Coverage tools

- Program is typically compiled with special options, to add extra source or object code.
  - Additional data structures, such as a flow graph, may also be created.
- Program is run, possibly via test cases
  - During execution, information is accumulated and written to an output file.
- Post-processing phase:
  - User report is generated from output file.

Java Code Coverage Library (JaCoCo)

- Open-source tool
  - Supports class, method, "basic block", and line coverage.
  - "Fractional" line coverage supported, but not branch coverage.
  - Standalone version works with Ant builds
  - http://emma.sourceforge.net
  - Eclipse plugin EclEmma also available
  - http://www.eclemma.org

Block Coverage

- Block coverage assumes that if a block of statements without branches is entered and exited, all statements in the block were executed.
  - That is, the counter is at the end of the block, instead of before the source code statement.
- Result: If an exception occurs in the block, the entire block is not recorded as having executed.
  - This may be fine for application source code, but it does not work well with JUnit test source code or in code for which exceptions are commonplace.
  - JUnit throws exceptions internally when tests fail, so the test may not have appeared to be executed.

Emma coverage report

Java - MyMathTest.java - Eclipse SDK

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Problems | Javadoc | Declaration | Coverage

MyMathTest (1-Feb-2007 1:32:08 PM)

Element	Coverage	Covered Lines	Total Lines
JUnit demo	18.6 %	8	43
src	42.9 %	3	7
csi5118	42.9 %	3	7
MyMath.java	42.9 %	3	7
MyMath	42.9 %	3	7
div(int, int)	100.0 %	3	3
main(String[])	0.0 %	0	3
test	13.9 %	5	36
csi5118	13.9 %	5	36
MyMathTest.java	31.2 %	5	16
MyMathTest	31.2 %	5	16
suite()	0.0 %	0	1
testDivError()	0.0 %	0	4
testDivException()	0.0 %	0	2
testDivFail()	0.0 %	0	4
testDivPass()	100.0 %	4	4
MyMathTest3.java	0.0 %	0	20

Instruction Counters
Block Counters
• Line Counters
Method Counters
Type Counters

Emma coverage report

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Emma source code annotations

Java - MyMathTest.java - Eclipse SDK

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Package Explorer | JUnit

Finished after 0.531 seconds

Runs: 4/4 Errors: 1 Failures: 1

csi5118.MyMathTest [Runner: JUnit 4]
- testDivPass
- testDivFail
- testDivError
- testDivException

Failure Trace

java.lang.AssertionError: expected:<19> but was:<3>
at csi5118.MyMathTest.testDivFail(MyMathTest.java:4

MyMathTest.java

```
25      */
26     @Test
27     public void testDivPass( )
28     {
29         int expected = 3;
30         int actual = MyMath.div( 6, 2 );
31
32         assertEquals( expected, actual );
33     }
34
35     /**
36      * Test method for {@link csi5118.MyMath#div(int, i
37      */
38     @Test
39     public void testDivFail( )
40     {
41         int expected = 19;
42         int actual = MyMath.div( 6, 2 );
43
44         assertEquals( expected, actual );
45     }
46     /**
47      * Test method for {@link csi5118.MyMath#div(int, i
48      */
49     @Test
```

Fractional line coverage

```
1  public class MyClass
2  {
3      public static void main (final String [] args)
4      {
5          int vi = 1;
6          int vj = vi > 0 ? -1 : 1;
7
8          for (int vk = 0; vk < vj; ++ vk)
9          {
10             System.out.println ("vk = " + vk);
11         }
12     }
13
14     public MyClass () {}
15 }
```

Only part of conditional executed

Loop increment not executed

CodeCover

- Open source Eclipse plug in
  - Web site: http://codecover.org

- Performs source-code instrumentation to obtain:
  - Statement coverage
  - Branch coverage
  - Loop coverage: loop executed zero/once/many times.
  - MC/DC Coverage (Term coverage)
  - ?-Operator Coverage
  - Synchronized Operations Coverage

CodeCover summary report

Name	Statement	Branch	Loop	Term	?-Operato	Synchronized
BitTest	16.7 %	33.3 %	–	28.6 %	0.0 %	–
demo	16.7 %	33.3 %	–	28.6 %	0.0 %	–
Bit	16.7 %	33.3 %	–	28.6 %	0.0 %	–
hashCode	0.0 %	–	–	–	0.0 %	–
Bit	0.0 %	–	–	–	–	–
Bit	0.0 %	–	–	–	–	–
Bit	0.0 %	–	–	–	–	–
Bit	100.0 %	–	–	–	–	–
and	100.0 %	–	–	–	–	–
equals	33.3 %	50.0 %	–	50.0 %	–	–
getIntValue	0.0 %	0.0 %	–	0.0 %	–	–
not	0.0 %	–	–	–	–	–
or	0.0 %	–	–	–	–	–
setValue	0.0 %	0.0 %	–	0.0 %	–	–
setValue	0.0 %	–	–	–	–	–
toString	0.0 %	–	–	–	–	–
xor	0.0 %	–	–	–	–	–

CodeCover detailed report

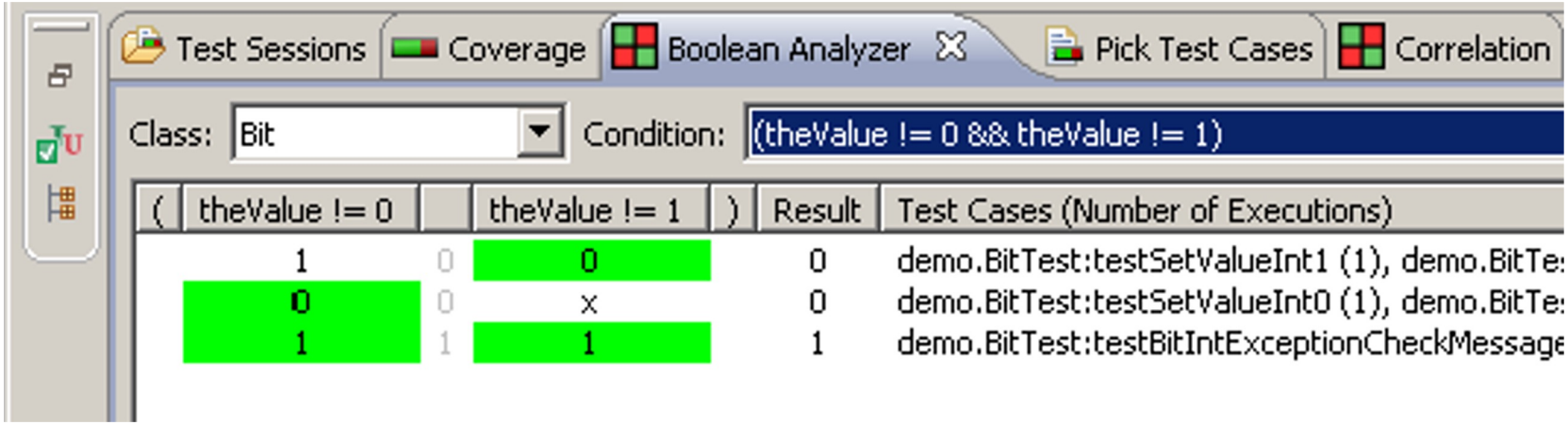
```
191         // Identity check
192
193         if ( this == obj )
194             return true;
195
196         // Null operand check
197
198         if ( obj == null )
199             return false;
200
201         // Type of objects must be the same
202
203         if ( getClass( ) != obj.getClass( ) )
204             return false;
205
206         // We now know there are two distinct Bit objects.  Compare their values.
207
208         final Bit other = ( Bit ) obj;
209         if ( value != other.value )
210             return false;
211         return true;
212     }
```

Unexecuted branches: then

CodeCover features

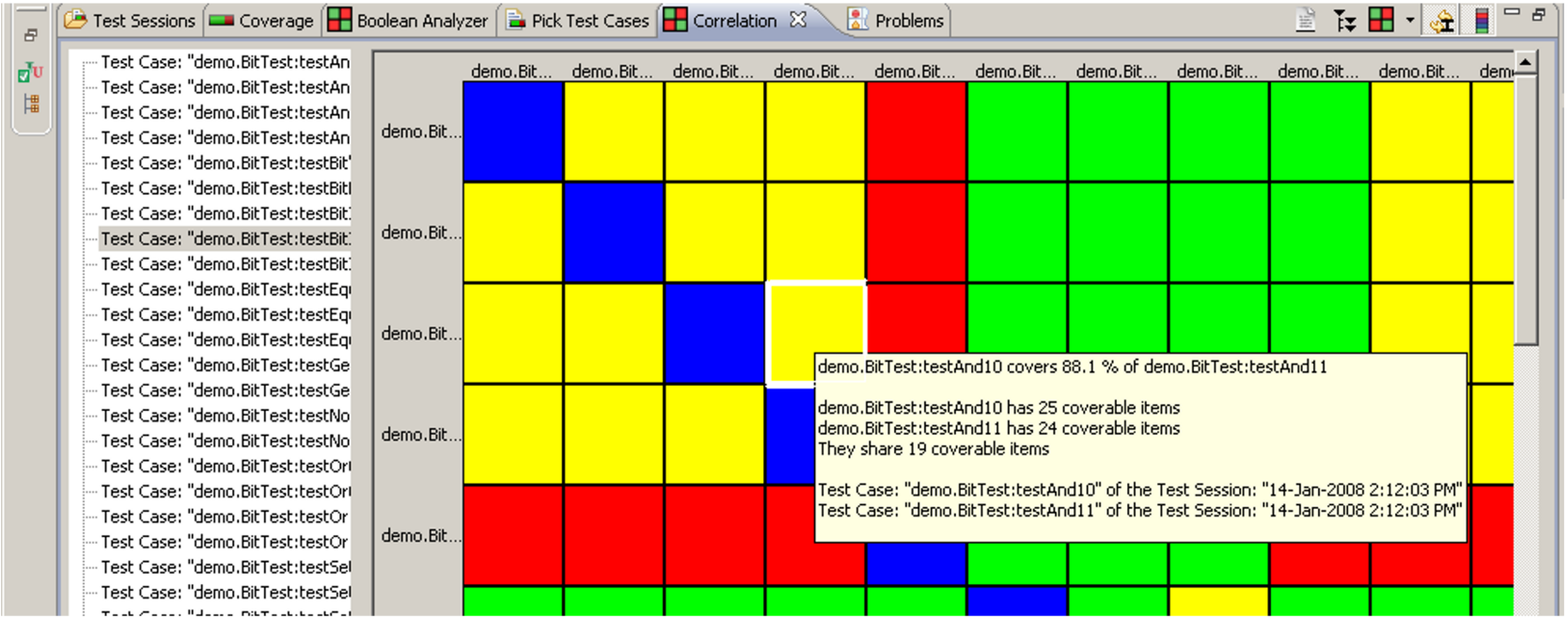
- Boolean value analyzer: shows how many Boolean combinations in conditions have been covered.
- Code "hot spots": highlighting of code that is executed more frequently than most.
- Test correlation matrix: for each pair of test cases, the overlap in coverage for the two test cases is shown.

CodeCover Boolean analyzer



- For the compound condition shown, combinations of atomic conditions that have occurred are shown.
  - The **x** shows a short-circuit evaluation.

CodeCover Correlation view



- The colours give an indication of the overlap for pairs of test cases.
  - The selected square shows that for these two test cases, they have 24 and 25 coverable items, and that 19 are shared, for an overlap of 88.1%

References

- Emma:
  - http://emma.sourceforge.net
  - http://www.eclemma.org

- CodeCover: http://codecover.org

- A. Glover, "Don't be fooled by the Coverage Report", IBM developer works article

  http://www-128.ibm.com/developerworks/java/library/j-cq01316

- S. Gornett, "Code Coverage Analysis"
  - http://www.bullseye.com/coverage.html