Topics

1) What are common types of testing?
   a) Testing like a user: through the UI.
   b) Testing like a dev: through the code.
2) How can we write code to test code (via JUnit 5)?
3) How to do effective unit testing?
4) What makes a good bug report?
Types of Testing
Types of Testing

• Test to find bugs and to show a product works.
• How can we test (types of testing)?
  – ..
  • Test overall application’s features
  • “Is the program acceptable to customer?”
  – ..
  • Test each class in isolation
  • “Does this class do anything wrong?”
• Testing can be done by a human (manual) or by code (automatic).
White vs Black Box

• When creating tests, do you have access to the system’s code/design?
  − Knowing the code can help you..
  − Not knowing the code can help you see the big picture and..

• Can see source code when writing tests.
  − Also called clear box or glass box.

• Have no access to system internals.
  − Often for user interface testing.
Acceptance Tests
Acceptance Testing

- Are needed features included?
- Do the features work as expected?

- Can generate acceptance tests from..
Ex: Requirements to Acceptance Tests

Requirement

• Scroll bar’s slider shows the proportion of how much of the content is shown in the window.
• Scroll bar only visible when all content can not be shown in window at once.

Acceptance Tests

• With enough content to need scroll bar, double amount of content and slider should be half as tall.
• With enough content to need scroll bar, double window height and slider height should double.
• ... etc.
Acceptance Testing details

• Acceptance tests often manually done by a tester.

<table>
<thead>
<tr>
<th>Quality Assurance Tester Job:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Writing Test Cases and Scripts based on business and functional requirements</td>
</tr>
<tr>
<td>• Executing high complexity testing tasks</td>
</tr>
<tr>
<td>• Recording and reporting testing task results</td>
</tr>
<tr>
<td>• Proactively working with project team members to improve the quality of project deliverables</td>
</tr>
</tbody>
</table>

• Acceptance tests may be part of deploying a product
  - Alpha testing: users try out software at developer’s site.
  - Beta testing: software deployed for limited initial testing at customer’s site.

Unit testing with JUnit
JUnit Unit Testing

• Unit Tests..

• Purpose:
  For you to “know” your code works.
  - Should test ~100% of a class.
  - Helps improve quality of code.
  - Supports aggressive refactoring because you can..
JUnit Context

- You create a test class which is...
- JUnit test runner executes your test class.

You implement

"Real" class to test.

Runs JUnit tests.
JUnit: “Test Runner” executes methods with..

Basic JUnit Architecture
package ca.cmpt276.junit5;
import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;
public class PuppyTest {

    @Test
    void testCreate() {
        Puppy rover = new Puppy("Rover", 100);
        assertEquals("Rover", rover.getName());
        assertEquals(100, rover.getWagRate());
    }

    @Test
    void testSetName() {
        Puppy rover = new Puppy("Rover", 100);
        rover.setName("Fluffy");
        assertEquals("Fluffy", rover.getName());
    }

    //... more tests omitted.
}

JUnit 5 Example

New instance of PuppyTest created for each JUnit test method:

Behaviour of one..

Tests are done using..

Test runner executes all methods with @Test annotation

= Puppy.java & PuppyTest.java
Test Runner

- Test runner executes @Test methods in test class.
- Displays results & coloured bar
  - Green-bar..
  - Red-bar..

```
Process finished with exit code 0
```

```
java.lang.AssertionError <2 internal calls>
at ca.sfu.cmpt213.PuppyTest.testSetName(PuppyTest.java:2)
```
JUnit 5 Asserts: Basics

```java
public class JUnitAssertTest {
    @Test
    public void demoAssertEquals() {
        String name = "Dr. Evil";
        assertEquals("Dr. Evil", name);
    }
    @Test
    public void demoOtherAsserts() {
        int i = 10;
        assertEquals(10, i);
        assertTrue(i == 10);
        assertFalse(i == -5);
    }
    @Test
    public void demoAssertEqualsOnDouble() {
        double weight = (1 / 10.0);
        assertEquals(0.1, weight, 0.000001);
    }
} // Array support: assertArrayEquals()
```

Doubles have limited precision. 3rd arg is the “delta” to tolerate
JUnit 5 Asserts: Exceptions

```java
public class JUnitAssertTest {
    private void throwOnNegative(int i) {
        if (i < 0) {
            throw new IllegalArgumentException();
        }
    }

    @Test
    void testThrows() {
        assertThrows(IllegalArgumentException.class, () -> {
            throwOnNegative(-1);
        });
    }

    @Test
    void testNoThrows() {
        throwOnNegative(1);
    }
}
```

Use to test exception throwing..

IllegalArgumentExecption

Lambdas: needs Java 1.8+ compatibility
File --> Project Structure --> Module -->
Select "app" in list, select Properties tab
Set Source Compatibility to 1.8 (Java 8)
Set Target Compatibility to 1.8 (Java 8)
JUnit 5 Asserts: Disable

```java
public class JUnitAssertTest {

    @Disable("DB does not yet support reconnecting")
    @Test
    void testDBReconnect() {
        // ... put your JUnit tests of the not-yet implemented code....
        fail(); // Automatic fail...
    }
}
```

Ignore the test so "to-be-done" style tests do not break testing.

Gives warning message to highlight that some tests not yet enabled.

```
DB does not yet support reconnecting.
Process finished with exit code 0
```
Android Studio Demo

1) Create JUnit Test Class:
   1) Open class under test,
   2) Click class name, alt-enter --> Create Test
   3) Select JUnit 5, click OK
   4) Select ...\app\src\test\java\..... folder

2) Execute Tests:
   1) Run --> Run... (alt-shift-F10)
   2) Select your JUnit test class.

3) Run app: Run --> Run...; select “app”

IntelliJ JUnit Video Tutorials:
Basics: https://www.youtube.com/watch?v=Bld3644bIAo&t
More: https://www.youtube.com/watch?v=xHk9yGZ1z3k&t
Unit Testing Discussion
Effective unit tests

- Unit testing should be..
- Test ‘class under test’ for:
  - Works for expected normal inputs.
  - Works for extreme or invalid inputs.

- Testing strategies
  - group input values which are "similar"
  - test based on these groupings.

  - use guidelines to choose test cases.
  - guidelines cover common programming errors.
Partition testing

- Identify groups, or regions of values in the input data and output results which...

- Ex: Multiplying two integers.
  - Input: Positive vs negative input values
  - Output: Positive vs negative result.

- Each of these groups is an...
  - Program behaves in an equivalent way for each group member.

- Test cases should be chosen from each partition.
  - test extremes of the partitions..
  - test a middle value of the partition
Equivalence Classes

- Identify the equivalence classes (partitions):
  /** Return a grade based on the \textit{percent}:
   * 50 to 100 = 'P'
   * 0 to <50 = 'F'
   * otherwise throw an exception.
  */
  char assignGrade(int percent);
General testing guidelines

Choose test inputs to:

- Cause buffers to overflow;
- Force calculation result to be too large (or small): (overflow & underflow).
- Testing With Arrays:
  - Different # elements. Ex..
  - Put desired element..
Code Coverage

• Code Coverage:

• Want ~100% Code Coverage
  – All lines of code executed at least once.
  – Quite hard to achieve (complex error cases, asserts, ..)
  – This should almost be the bare minimum:
    Tests run..

• Demo (Android Studio or IntelliJ)
  \textit{Run --> Run PuppyTest with Coverage}
Test Code Quality

• Unit tests are integral part software development:
  ..
  as the rest of the project.
  - Only possible if you don’t think of tests as throw-away or beneath your coding skill.

• Good code quality makes maintenance easier
  - Keeps tests current and relevant
  - Poor code makes tests obsolete fast (and useless)!
  - Unreliable tests cause developers to lose trust.
Finding Many Bugs

• If you find a function which is quite buggy, don’t debug it:
  
  ⚫ Good unit testing only finds..
  ⚫ A hacked together routine indicates poor understanding of its requirements:
    • If many bugs are discovered now, then many bugs will be encountered later!

• More tests cannot solve this problem:
  
  *Trying to improve software quality by increasing the amount of testing is like trying to lose weight by weighing yourself more often.*

  McConnel, 2004
Bug reports
Bug Report

- Submit a bug report when a defect is found.

<table>
<thead>
<tr>
<th>Bug Report Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concise, 1 line description of problem.</td>
</tr>
<tr>
<td></td>
<td>Which product had error.</td>
</tr>
<tr>
<td></td>
<td>Actions to cause error.</td>
</tr>
<tr>
<td></td>
<td>Does it always occur, or only occasionally?</td>
</tr>
<tr>
<td></td>
<td>Create simple example to demonstrate.</td>
</tr>
<tr>
<td></td>
<td>What the steps should do, vs what actually do.</td>
</tr>
<tr>
<td></td>
<td>Ensure it is actually an error not a feature: &quot;Working as intended&quot;?</td>
</tr>
<tr>
<td></td>
<td>Software version, OS, hardware, drivers, ...</td>
</tr>
</tbody>
</table>
## Bug Report Example

<table>
<thead>
<tr>
<th>Bug Report Component</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary</td>
<td>Upload crashes on MP3 file drag and drop.</td>
</tr>
<tr>
<td>Component</td>
<td>File upload window.</td>
</tr>
<tr>
<td>Steps to Reproduce</td>
<td>1. Open app to upload window.</td>
</tr>
<tr>
<td></td>
<td>2. Select two MP3 files in file explorer.</td>
</tr>
<tr>
<td></td>
<td>3. Drag into upload window.</td>
</tr>
<tr>
<td></td>
<td>4. Application flashes and crashes.</td>
</tr>
<tr>
<td></td>
<td>Crash is repeatable.</td>
</tr>
<tr>
<td>Expected vs Actual result</td>
<td>Expected “No flashing and no crashing”</td>
</tr>
<tr>
<td></td>
<td>(files should upload without app crashing)</td>
</tr>
<tr>
<td>Environment</td>
<td>ShareFiles 1.2.5, Win10, Dell XYZ, Norton 3</td>
</tr>
</tbody>
</table>

Inspired by an actual bug report submitted by someone I know.
Bug suggestions

• The better the bug report, the more likely the developer is to identify the problem and fix it.

• Example files:
  − For an office application, or a compiler, provide an example file which causes the problem.

• Screenshots:
  − A picture of the problem is great at definitively showing what happened.
  − Developers are often..
Life-cycle of a bug

- Some resolutions:
  - Fixed
  - Duplicate
  - Won't Fix
  - "ID-10-T"
  - "PLBKAC"
  - Enhancement / feature request

Image Source: Bugzilla – lifecycle.
Mozilla guidelines and bugzilla.
BUGS HAVE FEELINGS TOO

IF YOU FIND A BUG: REPORT IT
BUGS DON’T LIKE TO BE FORGOTTEN

IF YOU FIND A BUG: GET TO KNOW THEM
BUGS LIKE TO BE UNDERSTOOD

IF YOU FIND A BUG: TAKE A PHOTO
BUGS LIKE TO KEEP MEMORIES OF THE OCCASION

IF YOU FIND A BUG: GET TO KNOW THEIR MATES
BUGS ARE SOCIALITES

This ladybird has 3 spots

IF YOU FIND A BUG: REPORT IT QUICK
OTHERWISE BUGS SETTLE IN AND MAKE A HOME FOR THEMSELVES

IF YOU FIND A BUG: BE HONEST
BUGS DON’T LIKE GossipS

IF YOU FIND A BUG: NOTE HOW YOU MEET THEM
BUGS ARE ROMANTICS

IF YOU FIND A BUG: DON’T IGNORE IT
BUGS CAN BITE IF NOT APPRECIATED

Andy Glover cartoontester.blogspot.com Copyright 2010
Summary

- White-box knowledge of internals; Black-box uses external interface only.

- Test Types
  - Acceptance for checking features in product.
  - JUnit for detailed unit testing (white-box): assert...(), @Test, @Disable, assertThrows().

- Good JUnit tests
  - Partition testing using equivalence classes.
  - High-quality test code: maintain it!

- Bug reports include
  - Description, steps to reproduce, environment info.