Unit Testing with JUnit

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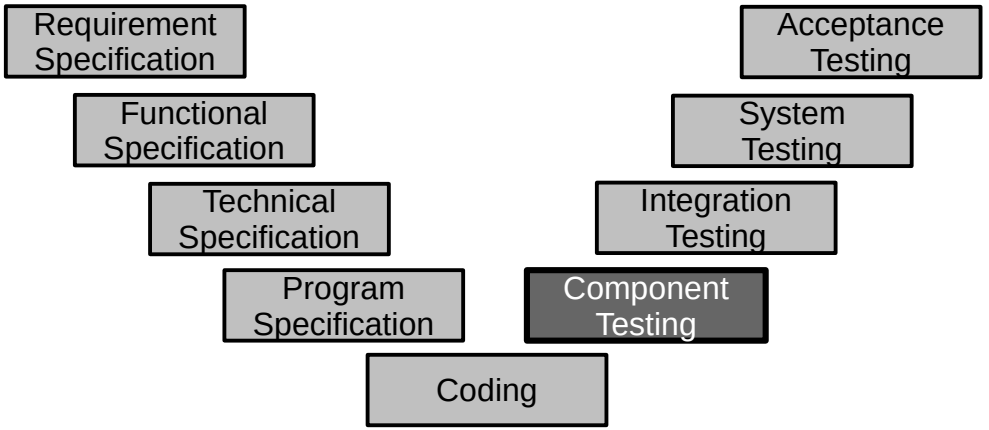
ADAP Y02

Definition Unit Testing

- Recap
- Unit = Component (in our context)
- Often classes are seen as units



Example of Test Harness

- JUnit (Java Unit Testing Framework)
  - A test harness implemented as an object-oriented testing framework
  - Supports tests and test suites, set-ups, tear-downs, etc.
  - Small and simple, easy to learn
  - Well-supported by tools / integrated into IDEs like Eclipse

JUnit popularized unit testing: “Never in the field of software development have so many owed so much to so few lines of code.” [M07]

JUnit Information

- Available from http://junit.org
  - Comes as pre-installed plug-in with Eclipse and most other IDEs
  - See course literature for an introduction to JUnit
- Version history of JUnit
  - Prior to JUnit 4 conventions rather than annotations
  - Wahlzeit uses JUnit 4
- JUnit 5
  - Is the new major version of the testing framework
  - Is a complete rewrite of JUnit 4
  - Provides new foundation for developer-side testing on the JVM
  - Uses Java 8 features, for example, lambdas
  - Has a modular concept, imports only what is needed

JUnit Example: Component Under Test

- Scheduler for tasks that are triggered the first time on a certain point in time and then in a defined fix interval

```java
package osrg.adap.testing;

import java.util.Date;

public class Scheduler {

    /***
     * ..... a lof of other Scheduler attributes and methods
     ***/

    public Date calculateExecutionDate(Date givenExecutionDate, long interval) {
        Date now = new Date();

        if (givenExecutionDate.after(now)) {
            return givenExecutionDate;
        }

        long offset = (now.getTime() - givenExecutionDate.getTime()) % interval;
        return new Date(now.getTime() + interval - offset);
    }
}
```

JUnit Example: Simple Unit Tests (1/2)

```java
package osrg.adap.testing;

import org.junit.Test;
import java.util.Date;
import static org.junit.Assert.*;

public class SchedulerTest {

    @Test
    public void testCalculateExecutionDateFromFutureDate() {
        Date futureDate = new Date(new Date().getTime() + 60000);

        Scheduler scheduler = new Scheduler();
        Date calculatedDate = scheduler.calculateExecutionDate(futureDate, 1000L);

        assertEquals(futureDate, calculatedDate);
    }

    @Test
    public void testCalculateExecutionDateFromPastDate() {
        Date pastDate = new Date(new Date().getTime() - 1000);

        Scheduler scheduler = new Scheduler();
        Date calculatedDate = scheduler.calculateExecutionDate(pastDate, 60000L);

        assertEquals(pastDate.getTime() + 60000, calculatedDate.getTime());
    }
}
```

- Annotate test method with **@Test**
- Conventions:
  - Containing class name ends with ‘Test’
  - Test methods start with ‘test’
  - File locations depend on build tool, e.g. Gradle
    - Sources: $project/src/main/java
    - Tests: $project/src/test/java
  - Test package hierarchy should mirror the main hierarchy

JUnit Example: Simple Unit Tests (2/2)

```java
package osrg.adap.testing;

import org.junit.Test;
import java.util.Date;
import static org.junit.Assert.*;

public class SchedulerTest {

    @Test
    public void testCalculateExecutionDateFromFutureDate() {
        Date futureDate = new Date(new Date().getTime() + 60000);

        Scheduler scheduler = new Scheduler();
        Date calculatedDate = scheduler.calculateExecutionDate(futureDate, 1000L);

        assertEquals(futureDate, calculatedDate);
    }

    @Test
    public void testCalculateExecutionDateFromPastDate() {
        Date pastDate = new Date(new Date().getTime() - 1000);

        Scheduler scheduler = new Scheduler();
        Date calculatedDate = scheduler.calculateExecutionDate(pastDate, 60000L);

        assertEquals(pastDate.getTime() + 60000, calculatedDate.getTime());
    }
}
```

- **Assertions** for checking the results
- Explicit assertions / failures in code
  - assert(...)
  - fail(...)
- Annotations with expected results
  - @Test(expected = SomeException.class)
  - @Test(timeout = 500)

3A Pattern

```java
@Test
public void testCalculateExecutionDateFromFutureDate() {
    Date futureDate = new Date(new Date().getTime() + 60000);

    Scheduler scheduler = new Scheduler();
    Date calculatedDate = scheduler
        .calculateExecutionDate(futureDate, 1000L);

    assertEquals(futureDate, calculatedDate);
}
```

1. **Arrange**
2. **Act (execute)**
3. **Assert (check)**

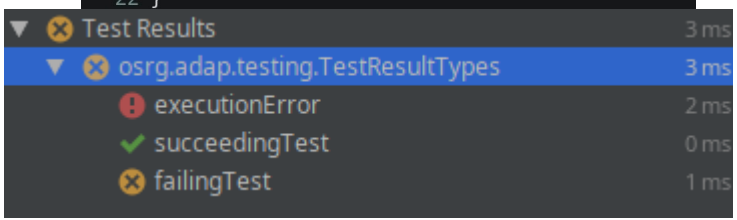
Test Results

1) **Pass**

2) **Fail**
   - a) Program is defect
   - b) Test is defect

3) Test execution error

```java
package osrg.adap.testing;

import org.junit.Test;
import static org.junit.Assert.fail;

public class TestResultTypes {

    @Test
    public void succeedingTest() {
        return;
    }

    @Test
    public void failingTest() {
        fail();
    }

    @Test
    public void executionError() {
        throw new IllegalStateException();
    }
}
```



JUnit Static Test Setup & Teardown

- Setting up / tearing down test environment **for every** test in a class
  - @Before
  - @After
- Setting up / tearing down test environment **once for all** tests in a class
  - @BeforeClass
  - @AfterClass

```java
package osrg.adap.testing;

import org.junit.After;
import org.junit.Before;
import org.junit.Test;

public class SimpleSetupTearDown {

    private Scheduler schedulerUnderTest;

    @Before
    public void setupScheduler() {
        schedulerUnderTest = new Scheduler();
        schedulerUnderTest.setMode("BEST_EFFORT");
        schedulerUnderTest.start();
    }

    @After
    public void teardownScheduler() {
        schedulerUnderTest.stop();
    }

    @Test
    public void testSchedulerDryrun() {
        // just a dry-run
    }
}

```

JUnit Dynamic Test Setup & Teardown

- Reusable Setup and Teardown
- TestRule
  - e.g. TmpDir Rule
    - Temporary directory that is cleared after each test case
  - Rule chain supports composition of test rules
    - Rule chain lines up test rules in sequence
    - Fluid programming style chains methods
  - Use @Rule and @ClassRule analogous to @Before and @BeforeClass
- ExternalResource
  - More complex set-ups to be run once or only a few times
  - Applies, for example, to heavyweight database set-up

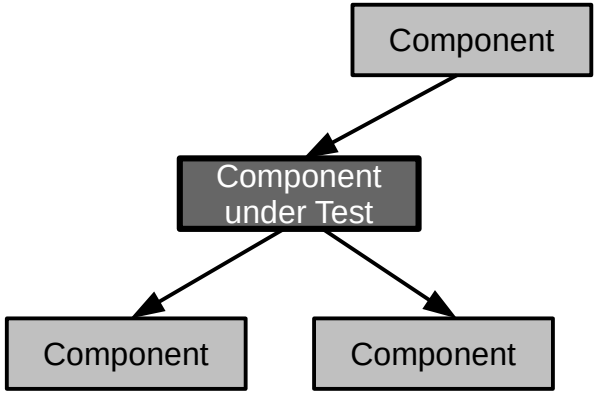
```java
package osrg.adap.testing;

import org.junit.Rule;
import org.junit.Test;
import org.junit.rules.TemporaryFolder;
import java.io.File;
import java.io.IOException;
import static org.junit.Assert.assertTrue;

public class TmpDirTest {

    @Rule
    public TemporaryFolder folder = new TemporaryFolder();

    @Test
    public void testTmpFolder() throws IOException {
        File file = folder.newFile("testfile.txt");
        assertTrue(file.exists());
    }
}
```

Changes in JUnit Versions

- Tests are implemented in test classes
  - JUnit 3.8 or before
    - Start test method name with “test”
    - End test class name with “Test”
  - JUnit 4
    - Annotate test method with @Test
    - **Annotate set-up methods with @Before and @BeforeClass**
    - **Annotate tear-down methods with @After and @AfterClass**
    - End class name with Test (optional)
  - JUnit 5
    - Annotate test method with @Test
    - **Annotate set-up methods with @BeforeEach and @BeforeAll**
    - **Annotate tear-down methods with @AfterEach and @AfterAll**
    - End class name with Test (optional)

Test Drivers and Test Doubles

- Components are part of a dependency graph
- We need to isolate components in order to test them as a single unit
- **Using components** as inspiration for test drivers (calling the component under test)
- **Used components** need to be replaced by test doubles



Isolating Units with Test Doubles

- Test Doubles
  - Object or component that we install in place of the real component for a test
- Dummy Object
  - Placeholder object that is passed to the SUT as an argument (or an attribute of an argument) but is never actually used
- Test Stub
  - Replaces component that SUT depends on, configure indirect inputs to the SUT
- Mock Object
  - Test Stub + ability to verify inputs of the SUT by behaviour expectation
- Test Spy
  - Test Stub + ability to verify inputs of the SUT by recording calls to the spy that can be verified
- Fake Object
  - Replaces component with an alternative implementation of the same functionality

xUnit Test Patterns: Refactoring Test Code by Gerard Meszaros, Published by Addison-Wesley Professional, 2007

Mockito

- Available from https://site.mockito.org/
- Serves a variety of testing double functionality
  - Stubbing
  - Mocking
  - Spying
  - Etc.
- Easy syntax to create test doubles
- Easy syntax to verify test double behaviour
- Interacts very well with JUnit

Mockito Example: Component under Test

```java
package osrg.adap.testing;

public class TodoService {

    private TodoRepository todoRepository;
    private SlackNotificator notificator;

    public TodoService(TodoRepository todoRepository, SlackNotificator notificator) {
        this.todoRepository = todoRepository;
        this.notificator = notificator;
    }

    public void setDone(long id) {
        TodoItem todo = this.todoRepository.get(id);
        todo.setDone(true);

        this.todoRepository.save(todo);
        this.notificator.notify("Todo " + todo.getId() + " has been settled!");
    }
}
```

Inversion of Control

Mockito Example

```java
package osrg.adap.testing;

import org.junit.Test;
import static org.mockito.Mockito.*;

public class TodoServiceTest {

    @Test
    public void testSetDone() {
        // ARRANGE
        TodoRepository repository = mock(TodoRepository.class);
        SlackNotificator notificator = mock(SlackNotificator.class);

        long todoId = 123L;
        TodoService todoService = new TodoService(repository, notificator);
        when(repository.get(todoId)).thenReturn(new TodoItem(todoId, "test todo"));

        // ACT
        todoService.setDone(todoId);

        // ASSERT
        verify(repository, times(1)).get(todoId);
        verify(repository, times(1)).save(new TodoItem(todoId, "test todo", true));
        verify(notificator, times(1)).notify(anyString());
    }
}
```

- Mock creation with static *mock* method or with *@Mock* annotation
- Behaviour specification with static *when* method
- Behaviour verification with static *verify method*

{ **Inversion of Control**

Thank you! Questions?

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- Contributions
  - Georg Schwarz (2019)