

# Are You Covered?

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Coverage  
Tools Live

# What is Coverage?

Measurement of how well your tests exercise your code

Metric: percent coverage

Coverage tools modify bytecode, inserting counters, then report result

# Bytecode Modification

```
public class Hello
{
    public static void main(String[] argv)
    throws Exception
    {
        System.out.println("Hello, World");
    }
}
```

*javac*

```
public static void main(java.lang.String[])
throws java.lang.Exception;
Code:
  0:  getstatic      #19; //Field
java/lang/System.out:Ljava/io/PrintStream;
  3:  ldc           #25; //String Hello, World
  5:  invokevirtual #27; //Method
java/io/PrintStream.println:(Ljava/lang/String;)V
  8:  return
```

```
public static void main(java.lang.String[])
throws java.lang.Exception;
Code:
  0:  getstatic     #41; //Field $VR4019:[]Z
  3:  iconst_1
  4:  aaload
  5:  astore_1
  6:  getstatic     #19; //Field
java/lang/System.out:Ljava/io/PrintStream;
  9:  ldc           #25; //String Hello,
World
 11:  invokevirtual #27; //Method
java/io/PrintStream.println:(Ljava/lang/String;)V
 14:  aload_1
 15:  iconst_0
 16:  iconst_1
 17:  bastore
 18:  return
```

*emma*

# Levels of Coverage

Class / Method / Line

Obsolete

Basic Block

Inserts counters after every branch

Shows partial coverage of if / loop / ternary

# Reporting

The screenshot shows a Mozilla Firefox browser window titled "Coverage Report - Mozilla Firefox". The address bar shows the file path: `file:///C:/tmp/site/cobertura/index.html`. The page content is a "Coverage Report - All Packages" table. The table has columns for Package, # Classes, Line Coverage, Branch Coverage, and Complexity. The data is as follows:

Package	# Classes	Line Coverage	Branch Coverage	Complexity
<b>All Packages</b>	44	94% 1629/1737	93% 809/871	3.786
<a href="#">net.sf.practicalxml</a>	9	92% 509/553	91% 257/283	3.333
<a href="#">net.sf.practicalxml.builder</a>	10	94% 91/97	90% 18/20	1
<a href="#">net.sf.practicalxml.converter</a>	3	77% 17/22	0% 0/2	0
<a href="#">net.sf.practicalxml.converter.bean</a>	11	95% 291/306	97% 163/168	0
<a href="#">net.sf.practicalxml.converter.internal</a>	17	95% 126/133	89% 34/38	0
<a href="#">net.sf.practicalxml.converter.json</a>	5	97% 232/238	89% 127/142	9.75
<a href="#">net.sf.practicalxml.internal</a>	1	97% 28/29	94% 34/36	4.75
<a href="#">net.sf.practicalxml.junit</a>	1	84% 31/37	100% 2/2	0
<a href="#">net.sf.practicalxml.util</a>	5	61% 14/23	100% 4/4	1
<a href="#">net.sf.practicalxml.xpath</a>	9	97% 271/278	96% 158/164	0
<a href="#">net.sf.practicalxml.xpath.function</a>	4	90% 19/21	100% 12/12	0

The browser window also shows a sidebar with "Packages" and "Classes" sections. The "Classes" section lists various classes with their coverage percentages, such as `AbstractFunction (93%)`, `AttributeNode (100%)`, `Bean2XmlAppenders (90%)`, `Bean2XmlConverter (92%)`, `Bean2XmlOptions (100%)`, `BeanConverter (80%)`, and `CommentNode (100%)`. The status bar at the bottom indicates "Done" and "Fiddler: Disabled".

# Tools

## Cobertura

<http://cobertura.sourceforge.net/>

Plugins for Ant, Maven 2

Licensed under GPL

## Emma

<http://emma.sourceforge.net/>

Plugins for Ant, Maven 1, Eclipse

Can instrument on-the-fly via classloader

Licensed under IBM CPL

# When to Run?

## Daily or after Significant Change

Every build is too often

“Just before release” is not enough

Run first thing in morning, or after lunch

IDE integration encourages usage

Useful habit: follow with FindBugs™

# Coverage Beyond the Unit Test

## Interactive (desktop) applications

Instrumentation adds minimal overhead

Goal: identify action invocations (class-level coverage sufficient)

## In-container testing of web-apps

Integration tests

Check on manual QA

# The Problem

Coverage tools can only tell you whether your tests exercise your code

They won't tell you about missing features or missed specifications

The report can be misleading

You can get 100% coverage without fully testing your code

# Misleading Reports

It's easy to put counters in bytecode

It's harder to tie back to Java

Particularly if Hotspot modifies that code

Different tools may report different coverage for same code

Example: switch statement

# Independent Paths

How many paths through this code?

```
public int myFunc(int a, int b, int c)
{
    if (a > 5)
        c += a;
    if (b > 5)
        c += b;
    return c;
}
```

How many tests for 100% coverage?

```
assertEquals(2, myFunc(2, 2, 2));
assertEquals(21, myFunc(7, 7, 7));
```

# Independent Paths

Every non-trivial program has independent paths

Number of paths increases geometrically with number of “ifs”

Multi-threaded programs add time dimension — infinite number of paths

# Independent Path Identification

## Truth Table

Can become unmanageable

Useful as checklist for high-level code

## Cyclomatic Complexity

Generated as part of Cobertura report

Bob Martin's "C.R.A.P." index

# Independent Path Resolution

Refactor Mercilessly

Goal: one decision per method

High-level tests simply verify that lower-level methods were called

# Exceptions

Most tests verify “happy path”

Need tests for likely exceptions

Understand boundary conditions

Not all exceptions can/should be tested

- Configuration exceptions from third-party libraries

- Exceptions that are rethrown or logged

# Missing Features

“That test, I do not think it tests what you think it tests”

Tests should be tied to specifications

Are any specifications sufficiently detailed?

# What about TDD?

## Formal Test Driven Development:

Write minimal failing unit test

Write minimal mainline code to pass this test

Refactor and repeat

This guarantees 100% coverage!

Beware when removing duplicated code

Coverage tools useful to find dead code

Sometimes, different code does different stuff

# What about Getters & Setters?

Should be tested as part of normal use

Don't write tests just to validate they work

If not, why are they there?

Is your code accessing the underlying members?

Or is the data never used?

# Code That Can't Be Tested

## Unreachable code

Example: default switch clause for enum

## Exceptions that require drastic effort to induce

Example: configuration exception for JDK XML parser

Should such code even exist?

# The Bottom Line

Coverage tools are valuable

They clearly highlight code that isn't tested / used

100% coverage is unreasonable

Defensive coding may create unreachable code

100% coverage is not enough

Tests need to validate, not simply exercise

# The Real Bottom Line

There's no substitute for a  
dedicated, thoughtful,  
test-infected programmer

# For More Information

<http://www.kdgregory.com/index.php?page=junit.coverage>