inner*

---

# Part III

---

## API Check Tool

This appendix describes how to use the API Check tool to track API changes and check for source and binary compatibility.

This part includes the following chapters:

- [Chapter 6, "Introduction API Check Tool"](#)
- [Chapter 7, "Using the API Check Tool"](#)



# 6

---

## Introduction API Check Tool

This chapter introduces the API Check Tool. [Chapter 7](#) describes how to use the tool.

### 6.1 The API Check Tool

The API Check tool tracks API changes and checks for source and binary compatibility. Much like Signature Test tool, it compares the reference implementation of an API recorded as golden signature file with a tested implementation. Unlike Signature Test tool, which requires that all classes (and the classes they depend on) be specified to the tool, API Check tool does not require dependencies to be specified. For that reason, API Check tool is faster than Signature Test tool, but less rigorous.

As an example of how this can be useful, consider the case of a developer who uses the JavaMail API. The developer might wish to check whether a new implementation of the JDK software contains all members that the JavaMail API calls — essentially a quick signature check that looks for missing signatures. API Check tool provides a fast and simple way to generate a report to show this.



---

# Using the API Check Tool

API Check tool behaves much the same as Signature Test tool and uses the same options and signature files. See [Chapter 3](#) for a description of the options. The input signature file is generated by the Signature Test tool Setup command using the `-NonClosedFile` option. Neither the CLASSPATH variable used for reflection mode, nor classes listed with `-classpath` option for static mode can contain base classes. See [Section 3.1.4, "CLASSPATH and -classpath Settings"](#) for more information.

## 7.1 API Check Tool Verification Scope

API Check tool verifies classes in signature files that are also covered by packages defined using the `-package` option. If the specified signature file is generated using the `-NonClosedFile` option, all superclasses and superinterfaces outside this scope are not checked.

As an example, consider a signature file that contains `java.util` classes. Use the following command to create the signature file:

```
java -jar sigtestdev.jar setup -classpath $JAVA_HOME/jre/lib/rt.jar  
-filename java-util.sig -nonclosedfile -package java.util
```

Use the following command to verify the `java.util.ArrayList` class using the signature file created in the previous command:

```
java -jar apicheck.jar -static -classpath $JAVA_HOME/jre/lib/rt.jar -filename  
java-util.sig -package java.util.ArrayList
```

Because `java.util.ArrayList` is specified as the scope for checking, it is the only class verified. `ArrayList` has a branching class and interface hierarchy that belongs to the `java.lang`, `java.util` and `java.io` packages as shown in [Figure 7-1](#). Because the input signature file only contains classes from the `java.util` package, only the `ArrayList` class superclasses and superinterfaces from `java.util` are analyzed and their members are checked as `ArrayList` class inherited members.

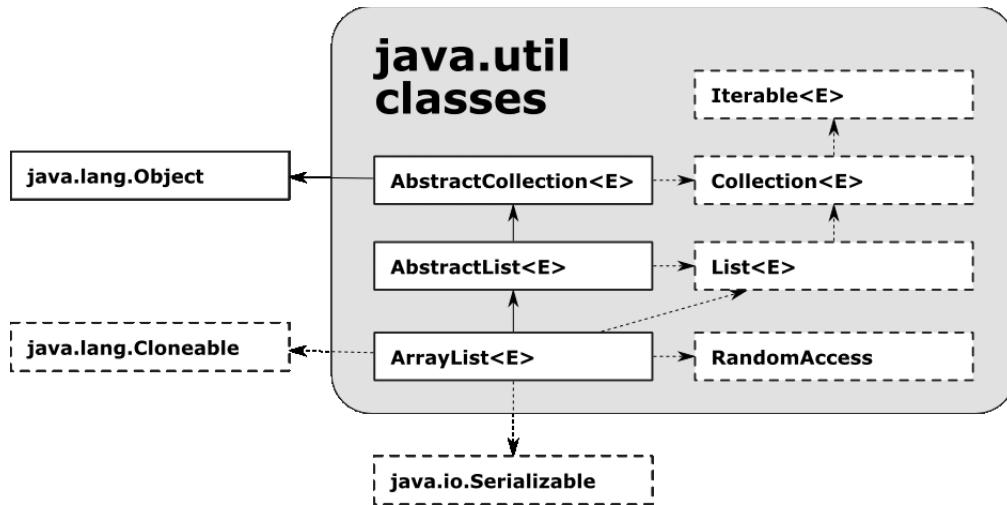
**Figure 7-1** `java.util` **Classes**

Image shows the `java.util` classes and their relationships to each other

\*\*\*\*\*

Consider a similar signature file that contains `java.lang` classes. In a similar check for the `RuntimePermission` class, the `RuntimePermission` hierarchy starts in the `java.lang.Object` class, departs the `java.lang` package to `java.security` and finally returns to the `java.lang` package:

```

java.lang.Object
    extended by java.security.Permission
        extended by java.security.BasicPermission
            extended by java.lang.RuntimePermission
  
```

API Check tool cannot verify any of the `RuntimePermission` class hierarchy because its direct superclass is outside the scope. In this case, even though `java.lang.Object` is in scope no inherited members are taken into account, and only members declared in `RuntimePermission` itself are analyzed.

## 7.2 Running API Check Tool

API Check tool command synopsis:

```

% java -jar apicheck.jar [options]
or
% java com.sun.tdk.apicheck.Main [options]
  
```

The rules described in [Section 3.3.2, "Case Sensitivity of Option Arguments"](#) apply.

The command options are the same as those for Signature Test Tool and are listed in [Table 3-5](#).

The settings for the CLASSPATH environment variable and the `-classpath` option are the same as those for Signature Test Tool and are listed in [Table 3-1](#).

# Part IV

---

## Appendix

This part contains appendices that include step-by-step examples that show how to use the tools, API migration rules, and information about using the tools with Ant and Maven.

This part includes the following appendices:

- [Appendix A, "Signature Test Tool Quick Start Examples"](#)
- [Appendix B, "API Coverage Tool Quick Start Examples"](#)
- [Appendix C, "API Migration Compatibility Rules \(Signature Test\)"](#)
- [Appendix D, "Merge Command Operative Principles"](#)
- [Appendix E, "Using the SigTest Tools With Ant"](#)
- [Appendix F, "Using the SigTest Tools With Apache Maven"](#)



# A

---

## Signature Test Tool Quick Start Examples

This appendix contains the following two step-by-step examples that show you how to use the Signature Test tool:

- [Example 1: Compare Two Different Implementations of the Same API](#)
- [Example 2: Merge Two Signature Files](#)

### A.1 Example Programs

Sample sources used in the examples, along with simple UNIX operating system shell and Windows batch scripts are provided in the `examples/usersguide` directory. You can use these to help run the examples. The `README` file in that directory explains how to use them.

---

**Note:** The examples use UNIX operating system syntax.

---

---

**Caution:** Code examples are an optional part of the SigTest distribution and are not required to use the SigTest tools. You can remove the example directory (`$_SIGTEST_HOME/examples`) if you are concerned about security issues the examples might create.

---

[Example A-1](#) and [Example A-2](#) show the two implementations of the test API used throughout these examples.

***Example A-1 Version 1.0 of test.java***

```
package example;
public class test {
    public <T> T get (T x) {
        return x;
    }
}
```

***Example A-2 Version 2.0 of test.java***

```
package example;

public class test {

    public String get (int x) {
```

```
        return "";
    }

    public void put () {
    }
}
```

## A.2 Example 1: Compare Two Different Implementations of the Same API

You can compare two implementations of an API in two ways:

- Run the `Setup` command to create a signature file for the first implementation and then run the `SignatureTest` command to compare them. This is shown in the first part of this example: A.2.1.
- Run the `SetupAndTest` command. The command combines the `Setup` and `SignatureTest` commands. This is shown in the second part of this example: A.2.2.

### A.2.1 Using the `Setup` and `SignatureTest` Commands

This example shows how to compare the following implementations of the `test.java` API using the `Setup` and `SignatureTest` commands.

1. Make `SigTest-directory/examples/usersguide` the current directory.
2. Compile the two implementation files.

`SigTest` tool works with class files. Use the following commands to compile the source files into class file:

```
% javac -d V1.0 V1.0/test.java
% javac -d V2.0 V2.0/test.java
```

3. Set the `CLASSPATH` environment variable to include the path to `sigtestdev.jar`.  

```
% setenv CLASSPATH=../../lib/sigtestdev.jar
```
4. Set the `JAVA_HOME` environment variable to include the base directory of the Java platform runtime installation on your system.  

```
% setenv JAVAHOME=java_runtime_path
```
5. Use the `Setup` command to create a signature file for the V1.0 implementation.

Note that the “\” characters are used to break long lines. Type this as a single line at the command line.

```
% java com.sun.tdk.signaturetest.Setup \
-classpath V1.0:$JAVA_HOME/jre/lib/rt.jar \
-static \
-apiVersion V1.0 \
-package example \
-fileName test.sig
```

The `Setup` command emits console output similar to the following:

```
Constant checking: on
Found in total: 16260 classes
Selected by -Package: 1 classes
Written to sigfile: 2 classes
STATUS:Passed.
```

6. Confirm that the contents of the signature file are correct by comparing it to the following file:

```
#Signature file v4.0

CLSS public example.test
cons public test()
meth public <%0 extends java.lang.Object> {%%0} get({%%0})
supr java.lang.Object

CLSS public java.lang.Object
cons public Object()
meth protected java.lang.Object clone() throws
java.lang.CloneNotSupportedException
meth protected void finalize() throws java.lang.Throwable
meth public boolean equals(java.lang.Object)
meth public final java.lang.Class<?> getClass()
meth public final void notify()
meth public final void notifyAll()
meth public final void wait() throws java.lang.InterruptedException
meth public final void wait(long) throws java.lang.InterruptedException
meth public final void wait(long,int) throws java.lang.InterruptedException
meth public int hashCode()
meth public java.lang.String toString()
```

7. Use the `SignatureTest` command to compare the V2.0 API signature with the V1.0 signature file you created in Step 5.

```
%   java com.sun.tdk.signaturetest.Setup \
    -classpath V2.0:$JAVA_HOME/jre/lib/rt.jar \
    -static \
    -package example \
    -fileName test.sig \
    -out report.txt
```

The `-out` option directs the command to write its results to `report.txt`.

A message similar to the following is written to the console when the command terminates:

```
See log recorded to file report.txt for more details.
STATUS:Failed.3 errors
```

8. Confirm that the contents of the `report.txt` file are correct by comparing it to the following file:

---

**Note:** There might be some minor differences because of system-specific information.

---

```
SignatureTest report
Tested version:
Check mode: src [throws normalized]
Constant checking: off
```

```
Missing Methods
-----
```

```
example.test:      method public <%0 extends java.lang.Object> {%%0}
example.test.get({%%0})
```

```
Added Methods
-----
example.test:     method public java.lang.String example.test.get(int)
example.test:     method public void example.test.put()

STATUS:Failed.3 errors
```

## A.2.2 Using the SetupAndTest Command

The SetupAndTest command combines the functionality of the Setup and SignatureTest commands into a single command.

1. Follow steps 1 - 4 in the previous example.
2. Use the following SetupAndTest command to create a signature file.

```
%   java $CLASSPATH com.sun.tdk.signaturetest.SetupAndTest \
  -reference V1.0:$JAVA_HOME/jre/lib/rt.jar \
  -test V2.0:$JAVA_HOME/jre/lib/rt.jar \
  -package example
```

The SetupAndTest command reports results similar to following example to standard output.

```
Invoke Setup ...
Class path: "V1.0;C:\java\jdk1.5.0_06\jre\lib\rt.jar"
Constant checking: on
Found in total: 12749 classes
Selected by -Package: 1 classes
Written to sigfile: 2 classes
Invoke SignatureTest ...
SignatureTest report
Tested version: 2.0
Check mode: src [throws normalized]
Constant checking: on
```

```
Missing Methods
-----
example.test:     method public <%0 extends java.lang.Object> {%%0}
example.te
st.get({%%0})

Added Methods
-----
example.test:     method public java.lang.String example.test.get(int)
example.test:     method public void example.test.put()

STATUS:Failed.3 errors
```

## A.3 Example 2: Merge Two Signature Files

This example shows how to use the Merge command to accomplish the following:

1. Compile three .java files to produce .class files.

2. Run the Setup command on each .class file to produce a signature file.
3. Use the Merge command to combine the files.

### A.3.1 Running Merge Example

These examples use the environment variables listed below:

Environment Variable	Description
CLASSPATH	Must include the sigtestdev.jar file. For example:/sigtest-1.5/lib/sigtestdev.jar
RT_JAR	The location of the runtime rt.jar file. For example: /opt/jdk1.5.0_09/jre/lib/rt.jar

1. Set up the environment with the environment variable settings in the table above.
2. Create each of the files shown in the following examples. Create each in a different directory but with the same file name.

Create directories named 1, 2, and 3. Add the appropriate file to each directory.

```
package x;
public class A {
    public void abc() {}
    public void foo() {}
}
```

```
package x;
public class A {
    public void abc() {}
    public void bar() {}
}
```

```
package x;
public class A {
    public static void abc() {}
}
```

3. Run these commands to compile each file into a separate x subdirectory:

```
% javac -d 1 1/A.java
% javac -d 2 2/A.java
% javac -d 3 3/A.java
```

This creates the following class files:

- a. ./1/x/A.class
- b. ./2/x/A.class
- c. ./3/x/A.class

4. Run the following three Setup commands on each A.class file to produce the three x#.sig files like the ones shown in following examples.

**a. Command #1:**

```
% java -cp 1:$CLASSPATH com.sun.tdk.signaturetest.Setup \
-static -classpath 1:$RT_JAR -package x -FileName x1.sig
```

The command generates the `./x1.sig` file like the one shown in the following example and produces a similar console message.

```
Class path: "1:/opt/jdk1.5.0_09/jre/lib/rt.jar"
Constant checking: on
Found in total: 13185 classes
Selected by -Package: 1 classes
Written to sigfile: 2 classes
STATUS:Passed.
```

**b. Command #2:**

```
% java -cp 2:$CLASSPATH com.sun.tdk.signaturetest.Setup \
-static -classpath 2:$RT_JAR -package x -FileName x2.sig
```

The command generates the `./x2.sig` file shown in the following example and produces a console message similar to this indicating successful setup.

```
Class path: "2:/opt/jdk1.5.0_09/jre/lib/rt.jar"
Constant checking: on
Found in total: 13185 classes
Selected by -Package: 1 classes
Written to sigfile: 2 classes
STATUS:Passed.
```

**c. Command #3:**

```
% java -cp 3:$CLASSPATH com.sun.tdk.signaturetest.Setup \
-static -classpath 3:$RT_JAR -package x -FileName x3.sig
```

The command generates the `./x3.sig` file shown in following example and produces a console message similar to this indicating successful setup.

```
Class path: "3:/opt/jdk1.5.0_09/jre/lib/rt.jar"
Constant checking: on
Found in total: 13185 classes
Selected by -Package: 1 classes
Written to sigfile: 2 classes
STATUS:Passed.
```

5. Run the following command to merge `x1.sig` and `x2.sig` and produce the `x1+x2.sig` file shown in the following example:

```
% java -cp $CLASSPATH com.sun.tdk.signaturetest.Merge -Files \
x1.sig:x2.sig -Write x1+x2.sig
```

The command generates a console message similar to the following message:

```
Warning: class java.lang.Throwable not found
STATUS:Passed.
```

6. Run this command to merge `x2.sig` and `x3.sig` attempting to produce the `x2+x3.sig` file:

```
% java -cp $CLASSPATH com.sun.tdk.signaturetest.Merge -Files \
x2.sig:x3.sig -Write x2+x3.sig
```

The command prints a message to the console similar to the following. it indicates a conflicting `static` modifier, and no signature file is created:

```
x.A.abc : <static> modifier conflict
STATUS:Error.Error
```

The conflict occurs because `x2.sig` contains this method (see [Example A-4](#)):

```
meth public void x.A.abc()
and x3.sig contains this method:
meth public static void x.A.abc()
```

### A.3.2 Example Result Files

This section contains the files that are generated from the previous Merge examples.

**Example A-3** *Contents of ./x1.sig*

```
#Signature file v4.0
#Version

CLSS public java.lang.Object
cons public Object()
meth protected java.lang.Object clone() throws
java.lang.CloneNotSupportedException
meth protected void finalize() throws java.lang.Throwable
meth public boolean equals(java.lang.Object)
meth public final java.lang.Class<?> getClass()
meth public final void notify()
meth public final void notifyAll()
meth public final void wait() throws java.lang.InterruptedException
meth public final void wait(long) throws java.lang.InterruptedException
meth public final void wait(long,int) throws java.lang.InterruptedException
meth public int hashCode()
meth public java.lang.String toString()
CLSS public x.A
cons public A()
meth public void abc()
meth public void foo()
supr java.lang.Object
```

**Example A-4** *Contents of ./x2.sig*

```
#Signature file v4.0
#Version

CLSS public java.lang.Object
cons public Object()
meth protected java.lang.Object clone() throws
java.lang.CloneNotSupportedException
meth protected void finalize() throws java.lang.Throwable
meth public boolean equals(java.lang.Object)
meth public final java.lang.Class<?> getClass()
meth public final void notify()
meth public final void notifyAll()
meth public final void wait() throws java.lang.InterruptedException
meth public final void wait(long) throws java.lang.InterruptedException
meth public final void wait(long,int) throws java.lang.InterruptedException
meth public int hashCode()
meth public java.lang.String toString()

CLSS public x.A
cons public A()
meth public void abc()
meth public void bar()
supr java.lang.Object
```

**Example A-5 Contents of ./x3.sig**

```
#Signature file v4.0
#Version

CLSS public java.lang.Object
cons public Object()
meth protected java.lang.Object clone() throws
java.lang.CloneNotSupportedException
meth protected void finalize() throws java.lang.Throwable
meth public boolean equals(java.lang.Object)
meth public final java.lang.Class<?> getClass()
meth public final void notify()
meth public final void notifyAll()
meth public final void wait() throws java.lang.InterruptedException
meth public final void wait(long) throws java.lang.InterruptedException
meth public final void wait(long,int) throws java.lang.InterruptedException
meth public int hashCode()
meth public java.lang.String toString()

CLSS public x.A
cons public A()
meth public static void abc()
supr java.lang.Object
```

**Example A-6 Contents of ./x1+x2.sig**

```
#Signature file v4.0
#Version

CLSS public java.lang.Object
cons public Object()
meth protected java.lang.Object clone() throws
java.lang.CloneNotSupportedException
meth protected void finalize() throws java.lang.Throwable
meth public boolean equals(java.lang.Object)
meth public final java.lang.Class<?> getClass()
meth public final void notify()
meth public final void notifyAll()
meth public final void wait() throws java.lang.InterruptedException
meth public final void wait(long) throws java.lang.InterruptedException
meth public final void wait(long,int) throws java.lang.InterruptedException
meth public int hashCode()
meth public java.lang.String toString()

CLSS public x.A
cons public A()
meth public void abc()
meth public void bar()
meth public void foo()
supr java.lang.Object
```

# B

---

## API Coverage Tool Quick Start Examples

This section contains step-by-step examples that show how to produce test coverage reports using the API Coverage tool. The examples are located in the following directory:

*SIGTEST\_HOME/examples/userguide/apicover*

The appendix consists of the following examples. The examples build upon each other.

- [Set Up the API Coverage Tool Ant Build Script](#)
- [Build API Coverage Tool Examples](#)
- [Run the Example Test Suite](#)
- [Run the Example Test Suite](#)
- [Use the API Coverage Tool to Calculate Test Coverage](#)

---

**Note:** The examples use UNIX operating system syntax.

---

---

**Caution:** Code examples are an optional part of the SigTest distribution and are not required to use the SigTest tools. You can remove the example directory (*\$SIGTEST\_HOME/examples*) if you are concerned about security issues the examples might create.

---

### B.1 Example Procedures

The following procedures describes how to set up and use the API Coverage tool.

#### B.1.1 Set Up the API Coverage Tool Ant Build Script

1. Make *SIGTEST\_HOME/examples/userguide/apicover* the current directory.
2. Make sure that the *JAVA\_HOME* environment variable refers to JDK 5.0 or higher.
3. Edit the following file:

*SIGTEST\_HOME/examples/userguide/apicover/build.properties*

Set the *junit.jar* property to point to the *junit.jar* file. Obtain this file from version 3.7 or higher of the JUnit test harness product.

4. Make sure Apache Ant 1.7 or higher is available and properly configured on your system.

## B.1.2 Build API Coverage Tool Examples

1. Run the ant command and specify the “build” target.

This command builds the following:

- API classes
- Example application (helloWorld.jar)
- Test suite
- API documentation (doc / directory)

2. Run the example application to verify that it built correctly.

```
%java -jar helloWorld.jar
```

The application’s output should look like this:

```
Good morning, Brazil!
Good morning, USA!
Good evening, China!
Good afternoon, Czech Republic!
Good afternoon, Russia!
Good afternoon, United Kingdom!
Good evening, India!
Good afternoon, Mali!
Hello, world!
```

## B.1.3 Run the Example Test Suite

1. Use the Ant “test” target to run the test suite.

```
%ant test
```

The test suite runs and produces the following output:

```
[junit] Running TestGreet
[junit] Tests run: 4, Failures: 0, Errors: 1, Time elapsed: 0.219 sec
[junit] Test TestGreet FAILED
```

## B.1.4 Generate a Signature File for the Tested API

1. Use the Ant “sigtest” target to generate the signature file.

```
%ant sigtest
```

The “sigtest” target executes the following command:

```
java -jar sigtestdev.jar setup -filename reports/greetapi.sig
-package com.sun.tdk.samples.helloworld.api -classpath
helloWorld.jar:$JAVA_HOME/jre/lib/rt.jar
```

This command generates the file reports/greetapi.sig. While the command runs you should see the following output:

```
sigtest:
[java] Class path: "helloWorld.jar:/opt/java/jdk1.5.0_16/jre/lib/rt.jar"
[java] Constant checking: on
[java] Found in total: 13217 classes
[java] Selected by -Package: 5 classes
[java] Written to sigfile: 8 classes
[java] STATUS:Passed.
[java] Java Result: 95
```

## B.1.5 Use the API Coverage Tool to Calculate Test Coverage

1. Use the Ant “apicov” target to calculate static test coverage

```
%ant apicov
```

## B.1.6 Worst Case Mode

The script executes the following command:

```
java -jar apicover.jar -ts test_classes -api reports/greetapi.sig -apiinclude
com.sun.tdk.samples.helloworld.api -mode w -report reports/cov-worst-case.txt
```

This mode reports that about of 37% of the API is covered by the tests. Some members that are defined in superclasses, such as finalize() or clone(), are marked as not covered. Some fields are also marked as not covered by the tests. The output written to a file named reports/cov-worst-case.txt and should appear as shown below.

Coverage Report				
Package	Class	Member	classes	members tested %%
com			4	35 13 37%
com.sun			4	35 13 37%
com.sun.tdk			4	35 13 37%
com.sun.tdk.samples			4	35 13 37%
com.sun.tdk.samples.helloworld			4	35 13 37%
com.sun.tdk.samples.helloworld.api			4	35 13 37%
	Greet			3 3 100%
	GreetFactory			6 1 16%
		- clone() - equals(java.lang.Object) - finalize() - hashCode() - toString()		
	Places		16	5 31%
		- finalize() - getCountry() - toString() - valueOf(java.lang.Class,java.lang.String) - valueOf(java.lang.String) - Brazil - China - Czech - India - Mali - UK		
	TimeOfDay		10	4 40%

## B.1.7 Real World Mode

The script executes the following command:

```
java -jar apicover.jar -ts test_classes -api reports/greetapi.sig -apiinclude  
com.sun.tdk.samples.helloworld.api -mode r -report reports/cov-realworld.txt
```

This estimation does not take into account overridden members defined in superclasses. Overall coverage is 52%.

The report is named `reports/cov-realworld.txt` and is shown below.

Coverage Report

```
=====
Package           classes
  Class           members tested  %%
  Member
=====
com               4          25      13      52%
-----
com.sun           4          25      13      52%
-----
com.sun.tdk       4          25      13      52%
-----
com.sun.tdk.samples 4          25      13      52%
-----
com.sun.tdk.samples.helloworld 4          25      13      52%
-----
com.sun.tdk.samples.helloworld.api 4          25      13      52%
-----
          Greet           3          3      100%
          GreetFactory     1          1      100%
          Places          13         5      38%
            - getCountry()
            - valueOf(java.lang.String)
            - Brazil
            - China
            - Czech
            - India
            - Mali
            - UK
          TimeOfDay         8          4      50%
            - AFTERNOON
            - EVENING
            - MORNING
            - NIGHT
=====
Overall coverage   4          25      13      52%
=====

Configuration
ts  test_classes
api  reports/greetapi.sig
mode r
```

## B.1.8 Real World Mode Without Fields and Enum Constants

The script executes the following command:

```
java -jar apicover.jar -ts test_classes -api reports/greetapi.sig -apiinclude
com.sun.tdk.samples.helloworld.api -mode r -excludeFields -report
reports/cov-realworld-without-fields.txt
```

In this case test coverage is 84%.

The report is named `reports/cov-realworld-without-fields.txt` and is shown below.

Coverage Report

```
=====
Package           classes
Class
Member
=====
com               4      13     11    84%
-----
com.sun           4      13     11    84%
-----
com.sun.tdk       4      13     11    84%
-----
com.sun.tdk.samples 4      13     11    84%
-----
com.sun.tdk.samples.helloworld 4      13     11    84%
-----
com.sun.tdk.samples.helloworld.api 4      13     11    84%
-----
Greet
      3      3     100%
-----
GreetFactory
      1      1     100%
-----
Places
  - getCountry()
  - valueOf(java.lang.String)
      5      3      60%
-----
TimeOfDay
      4      4     100%
-----
Overall coverage 4      13     11    84%
=====

Configuration
ts      test_classes
api    reports/greetapi.sig
excludeFields yes
mode    r
```



# C

---

## API Migration Compatibility Rules (Signature Test)

This appendix describes the rules used by the Signature Test tool API migration feature.

### C.1 The Compatibility Rules

The following sections and tables describe the rules and show whether they break only source compatibility or both source and binary compatibility. Comments and clarifications follow the table for rules that have an asterisk after their number.

---

**Note:** A class is called *subclassable* if it has subclasses outside its package. In other words, this class is not final and has public constructor

---

#### C.1.1 General Rules

The rules from this group are triggered if the more specific rules from the other groups below are not triggered. For example, adding an interface method defined in rule 2.1, adding constructor in the rule 5.5. In such cases more general rule 1.1 is ignored.

**Table C-1 API Migration Compatibility Rules - General**

Rule #	Description	Breaks	Severity
1.1 *	API (public or protected) type (class, interface, enum, annotation type) or member (method, field) added	Source	Warning
1.2	API (public or protected) type (class, interface, enum, annotation type) or member (method, field) removed	Both	Severe
1.3	Narrowing type or member visibility - from public to non-public, from protected to package or private	Both	Severe
1.4 *	Generification of the public API type	None	

#### C.1.2 Interfaces and Annotation Types

The rules in this group apply to interfaces and annotation types.

**Table C-2 API Migration Compatibility Rules - Interfaces and Annotation Types**

Rule #	Description	Breaks	Severity
2.1	Add methods	Both	Severe
2.2	Add fields	Both	Severe
2.3 *	Expand the set of superinterfaces (direct or indirect) if the added interface has a field (constant)	Source	Warning
2.4	Contract superinterface set (direct or inherited)	Both	Severe
2.5 *	Add member without default value to annotation type	Source	Severe
2.6 *	Add member with default value to annotation type	None	
2.7	Remove member from annotation type	Both	Severe
2.8	Remove default value from member of annotation type	Both	Severe

### C.1.3 Interfaces and Class Methods

The rules in this group apply to interfaces and class methods.

---

**Note:** Some rules in this group apply only for class methods.

---

**Table C-3 API Migration Compatibility Rules - Interfaces and Class Methods**

Rule #	Description	Breaks	Severity
3.1	Change signature and/or return type	Both	Severe
3.2	Change last parameter from array type T[] to variable array T...	None	
3.3	Change last parameter from array T... to array type T[]	Source	Severe
3.4	Change normalized throw list	Source	Severe
3.5	Decrease access from public to protected	Both	Severe
3.6 *	Increase access from protected to public if the class is subclassable	Source	Warning
3.7	Change method from abstract to non-abstract	None	
3.8	Change method from non-abstract to abstract (if the class can be subclassed)	Both	Severe
3.9	Change method from final to non-final	None	
3.10	Change method from non-final to final	Both	Severe
3.11	Change method from static to non-static	Both	Severe
3.12	Change method from non-static to static	Both	Severe
3.13	Change method from native to non-native	None	
3.14	Change method from non-native to native	None	
3.15	Change method from synchronized to non-synchronized	None	
3.16	Change method from non-synchronized to synchronized	None	

### C.1.4 Interfaces and Class Fields

The rules in this group apply to interfaces and class methods.

---

**Note:** Some rules from this group apply only for class fields

---

**Table C-4 API Migration Compatibility Rules - Interfaces and Class Fields**

Rule #	Description	Breaks	Severity
4.1	Change type	Both	Severe
4.2	Change/Remove constant value	Both	Warning
4.3	Decrease access	Both	Severe
4.4	Increase access	None	
4.5	Change from final to non-final	None	
4.6	Change from non-final to final	Both	Severe
4.7	Change from static to non-static	Both	Severe
4.8	Change from non-static to static	Both	Severe

### C.1.5 Classes

The rules in this group apply to classes.

**Table C-5 API Migration Compatibility Rules - General**

Rule #	Description	Breaks	Severity
5.1 *	Add non-abstract and non-static methods	Both	Warning
5.2	Add abstract methods (if the class can be subclassed)	Both	Severe
5.3	Add static methods (if the class can be subclassed)	Both	Warning
5.4	Remove constructors	Both	Severe
5.5	Add first constructor with arguments or throws clause	Both	Severe
5.6	Add fields	Both	Severe
5.7	Expand implemented interface set (direct or indirect)		
5.7.1	The added interface adds abstract methods	Both	Severe
5.7.2	The new interface adds fields or inner classes	Source	Severe
5.7.3	If 5.7.1 and 5.7.3 are not true	None	
5.8	Contract implemented interface set (direct or indirect)	Both	Severe
5.9	Expand superclass set (direct or indirect)		
5.9.1	Add superclass adds abstract method (see rules 5.1 - 5.3)		
5.9.2	Add superclass adds field (see rule 5.6)		
5.9.3	Other cases		
5.10	Contract superclass set (direct or indirect)	Both	Severe
5.11	Change abstract to non-abstract	None	
5.12	Change non-abstract to abstract (if the class can be subclassed)	Both	Severe
5.13	Change final to non-final	None	
5.14	Change non-final to final	Both	Severe

## C.2 Comments and Clarifications

The following sections contain comments and clarifications that make the rules more clear.

### C.2.1 Rule 1.1

Adding a class can theoretically break source code compatibility because new classes can be incorrectly resolved in an existing client's code with type-import-on-demand declarations (also known as wildcard imports). This can happen if the code uses another type with the same simple name. For example:

```
//client's code

import com.acme.*;
import com.client.*;

.....

Policy p = new Policy(); // this is com.client.Policy

.....
```

In this case, after adding class `com.acme.Policy`, the compiler raises the error reference to `Policy` is ambiguous, both class `com.acme.Policy` in `com.acme` and class `com.client.Policy` in `com.client` match.

This rule is considered a warning because it will probably not affect binary compatibility and adhering to this rule makes API evolution very difficult.

### C.2.2 Rule 1.4

Generics are a facility of generic programming that was added to the Java programming language as part of Java SE version 5.0. Generics allow a type or method to operate on objects of various types while providing compile-time type safety. Generification upgrades types using support to-be-specified-later types that are instantiated as needed for specific types that are provided as type parameters.

The Java programming language implements generics using erasure, which ensures that legacy and generic versions usually generate identical class files, except for some auxiliary information about types. Binary compatibility is not broken because it is possible to replace a legacy class file with a generic class file without changing or recompiling any client code.

To facilitate interfacing with non-generic legacy code, it is also possible to use the erasure of a parameterized type as a type. Such a type is called a raw type (*Java Language Specification 3/4.8*). Allowing the raw type also ensures backward compatibility for source code.

According to this, the following versions of the `java.util.Iterator` class are both binary and source code backward compatible:

- Class `java.util.Iterator` as it is defined in Java SE version 1.4:

```
public interface Iterator {
    boolean hasNext();
    Object next();
    void remove();
}
```

- Class `java.util.Iterator` as it is defined in Java SE version 5.0:

```
public interface Iterator<E> {
    boolean hasNext();
    E next();
    void remove();
}
```

### C.2.3 Rule 2.3

Adding a superinterface with a constant field can shadow another entity with the same simple name. Consider the following code:

```
public interface Poet{
    boolean LITERATE = true;
}

public interface Playwright{
    boolean LITERATE = true;
}

public interface Shakespeare extends Poet {

}
```

Suppose that a new version of the `Shakespeare` interface implements interface `Playwright` as well as `Poet` as shown here:

```
public interface Shakespeare extends Poet, Playwright {

}
```

The following client code will not compile because the reference to `LITERATE` is ambiguous.

```
// client code
public class ShakespeareImpl implements Shakespeare {
    void introduce() {
        System.out.println("Hi, my name is Shakespeare and I'm " + LITERATE ?
            "quite literate" : "rather illiterate");
    }
}
```

### C.2.4 Rules 2.5, 2.6

The example below shows how adding a member without a default value to an annotation type breaks source code compatibility.

```
// annotation type v1
@interface Agent{
    String name();
}

// client's code which uses this annotation type v1
@Agent(name="James Bond")

// annotation type v2.1
@interface Agent{
    String name();
    String id(); // added member
```

```
}

// legacy code is not compilable due to
// error - annotation Agent is missing id
@Agent(name="James Bond")

// annotation type v2.2
@interface Agent{
    String name();
    String id() default "007"; // added member with default value
}

// legacy code is compilable
@Agent(name="James Bond")
```

## C.2.5 Rule 3.6

Changing a method from protected to public can break source code compatibility if this method was overridden as protected. In this case the legacy code can not be recompiled because “access narrowing” is prohibited in the Java programming language. This rule is only a warning because it does not affect binary compatibility, and the probability of its affecting source code compatibility is very low.

## C.2.6 Rule 4.2

Changing or removing constant values can break source code compatibility. For example, consider the following client code example. An integer constant named NOTHING with a value of 0 is used:

```
switch (i) {
    case NOTHING:
        // some actions
    case -1:
        // some other actions
}
```

Assume that the value of the constant NOTHING is changed from 0 to -1. The client code will not compile because of the duplicate case label. This rule is only a warning because it does not affect binary compatibility, and the probability of its affecting source code compatibility is very low.

## C.2.7 Rule 5.1

Adding a regular method to a subclassable class can break source code and binary compatibility because a subclass can have a method with the same signature but with weaker access privileges. For example consider the following code example:

```
class ClientClass extends APIClass {
    private void foo() {}
}
```

Assume that the class APIClass is changed, and the method

```
protected void foo() {}
```

is added. The code cannot be recompiled due of an error that generates the following error message:

foo() in ClientClass cannot override foo() in APIClass; attempting to assign weaker access privileges; was protected

Binary compatibility is broken as defined in JLS 3/3.14.12

### C.2.8 Rule 5.3

Adding a static method to a subclassable class can break source code and binary compatibility, because a subclass can have a method with the same signature. For example consider the following code example:

```
class ClientClass extends APIClass {  
    protected void foo() {}  
}
```

Suppose that the class APIClass is changed and the method

```
protected static void foo() {}
```

is added. The code can not be recompiled due to an error that generates the following error message:

foo() in ClientClass cannot override foo() in APIClass; overridden method is static

Binary compatibility is be broken as defined in JLS 3/3.14.12

### C.2.9 Rule 5.7.2

As in the case of rule 2.3, adding a superinterface with a constant field can shadow another entity with the same simple name.



# D

---

## Merge Command Operative Principles

This appendix describes the command operative principles used by the Signature Test tool.

### D.1 Merge Command Operative Principles

The Merge command operates according to the following principles, where A and B are input APIs that are combined into the resulting API C:

- The Merge operation is commutative, so with API A and B,  $A + B = B + A$ .
- It recognizes either binary or source compatibility when merging APIs.
- For any application X that is compatible with either API A or B, when A and B are merged then X must be compatible with the resulting API C.
- The resulting API C cannot contain a class that is not found in either of the A or B input APIs. This means that any class in C has to have corresponding classes in either A or B or both A and B.
- API C must not contain a class member that is not found in its corresponding classes in A and B. This applies only to declared class members and not inherited members.
- If some class in A or B, or both, has a member that overrides a member from a superclass, then the corresponding class in C must also have this overriding member.
- Each API element in C has a set of attributes derived from the attributes of its corresponding elements in A and B, and this is the smallest possible set of attributes that does not break compatibility. So if `attr` is an attribute of an element from API C, then `attr` must be defined for the corresponding element from A or B, and `attr` cannot be omitted without breaking compatibility between A and C or between B and C.
- No unnecessary APIs or relationships between classes or interfaces can be introduced.

The basic algorithmic rules for combining two input APIs A and B into a signature file that represents the resulting API C are as follows:

- If one of the input APIs A or B contains an element that the other does not, then this element goes into the resulting signature file of API C without modification except for the following case: If the element in question is the first declared class member in the inheritance chain of input API A or B, and the other input API inherits the same element, then this element represented the resulting API C.

- If both of the input APIs contain two identical elements, only one of them is represented in the resulting API.
- If both of the input APIs contain a corresponding element, but with a different set of attributes, then either of the following occurs:
  - A conflict wherein the resulting API cannot exist.
  - A compromise wherein the new element with a composite set of attributes is created and it is represented in the resulting API-set.

### D.1.1 Element Handling by Merge

General rules for handling elements of all kinds during the Merge process are as follows.

- When there are two different access modifiers select the more visible one.  
For example, if A is a `public int foo`, and B is `protected int foo`, then the merge into C results into `public int foo`.
- If the elements differ in the `final` modifier, do not include it. If a class is `final`, then all of its methods are implicitly `final` according to Section 8.4.3.3 of *The Java Language Specification, 2nd Edition*.
- If corresponding elements differ in the `static` modifier, then declare a conflict.

Element-specific rules are as follows:

- If corresponding classes differ in the `abstract` modifier, then declare a conflict.
- Apply the following rules for classes or interfaces and nested classes or interfaces, where for the purpose of this description, `c1` and `c2` are corresponding classes from the input APIs:

If a superclass of `c1` is a subclass of a superclass of `c2`, use the superclass of `c1` as the superclass for the new element. Otherwise, if a superclass of `c2` is a subclass of a superclass of `c1`, use the superclass of `c2` as the superclass for the new element. If neither of the previous two conditions are possible, then declare a conflict.

- For classes or interfaces and nested classes or interfaces, create a combined set of superinterfaces of the corresponding classes and dismiss duplicates. Use the combined set for the new element.
- For methods and constructors, construct a `throws` list as follows:
  - In binary compatibility mode, an empty `throws` list results independently of the source lists.
  - In source compatibility mode, both `throws` lists are normalized as described in [Table 3-3](#) before they are compared. If the normalized lists are equal, one is used as the result, otherwise, a conflict is declared.
- Methods that differ in the `abstract` modifier are not included.
- If a method result type is not identical a conflict is declared.
- If a field value type is not identical a conflict is declared.
- If a field element differs in the `volatile` modifier, it is included.
- Process constant field values as follows:
  - If one of the fields has a constant value and other does not, include the constant value in the result field.

- If both fields have a constant value then declare a conflict if the values are different, otherwise include the value in the result field.



---

# Using the SigTest Tools With Ant

This appendix describes how to use the SigTest tools in Ant build scripts.

## E.1 Using the Setup Command From an Ant Script

The Signature Test tool `Setup` command can be invoked from an Ant script. The `sigtestdev.jar` file contains the corresponding Ant task.

Use the following task definition in your Ant build script:

```
<taskdef name="setup" classname="com.sun.tdk.signaturetest.ant.ASetup"
classpath="sigtestdev.jar"/>
```

**Table E-1** lists required and optional attributes and nested elements for the “setup” task.

**Table E-1 Setup Attributes Available for Ant Scripts**

Attribute	Description
Required	
“package” attribute or nested “package” elements	Corresponds to the <code>-package</code> option
“classpath” attribute or nested “classpath” elements	Corresponds to the <code>-classpath</code> option
“filename” attribute	Corresponds to the <code>-filename</code> option
Optional:	
“failonerror” attribute	Stops the build process if the command exits with an error. Default value is <code>false</code>
“apiVersion” attribute	Corresponds to <code>-apiVersion</code> . Set API version for signature file
“exclude” attribute or nested “exclude” elements	Corresponds to <code>-exclude</code> option. Specifies package(s) or class(es), which is not required to be tested
“negative” attribute	Treats a failed result as successful and a successful result as failed. Used for negative tests. Default value is “ <code>false</code> ”.

The following code shows how to use the `Setup` command in an Ant script:

```
<target name="td" description="Setup task definition">
```

```

<taskdef name="setup" classname="com.sun.tdk.signaturetest.ant.ASetup"
  classpath="${sigtest.home}/sigtestdev.jar"/>
</target>

<target name="setup"
  description="Runs signature test setup for com.acme.openapi package with subpackages"
  depends="td">
  <setup package="com.acme.openapi" failonerror="true" apiVersion="openapi-v2"
    filename="acme-openapi-v1.sig">
    <classpath>
      <pathelement location="${java.home}/jre/lib/rt.jar"/>
      <pathelement location="${testd.home}/lib/acmeAPIv2.jar"/>
    </classpath>
    <exclude class="com.acme.openapi.NotTested"/>
  </setup>
</target>

```

## E.2 Using the SignatureTest Command From an Ant Script

The `SignatureTest` command can be invoked from Ant script. Both `sigtestdev.jar` and `sigtest.jar` contain corresponding Ant tasks. Unlike the ordinary `SignatureTest` command, its Ant wrapper can run the test only in static mode—reflection mode is not supported. Use the following task definition in your Ant build script:

```

<taskdef name="test"  classname="com.sun.tdk.signaturetest.ant.ATest"
  classpath="sigtest.jar"/>

```

[Table E-2](#) lists required and optional attributes and nested elements for “test” Ant task.

**Table E-2 SignatureTest Attributes Available for Ant Scripts**

Attribute	Description
Required:	
“package” attribute or nested “package” elements	Corresponds to the <code>-package</code> option
“classpath” attribute or nested “classpath” elements	Corresponds to the <code>-classpath</code> option
“filename” attribute	Corresponds to the <code>-filename</code> option
Optional:	
“failonerror” attribute	Stops the build process if the command exits with an error. Default is <code>false</code>
“apiVersion” attribute	Corresponds to the <code>-apiVersion</code> option. Sets the API version for signature files.
“exclude” attribute or nested “exclude” elements	Corresponds to the <code>-exclude</code> option. Specifies package(s) or class(es), do not require testing.
“binary” attribute	Corresponds to the “ <code>-mode bin</code> ” option. Runs the test in binary mode. Default is “ <code>false</code> ”.
“errorAll” attribute	Corresponds to the <code>-errorAll</code> option. Handles warnings as errors. Default is “ <code>false</code> ”.
“debug” attribute	Corresponds to the <code>-debug</code> option. Prints debug information such as detailed stack traces. Default is “ <code>false</code> ”.

**Table E-2 (Cont.) SignatureTest Attributes Available for Ant Scripts**

Attribute	Description
“backward” attribute	Corresponds to the –Backward option. Runs backward compatibility checking. Default is “false”.
“formatHuman” attribute	Corresponds to the –formatHuman option. Processes human readable error output. Default is “false”.
“output” attribute	Corresponds to the –out option. Specifies the report file name.
“negative” attribute	Treats a failed result as successful and a successful result as failed. Used for negative tests. Default value is “false”.

The following code sample shows how to use the SignatureTest command with an Ant script.

```

<target name="td" description="Signature test task definition">
  <taskdef name="test" classname="com.sun.tdk.signaturetest.ant.ATest"
    classpath="${sigtest.home}/sigtest.jar"/>
</target>

<target name="test"
  description="Runs migration compatibility test for com.acme.openapi
  package with subpackages, tests v2 against v1 signature file"
  depends="td">
  <test failonerror="true" apiVersion="openapi-v2"
    filename="acme-openapi-v1.sig" backward="true" output="st_report.txt">
    <package name="com.acme.openapi" />
    <exclude class="com.acme.openapi.NotTested"/>
    <classpath>
      <pathelement location="${java.home}/jre/lib/rt.jar"/>
      <pathelement location="${testd.home}/lib/acmeAPIv2.jar"/>
    </classpath>
  </test>
</target>

```

### E.3 Using the Merge Command From an Ant Script

The Signature Test tool Merge command can be invoked from an Ant script. Both the sigtestdev.jar and sigtest.jar files contain the corresponding Ant task. Use the following task definition in your Ant build script:

```

<taskdef name="merge" classname="com.sun.tdk.signaturetest.ant.AMerge"
  classpath="sigtest.jar"/>

```

[Table E-3](#) and [Table E-4](#) list required and optional attributes and nested elements for the “merge” task.

**Table E-3 Required Setup Attributes Available for Ant Scripts**

Attribute	Description
“file” nested elements	Corresponds to the –files option
“write” attribute	Corresponds to the –write option

**Table E-4 Optional Setup Attributes Available for Ant Scripts**

Attribute	Description
“binary” attribute	Corresponds to the <code>-binary</code> option. Default value is “false”.
“failonerror” attribute	Stop the build process if the command exits with an error. Default value is “false”.
“negative” attribute	Treats a failed result as successful and a successful result as failed. Used for negative tests. Default value is “false”.

**Table E-5 SAMPLE of REDOING TABLE UNITS: Setup Attributes Available for Ant Scripts**

Attribute	Description	Status
“file” nested elements	Corresponds to the <code>-files</code> option	Required
“write” attribute	Corresponds to the <code>-write</code> option	Required
“binary” attribute	Corresponds to the <code>-binary</code> option. Default value is “false”.	Optional
“failonerror” attribute	Stop the build process if the command exits with an error. Default value is “false”.	Optional
“negative” attribute	Treats a failed result as successful and a successful result as failed. Used for negative tests. Default value is “false”.	Optional

The following code shows how to use the `Merge` command in an Ant script:

```
<target name="mergeFiles" description="Merges signature files">
    <taskdef name="merge" classname="com.sun.tdk.signaturetest.ant.AMerge"
        classpath="${sigtest.jar}" />      <merge write="${build.test.dir}/core_and_loaders.sig"
failonerror="true">
    <file name="${build.test.dir}/core.sig"/>
    <file name="${build.test.dir}/loaders.sig"/>
    </merge>
</target>
```

## E.4 Using APICheck From an Ant Script

The API Check tool command can be invoked from an Ant script. The `apicheck.jar` file contains the corresponding Ant task. Use the following task definition in your Ant build script:

```
<taskdef name="apicheck" classname="com.sun.tdk.apicheck.ant.ACheck"
classpath="apicheck.jar:sigtest.jar" />
```

All required and optional attributes and nested elements for the “apicheck” task are the same as used for the Signature Test Tool “test” Ant command and are listed in [Table E-2](#).

See B.1.1 for an example that shows how to set up APICheck in an Ant script.

---

# Using the SigTest Tools With Apache Maven

The Apache Maven SigTest plug-in (`sigtest-plugin`) makes the functionality of the Sigtest, Setup and Merge commands available from Maven 2 build scripts. The Maven APICover plug-in (`apicover-plugin`) makes the functionality of the APICover tool available to Maven 2 build scripts. All goals are bound by default to the “test” life cycle phase.

## F.1 Goal Overview

The the four `sigtest-plugin` goals are described in [Table F-1](#):

**Table F-1 The `sigtest-plugin` Goals**

Goal	Description
<code>sigtest-plugin:setup</code>	Provides Setup command functionality to Maven 2 build scripts. Creates a signature file from an API defined by a specification or a reference implementation.
<code>sigtest-plugin:test</code>	Provides static mode SignatureTest functionality to Maven 2 build scripts. Compares the reference API represented in the signature file to the API under test and produces a report.
<code>sigtest-plugin:merge</code>	Provides Merge functionality to Maven 2 build scripts. Creates a combined signature file from several signature files representing different Java platform APIs in one Java runtime environment according to the JSR 68 rules.
<code>apicover-plugin:apicover</code>	Provides API Coverage tool functionality to Maven 2 build scripts, This goal is used to estimate the test coverage that a test suite under development affords to implementations of its related API specification.

## F.2 Goal Descriptions

The following sections describe the requirements and parameters for each of the goals listed in [Table F-1](#). An example follows each section.

### F.2.1 `sigtest-plugin:setup`

The `setup` goal accepts a reference implementation of an API as input. The command processes API input in order to generate a signature file that represents the API to be used as a reference for comparison during signature testing.

- Full name: `com.sun.tdk:sigtest-plugin:2.2:setup`
- Requires a Maven 2.0 project to be executed.

- Binds by default to the life cycle phase: test

**Table F-2 Required Parameters (sigtest-plugin:setup)**

Name	Type	Corresponding Setup Command Option	Description
fileName	String	-filename	Specifies the name of the signature file to be created.
pathElements	List	-classpath	Specifies the path to one or more APIs that generate the signature file. Can contain multiple directories, Zip files or JAR files.
packages	List	-package	Specifies classes or packages to be included in the signature file including its subpackages if a package is specified.

**Table F-3 Optional Parameters (sigtest-plugin:setup)**

Name	Type	Corresponding Setup Command Option	Default Value	Description
excludes	List	-exclude		Specifies a package or class to be excluded from the signature file, including its subpackages.
nonClosedFile	boolean	-NonClosedFile	FALSE	Causes direct and indirect superclasses and superinterfaces of tested classes <i>not</i> to be included in the signature file. This eliminates cases where they do not belong to the scope defined by “packages” parameters.
apiVersion	String	-apiVersion		Specifies the API version string to be recorded in the second line of the signature file.
failOnError	boolean		TRUE	Stops the build process if the command exits with an error.
negative	boolean		FALSE	Treats tests that do not succeed as having passed, and tests that do succeed as having failed. Used for negative tests.

**Example F-1 Sample Plugin Configuration (pom.xml)**

```

<project>
  ...
  <build>
    ...
    <plugins>
      <plugin>
        ...
        <groupId>com.sun.tdk</groupId>
        <artifactId>sigtest-plugin</artifactId>
        <configuration>

```

```

<fileName>java-awt-lang-math.sig</fileName>
<packages>
  <package>java.awt</package>
  <package>java.lang</package>
  <package>java.math</package>
</packages>
<excludes>
  <exclude>java.lang.Math</exclude>
  <exclude>java.lang.ref</exclude>
</excludes>
<pathElements>
  <pathElement>${ref.jhome}/jre/lib/rt.jar</pathElement>
</pathElements>
<apiVersion>Java Six</apiVersion>
</configuration>
</plugin>
. .
</plugins>
. .
</build>
. .
</project>

```

## F.2.2 sigtest-plugin:test

The `test` goal compares the reference API (represented in a signature file) to the API under test and produces a report. Unlike the `SignatureTest` command it only supports static mode—reflection is not supported

- Full name: `com.sun.tdk:sigtest-plugin:2.2:test`
- Requires a Maven 2.0 project to be executed.
- Binds by default to the life cycle phase: `test`

**Table F-4 Required Parameters (sigtest-plugin:test)**

Name	Type	Corresponding Setup Option	Description
fileName	String	<code>-filename</code>	Specifies the name of the signature file to be created.
pathElements	List	<code>-classpath</code>	Specifies the path to one or more APIs that generate the signature file. Can specify multiple directories, Zip files or JAR files.
packages	List	<code>-package</code>	Specifies classes or packages to be included in the signature file, including its subpackages if a package is specified.

**Table F-5 Optional Parameters (sigtest-plugin:test)**

Name	Type	Corresponding SignatureTest Option	Default Value	Description
excludes	List	<code>-exclude</code>		Specifies a package or class to be excluded from the signature file, including its subpackages.
apiVersion	String	<code>-apiVersion</code>		Specifies the API version string to be recorded in the second line of the signature file.

**Table F-5 (Cont.) Optional Parameters (sigtest-plugin:test)**

Name	Type	Corresponding SignatureTest Option	Default Value	Description
binary	boolean	-mode bin	FALSE	Specifies that binary mode be used during the signature test instead of the source code compatibility mode.
backward	boolean	-Backward	FALSE	Specifies migration instead of mutual compatibility check mode.
human	boolean	-FormatHuman	FALSE	Specifies the human-readable report output format.
errorAll	boolean	-ErrorAll	FALSE	Specifies that the signature test be made stricter by upgrading certain warnings to errors.
debug	boolean	-debug	FALSE	Enables printing of the stack trace for debugging purposes if SignatureTest fails.
failOnError	boolean		TRUE	Stops the build process if the command exits with an error.
negative	boolean		FALSE	Treats tests that do not succeed as having passed, and tests that do succeed as having failed. Used for negative tests.

**Example F-2 Sample Plugin Configuration (pom.xml)**

```

<project>
  ...
  <build>
    ...
    <plugins>
      <plugin>
        ...
        <groupId>com.sun.tdk</groupId>
        <artifactId>sigtest-plugin</artifactId>
        <configuration>
          <fileName>java.awt.lang.math.sig</fileName>
          <packages>
            <package>java.awt</package>
            <package>java.lang</package>
            <package>java.math</package>
          </packages>
          <excludes>
            <exclude>java.lang.Math</exclude>
            <exclude>java.lang.ref</exclude>
          </excludes>
          <pathElements>
            <pathElement>${ref.jhome}/jre/lib/rt.jar</pathElement>
          </pathElements>
          <apiVersion>Java Six</apiVersion>
          <failOnError>false</failOnError>
          <human>true</human>
          <backward>true</backward>
          <out>report.txt</out>
          <debug>true</debug>
        </configuration>
      </plugin>
    </plugins>
  </build>
</project>

```

```

    . . .
  </plugins>
  . . .
</build>
. . .
</project>

```

### F.2.3 sigtest-plugin:merge

The merge goal command combines (merges) a number of input signature files into a single signature file.

- Full name: com.sun.tdk:sigtest-plugin:2.2:merge
- Requires a Maven 2.0 project to be executed.
- Binds by default to the life cycle phase: test

**Table F-6 Required Parameters (sigtest-plugin:merge)**

Name	Type	Corresponding Merge option	Description
write	String	-Write	Specifies the resulting output signature file.
files	List	-Files	Specifies the names of the signature files to be merged.

**Table F-7 Optional Parameters (sigtest-plugin:merge)**

Name	Type	Corresponding Merge Option	Default Value	Description
binary	boolean	-Binary	FALSE	Specifies that binary mode be used during the signature test instead of the source code compatibility mode.
failOnError	boolean		TRUE	Stops the build process if the command exits with an error.
negative	boolean		FALSE	Treats tests that do not succeed as having passed, and tests that do succeed as having failed. Used for negative tests.

**Example F-3 Sample Plugin Configuration (pom.xml)**

```

<project>
  . . .
  <build>
    . . .
    <plugins>
      . . .
      <plugin>
        . . .
        <groupId>com.sun.tdk</groupId>
        <artifactId>sigtest-plugin</artifactId>
        <configuration>
          <files>
            <file>baseAPI.sig</file>
            <file>optionalAPI1.sig</file>
          . . .
        </configuration>
      </plugin>
    </plugins>
  </build>
</project>

```

```

        <file>optionalAPI2.sig</file>
    </files>
    <write>result.sig</write>
    <failOnError>false</failOnError>
</configuration>
</plugin>
...
</plugins>
...
</build>
...
</project>

```

## F.2.4 apicover-plugin:apicover

The apicover-plugin:apicover goal is used to estimate the test coverage that a test suite under development affords to implementations of its related API specification. It does this by determining how many public class members the test suite references within the API specification that it is designed to test against. The tool uses a signature file representation of the API specification as the basis of its specification analysis.

- Full name: com.sun.tdk:apicover-plugin:2.2:apicover
- Requires a Maven 2.0 project to be executed.
- Binds by default to the life cycle phase: test

**Table F-8 Required Parameters (apicover-plugin:apicover)**

Name	Type	Corresponding APICover Option	Description
tests	List	-ts	Specifies the path to the test suite classes to be analyzed. Also accepts a JAR file.
api	String	-api	Specifies the location of the signature file representing the API under examination.

**Table F-9 Optional Parameters (apicover-plugin:apicover)**

Name	Type	Corresponding APICover Option	Default Value	Description
tsIncludes	List	-tsInclude		Recursively includes classes from the specified test suite package.
tsIncludeWs	List	-tsIncludeW		Includes classes from the specified test suite package without subpackages.
tsExcludes	List	-tsExclude		Recursively excludes classes from the specified test suite package.
apiIncludes	List	-apiInclude		Recursively includes classes from the specified API package.
apiIncludeWs	List	-apiIncludeW		Includes classes from the specified API package without subpackages.

**Table F-9 (Cont.) Optional Parameters (apicover-plugin:apicover)**

Name	Type	Corresponding APICover Option	Default Value	Description
apiExcludes	List	-apiExclude		Recursively excludes classes from the specified API package.
excludeLists	List	-excludeList		Specifies the file name of an exclude list that contains API elements to be excluded from the coverage calculation.
excludeInterfaces	boolean	-excludeInterface	FALSE	Excludes all interface classes.
excludeAbstractClasses	boolean	-excludeAbstract	FALSE	Excludes all abstract classes including interfaces.
excludeAbstractMethods	boolean	-excludeAbstract	FALSE	Excludes all abstract methods from all classes and interfaces
excludeFields	boolean	-excludeFields	FALSE	Excludes all fields from all classes and interfaces.
includeConstantFields	boolean	-includeConstant	FALSE	Specifies the inclusion of all final fields of any type in the coverage calculation.
mode	String	-mode	w (worst case)	Specifies the mode of coverage calculation as "w" which represents the worst case or "r" which represents the real world.
detail	String	-detail	2	Specifies the level of report detail as an integer from 0-4
format	String	-format	plain	Specifies the report format as plain text or XML. The values can be "plain" or "xml". Note that an example of the XML output is available in <i>SIGTEST_HOME/msc</i> .
report	String	-report	See the description.	Specifies the location of the generated report file. The path argument defaults to the working directory when only a file name is specified. If a file name is not specified, it defaults to the Maven logger
out	String	-out	See the description	Generates a specially formatted report file for use by other applications and places it at the specified location/file name. The path defaults to the working directory.

**Example F-4 Sample Plugin Configuration (pom.xml)**

&lt;project&gt;

```
    . . .
    <build>
        . . .
        <plugins>
            . . .
            <plugin>
                . . .
                <groupId>com.sun.tdk</groupId>
                <artifactId>apicover-plugin</artifactId>
                <configuration>
                    <api>publicAPIv3.sig</api>
                    <tests>
                        <test>${ts.path}/testSet1.jar</test>
                        <test>${ts.path}/testSet2.jar</test>
                        <test>${ts.path}/testSet3.jar</test>
                    </tests>
                    <apiIncludes>
                        <apiInclude>com.acme.api</apiInclude>
                    </apiIncludes>
                    <mode>r</mode>
                    <detail>4</detail>
                    <format>plain</format>
                    <report>${report.path}/covrep_real.txt</report>
                </configuration>
                . . .
            </plugin>
        . . .
    </plugins>
    . . .
</build>
. . .
</project>
```

---

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