20+ Minutes

JUNIT

JUnit

- Kent Beck and Erich Gamma (of Design Patterns fame) developed a unit testing framework for Java programs called **Junit**.

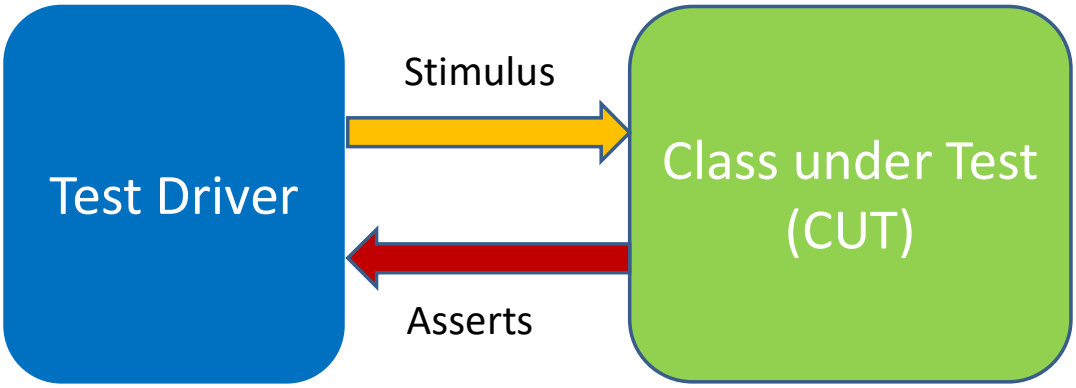
  http://www.junit.org

- JUnit 4.0 introduced annotations in the **org.junit** package for marking test code.
  - **@Test**, **@Before**, **@After**, **@BeforeClass**, **@AfterClass**, **@Ignore**, **@Test** etc.

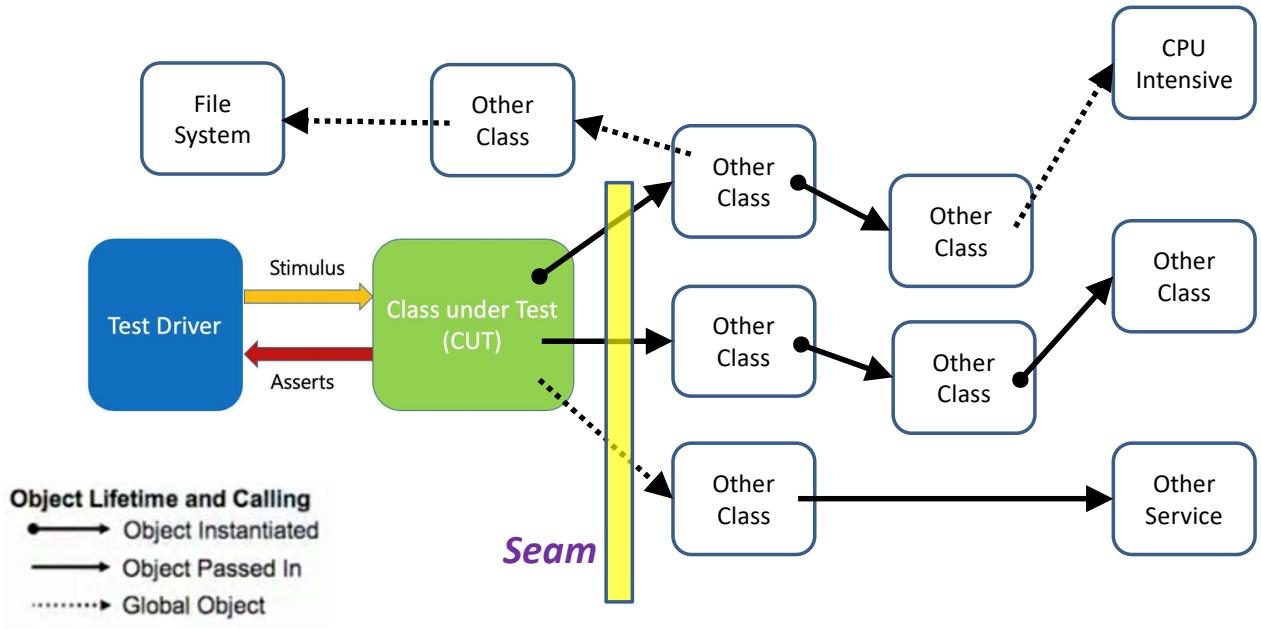
What is a unit?

- "The smallest component that it makes sense to test"
- Unit for testing depends on individual programmers or teams
- Generally, a unit means
  - class or an interface
  - a single method or function.

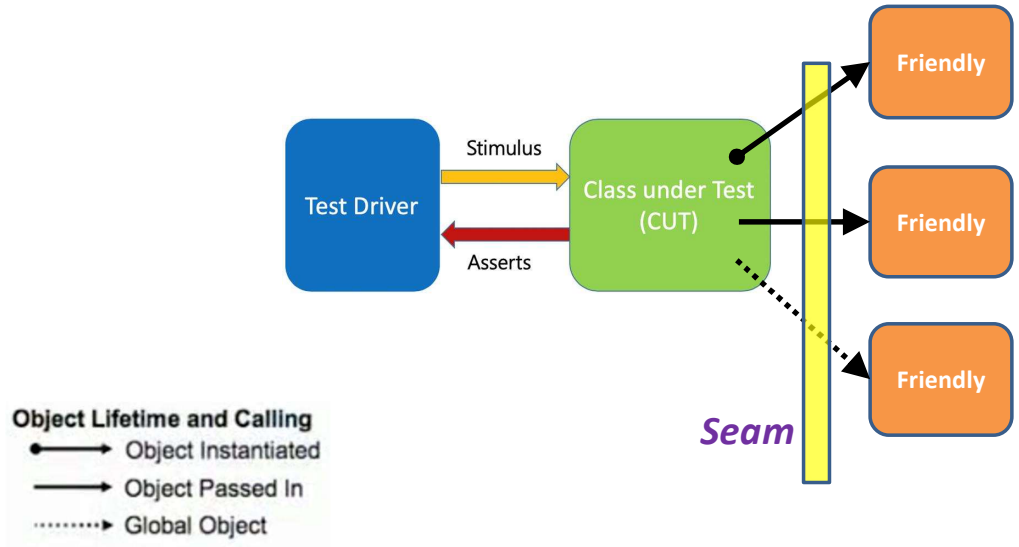
Unit Testing a Class



Unit Testing a Class



Unit Testing a Class



What is unit testing?

- Unit testing is a method that
  - instantiates a small part of our code (i.e., unit of work) and
  - verifies its behavior
  - ***independently*** from any other parts (Unit, Code etc.) of the project.
- External dependencies are managed by **Test Doubles** (Dummies/Fakes/Mocks/Stubs/Spies)

Terminology

- A **unit test** is a test of a *single* class
- A **test fixture** is a fixed state of a set of objects used as a baseline for running tests.
  - The purpose is to ensure that there is a well known and fixed environment in which tests are run so that results are repeatable.
- A **test case** tests the response of a single method to a particular set of inputs.
- A **test suite** is a collection of test cases.

Structure of a JUnit test class

- To test a class named **Foo**
- Create a test class **FooTest**

```
import static org.junit.jupiter.api.Assertions.*;
import org.junit.jupiter.api.Test;

class FooTest {

    @Test
    void test() {
        fail("Not yet implemented");
    }

}
```


Test Cases

- Methods annotated with **@Test** are considered to be test cases:
  - Their order of execution is not specified

```
@Test
void testadd() {...}

@Test
@DisplayName("Test for toString")
void testToString() {...}

@Disabled
void testAnother() {...}
```

Test Fixtures

- Methods annotated with **@BeforeEach** will execute before every test case.
- Methods annotated with **@AfterEach** will execute after every test case

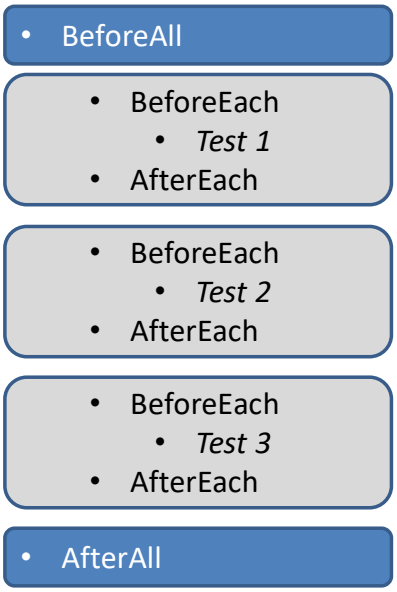
```
@BeforeEach
public void setUp() {...}

@AfterEach
public void tearDown() {...}
```


Class Test fixtures

- Methods annotated with **@BeforeAll** will execute once *before* all test cases.
- Methods annotated with **@AfterAll** will execute once *after* all test cases.
- These are useful if you need to allocate and release expensive resources once.

What JUnit does

- For *each* test case **t**:
  - JUnit executes all **@BeforeEach** methods
  - JUnit executes **t**
    - Any exceptions during its execution are logged
  - JUnit executes all **@AfterEach** methods
- Report for all test cases is presented

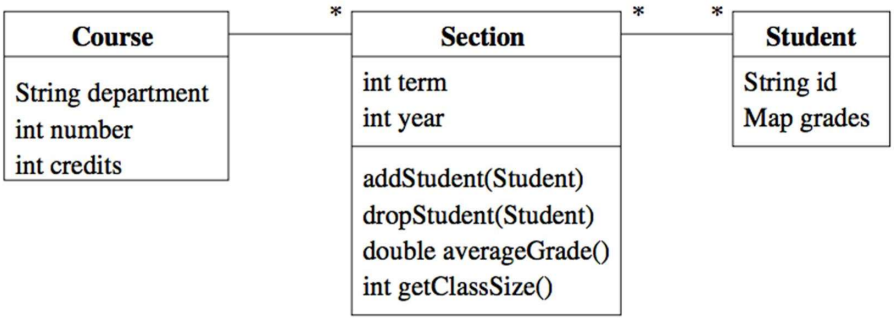


Within a test case

- Call the methods of the class being tested.
- Assert what the correct result should be with one of the provided **assert** methods.
  - `assertEquals(expected, actual);`
- These steps can be repeated as many times as necessary.
- An **assert** method is a **JUnit** method that performs a test, and throws an **AssertionError** if the test fails.
  - **Junit** catches these exceptions and shows you the results.

Example Classes

- To demonstrate writing unit tests, we are going to develop some classes for modeling **Student**s that are enrolled in a **Section** of a **Course**.



Writing a simple test case

```
public class SectionTest {
  @Test
  public void testAddStudent() {
    Student student = new Student("123-45-6789");
    Course course = new Course("CS", 410, 4);
    Section section =
      new Section(course, Section.SPRING, 2001);

    section.addStudent(student);

    assertEquals(1, section.getClassSize());
  }
}
```

Given

When

Then

The left class tests that adding a **Student** increases the enrollment by one

The **assertEquals** method is imported from the **Assert** class. If its arguments are not equal, then the test fails.

Testing Error Conditions

```
@Test
void testDropStudentNotEnrolled() {
    Student student = new Student("123-45-6789");
    Course course = new Course("CS", 410, 4);
    Section section =
      new Section(course, Section.SPRING, 2001);

    assertThrows(IllegalArgumentException.class,
       () -> section.dropStudent(student));
}
```

- Making sure that your program fails in a well-understood fashion is very important.
- To test that the **dropStudent** method throws an **IllegalArgumentException**

Testing Error Conditions

```
@Test(expected = IllegalArgumentException.class)
  public void testDropStudentNotEnrolled() {
    Student student = new Student("123-45-6789");
    Course course = new Course("CS", 410, 4);
    Section section =
      new Section(course, Section.SPRING, 2001);

    section.dropStudent(student);
}
```

- Making sure that your program fails in a well-understood fashion is very important.
- To test that the **dropStudent** method throws an **IllegalArgumentException.**

The Assert class

- The **Assert** contains methods for validating that certain conditions are true.
  - **assertEquals**: Two entities (objects, ints, etc.) should be equal
    - (compares objects using **equals()**)
  - **assertNotNull**: A value should not be null
  - **assertSame**: Two object references should be the same
    - (compare objects using ==)
  - **assertTrue**: A boolean expression should be true
  - **assertFalse**: A boolean expression should be false
  - **fail**: The test should fail

The Assertions class

- When an assertion evaluates to false, the test fails.
- Each **assert** method is overloaded to have a **String** message.

```
assertEquals(1, section.getClassSize());
```


```
assertEquals(
  1, section.getClassSize(), "Wrong number of students"
);
```

Test classes and packages

Should test classes be in the same package as the code they are testing?

Pros:

- Test code can access package-protected methods and fields.
- Easy to associate test code with domain code.

Cons:

- Don't want to test code to interfere with domain code.
- Don't want to ship test code.

How to organize Tests (JUnit Java files)

- The better way is to place the tests in a separate parallel directory structure with package alignment.

```
── pom.xml
└── src
    ├── main
    │   ├── java
    │   │   └── com
    │   │       └── javadevelopersguide
    │   │           └── junit
    │   │               └── Calculator.java
    │   └── resources
    └── test
        ├── java
        │   └── com
        │       └── javadevelopersguide
        │           └── junit
        │               └── CalculatorTest.java
        └── resources
```

More readable assertions

JUnit provides some basic methods for validating the state of your tests (assertions), but the code and the failure messages can be hard to read

```
assertTrue(myString.contains("Hello"));
```

When the above fails, all you get is an “expected true, but got false” error message.

The **Hamcrest** assertion framework provides powerful “matchers” that provide readable assertion statements with detailed and specific failure messages:

http://hamcrest.org/JavaHamcrest

Hamcrest assertion statements

Hamcrest provides an **assertThat** method that asserts that some value “matches” a “matcher” .

Each “matcher” has a static factory method.

Matchers are composed to form complex assertions.

The matcher is syntactic sugar that aids readability.

```
import org.junit.Jupiter.api.Test;
import static org.hamcrest.Matchers.*;
import static org.hamcrest.MatcherAssert.assertThat;
class HamcrestMatchersTest {

  @Test
  void isEqualTo() {
    Integer int1 = new Integer("123");
    Integer int2 = new Integer("123");

    assertThat(int1, is(equalTo(int2)));
  }
```

Examples of Hamcrest assertions

```
@Test
void isNullValue() {
  assertThat(null, is(nullValue()));
}

@Test
void isSameInstance() {
  Object o = new Object();
  assertThat(o, is(sameInstance(o)));
}

@Test
public strings() {
String s = "Hamcrest is awesome";

  assertThat(s, startsWith("Hamcrest"));
  assertThat(s, endsWith("awesome"));
  assertThat(s, containsString("is"));
  assertThat(s, is(not(isEmptyString())));
  assertThat(s, is(equalToIgnoringCase("HAMCREST IS AWESOME")));
}
```

Alternative to Hamcrest framework
https://assertj.github.io/doc/

AssertJ

Fluent assertions for java

Annotations

Features	JUnit 5	JUnit 4
Declares a test method	@Test	@Test
Denotes that the annotated method will be executed before all test methods in the current class	@BeforeAll	@BeforeClass
Denotes that the annotated method will be executed after all test methods in the current class	@AfterAll	@AfterClass
Denotes that the annotated method will be executed before each test method	@BeforeEach	@Before
Denotes that the annotated method will be executed after each test method	@AfterEach	@After
Disable a test method or a test class	@Disable	@Ignore
Denotes a method is a test factory for dynamic tests in JUnit 5	@TestFactory	N/A
Denotes that the annotated class is a nested, non-static test class	@Nested	N/A
Declare tags for filtering tests	@Tag	@Category
Register custom extensions in JUnit 5	@ExtendWith	N/A
Repeated Tests in JUnit 5	@RepeatedTest	N/A

Assertions

JUnit 4	JUnit 5
fail	fail
assertTrue	assertTrue
assertThat	N/A
assertSame	assertSame
assertNull	assertNull
assertNotSame	assertNotSame
assertNotEquals	assertNotEquals
assertNotNull	assertNotNull
assertFalse	assertFalse
assertEquals	assertEquals
assertArrayEquals	assertArrayEquals
	assertAll
	assertThrows

Golden Master Testing

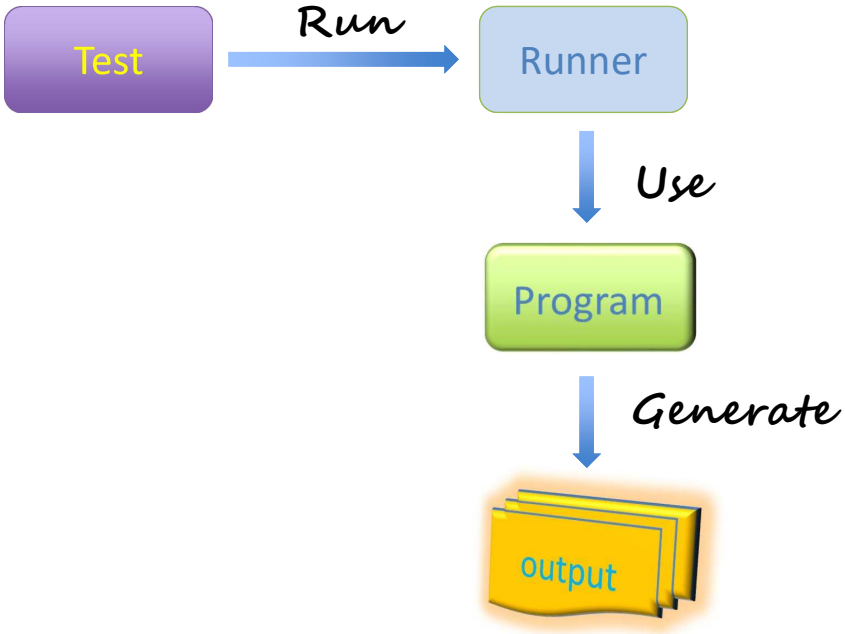
Golden master testing refers to *capturing the result of a process, and then comparing future runs against the saved "gold master"* to discover unexpected changes.

Rather than trying to specify all of the logical paths through an untested module, you can *feed it a varied set of inputs and turn the outputs into automatically verifying tests*.

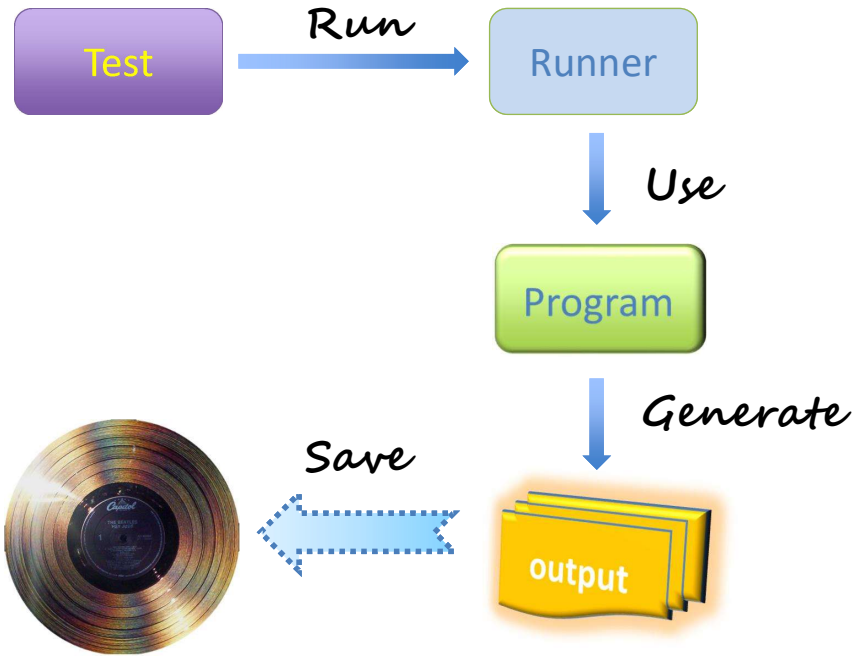
No guarantee of the outputs' correctness, but at least can be sure they don't change.

Common when working with legacy code.

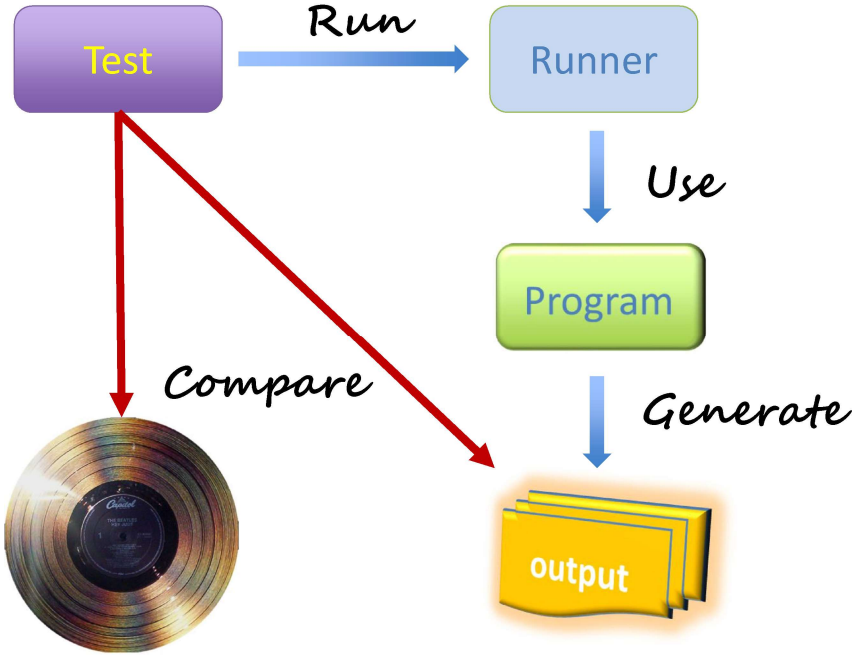
Step 1



Step 2


Test
Run
Runner
Use
Program
Generate
output
Save

Step 3


Test
Run
Runner
Use
Program
Generate
output
Compare

How to implement golden master testing

1. Choose (or randomly generate, using a known seed) a set of inputs for your module or program.
2. Run the inputs through the system, persisting the output.
3. When testing a change, run the same inputs through the new version of the system and flag any output variation.
4. For each variation, have a human determine whether or not the change is expected and desirable. If it is, update the persisted gold master records.