Unit Testing

SWEN-261
Introduction to Software Engineering

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There are many levels of software testing.

The developer of the software has the sole responsibility for creating and verifying unit tests.

https://insights.sei.cmu.edu/sei_blog/2013/11/using-v-models-for-testing.html
The scientific method that you studied in your physics courses is not just for science!

- Software testing and debugging is experimentation using the scientific method
  - **Make a hypothesis**
    - Your software executes per the requirements
    - A certain place in your code is responsible for a bug
  - **Create an experiment to test the hypothesis**
    - Write unit tests
    - Determine the scenario that triggers the bug and set breakpoints where you think the bug arises
  - **Run the experiment**
    - Run the unit tests
    - Run the system to the breakpoint
  - **Analyze the results to decide if the hypothesis is true**
    - If unit tests pass, the hypothesis is true
    - If the problem is seen, you have found the bug location
These are the essential characteristics that should be your goals when you write unit tests.

- Automatic
- Thorough
- Repeatable
- Independent
  - *Test only one thing at a time*
  - *Tests should not depend on each other*
- Professional
  - *Readable*
  - *Use standard OO principles*
- Fast
  - *Using Maven, unit tests are run on each build*
This is the checklist of items that you should ensure get tested by a class' unit tests.

- **Business logic**
  - *Tests for each path through a method*
  - *Happy path as well as failure paths*

- **Constructors and accessors**

- **Defensive programming checks**
  - *Validation of method arguments*
    - NullPointerException
    - IllegalArgumentException
  - *Validation of component state*
    - IllegalStateException

- The *equals* and *hashCode* methods, as needed

- **Exception handling**
Here's the typical formula for a test.

- Create a test class for each component under test (CuT) that has privileged access to the component.
  - *In Java, the test code typically has package access.*

- Create a test method that covers each happy and failure scenario.
  - *Setup test scenario*
  - *Invoke the test*
  - *Analyze the test results*

- This simple formula can be adjusted as needed.

- Note: see the [after-class exercise](#) for more detailed instructions for unit testing with JUnit, Mockito, and Maven along with examples from the GuessGame unit tests.
Unit testing frameworks like JUnit have many built-in assertions for analysis in your tests.

- **Test truth-hood**
  - ```assertTrue(condition[, message])```
  - ```assertFalse(condition[, message])```

- **Test values or objects for equality**
  - ```assertEquals(expected, actual[, message])```
  - ```assertNotEquals(expected, actual[, message])```

- **Test objects for identity** (obj1 == obj2)
  - ```assertSame(expected, actual[, message])```
  - ```assertNotSame(expected, actual[, message])```

- **Test null-hood**
  - ```assertNull(object[, message])```
  - ```assertNotNonNull(object[, message])```

- **Automatic failure**: `fail(message)`
One tip for coding for testability is to make strings and constants available to the unit test.

- **Idioms for testable code:**
  - *Make message strings (and other values) constants*
  - *Make these members package-private (or public)*

- **Example:**

```java
public class GameCenter {

  final static String NO_GAMES_MESSAGE = "No games have been played so far.";
  final static String ONE_GAME_MESSAGE = "One game has been played so far.";
  final static String GAMES_PLAYED_FORMAT = "There have been %d games played.";

  public synchronized String getGameStatsMessage() {
    if (totalGames > 1) {
      return String.format(GAMES_PLAYED_FORMAT, totalGames);
    } else if (totalGames == 1) {
      return ONE_GAME_MESSAGE;
    } else {
      return NO_GAMES_MESSAGE;
    }
  }
}
```
To write an "independent" unit test of a class, you will need to control the dependencies.

- Most components will have dependent classes
  - Stored as attributes
  - Passed in as arguments

- This coupling forms a "seam" between the component under test and its dependencies:

- Use dependency injection rather than direct instantiation.
Isolate the CuT by injecting *friendly* and mock objects.

- Fully tested internal components (usually Model objects like Entities and Value Objects)
- Mock objects that stand in for internal or external components
- There are other variations on test instruments: Spy, Dummy, Fake, Simulator.
Mock object frameworks like Mockito have APIs for setting up test scenarios and inspecting results.

- **Setting up test scenarios**
  - *Specify the response, e.g. return value or exception thrown, when a method is called on a mock object*
  - `when(mock.method(args)).thenReturn(value)`

- **Verify that interactions occurred during a unit test**
  - *Check if methods were called the expected number of times in the manner expected*
  - `verify(mock, times(1)).method(args)`

- **Answer objects that allow you to capture and later test intermediate results of unit test**
Make unit testing part of your project's *Definition of Done* and your quality will rise!

- Unit testing is a subtle art.
- Keep your test code isolated from production code.
- Use the testing formula: arrange, invoke, analyze.
- Use an Assertion library like JUnit.
- Use a Mock object framework like Mockito.

- See [after-class exercise](#) for more detailed examples of doing unit tests with JUnit, Mockito, and maven.
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