# Practical Unit Testing jUnit

Atul Prakash

## Unit Testing

- Software must be reliable for it to be useful
- You would not like a microwave oven or TV that keeps misbehaving. It could be even dangerous
- Same thing with software. Today, software controls your car, iPod, cellphone, your records at the university, etc. It is everywhere even though you don't see it.

## Role of Testing in Development

- Typically, companies spend 50-60% of their software budgets on testing. More than on development.
- If bugs remain in the code after release, it is usually expensive to fix them.
  - Bad publicity; releasing patches on a time cycle that is not under your control; legal liability; fixes may break other things; etc.

## Unit Testing

- As you write each module (e.g., class), write the corresponding tests.
- If you find a bug in your code that is not uncovered by testing, add a test case as well that exhibits the bug first. That way, you will prevent the bug from creeping back again.
- Software changes all the time. Testing helps ensure that changes don't break old tests.

## Testing we have seen so far...

- SpaceshipGameTest: we wrote that to test some of the functions provided by the game.
- Assignment 4:
  - SquareShipTest: test a square-shaped ship.
  - BirdOfPreyTest: test a ship of another shape

## Making testing convenient

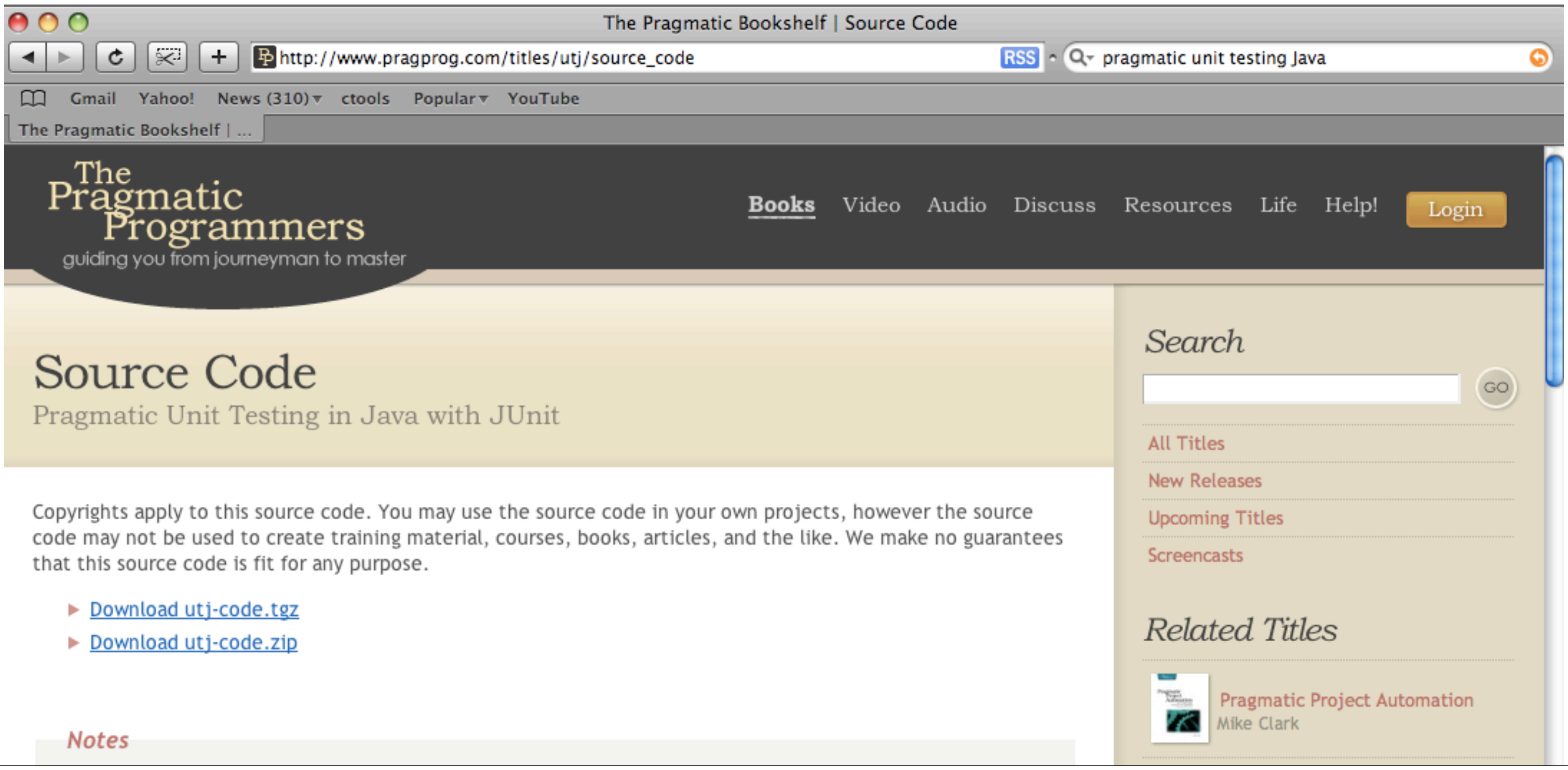
- Break your tests into small, independent tests. That way, you can say that your program passes m out of n tests. Fixes will be easier as well.
- What is it that you would like to see improved in the way we have been testing so far?

## jUnit

- jUnit is a standard unit testing framework for Java.
- pyUnit: similar framework in Python
- cppUnit: a similar framework for C++

# Sample Program and Test

- Download the zip file from Pragmatic Unit Testing book to a directory of your choice.


The Pragmatic Bookshelf | Source Code
http://www.pragprog.com/titles/utj/source_code
RSS
pragmatic unit testing Java
Gmail
Yahoo!
News (310)
ctools
Popular
YouTube
The Pragmatic Bookshelf | ...
The Pragmatic Programmers
guiding you from journeyman to master
Books
Video
Audio
Discuss
Resources
Life
Help!
Login
Search
GO
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Upcoming Titles
Screencasts
Related Titles
Pragmatic Project Automation
Mike Clark

Source Code

Pragmatic Unit Testing in Java with JUnit

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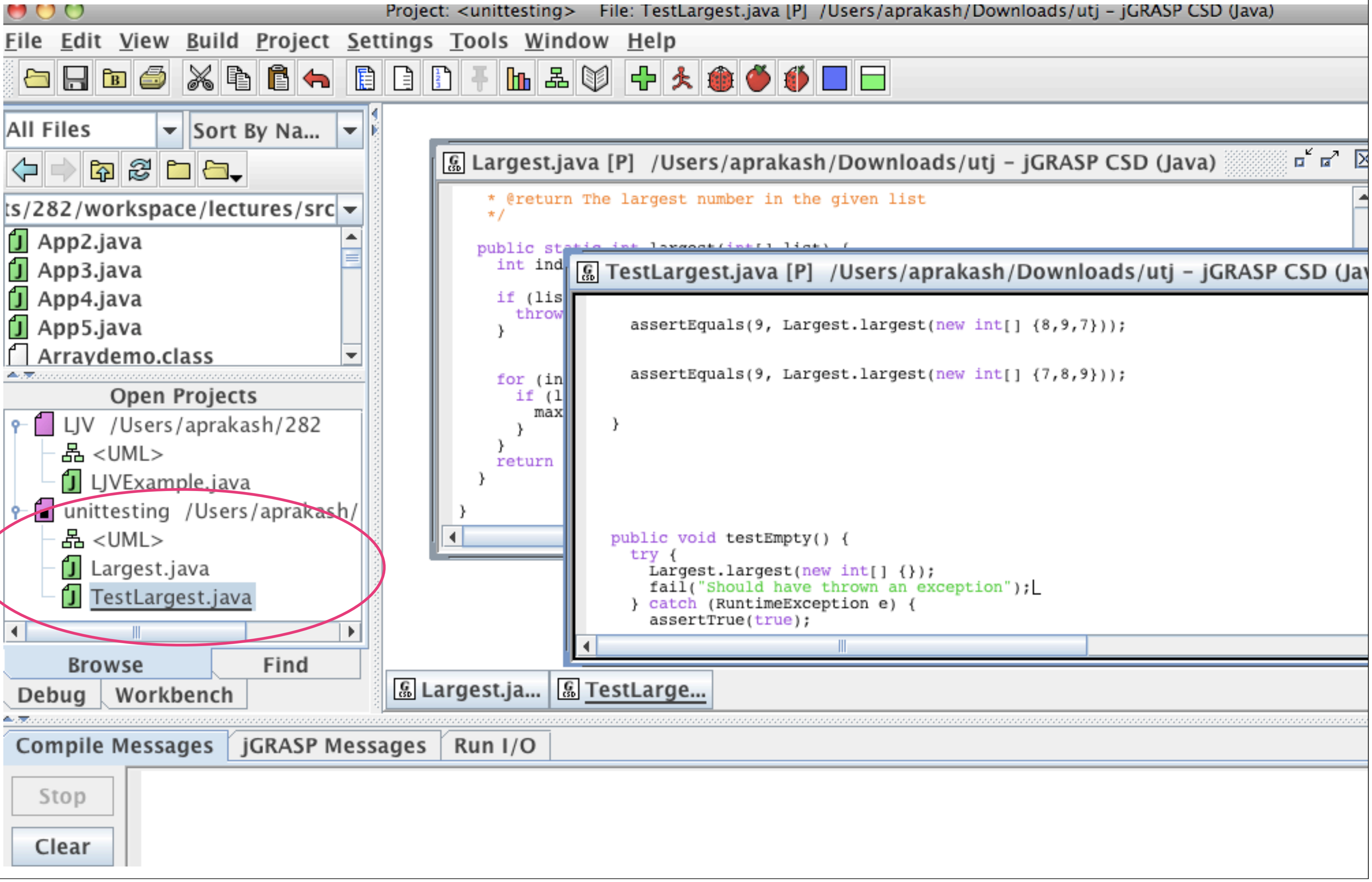
- Download utj-code.tgz
- Download utj-code.zip

Notes

## Add the files to jGrasp or Eclipse

- unzip the downloaded files to a directory.
- In jGrasp, go to Project -> New… and go to the directory containing the downloaded files. Create a project there called junittesting.
- Add the files "Largest.java" and "TestLargest.java" to the junittesting project.


Project: <unittesting>    File: TestLargest.java [P]  /Users/aprakash/Downloads/utj - jGRASP CSD (Java)
File Edit View Build Project Settings Tools Window Help
All Files
Sort By Na...
ts/282/workspace/lectures/src
App2.java
App3.java
App4.java
App5.java
Arraydemo.class
Open Projects
LJV  /Users/aprakash/282
<UML>
LJVExample.java
unittesting  /Users/aprakash/
<UML>
Largest.java
TestLargest.java
Browse
Find
Debug
Workbench
Largest.java [P]  /Users/aprakash/Downloads/utj - jGRASP CSD (Java)
TestLargest.java [P]  /Users/aprakash/Downloads/utj - jGRASP CSD (Ja
Largest.ja...
TestLarge...
Compile Messages
jGRASP Messages
Run I/O
Stop
Clear

```
   * @return The largest number in the given list
   */

  public st
    int ind

    if (lis
      throw
    }


    for (in
      if (l
        max
      }
    }
    return
  }

}
```

```
    assertEquals(9, Largest.largest(new int[] {8,9,7}));


    assertEquals(9, Largest.largest(new int[] {7,8,9}));


  }




  public void testEmpty() {
    try {
      Largest.largest(new int[] {});
      fail("Should have thrown an exception");
    } catch (RuntimeException e) {
      assertTrue(true);
```

## Take a few minutes ...

- Read through the tests that are there in the TestLargest.java. Understand what they are doing.
- Largest takes an int array and finds the largest value in that array

# Test structure

```java
import junit.framework.*;

public class TestLargest extends TestCase {

  public TestLargest(String name) {
    super(name);
  }

  public void testOrder() {

    assertEquals(9, Largest.largest(new int[] {9,8,7}));

    assertEquals(9, Largest.largest(new int[] {8,9,7}));


    assertEquals(9, Largest.largest(new int[] {7,8,9}));


  }

  public void testEmpty() {
    try {
      Largest.largest(new int[] {});
      fail("Should have thrown an exception");
    } catch (RuntimeException e) {
      assertTrue(true);
    }
  }


  public void testOrder2() {
    int[] arr = new int[3];
    arr[0] = 8;
    arr[1] = 9;
    arr[2] = 7;
    assertEquals(9, Largest.largest(arr));
  }

}
```

## Junit Tests

- Class inherits from TestCase
- Constructor needed as given.
- It provides a few new methods:
  - assertEquals(value, expression)
  - assertTrue(expr)
  - assertFalse(expr)
  - fail(msg)
- Each test run till it either completes or an assertion fails

## Assertions

- Assertions are simply a condition that you expect to be true at a given point in the program, based on its specs:
- We saw:
  - assert expression
- If the expression is false, the program quits.

# jUnit Assertions

- jUnit provides a few additional ways of expressing assertions.
- assertTrue(expr) is similar to
  - assert expr
- assertFalse(expr) is similar to:
  - assert !expr
- assertEquals(val, expr) is similar to:
  - assert val ==expr
- fail(msg) is similar to
  - assert false
  - But it also prints a msg.

# Example Test

```
public void testOrder2() {
  int[] arr = new int[3];
  arr[0] = 8;
  arr[1] = 9;
  arr[2] = 7;
  assertEquals(9, Largest.largest(arr));
}
```

## Equivalent test

```
public void testOrder2() {
  int[] arr = new int[3];
  arr[0] = 8;
  arr[1] = 9;
  arr[2] = 7;
  assertTrue(Largest.largest(arr) == 9);
}
```

## jUnit: Pros

- Unlike our tests so far, jUnit is more flexible. If one test fails (because an assertion failed), it continues to the next test.
- No main required. jUnit provides one in its junit.textui.TestRunner class.

## Digression: Java Code Organization

- Java provides a way to organize code
  - Not use a package: Default package
  - Using packages

## Packages

- Naming packages
  - The package names matches the directory name and can be hierarchical
    - java.util has classes stored in
      - [path-to-java-packages]/java/util

## Declaring your file to be within a package

- At the top of your source file, you add

```
package edu.um.eecs282.hello;

class HelloWorld {

   // …

}
```

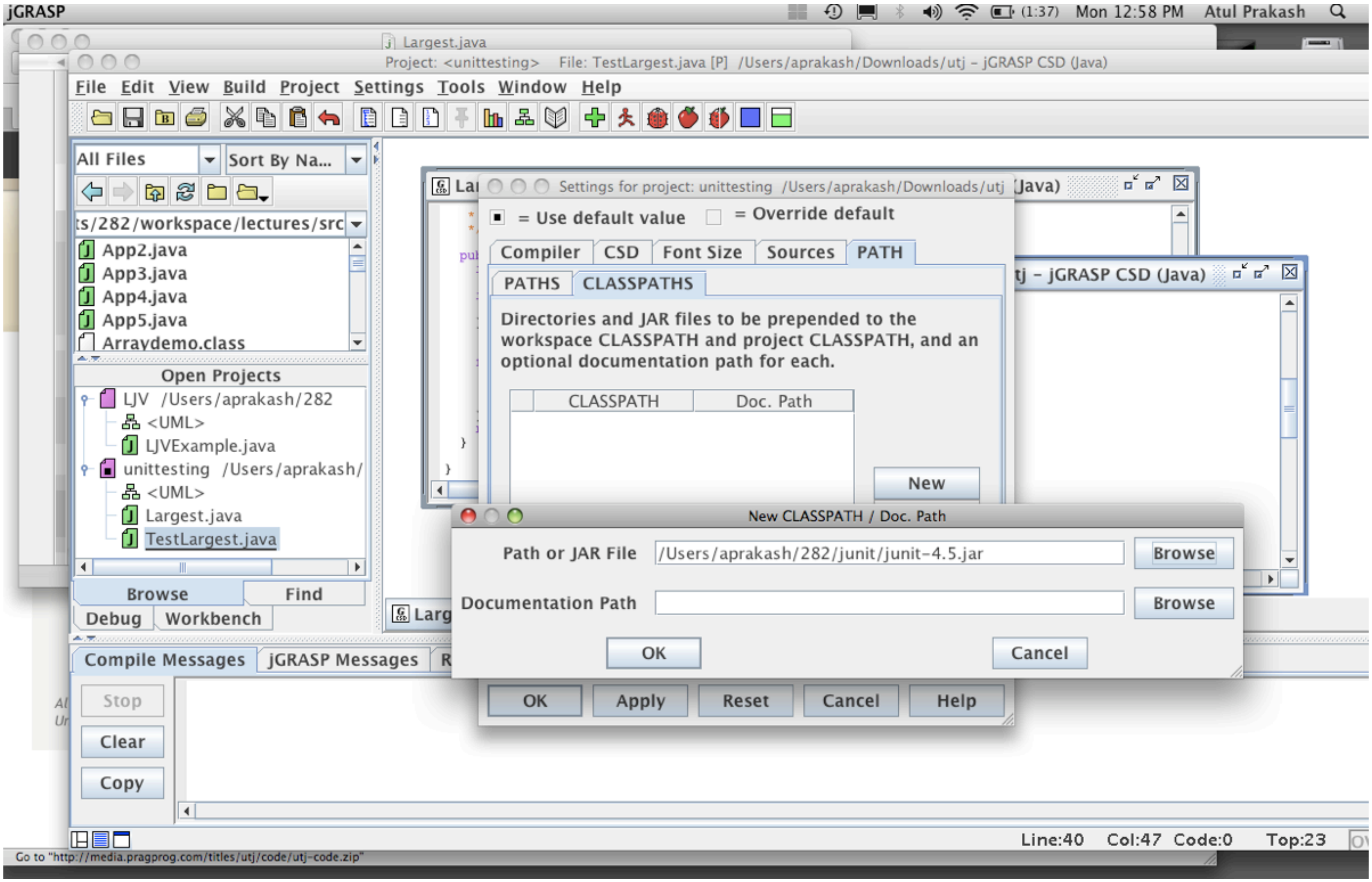
- For this example
  - File name = HelloWorld.java
  - Class name = HelloWorld.class
  - Location = [path-to]edu/um/eecs285/hello

# CLASSPATH

- jar files: Packages in Java are often compressed into a jar file. E.g., junit-4.5.jar.
  - To extract (you do not need to though), you can use the jar command:
    - jar xf junit-4.5.jar
- Java uses an environment variable called CLASSPATH to find jar files or other packages.
  - Format: dir1;dir2…;dirN on Windows
  - dir1:dir2:…:dirN on Unix/Mac OS.

# jGrasp and jUnit

- You need to tell jGrasp where the jUnit package is.
- Go to Settings -> Path/ClassPath -> Project …
- Add the directory containing junit's jar file to the path.



Settings for project: unittesting /Users/aprakash/Downloads/utj

■ = Use default value   ☐ = Override default

Compiler | CSD | Font Size | Sources | PATH

PATHS | CLASSPATHS

Directories and JAR files to be prepended to the workspace CLASSPATH and project CLASSPATH, and an optional documentation path for each.

| | CLASSPATH | Doc. Path |
|---|---|---|

New CLASSPATH / Doc. Path

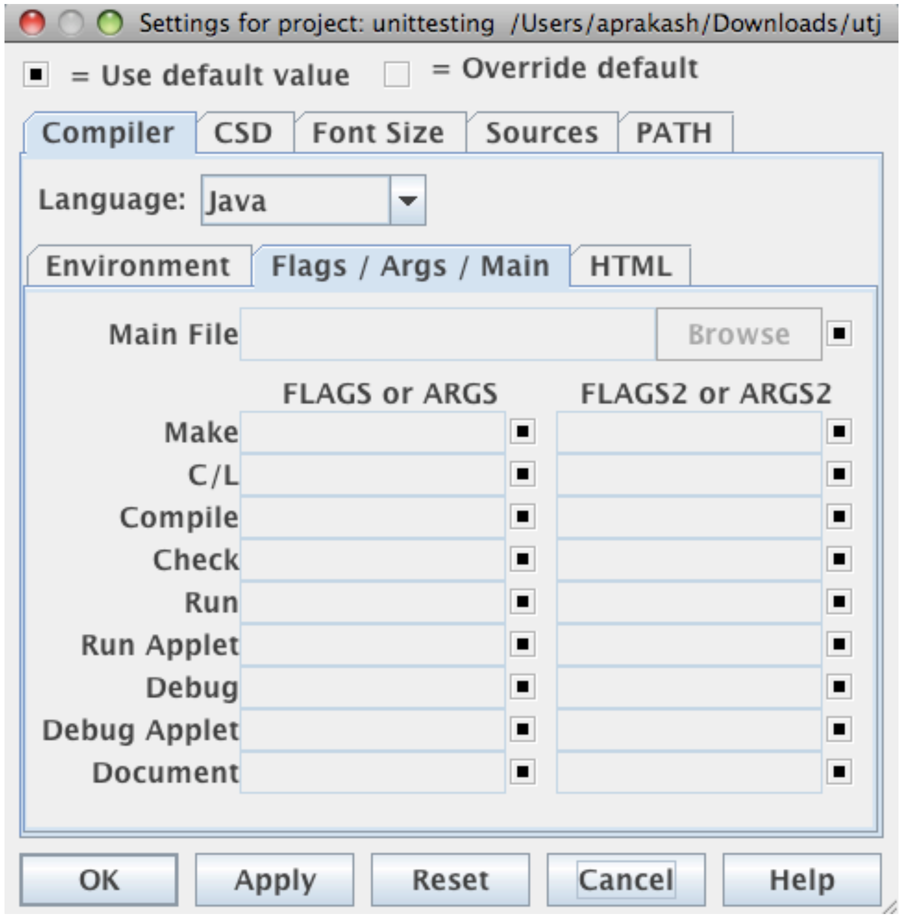
Path or JAR File: /Users/aprakash/282/junit/junit-4.5.jar

Documentation Path:

# jGrasp and jUnit

- jUnit provides its own main method for running tests. From command-line (provided your CLASSPATH includes junit's jar file):
  - java junit.textui.TestRunner TestLargest
- Tell jGrasp to use that:
  - Settings->Compiler Settings -> Project <unittesting>

- Select the Flags/Args tab under Compiler

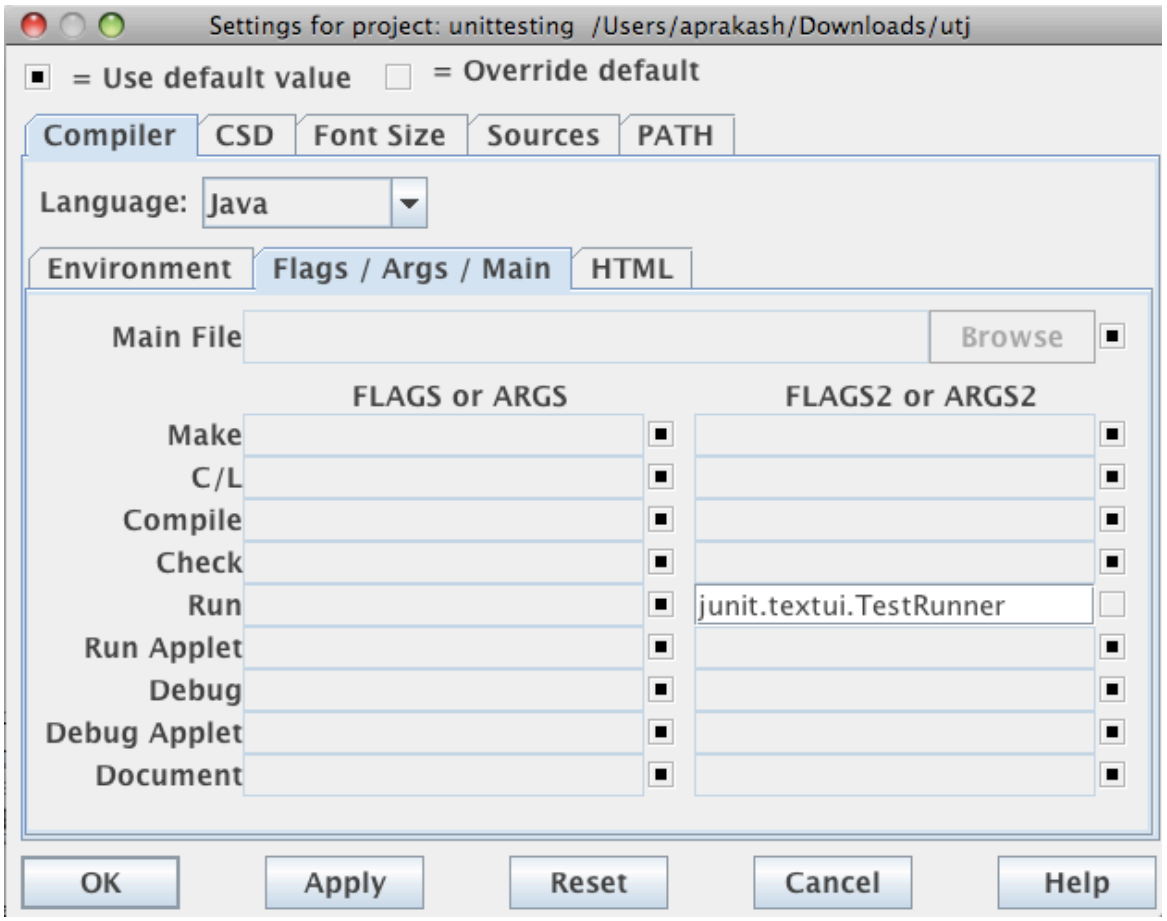


Language: Java

Main File ■

| | FLAGS or ARGS | | FLAGS2 or ARGS2 | |
|---|---|---|---|---|
| Make | | ■ | | ■ |
| C/L | | ■ | | ■ |
| Compile | | ■ | | ■ |
| Check | | ■ | | ■ |
| Run | | ■ | | ■ |
| Run Applet | | ■ | | ■ |
| Debug | | ■ | | ■ |
| Debug Applet | | ■ | | ■ |
| Document | | ■ | | ■ |

# Modify FLAG2 for Run



Settings for project: unittesting /Users/aprakash/Downloads/utj

■ = Use default value ☐ = Override default

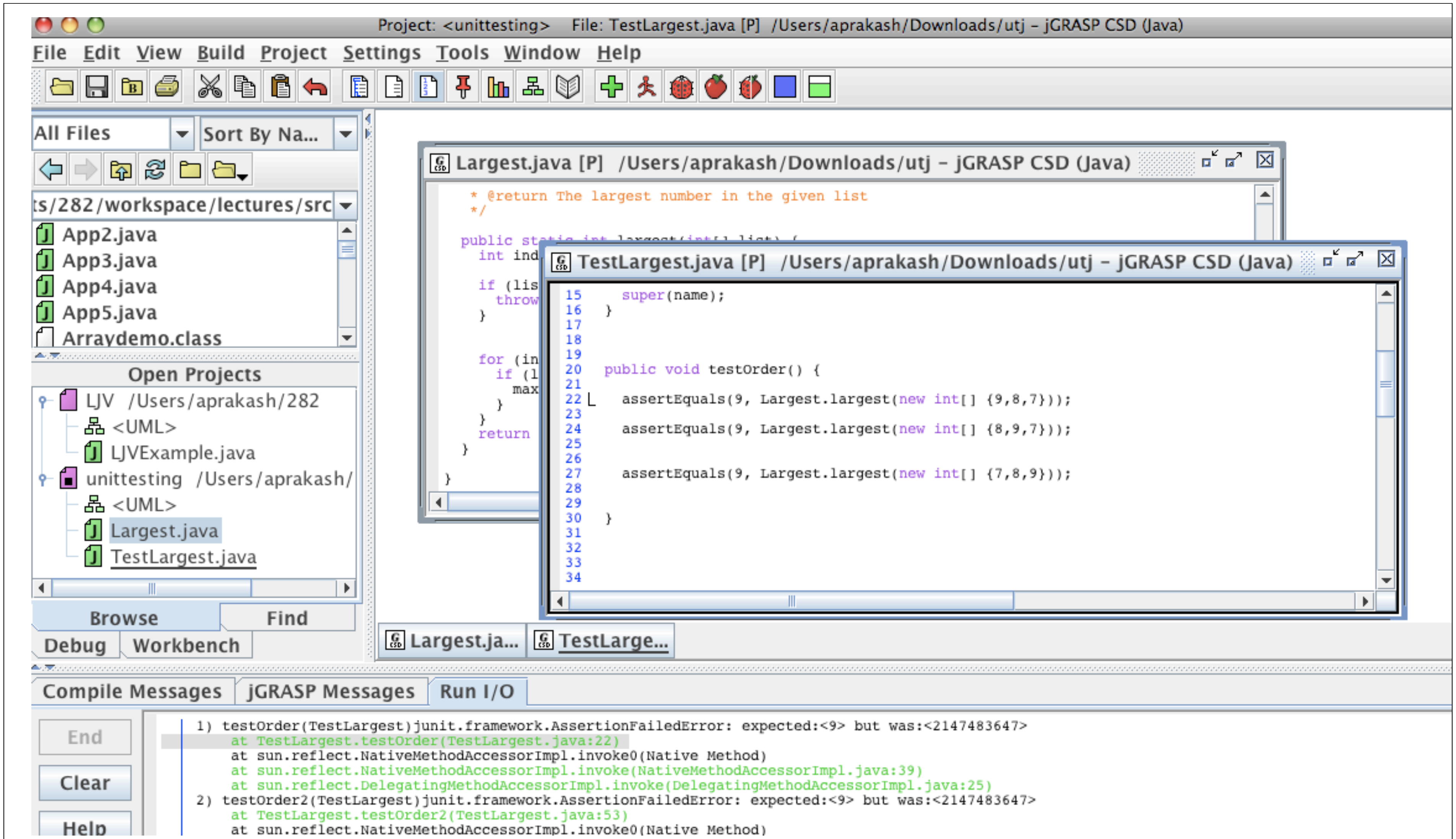
Language: Java

Main File ■

| | FLAGS or ARGS | | FLAGS2 or ARGS2 | |
|---|---|---|---|---|
| Make | | ■ | | ■ |
| C/L | | ■ | | ■ |
| Compile | | ■ | | ■ |
| Check | | ■ | | ■ |
| Run | | ■ | junit.textui.TestRunner | ☐ |
| Run Applet | | ■ | | ■ |
| Debug | | ■ | | ■ |
| Debug Applet | | ■ | | ■ |
| Document | | ■ | | ■ |

## Running the tests

- Compile the project and run TestLargest
- You should see the list of failed tests and the line number


Project: <unittesting>    File: TestLargest.java [P]  /Users/aprakash/Downloads/utj – jGRASP CSD (Java)
File Edit View Build Project Settings Tools Window Help
All Files
Sort By Na...
ts/282/workspace/lectures/src
App2.java
App3.java
App4.java
App5.java
Arraydemo.class
Open Projects
LJV  /Users/aprakash/282
<UML>
LJVExample.java
unittesting  /Users/aprakash/
<UML>
Largest.java
TestLargest.java
Browse
Find
Debug
Workbench
Largest.java [P]  /Users/aprakash/Downloads/utj – jGRASP CSD (Java)
TestLargest.java [P]  /Users/aprakash/Downloads/utj – jGRASP CSD (Java)
Largest.ja...
TestLarge...
Compile Messages
jGRASP Messages
Run I/O
End
Clear
Help

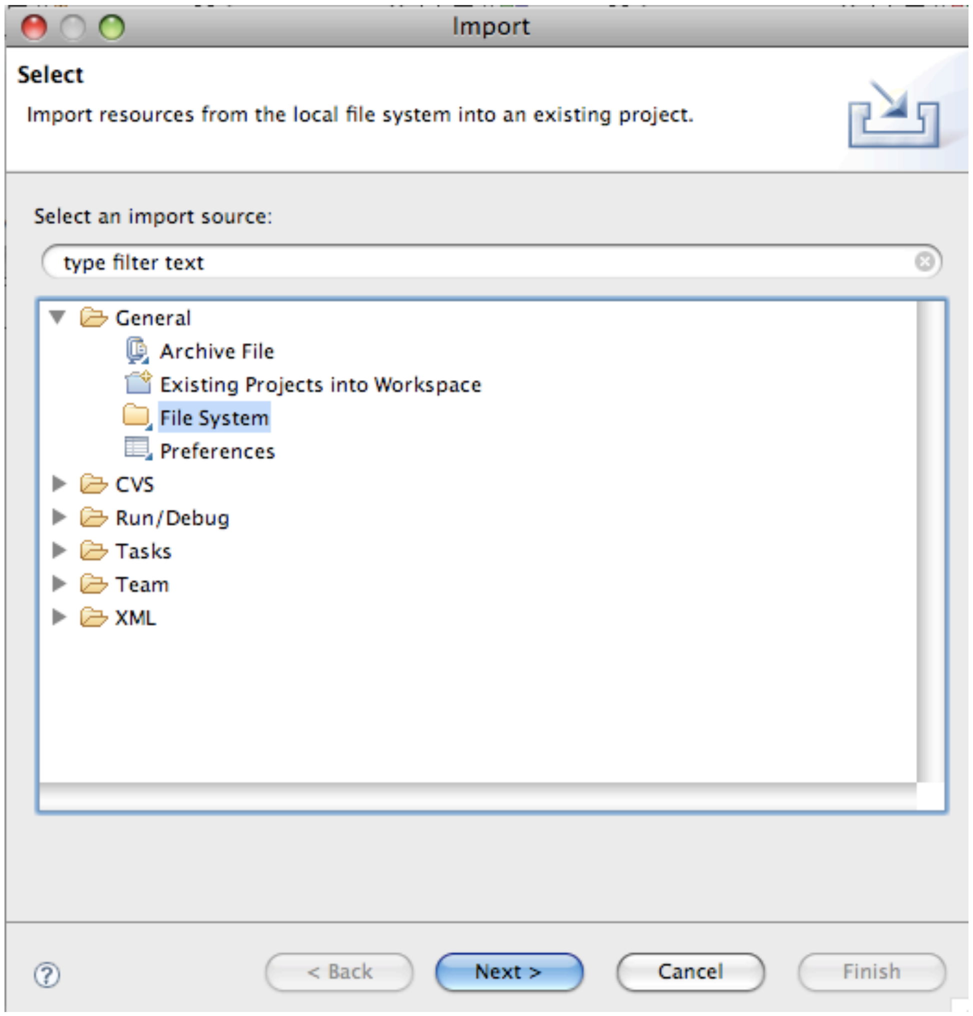
```
     * @return The largest number in the given list
     */

    public static int largest(int[] list) {
      int ind

      if (lis
        throw
      }

      for (in
        if (l
          max
      }
      return
    }

}
```

```
15      super(name);
16    }
17
18
19
20    public void testOrder() {
21
22      assertEquals(9, Largest.largest(new int[] {9,8,7}));
23
24      assertEquals(9, Largest.largest(new int[] {8,9,7}));
25
26
27      assertEquals(9, Largest.largest(new int[] {7,8,9}));
28
29
30    }
31
32
33
34
```

```
1) testOrder(TestLargest)junit.framework.AssertionFailedError: expected:<9> but was:<2147483647>
     at TestLargest.testOrder(TestLargest.java:22)
     at sun.reflect.NativeMethodAccessorImpl.invoke0(Native Method)
     at sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:39)
     at sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:25)
2) testOrder2(TestLargest)junit.framework.AssertionFailedError: expected:<9> but was:<2147483647>
     at TestLargest.testOrder2(TestLargest.java:53)
     at sun.reflect.NativeMethodAccessorImpl.invoke0(Native Method)
```

## Eclipse

- Eclipse is much easier. Simply select junit version 4 if you are given the choice (or the latest version) anywhere.
- File->Import -> General -> FileSystem
-



**Select**

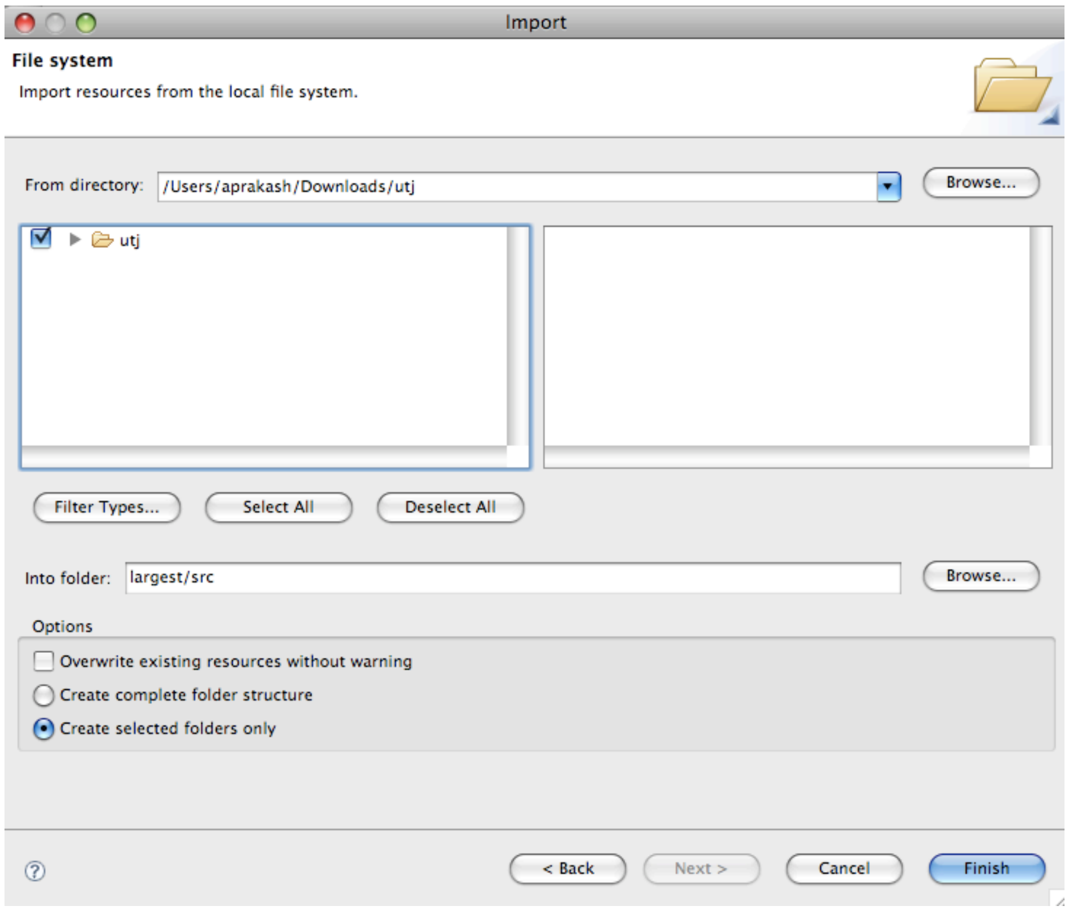
Import resources from the local file system into an existing project.

Select an import source:

type filter text

- General
  - Archive File
  - Existing Projects into Workspace
  - File System
  - Preferences
- CVS
- Run/Debug
- Tasks
- Team
- XML

# Select From directory



Import

File system

Import resources from the local file system.

From directory: /Users/aprakash/Downloads/utj

[✓] utj

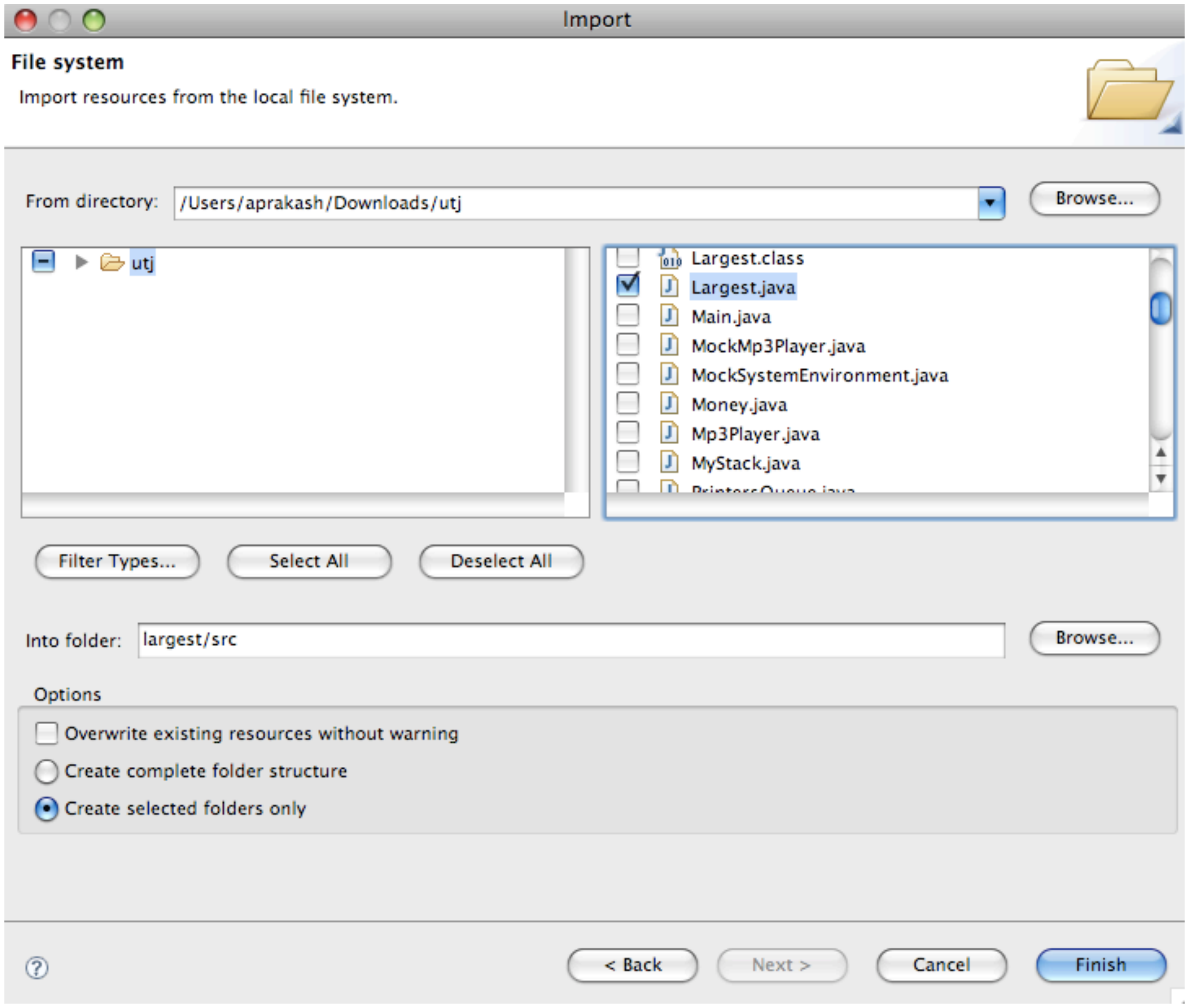
Into folder: largest/src

Options

- [ ] Overwrite existing resources without warning
- ○ Create complete folder structure
- ● Create selected folders only

## Next steps

- Click on the directory "utj". You should see the files on the right side. Deselect all and select Largest.java and TestLargest.java.


Import

**File system**

Import resources from the local file system.

From directory: /Users/aprakash/Downloads/utj

utj

- [ ] Largest.class
- [✓] Largest.java
- [ ] Main.java
- [ ] MockMp3Player.java
- [ ] MockSystemEnvironment.java
- [ ] Money.java
- [ ] Mp3Player.java
- [ ] MyStack.java

Into folder: largest/src

Options

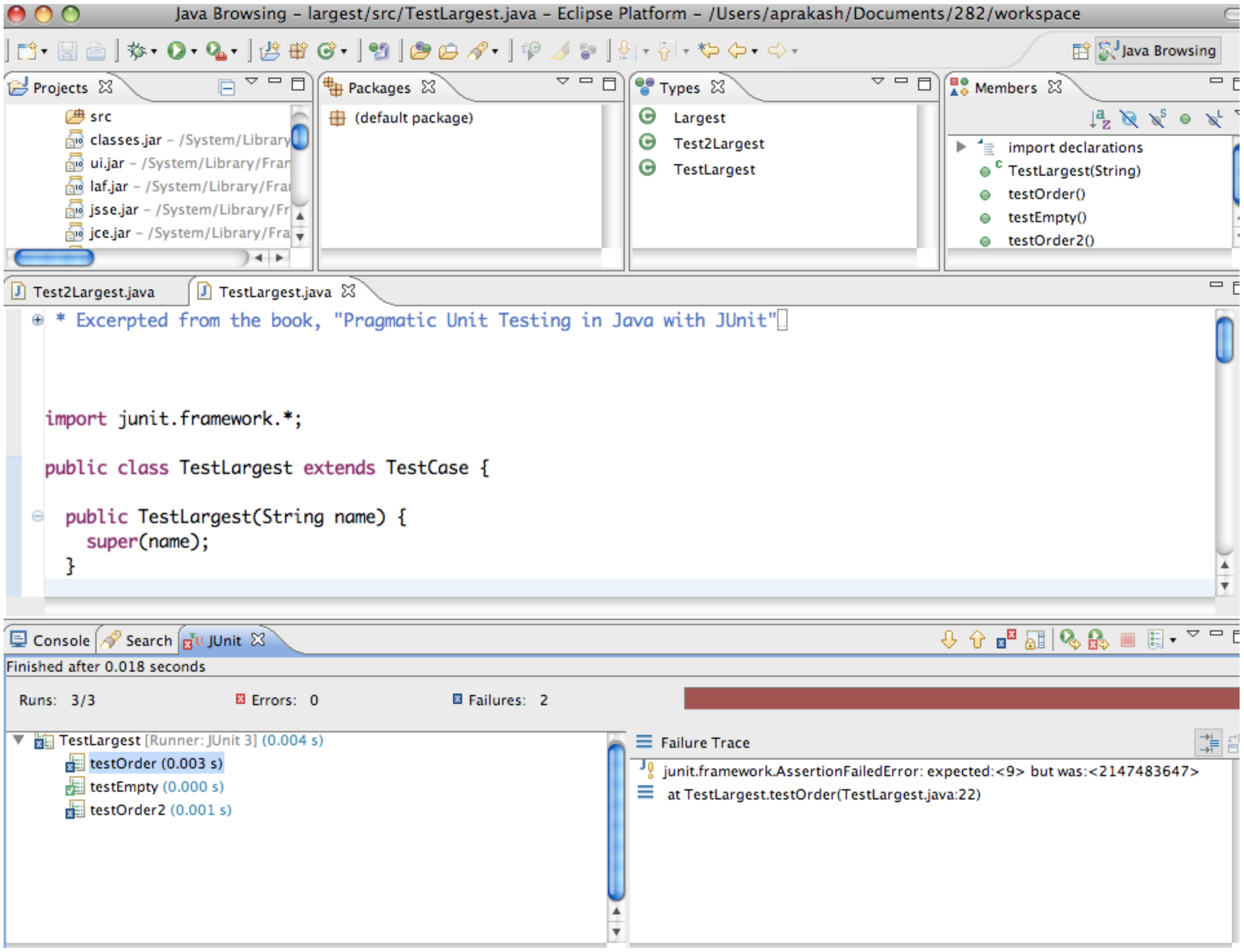
- [ ] Overwrite existing resources without warning
- ○ Create complete folder structure
- ● Create selected folders only

## Fix errors

- TestLargest.java may show errors. Hover your mouse over the word "junit" and select a fix to reorganize the project. You may have to add junit3 to the project in Eclipse.

## Run the test

- Run the TestLargest as a jUnit test. You should see a window showing the failed tests. Clicking on the failed line should take you to that line in TestLargest.
- Select Project -> Run, when you have selected TestLargest.


Java Browsing - largest/src/TestLargest.java - Eclipse Platform - /Users/aprakash/Documents/282/workspace
Java Browsing
Projects
src
classes.jar - /System/Library
ui.jar - /System/Library/Fran
laf.jar - /System/Library/Fra
jsse.jar - /System/Library/Fr
jce.jar - /System/Library/Fra
Packages
(default package)
Types
Largest
Test2Largest
TestLargest
Members
import declarations
TestLargest(String)
testOrder()
testEmpty()
testOrder2()
Test2Largest.java
TestLargest.java
Console
Search
JUnit
Failure Trace

```
* Excerpted from the book, "Pragmatic Unit Testing in Java with JUnit"


import junit.framework.*;

public class TestLargest extends TestCase {

  public TestLargest(String name) {
    super(name);
  }
```

```
Finished after 0.018 seconds

Runs:  3/3          Errors:  0          Failures:  2

TestLargest [Runner: JUnit 3] (0.004 s)
    testOrder (0.003 s)
    testEmpty (0.000 s)
    testOrder2 (0.001 s)

junit.framework.AssertionFailedError: expected:<9> but was:<2147483647>
at TestLargest.testOrder(TestLargest.java:22)
```

## Common Next Steps

- Read through your test and the code to see why the test failed.
- Set breakpoints and use a debugger if necessary to help identify the problems.
  - For jGrasp, you will have to change the FLAG2 settings for the Debugger.