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**).
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 cannot be shown in window at once.

**Acceptance Tests**

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

- Acceptance tests often manually done by a tester.

  Quality Assurance Tester Job:
  - Writing Test Cases and Scripts based on business and functional requirements
  - Executing high complexity testing tasks
  - Recording and reporting testing task results
  - Proactively working with project team members to improve the quality of project deliverables

- 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.
JUnit: “Test Runner” executes methods with.

Basic JUnit Architecture
JUnit 5 Example

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.
}

Test runner executes all methods with @Test annotaiton
Tests are done using..

New instance of PuppyTest created for each JUnit test method:
Behaviour of one..

= 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)
```
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; the 3rd arg is the “delta” to tolerate differences.
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);
    }
}
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.
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 the extremes of the partitions..
  – test a middle value of the partition
Identify the equivalence classes (partitions):

```c
/** Return a grade based on the 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)**
  *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. Does it always occur, or only occasionally? Create simple example to demonstrate.</td>
</tr>
<tr>
<td></td>
<td>What the steps should do, vs what actually do. 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><strong>Summary</strong></td>
<td>Upload crashes on MP3 file drag and drop.</td>
</tr>
<tr>
<td><strong>Component</strong></td>
<td>File upload window.</td>
</tr>
</tbody>
</table>
| **Steps to Reproduce** | 1. Open app to upload window. 
2. Select two MP3 files in file explorer. 
3. Drag into upload window. 
4. Application flashes and crashes. Crash is repeatable. |
| **Expected vs Actual result** | Expected “No flashing and no crashing” (files should upload without app crashing) |
| **Environment**      | ShareFiles 1.2.5, Win10, Dell XYZ, Kaspersky IS 9.                     |
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

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 cartoon tester.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.