



SENG3320/6320: Software Verification and Validation

School of Electrical Engineering and Computing

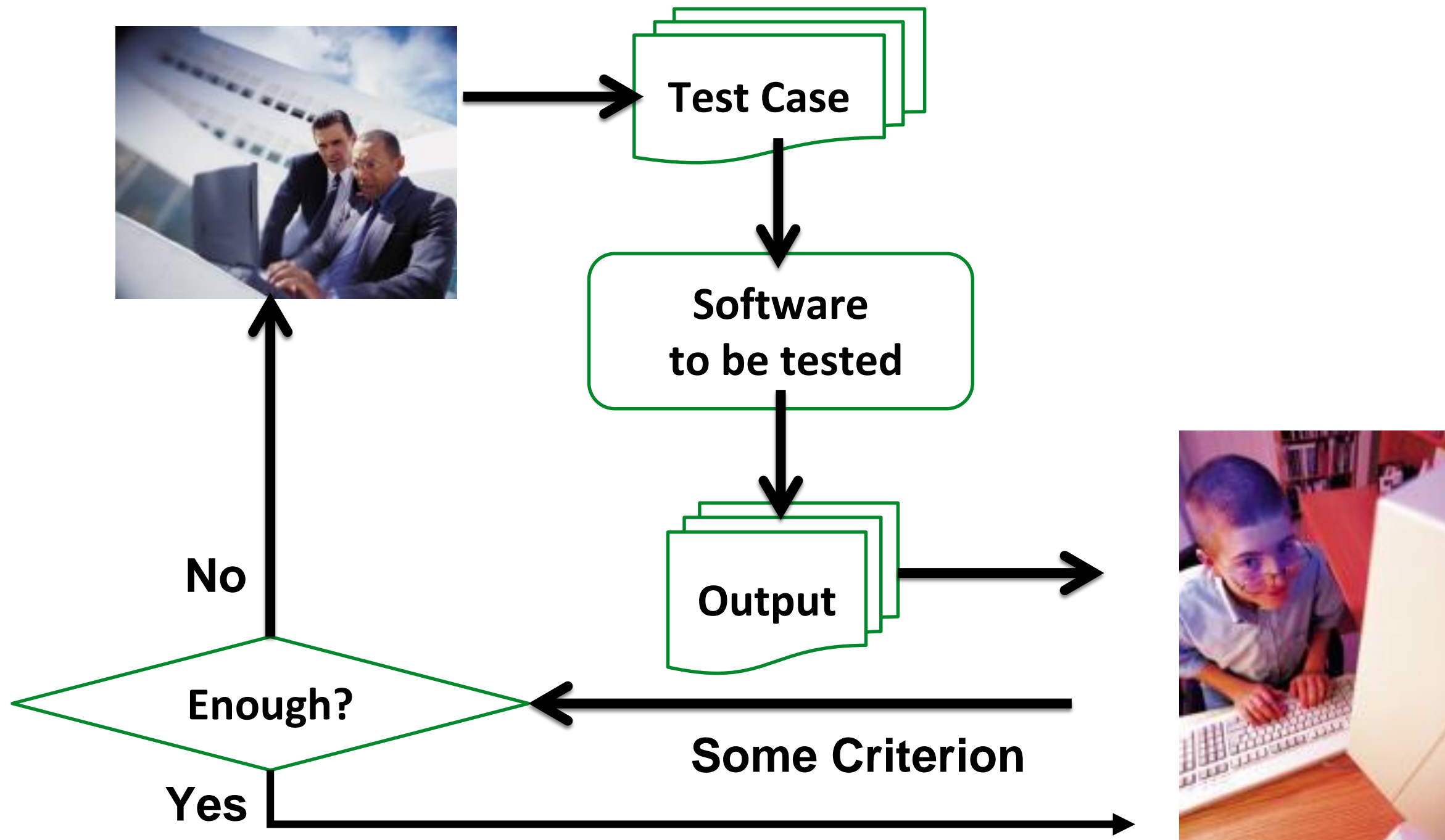
Semester I, 2020



Software Testing Tools – JUnit

A Typical Software Testing Process

Test case generation



```
package test;
```

```
public class myClass {
```

```
    public static void main(String[] args) {
```

```
        myClass t = new myClass();
```

```
        int n = t.checkbool(10, true, false);
```

```
        System.out.println("the check boolean result is " + n);
```

```
        n = t.checkbool(11, false, false);
```

```
        System.out.println("the check boolean result is " + n);
```

```
        n = t.checkbool(10, true, true);
```

```
        System.out.println("the check boolean result is " + n);
```

```
    }
```

```
    public int checkbool(int x, boolean a, boolean b) {
```

```
        if(a)
```

```
            x++;
```

```
        if(b)
```

```
            x--;
```

```
        return x;
```

```
    }
```

the check boolean result is 11

the check boolean result is 11

the check boolean result is 10

Tool support - testing framework

- xUnit
 - Created by Kent Beck in 1989
 - This is the same guy who invented XP and TDD
 - The first one was sUnit (for smalltalk)
 - There are about 70 xUnit frameworks for corresponding languages
- JUnit
 - A simple, flexible, easy-to-use, open-source, and practical xUnit framework for Java.
 - Can deal with a large and extensive set of test cases.
 - Refer to www.junit.org.

Terms

- Test Case: a set of test inputs, execution conditions, and expected results developed for a particular objective, such as to exercise a particular program path or to verify compliance with a specific requirement
- Test oracle: The expected outputs of software for given input. It is a part of a test case.
- Test driver: a software framework that can load a collection of test cases or a test suite.
- Test suite: a collection of test cases.

```
package test;
```

```
import static org.junit.jupiter.api.Assertions.*;  
import org.junit.jupiter.api.Test;
```

```
public class junit_test {  
    myClass t;
```

```
@Test
```

```
void testBool_1() {  
    t = new myClass();  
    assertEquals(11, t.checkbool(10, true, false));  
    assertEquals(10, t.checkbool(10, true, true));  
}
```

Test case

assertEquals([msg],
expected, actual)

Check that the two values
are equal

Test oracle

Limitation: Not clear which test case caused the failure

```
package test;
```

```
import static org.junit.jupiter.api.Assertions.*;  
import org.junit.jupiter.api.Test;
```

```
public class junit_test {  
    myClass t;
```

```
@Test  
void testBool_1() {  
    t = new myClass();  
    assertEquals(11, t.checkbool(10, true, false));  
}
```

Test case

```
@Test  
void testBool_2() {  
    t = new myClass();  
    assertEquals(10, t.checkbool(10, true, true));  
}
```

Test oracle

A Better Way

Eclipse Support

- Junit is supported by Eclipse

eclipse-workspace - test/src/test/junit_test.java - Eclipse IDE

File Edit Source Refactor Navigate Search Project Run Window Help

Package Explorer JUnit

Finished after 0.156 seconds

Runs: 2/2 Errors: 0 Failures: 0

Failure Trace

```

1 package test;
2
3 import static org.junit.jupiter.api.Assertions.*;
4
5
6 public class junit_test {
7     myClass t;
8
9     @Test
10    void testBool_1() {
11        t = new myClass();
12        assertEquals(11, t.checkbool(10, true, false));
13    //    assertFalse(11 == t.checkbool(10, true, false));
14    }
15
16    @Test
17    void testBool_2() {
18        t = new myClass();
19        assertEquals(10, t.checkbool(10, true, true));
20    }

```

Problems Javadoc Declaration Search Console Coverage

junit_test (29/02/2020 9:55:47 PM)

Element	Coverage	Covered Instructi...	Missed Instructi...	Total Instructions
test	12.8 %	42	285	327
junit_test.java	100.0 %	31	0	31
myClass.java	10.7 %	11	92	103

Writable Smart Insert 15 : 5

IntelliJ Support

- Junit is also supported by others IDEs such as IntelliJ

SENG3160 - [D:\SENG3160] - [SENG3160] - ...test\abc\com\MyEvenOddTest.java - IntelliJ IDEA 2017.2.2

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

SENG3160 > test > abc > com > MyEvenOddTest

Project: out, Reports, src, abc.com (50% classes, 61% lines covered), MyEvenOdd (100% methods, 100% lines covered), Time (0% methods, 0% lines covered), test, abc.com, MyEvenOddTest, TestAll, TimeTest, Testing-Course-Web-Demo

MyEvenOddTest.java

```

21 expected = 5;
22 actual = MyEvenOdd.median( x: 5, y: 8, z: 1);
23 Assert.assertSame( message: "The median number sho
24 }
25
26 @Test
27 public void testMedian_Y() {
28     // x<=y<=z
29     int expected = 6;
30     int actual = MyEvenOdd.median( x: -6, y: 6, z: 12);
31     Assert.assertSame( message: "The median number sho
32     // z<=y<=x
33     expected = 6;
34     actual = MyEvenOdd.median( x: 10, y: 6, z: 6);
35     Assert.assertSame( message: "The median number sho

```

Coverage MyEvenOddTest

50% classes, 61% lines covered in 'all classes in scope'

Element	Class, %	Method, %	Line, %
abc.com	50% (1/2)	66% (2/3)	61% (16/26)

Run MyEvenOddTest

4 tests done: 1 failed - 18ms

MyEvenOddTest (abc.com) 18ms

- testMedian_X 3ms
- testMedian_Y 14ms
- testMedian_Z 0ms
- isEvenNumber 1ms

"C:\Program Files\Java\jdk1.8.0_121\bin\java" ...

---- IntelliJ IDEA coverage runner ----

tracing and tracking per test coverage ...

include patterns:

abc\com\..*

exclude patterns:

java.lang.AssertionError: The median number should be 6. expected same:<6> was not:<7>

Expected :6

Actual :7

[<Click to see difference>](#)

<3 internal calls>

at abc.com.MyEvenOddTest.testMedian_Y(MyEvenOddTest.java:35) <22 internal calls>

JUnit: annotations

Annotation	Description
@Test	Identify test methods
@Test (timeout=100)	Fail if the test takes more than 100ms
@Before	Execute before each test method
@After	Execute after each test method
@BeforeClass	Execute before each test class
@AfterClass	Execute after each test class
@Ignore	Ignore the test method

JUnit: assertions

Assertion	Description
<code>fail([msg])</code>	Let the test method fail, optional msg
<code>assertTrue([msg], bool)</code>	Check that the boolean condition is true
<code>assertFalse([msg], bool)</code>	Check that the boolean condition is false
<code>assertEquals([msg], expected, actual)</code>	Check that the two values are equal
<code>assertNull([msg], obj)</code>	Check that the object is null
<code>assertNotNull([msg], obj)</code>	Check that the object is not null
<code>assertSame([msg], expected, actual)</code>	Check that both variables refer to the same object
<code>assertNotSame([msg], expected, actual)</code>	Check that variables refer to different objects

Task 1: Design jUnit test cases for the Median function.

Task 2: Compute test coverage

Task 3: Design more test cases to achieve 100% statement, branch and path coverage.

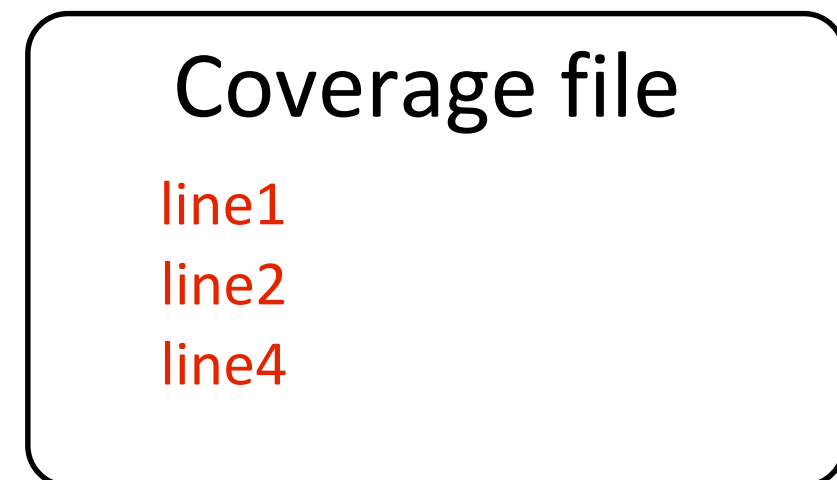
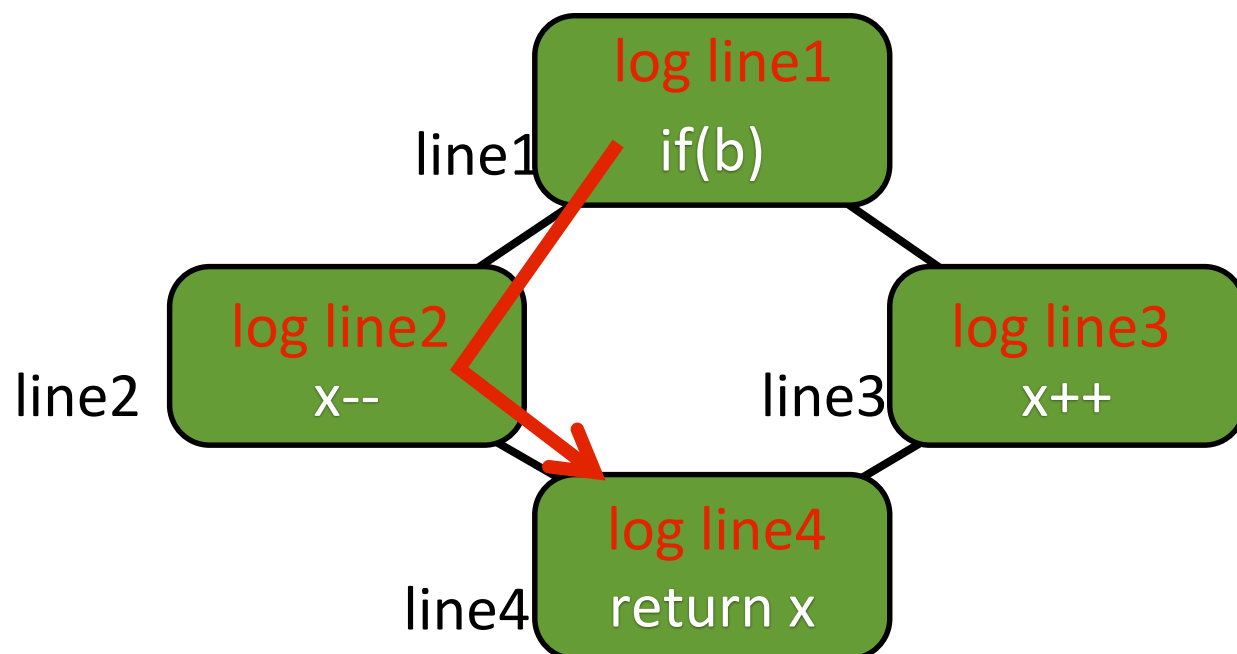
```
public static int median(int x, int y, int z) {  
    int median = 0;  
    if (x >= y && x <= z) { // y<=x<=z  
        median = x;  
    } else if (x >= z && x <= y) { // z<=x<=y  
        median = x;  
    } else if (y >= x && y < z) { // x<=y<=z  
        median = y;  
    } else if (y >= z && y <= x) { // z<=y<=x  
        median = y;  
    } else { // x<=z<=y or y<=z<=x  
        median = z;  
    }  
    return median;  
}
```



Software Testing Tools – EclEmma

Coverage collection: mechanism

- The code under test is instrumented (source/binary)
 - Log code that writes to a trace file is inserted in every branch, statement etc.
- When the instrumented code is executed, the coverage info will be written to trace file



Tool support - coverage collection

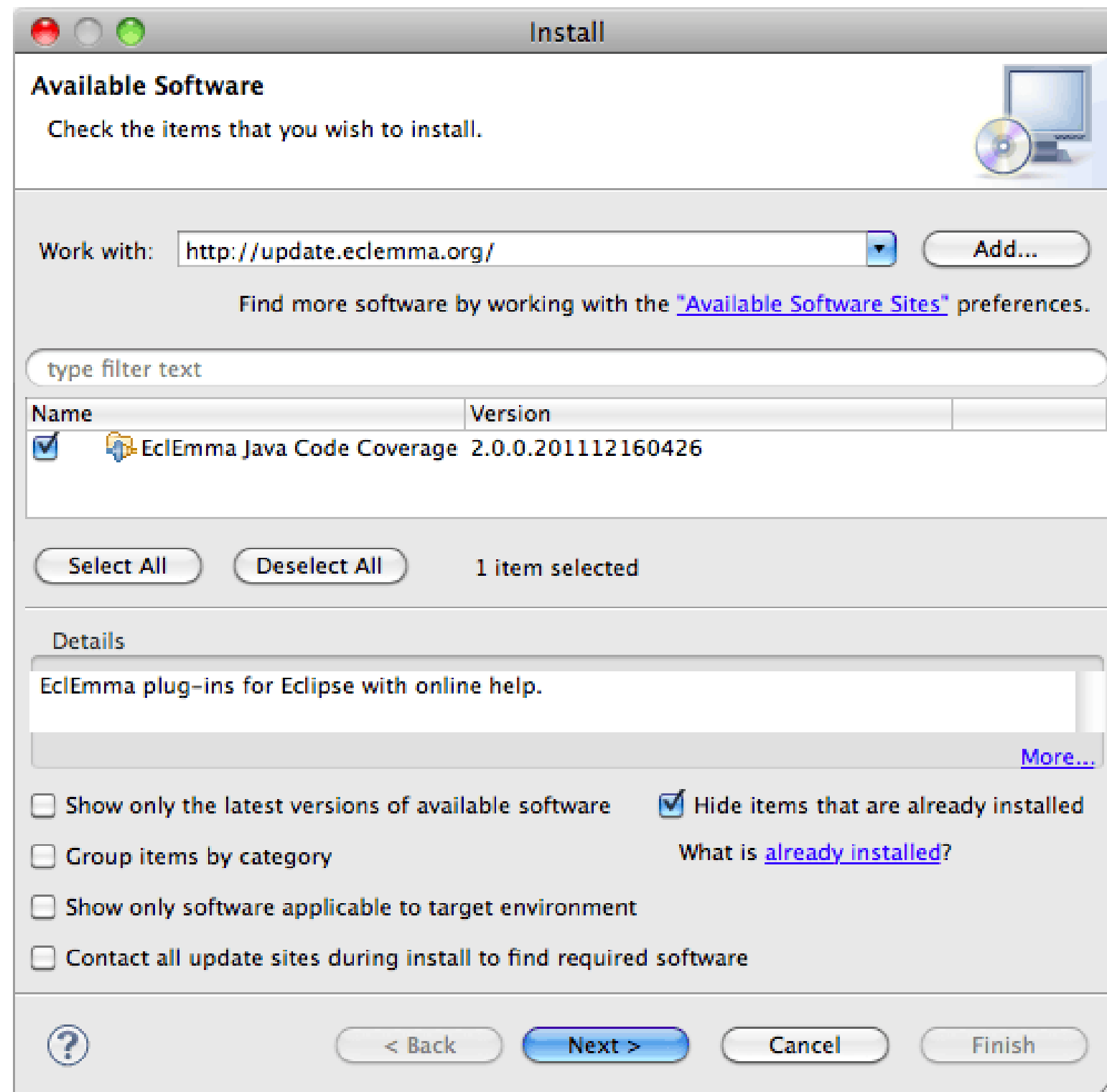
- Emma: <http://emma.sourceforge.net/>
- Eclemma: <http://www.eclemma.org/installation.html/>
- Cobertura: <http://cobertura.github.io/cobertura/>
- Clover: <https://www.atlassian.com/software/clover/overview>
- JCov: <https://wiki.openjdk.java.net/display/CodeTools/jcov>
- JaCoCo: <http://www.eclemma.org/jacoco/>

EclEmma: installation


- From your Eclipse menu select Help → Install New Software...
- In the Install dialog enter <http://update.eclemma.org/> at the Work with field
- Check the latest EclEmma version and press Next
- Follow the steps in the installation wizard.

EclEmma: installation

- From your Eclipse menu select Help → Install New Software...
- In the Install dialog enter <http://update.eclEmma.org/> at the Work with field
- Check the latest EclEmma version and press Next
- Follow the steps in the installation wizard.



EclEmma: execution

- The installation was successful if you can see the coverage launcher in the toolbar of the Java perspective:
- Coverage collection 







Properties for org.apache.commons.collections.bag

type filter text

► Resource
Coverage
 Run/Debug Settings

Coverage

Session: TestAllPackages (Oct 21, 2011 7:09:41 AM)

Counter	Coverage	Covered	Missed	Total
 Instructions	65.9 %	924	478	1402
 Branches	76.9 %	83	25	108
 Lines	66.9 %	234	116	350
 Methods	54.9 %	73	60	133
 Types	94.4 %	17	1	18
 Complexity	57.2 %	107	80	187

?

Cancel OK

EclEmma: Demo

eclipse-workspace - Eclipse IDE

File Edit Source Refactor Navigate Search Project Run Window Help

Package Explo... JUnit

Finished after 0.15 seconds

Runs: 2/2 Errors: 0 Failures: 0

Failure Trace

```

9      int m = median(20, 20, 30);
10     System.out.println("the median is " + m);
11 }
12
13 public String Hello() {
14     System.out.println("Hello, World");
15     return "Hello, World";
16 }
17
18 public static int median(int x, int y, int z){
19     int median = 0;
20     if(x >= y && x <= z){ // y<=x<=z
21         median = x;
22     }
23     else if(x >= z && x <= y){ // z<=x<=y
24         median = x;
25     } else if(y >= x && y < z){ // x<=y<=z
26         median = y;
27     } else if(y >= z && y <= x){ // z<=y<=x
28         median = y;
29     } else { // x<=z<=y or y<=z<=x
30         median = z;
31     }
32     return median;
33 }
34 }

```

Problems @ Javadoc Declaration Search Console Coverage

junit_test (02/03/2019 11:57:02 AM)

Element	Coverage	Covered Instructi...	Missed Instructi...	Total Instructions
test	46.3 %	44	51	95
junit_test.java	100.0 %	23	0	23
test.java	29.2 %	21	51	72

JUnit – Online Resources

https://www.tutorialspoint.com/junit/junit_quick_guide.htm

<http://www.vogella.com/tutorials/JUnit/article.html>

<https://help.eclipse.org/neon/index.jsp?topic=%2Forg.eclipse.jdt.doc.user%2FgettingStarted%2Fqs-junit.htm>

<https://blog.jetbrains.com/idea/2016/08/using-junit-5-in-intellij-idea/>

www.junit.org

Thanks!

