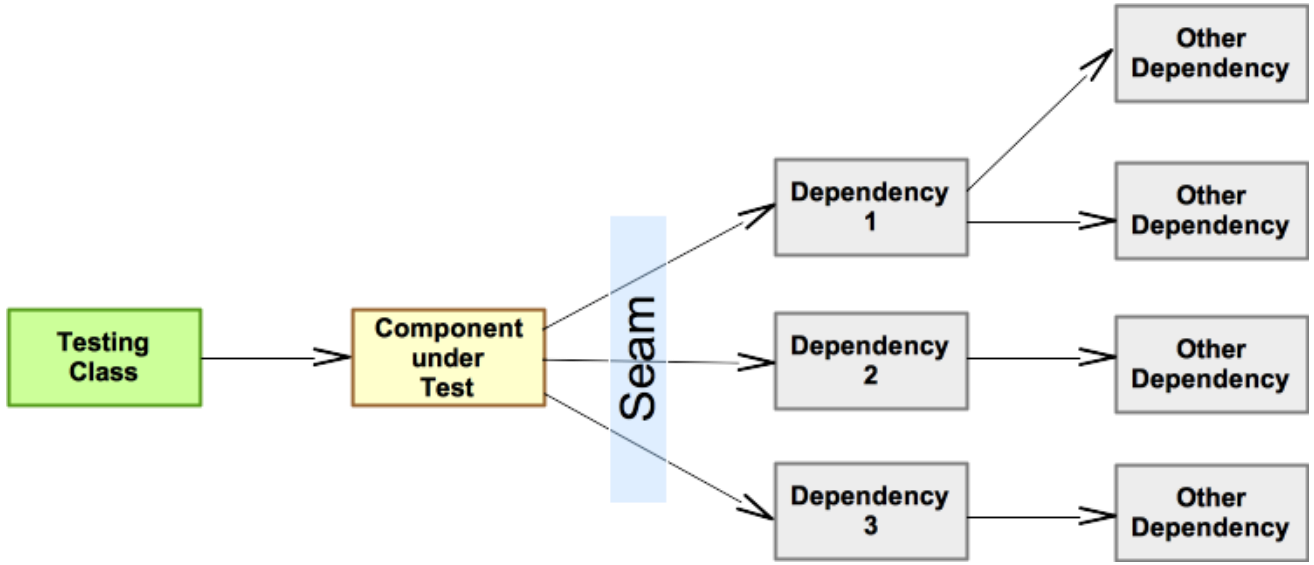
Unit Testing Activity



SWEN-261
Introduction to Software Engineering

Department of Software Engineering
Rochester Institute of Technology

Software Engineering
Rochester Institute of Technology

Your activity for the Unit Testing lesson is to build tests for existing Project components.

- These slides direct you through the process of creating unit tests for your project.

  ✓***Activity actions are highlighted in green with a checkmark.***

- But first, these slides provide technical details on:
  1. ***How to organize test classes using Maven***
  2. ***How to run tests using Maven***
  3. ***How to structure a typical test class***
  4. ***How to use JUnit assertion functions***
  5. ***How to use package-private constants in test code***
  6. ***How to use Mockito mock objects using Dependency Injection***

Maven provides a convenient structure for organizing unit test code.

- Put your test classes in a separate source path.
  - ***The goal is to keep the test source code separate from the production source code.***
  - ***Using Maven that is usually `src/test/java`.***

  ✓***Create this directory if it doesn't already exist.***

  ✓***(Optional) Link your IDE to this source path.***
- Most IDEs provide wizards for creating unit tests.
  - ***Make sure the IDE stores the test classes in the proper source path.***
- The unit test code examples in these slides are from the Heroes API starter code

Maven will run tests during builds and there is also the `test` target.

```
PS C:\Users\student\heroes-api-starter> mvn clean test
[INFO] Scanning for projects...
                                                    <SKIPPING SOME Maven OUTPUT>
[INFO] -------------------------------------------------------
[INFO]  T E S T S
[INFO] -------------------------------------------------------
[INFO] Running com.heroes.api.heroesapi.controller.HeroControllerTest
[INFO] Tests run: 2, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.947 s - in
com.heroes.api.heroesapi.controller.HeroControllerTest
[INFO] Running com.heroes.api.heroesapi.persistence.HeroFileDAOTest
[INFO] Tests run: 10, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.656 s - in com.heroes.api.heroesapi.persistence.HeroFileDAOTest
[INFO] Running com.heroes.api.heroesapi.HeroesApiApplicationTests
                                                    <SKIPPING SOME Maven OUTPUT>
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 3.185 s - in com.heroes.api.heroesapi.HeroesApiApplicationTests
[INFO] Running com.heroes.api.heroesapi.model.HeroTest
[INFO] Tests run: 5, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.003 s - in com.heroes.api.heroesapi.model.HeroTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 18, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO]
[INFO] --- jacoco-maven-plugin:0.8.7:report (report) @ heroes-api ---
[INFO] Loading execution data file C:\Users\student\heroes-api-starter\target\jacoco.exec
[INFO] Analyzed bundle 'heroes-api' with 5 classes
[INFO] ------------------------------------------------------------------------
[INFO] BUILD SUCCESS
[INFO] ------------------------------------------------------------------------
[INFO] Total time:  10.815 s
[INFO] Finished at: 2021-11-25T09:57:12-05:00
[INFO] ------------------------------------------------------------------------
```

Test files are kept in separate directories from the application code but in the same package.

- Name the test class after the *component under test* (CuT) in the same package.
  - ***So if CuT is `com.heroes.api.heroesapi.model.Hero`***
  - ***Then test class is: `com.heroes.api.heroesapi.model.HeroTest`***
  - ***Doing so gives the test code package-private access to CuT class.***

JUnit understands several annotations that you must use in your test files.

- Annotate each class with `@Tag` to indicate which architectural tier the class is in.
  - ***Use these tags:*** `Persistence-tier, Model-tier, Controller-tier`
  - ***You will learn more about the role of these tags in the Code Coverage lesson.***
- Annotate each test method with `@Test`.
- Use `@BeforeEach` or `@BeforeAll` annotated methods for setup before each test or setup done once before all tests
- Method annotations `@AfterEach` and `@AfterAll` serve similar clean up tasks after running tests.

Recall the checklist of types of 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`
- Special methods, e.g. `equals`, `hashcode`, `toString`, as needed
- Exception handling

Here's an example unit test suite for the `Hero` class.

```
package com.heroes.api.heroesapi.model;

import static org.junit.jupiter.api.Assertions.assertEquals;
import org.junit.jupiter.api.Tag;
import org.junit.jupiter.api.Test;

@Tag("Model-tier")
public class HeroTest {

    @Test
    public void testCtor() {…}

    @Test
    public void testName() {…}

    @Test
    public void testToString() {…}
}
```

Import JUnit assertion functions and Tags

Indicate Model tier

Test constructors

Test accessors and mutators

Special methods

Here's an example test methods for the Hero class.

```
@Test
public void testToString() {
    // Setup
    int id = 99;
    String name = "Wi-Fire";
    String expected_string = String.format(Hero.STRING_FORMAT,id,name);
    Hero hero = new Hero(id,name);

    // Invoke
    String actual_string = hero.toString();

    // Analyze
    assertEquals(expected_string,actual_string);
}
```

Here's an example of how to test an expected exception.

- Example from HeroFileDAOTest.java
  - ***Use the assertThrows assertion:***

```
@Test
public void testConstructorException() throws IOException {
    // Setup
    ObjectMapper mockObjectMapper = mock(ObjectMapper.class);
    doThrow(new IOException()).when(mockObjectMapper).readValue(new File("doesnt_matter.txt"),Hero[].class);

    // Invoke & Analyze
    assertThrows(IOException.class,() -> new HeroFileDAO("doesnt_matter.txt",mockObjectMapper),"IOException not thrown");
}
```

  - ***Roughly the same as:***

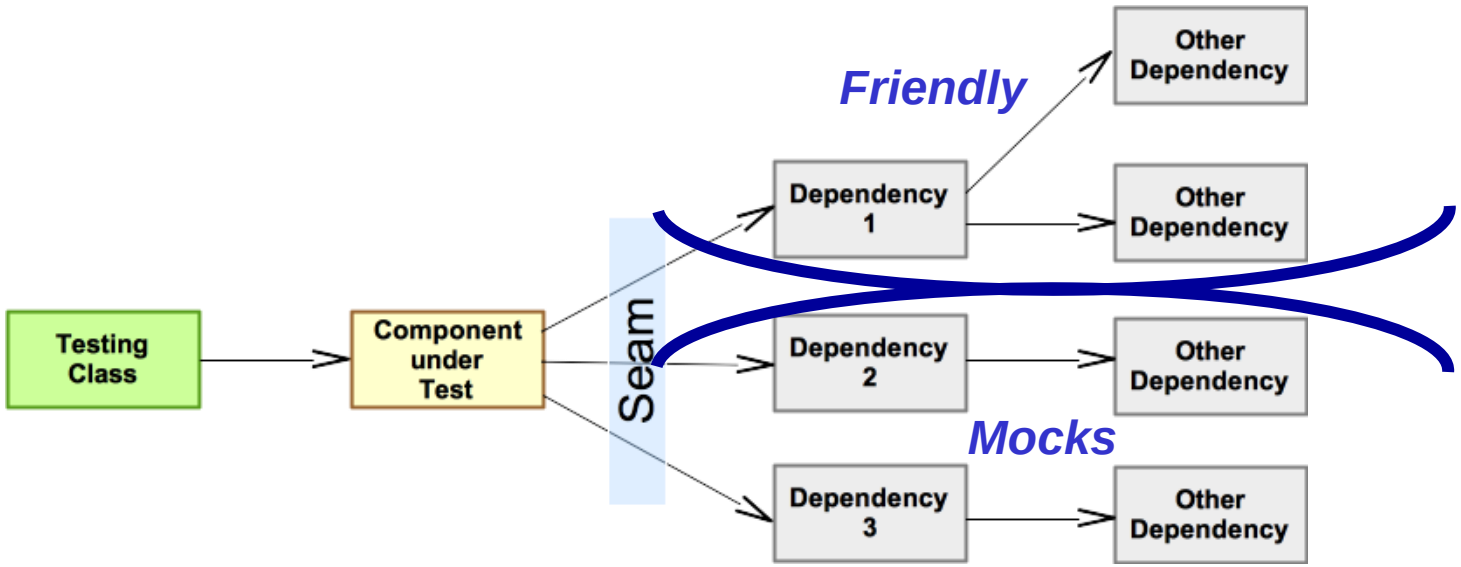
```
@Test
public void testConstructorException() throws IOException {
    // Setup
    ObjectMapper mockObjectMapper = mock(ObjectMapper.class);
    doThrow(new IOException()).when(mockObjectMapper).readValue(new File("doesnt_matter.txt"),Hero[].class);

    // Invoke
    try {
        new HeroFileDAO("doesnt_matter.txt",mockObjectMapper);
    // Analyze
        fail("IOException not thrown");
    }
    catch (IOException ioe) {}
}
```

JUnit has many built-in assertions you can use.

- 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])***
  - ***assertNotNull(object[, message])***
- Test exceptions
  - ***assertThrows(exception class, executable [, message])***
  - ***assertDoesNotThrow(executable [, message]])***
- Automatic failure
  - ***fail(message)***

When components have dependencies you have to consider how to isolate the dependencies.

- Dependencies are isolated along the testing seam for a component.
- There are three elements to consider
  - ***Component under Test (CuT)***
  - ***Friendly dependencies that can be trusted to work***
  - ***Other dependencies that must have mocks because they are not trusted or we need special control during the test***



Here's an example unit test suite for the HeroFileDAO class.

- Import the necessary Junit, Mockito, and Friendly dependencies

```
package com.heroes.api.heroesapi.persistence;

import java.io.File;
import java.io.IOException;

import static org.junit.jupiter.api.Assertions.assertDoesNotThrow;
import static org.junit.jupiter.api.Assertions.assertEquals;
import static org.junit.jupiter.api.Assertions.assertNotNull;
import static org.junit.jupiter.api.Assertions.assertNull;
import static org.junit.jupiter.api.Assertions.assertThrows;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Tag;
import org.junit.jupiter.api.Test;

import static org.mockito.ArgumentMatchers.any;
import static org.mockito.Mockito.doThrow;
import static org.mockito.Mockito.mock;
import static org.mockito.Mockito.when;

import com.fasterxml.jackson.databind.ObjectMapper;

import com.heroes.api.heroesapi.model.Hero;
```

Import JUnit assertion functions and tags

Import Mockito functions and classes

Used to create a mock object

Friendly

Here's an example unit test suite for the HeroFileDAO class.

- Setup and Happy Path Tests

```
@Tag("Persistence-tier")
public class HeroFileDAOTest {
    HeroFileDAO heroFileDAO;
    Hero[] testHeroes;
    ObjectMapper mockObjectMapper;

    @BeforeEach
    public void setupHeroFileDAO() throws IOException {…}

    @Test
    public void testGetHeroes() {…}

    @Test
    public void testFindHeroes() {…}

    @Test
    public void testGetHero() {…}

    @Test
    public void testDeleteHero() {…}

    @Test
    public void testCreateHero() {…}

    @Test
    public void testUpdateHero() {…}
```

Indicate controller tier

Setup function to be called before each test

Test business logic / CRUD operations.

Here's an example unit test suite for the HeroFileDAO class.

- Error Handling Tests

```
    @Test
    public void testSaveException() {…}

    @Test
    public void testGetHeroNotFound() {…}

    @Test
    public void testDeleteHeroNotFound() {…}

    @Test
    public void testUpdateHeroNotFound() {…}

    @Test
    public void testConstructorException() throws IOException {…}
}
```

Test defensive programming checks.

A quick review of dependency injection which is a key design technique to make classes testable.

```
@Component
public class HeroFileDAO implements HeroDAO {
    Map<Integer,Hero> heroes;
    private ObjectMapper objectMapper;
    private static int nextId;
    private String filename;

    public HeroFileDAO(@Value("${heroes.file}") String filename,ObjectMapper objectMapper) throws IOException {…}

    …
}
```

This class is instantiated by the `Spring Boot` framework by virtue of the `@Component` annotation.

The dependent ObjectMapper object is injected into the HeroFileDAO constructor

- We could create an ObjectMapper object in the HeroFileDAO constructor, but…
  - ***Recall that the ObjectMapper is responsible for deserialization and serialization of JSON objects to/from Java Objects and to write and read from a file***
  - ***Testing with an actual file would be difficult – the consistent state of the file would need to be ensured and the file may need to be read to validate***
  - ***By injecting the ObjectMapper, we can use a mock object in our tests***

We have to setup the mocks before each test.

```
@BeforeEach
public void setupHeroFileDAO() throws IOException {
    mockObjectMapper = mock(ObjectMapper.class);

    testHeroes = new Hero[3];
    testHeroes[0] = new Hero(99,“Wi-Fire");
    testHeroes[1] = new Hero(100,“Galactic Agent");
    testHeroes[2] = new Hero(101,“Ice Gladiator");

    when(mockObjectMapper
          .readValue(new File("doesnt_matter.txt"),Hero[].class))
            .thenReturn(testHeroes);

    heroFileDAO = new HeroFileDAO("doesnt_matter.txt",mockObjectMapper);
}
```

Use the Mockito `mock` function to create a mock object

Create an array of Hero objects that can be returned

Use the Mockito `when` and `thenReturn` APIs to simulate a reading Hero objects from a file

Inject the mock ObjectMapper into the HeroFileDAO constructor

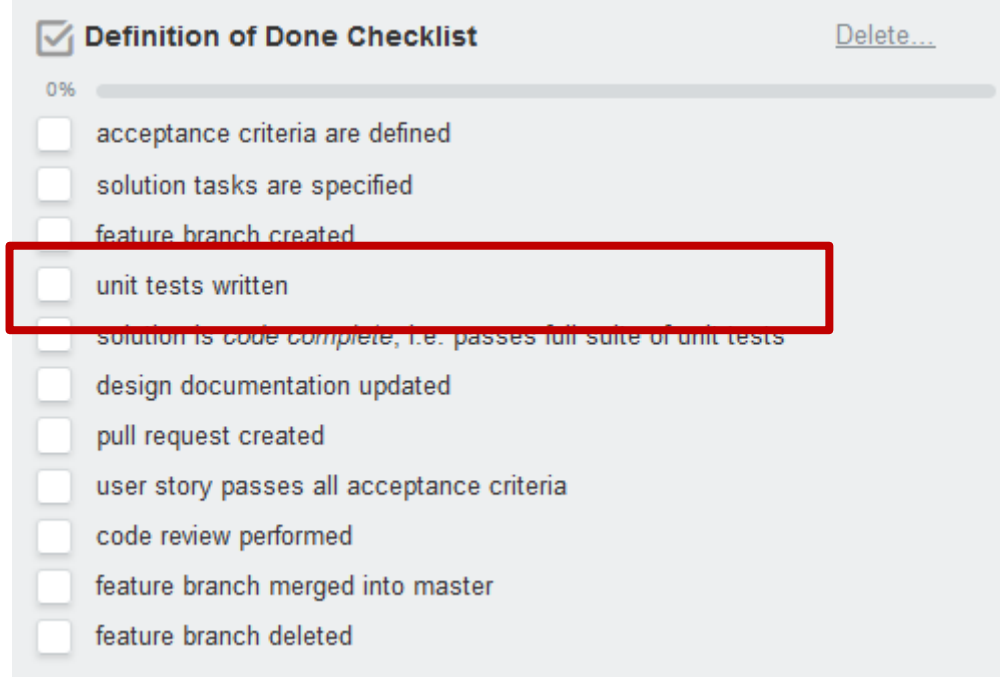
See HeroControllerTest for more examples of Mock Objects and Dependency Injection

Mockito has a rich API for setting scenarios and for inspecting test activity.

- Arranging scenarios:
  - *when(mock.method(args)).thenReturn(value)*
  - *when(mock.method(args)).thenThrow(new Exception())*
  - *when(mock.method(args)).thenAnswer(lambda)*
- Inspecting activity within the CuT method:
  - *verify(mock).method(args)*
  - *verify(mock, times(1)).method(args)*
  - *Other verification modes:*
    - *times(n), atLeast(n), atMost(n) & never()*
- Specifying arguments:
  - *An actual value or object: eq(value) or eq(object)*
  - *Any value (anyInt(), etc); any() for any Object*
  - *Many more types of **Matchers***

Your exercise is to build unit tests for two classes in your Project.

- ✓Each team member picks two classes in your project and builds unit tests for them.
  - ***Each team member will pick different classes to test.***
  - ***If you need to refactor the code to make the component more testable, then do so.***
- ✓Create the test class in the appropriate package in the test source path.
- ✓Create a reasonable set of test cases.
  - ***At least three test cases for each CuT.***
  - ***Focus on the business logic methods (eg, REST Controllers or Services).***

Your exercise is to build unit tests for two classes in your Project.

- ✓Upload the two unit test source files to the *Unit testing - individual* Dropbox in MyCourses.
- ✓You will now complete the *Definition of Done* unit testing checklist items to consider the story done.