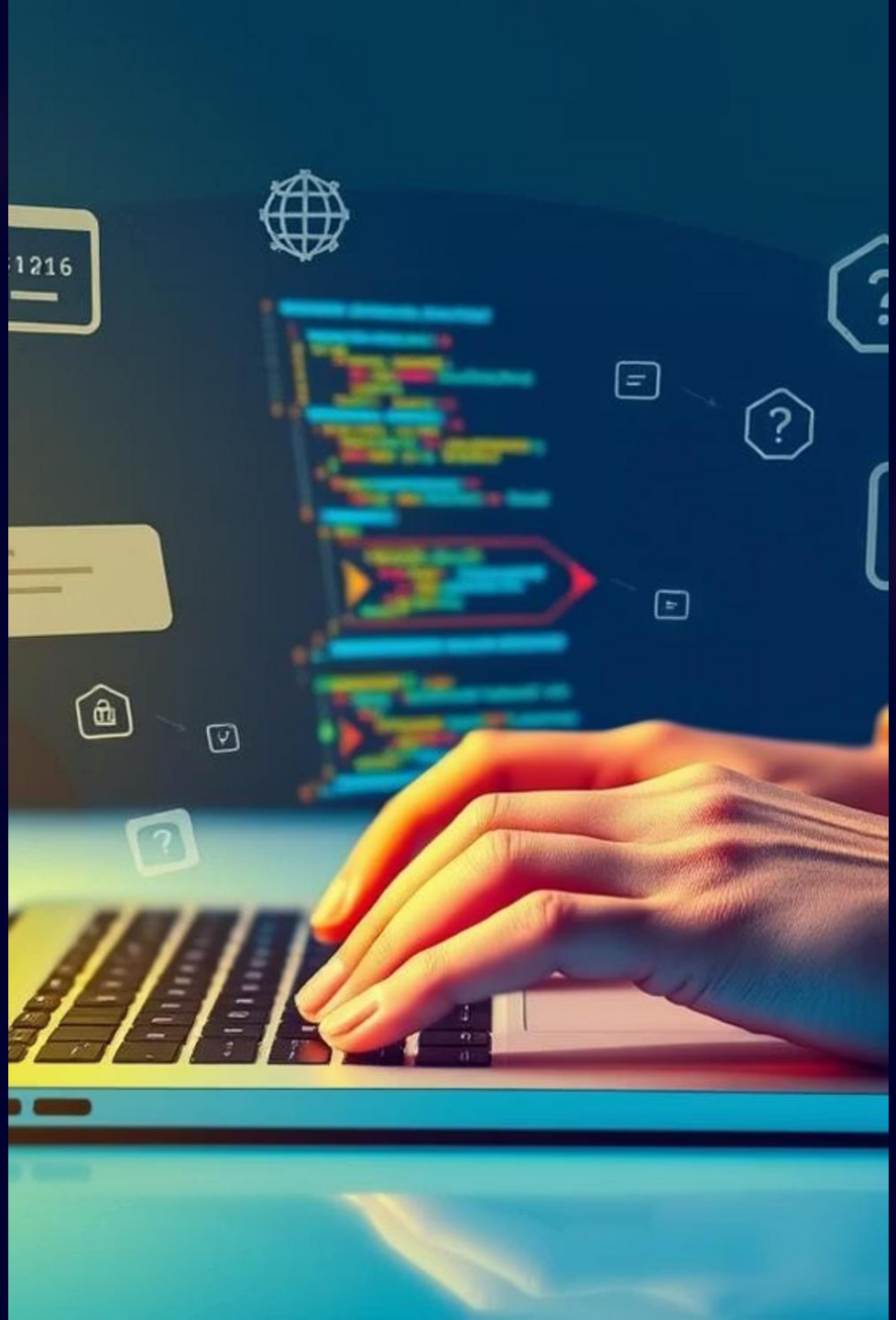


Spring Boot Unit Testing

JUnit 5 & Mockito Framework

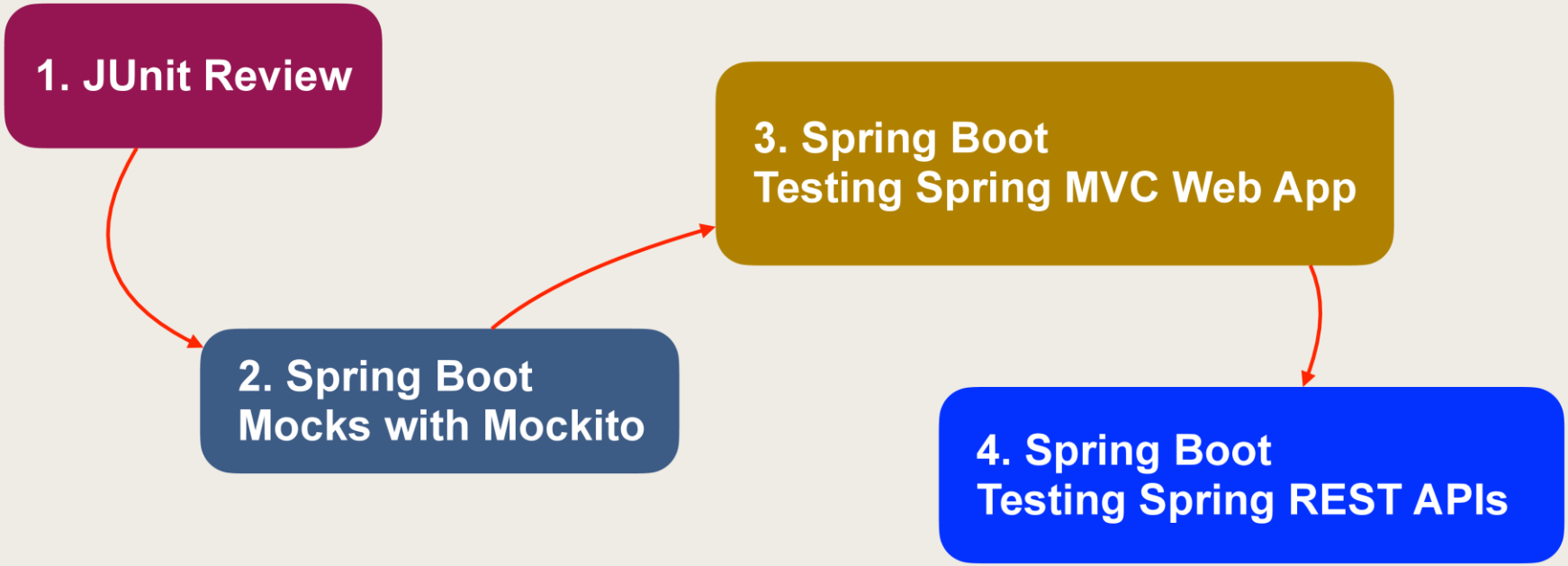
Unit testing forms the cornerstone of robust Spring Boot applications, acting as an early defect detection system. It significantly reduces debugging costs and enables agile development, leading to faster, more confident iterations.

Made with GAMMA

Spring Boot Unit Testing

- Spring Boot supports developing unit tests and integration tests using JUnit and Mockito.
- By developing tests, you can create applications with better code design, fewer bugs, and higher reliability.
- This course shows you how to take advantage of Spring Boot's testing support.

Course Road Map



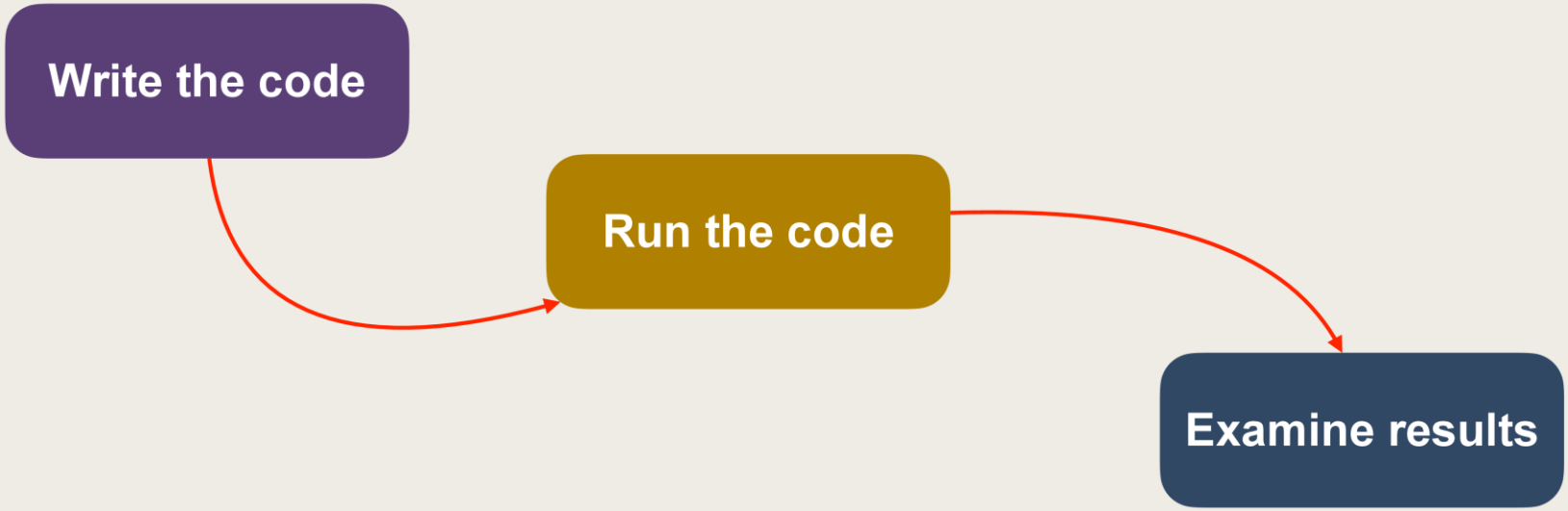
Prerequisites

- You should have prior experience with
  - Java
  - Spring Boot
  - Maven

Spring & Hibernate for Beginners

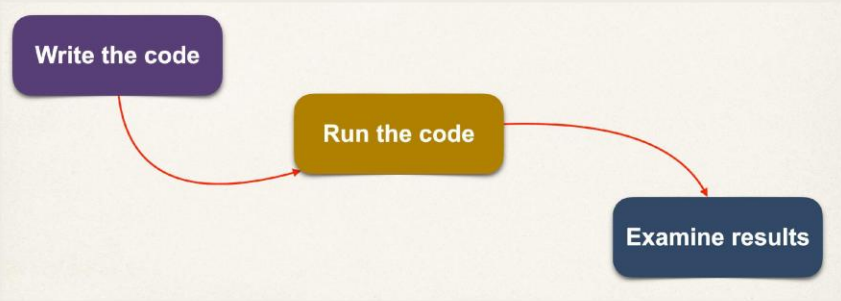
How Do We Test Code?

- Manual testing ... maybe this???



What's Wrong?

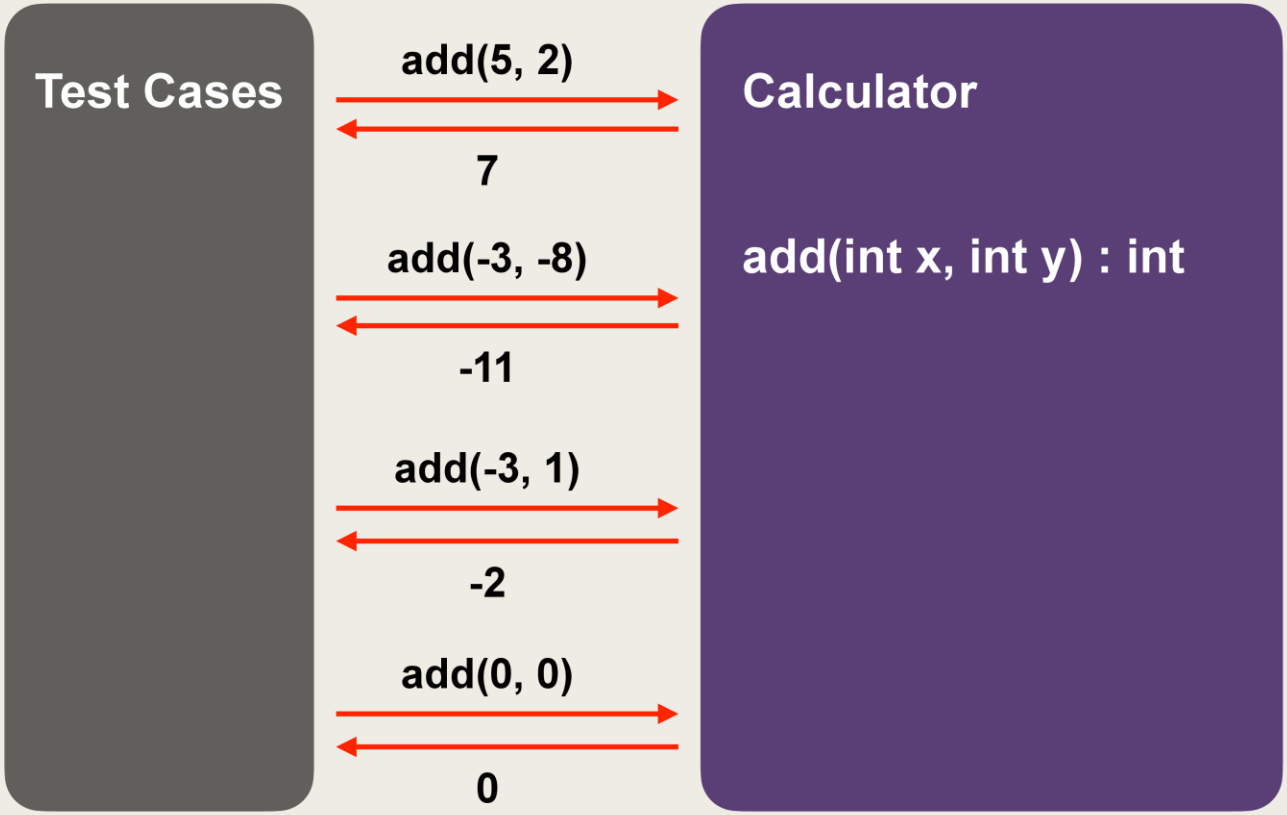
- Requires human interaction and analysis
- Test case is not reproducible
- No way to automate the test



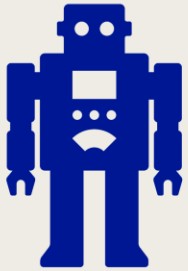
- What if I wanted to
  - Run a battery of tests for each code commit
  - Produce a report of test results

What is Unit Testing?

- Testing an individual unit of code for correctness
- Provide fixed inputs
- Expect known output


Test Cases
add(5, 2)
7
add(-3, -8)
-11
add(-3, 1)
-2
add(0, 0)
0
Calculator
add(int x, int y) : int

Benefits of Unit Testing



- Automated tests
- Better code design
- Fewer bugs and higher reliability
- Increases confidence for code refactoring ... did I break anything??
- Basic requirement for
  - DevOps and Build Pipelines
  - Continuous Integration / Continuous Deployment (CI/CD)

Integration Testing

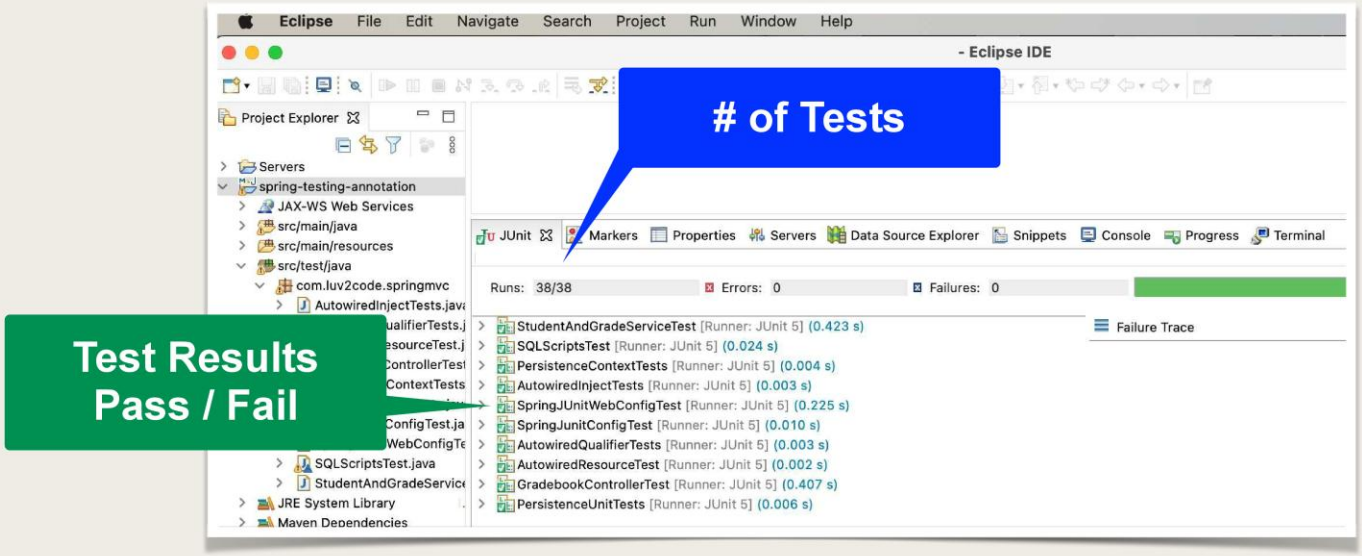
- Test multiple components together as part of a test plan
- Determine if software units work together as expected
- Identify any negative side effects due to integration
- Can test using mocks / stubs
- Can also test using live integrations (database, file system)

Unit Testing Frameworks

- JUnit
  - Supports creating test cases
  - Automation of the test cases with pass / fail
  - Utilities for test setup, teardown and assertions
- Mockito
  - Create mocks and stubs
  - Minimize dependencies on external components

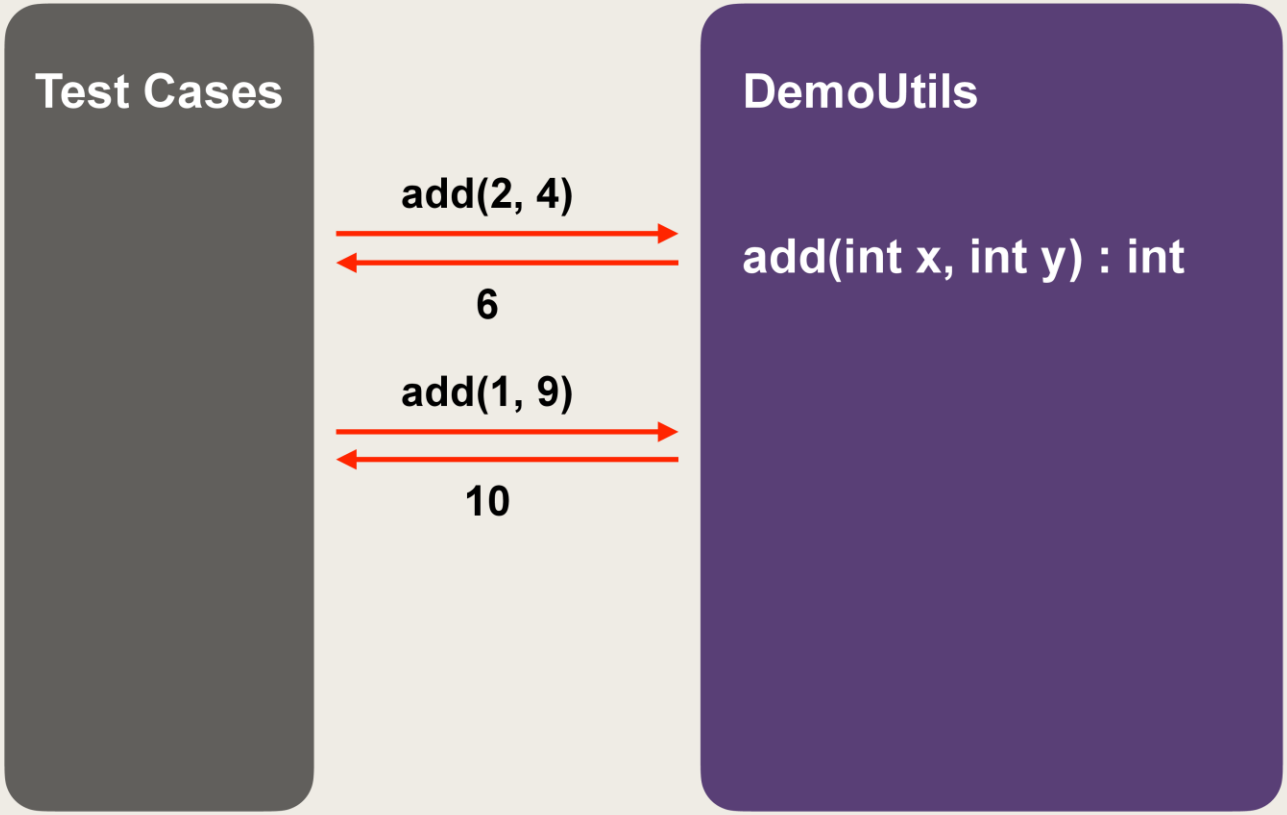
Unit Testing Tooling Support

- Eclipse



Getting Started

- Let's start with some simple examples for unit testing
- At the moment, we will focus on the JUnit fundamentals for testing
  - How to define a test
  - JUnit Assertions
  - Running tests
- Later we'll discuss other techniques such as Test-Driven-Development (TDD)


Test Cases
add(2, 4)
6
add(1, 9)
10
DemoUtils
add(int x, int y) : int

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

  public int add(int a, int b) {
    return a + b;
  }

}
```

Development Process

1. Add Maven dependencies for JUnit
2. Create test package
3. Create unit test
4. Run unit test

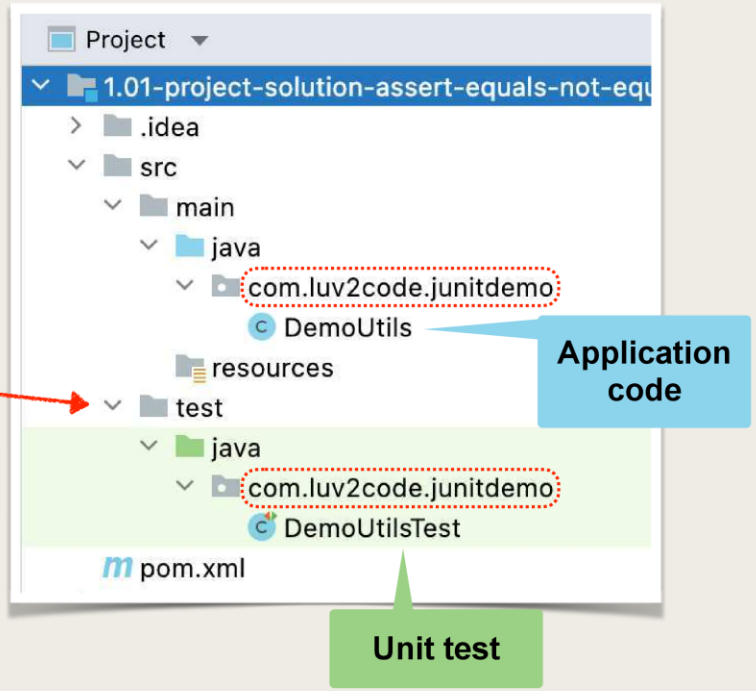
Step 1: Add Maven dependencies for JUnit

pom.xml

```
...

    <dependency>
        <groupId>org.junit.jupiter</groupId>
        <artifactId>junit-jupiter</artifactId>
        <version>5.8.2</version>
        <scope>test</scope>
    </dependency>

...
```

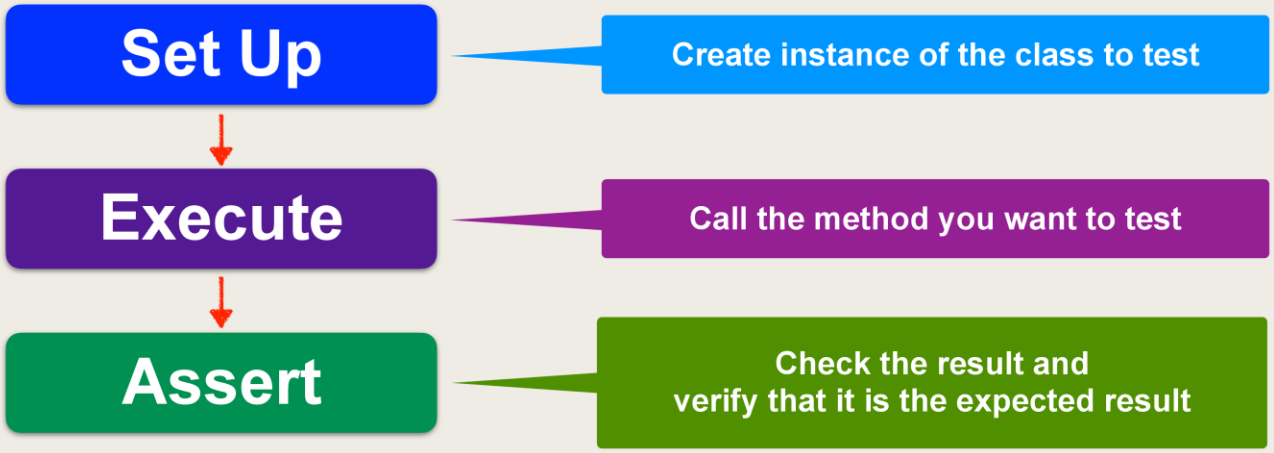
Step 2: Create test package

- The code we are testing is located in package:
  - `com.luv2code.junitdemo`
- A convention is to create test classes in similar package structure under `/test`
- Not a hard requirement, merely a convention
  - Helps with organization of test classes
  - Easy to find test classes when joining new projects
  - Special edge cases for accessing protected class members

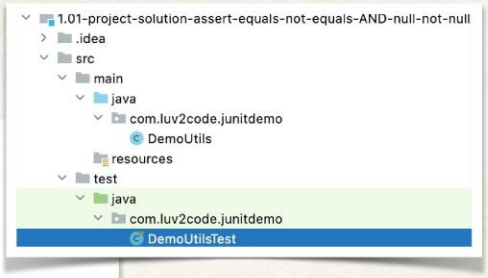


Step 3: Create unit test

- Unit tests have the following structure



Step 3: Create unit test



DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.Assertions;

class DemoUtilsTest {

    @Test
    void testEqualsAndNotEquals() {

        // set up
        DemoUtils demoUtils = new DemoUtils();

        int expected = 6;

        // execute
        int actual = demoUtils.add(2, 4);

        // assert
        Assertions.assertEquals(expected, actual, "2+4 must be 6");
    }

}
```

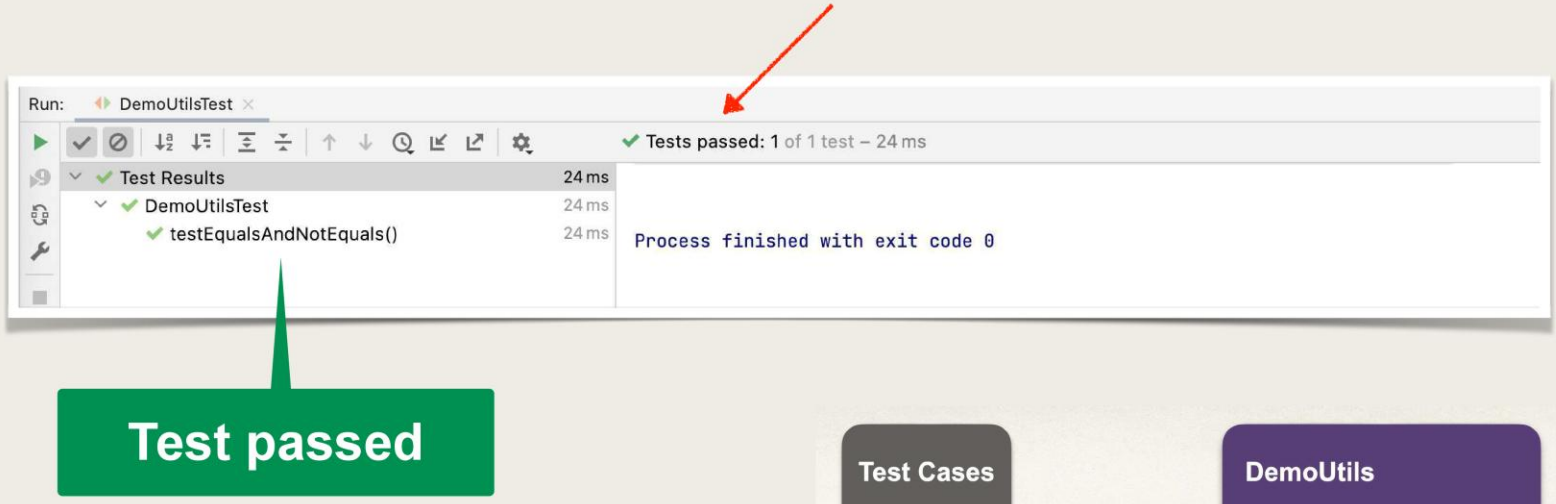
Annotate the method as a test method

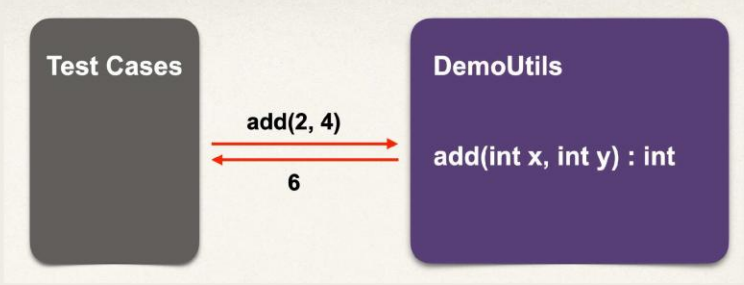
Create instance of the class to test

Call the method you want to test

Check the *actual* result and verify that it is the *expected* result

Step 4: Run unit test



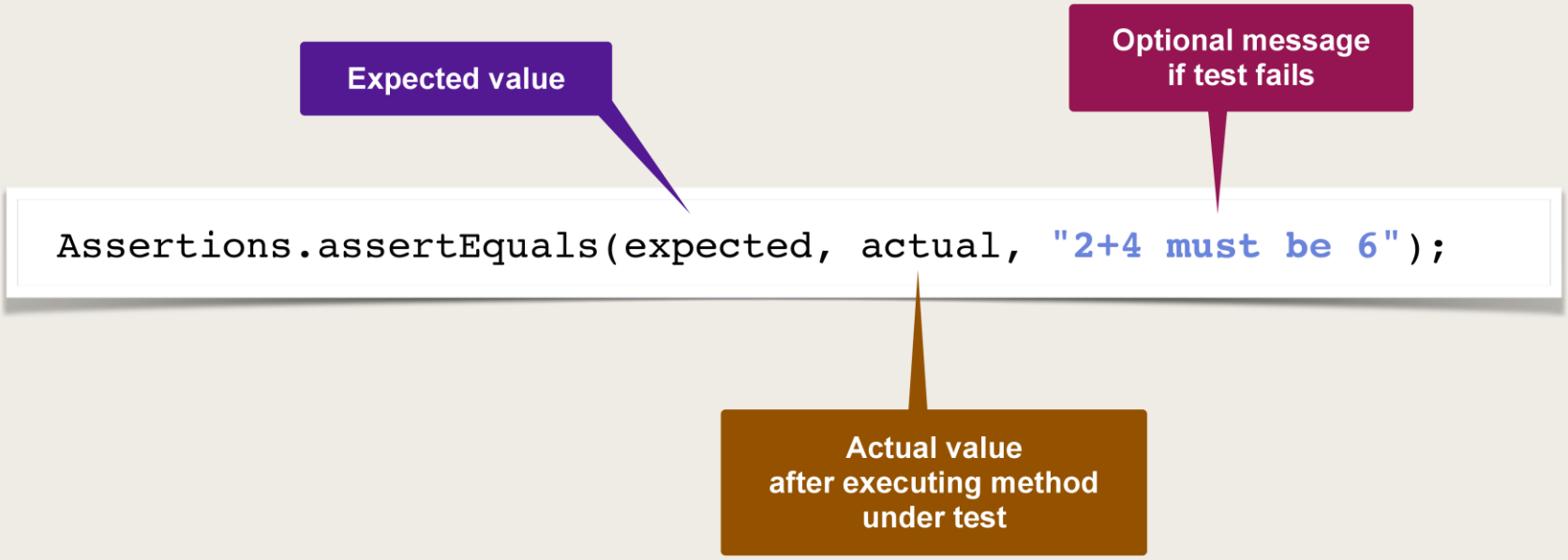


JUnit Assertions

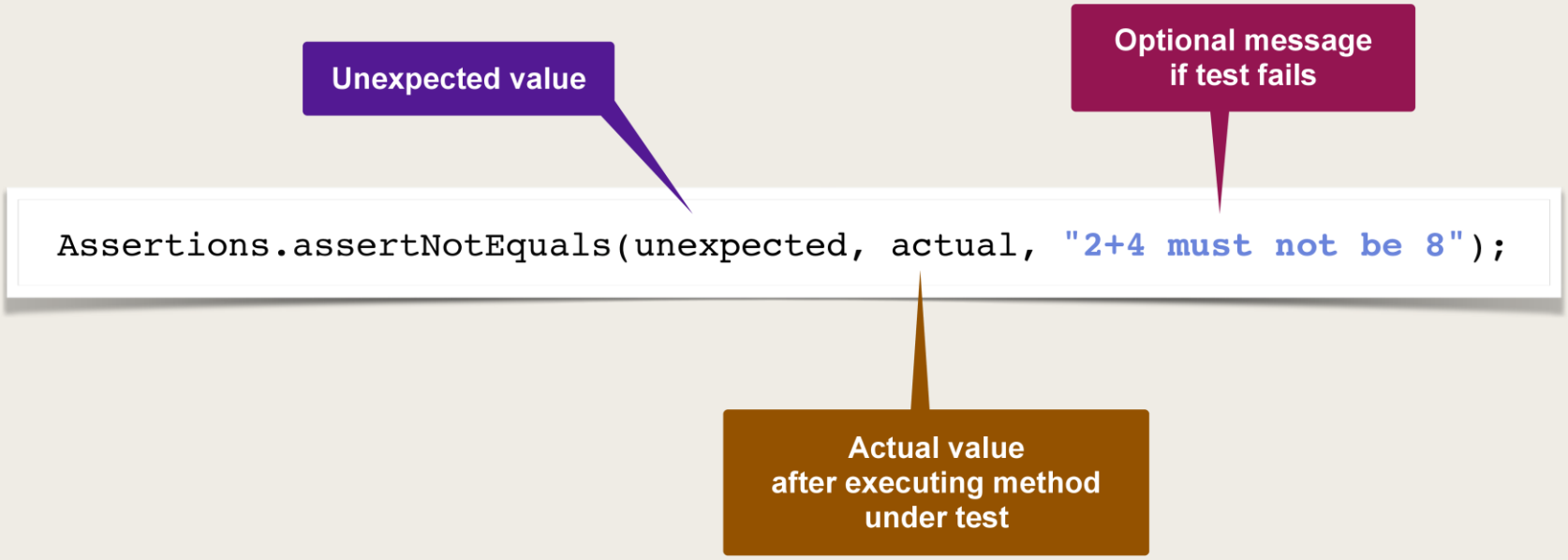
- JUnit has a collection of assertions
- Defined in class: `org.junit.jupiter.api.Assertions`

Method name	Description
`assertEquals`	Assert that the values are equal
`assertNotEquals`	Assert that the values are not equal
`assertNull`	Assert that the value is null
`assertNotNull`	Assert that the value is not null
…	…

assertEquals



assertNotEquals



DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.Assertions;

class DemoUtilsTest {

   @Test
   void testEqualsAndNotEquals() {

        // set up
        DemoUtils demoUtils = new DemoUtils();

        int expected = 6;
        int unexpected = 8;

        // execute
        int actual = demoUtils.add(2, 4);

        // assert
        Assertions.assertEquals(expected, actual, "2+4 must be 6");
        Assertions.assertNotEquals(unexpected, actual, "2+4 must not be 8");

   }

}
```

Create instance of the class to test

Call the method you want to test

Check the *actual* result and verify that it is NOT the *unexpected* result

Static Import

- Static import: a short-cut for referencing static methods & fields in a class

BEFORE

```
import org.junit.jupiter.api.Assertions;

   ...

   Assertions.assertEquals(expected, actual, "2+4 must be 6");
   Assertions.assertNotEquals(unexpected, actual, "2+4 must not be 8");
```

Class name

Method name

Short-cut for static methods & fields

Static import

AFTER

```
import static org.junit.jupiter.api.Assertions.assertEquals;
import static org.junit.jupiter.api.Assertions.assertNotEquals;

   ...

   assertEquals(expected, actual, "2+4 must be 6");
   assertNotEquals(unexpected, actual, "2+4 must not be 8");
```

Just give method name

Static Import

- Can also use wildcard for static import

BEFORE

```
import static org.junit.jupiter.api.Assertions.assertEquals;
import static org.junit.jupiter.api.Assertions.assertNotEquals;

  ...

  assertEquals(expected, actual, "2+4 must be 6");
  assertNotEquals(unexpected, actual, "2+4 must not be 8");
```

Wildcard

AFTER

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

  ...

  assertEquals(expected, actual, "2+4 must be 6");
  assertNotEquals(unexpected, actual, "2+4 must not be 8");
```

Just give method name

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

   public Object checkNull(Object obj) {

        if (obj != null) {
            return obj;
        }
        return null;

   }
}
```

Assertions: Null and NotNull

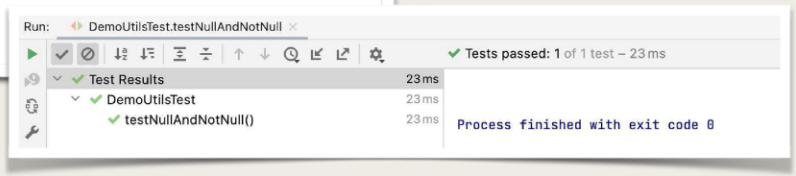
Method name	Description
`assertNull`	Assert that the value is null
`assertNotNull`	Assert that the value is not null
…	…

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

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

class DemoUtilsTest {

    @Test
    void testNullAndNotNull() {

        DemoUtils demoUtils = new DemoUtils();

        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");

    }

}
```

Optional message if test fails

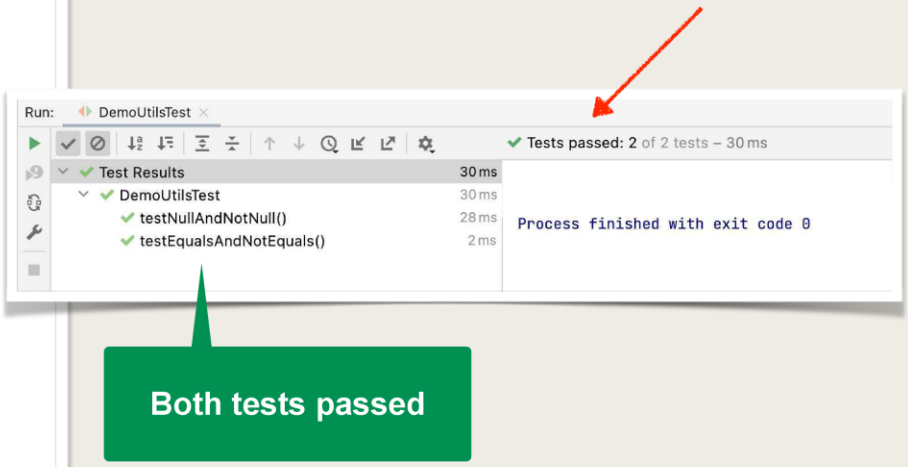
Actual value after executing method under test



Multiple Tests in One Class

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

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

class DemoUtilsTest {

    @Test
    void testEqualsAndNotEquals() {

        // set up
        DemoUtils demoUtils = new DemoUtils();

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");

    }

    @Test
    void testNullAndNotNull() {

        DemoUtils demoUtils = new DemoUtils();

        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");

    }

}
```



Lifecycle Methods

- When developing tests, we may need to perform common operations
- Before each test
  - Create objects, set up test data
- After each test
  - Release resources, clean up test data

DemoUtilsTest.java — BEFORE

```java
package com.luv2code.junitdemo;

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

class DemoUtilsTest {

    @Test
    void testEqualsAndNotEquals() {

        // set up
        DemoUtils demoUtils = new DemoUtils();

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void testNullAndNotNull() {

        // set up
        DemoUtils demoUtils = new DemoUtils();

        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }

}
```

DemoUtilsTest.java — AFTER

```java
package com.luv2code.junitdemo;

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

class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
        System.out.println("@BeforeEach executes before the execution of each test method");
    }

    @Test
    void testEqualsAndNotEquals() {

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }
}
```

Create object before each test

No need to create object ... handled by @BeforeEach

No need to create object ... handled by @BeforeEach

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.AfterEach;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
        System.out.println("@BeforeEach executes before the execution of each test method");
    }

    @AfterEach
    void tearDownAfterEach() {
        System.out.println("Running @AfterEach\n");
    }

    @Test
    void testEqualsAndNotEquals() {

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }
}
```

Run after each test

Execution Sequence

@BeforeEach

@Test Method One

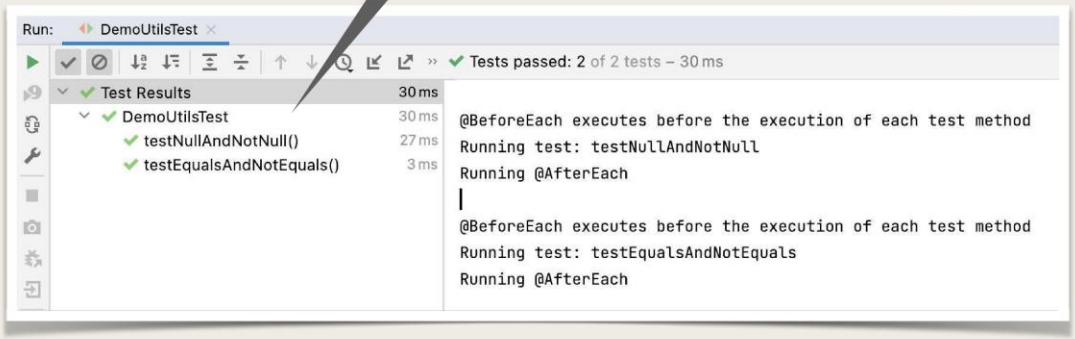
@AfterEach

@BeforeEach

@Test Method Two

@AfterEach

Don't worry about order of test methods. We'll cover that later.




```
@BeforeEach
void setupBeforeEach() {
    // set up
    demoUtils = new DemoUtils();
    System.out.println("@BeforeEach executes before the execution of each test method");
}

@AfterEach
void tearDownAfterEach() {
    System.out.println("Running @AfterEach\n");
}

@Test
void testNullAndNotNull() {

    System.out.println("Running test: testNullAndNotNull");


    String str1 = null;
    String str2 = "luv2code";

    assertNull(demoUtils.checkNull(str1), "Object should be null");
    assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
}

...
```

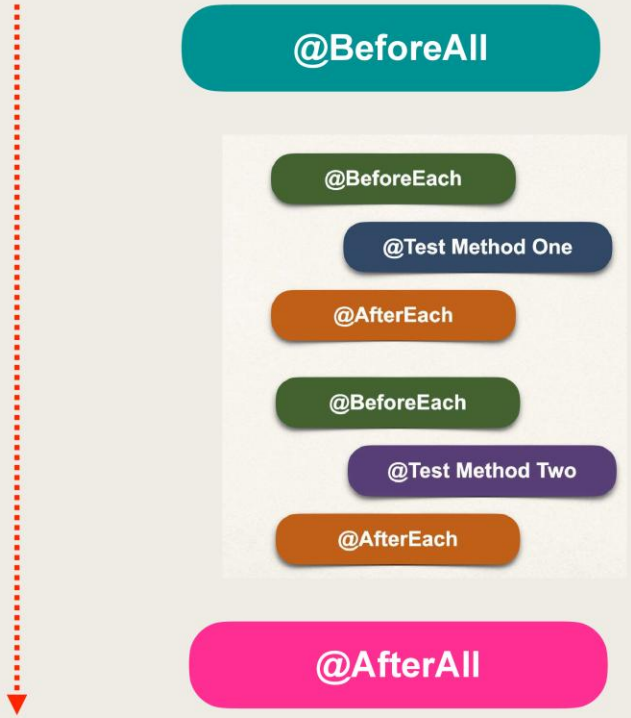
Lifecycle Methods

- When developing tests, we may need to perform one-time operations
- One-time set up before all tests
  - Get database connections, connect to remote servers ...
- One-time clean up after all tests
  - Release database connections, disconnect from remote servers ...

Lifecycle Method Annotations

Annotation	Description
`@BeforeAll`	Method is executed only once, before all test methods. *Useful for getting database connections, connecting to servers ...*
`@AfterAll`	Method is executed only once, after all test methods. *Useful for releasing database connections, disconnecting from servers ...*
...	...

Execution Sequence



Executed only once, before all test methods

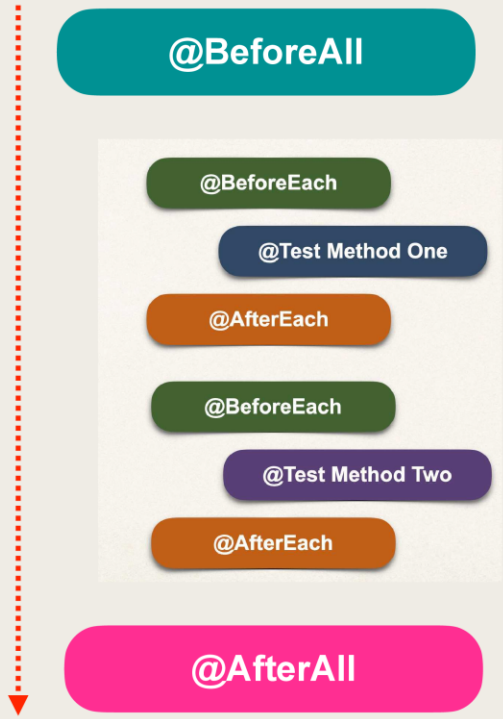
Executed only once, after all test methods

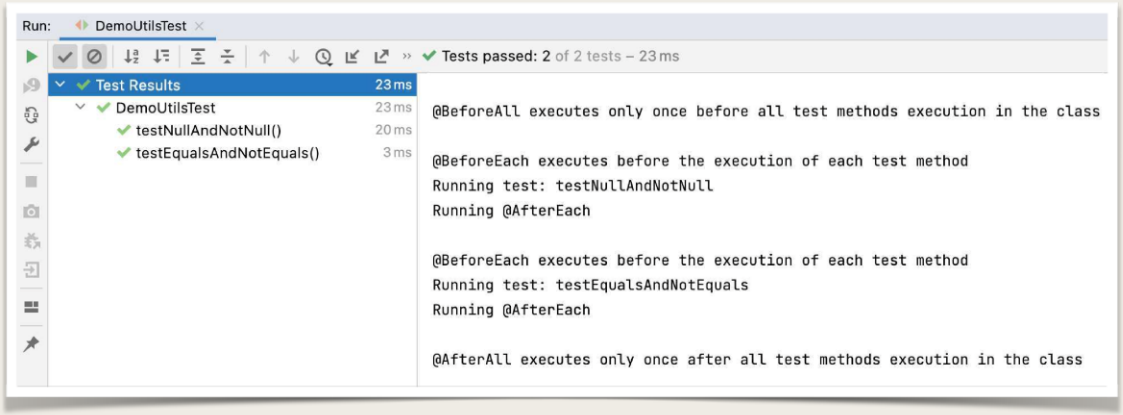
By default, methods must be static

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.AfterEeach;
import org.junit.jupiter.api.BeforeAll;
import org.junit.jupiter.api.AfterAll;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
        System.out.println("@BeforeEach executes before the execution of each test method");
    }

    @AfterEach
    void tearDownAfterEach() {
        System.out.println("Running @AfterEach\n");
    }

    @BeforeAll
    static void setupBeforeEachClass() {
        System.out.println("@BeforeAll executes only once before all test methods execution in the class\n");
    }

    @AfterAll
    static void tearDownAfterAll() {
        System.out.println("@AfterAll executes only once after all test methods execution in the class");
    }

    @Test
    void testEqualsAndNotEquals() {
        System.out.println("Running test: testEqualsAndNotEquals");
        ...
    }

    @Test
    void testNullAndNotNull() {
        System.out.println("Running test: testNullAndNotNull");
        ...
    }
}
```

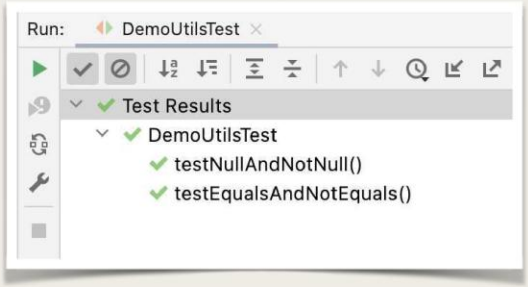
Execution Sequence






```
@BeforeAll
static void setupBeforeEachClass() {
    System.out.println("@BeforeAll executes only once before all test methods execution in the class\n");
}

@AfterAll
static void tearDownAfterAll() {
    System.out.println("@AfterAll executes only once after all test methods execution in the class");
}
```

Custom Display Names



- Currently the method names are listed in test results

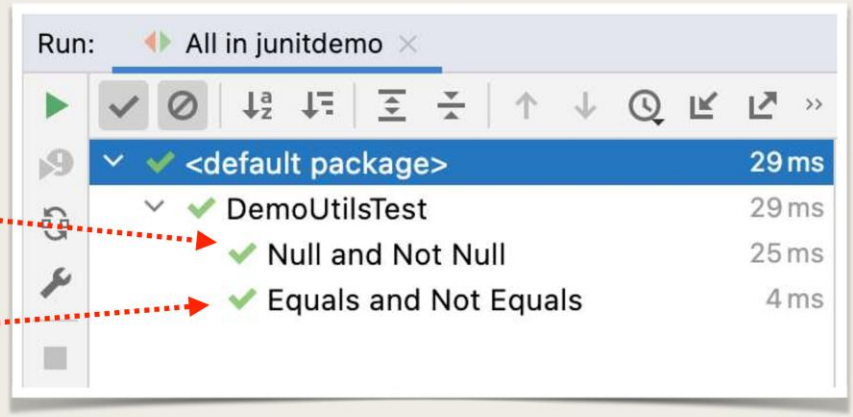
- We'd like to give custom display names
  - Provide a more descriptive name for the test
  - Include spaces, special characters: *Test for Equality to support JIRA #123*
  - Useful for sharing test reports with project management and non-techies

@DisplayName Annotation

Annotation	Description
`@DisplayName`	Custom display name with spaces, special characters and emojis. *Useful for test reports in IDE or external test runner*

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.DisplayName;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
    }

    @Test
    @DisplayName("Null and Not Null")
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }

    @Test
    @DisplayName("Equals and Not Equals")
    void testEqualsAndNotEquals() {

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }
}
```



Display Name Generators

- JUnit can generate display names for you

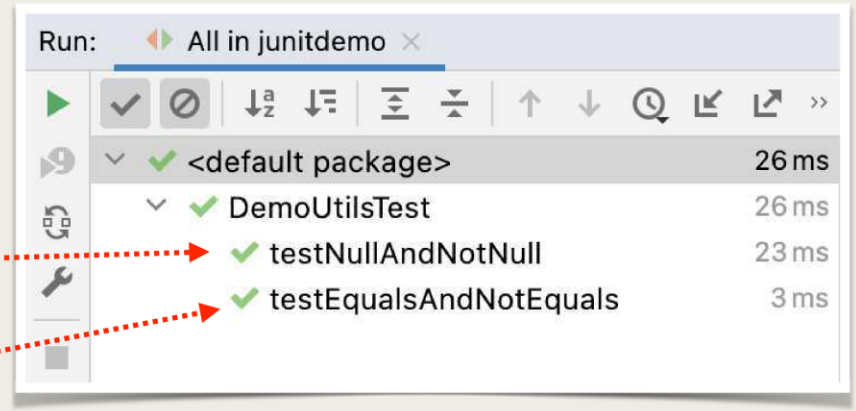
Name	Description
`Simple`	Removes trailing parentheses from test method name
`ReplaceUnderscores`	Replaces underscores in test method name with spaces
`IndicativeSentences`	Generate sentence based on test class name and test method name

Simple Generator

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.DisplayNameGeneration;
import org.junit.jupiter.api.DisplayNameGenerator;
import static org.junit.jupiter.api.Assertions.*;

@DisplayNameGeneration(DisplayNameGenerator.Simple.class)
class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
    }

    @Test
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }

    @Test
    void testEqualsAndNotEquals() {

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }
}
```

Removes trailing parentheses from test method name

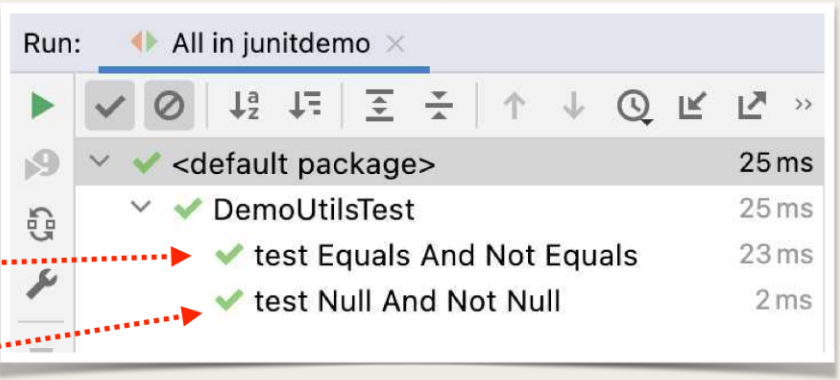


Replace Underscores Generator

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.DisplayNameGeneration;
import org.junit.jupiter.api.DisplayNameGenerator;
import static org.junit.jupiter.api.Assertions.*;

@DisplayNameGeneration(DisplayNameGenerator.ReplaceUnderscores.class)
class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
    }

    @Test
    void test_Equals_And_Not_Equals() {

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void test_Null_And_Not_Null() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }
}
```

Replaces underscores with spaces

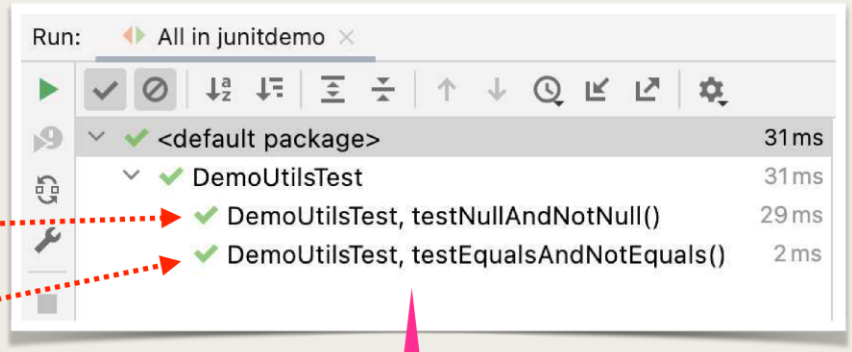


Indicative Sentences Generator

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.DisplayNameGeneration;
import org.junit.jupiter.api.DisplayNameGenerator;
import static org.junit.jupiter.api.Assertions.*;

@DisplayNameGeneration(DisplayNameGenerator.IndicativeSentences.class)
class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
    }

    @Test
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }

    @Test
    void testEqualsAndNotEquals() {

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }
}
```

Generate sentence based on test class name and test method name



<testClassName>, <methodName>

Assertions

- Test for Same and NotSame

Method name	Description
`assertSame`	Assert that items refer to same object
`assertNotSame`	Assert that items do not refer to same object

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

  private String academy = "Luv2Code Academy";
  private String academyDuplicate = academy;

  public String getAcademy() {
      return academy;
  }

  public String getAcademyDuplicate() {
      return academyDuplicate;
  }
}
```

Check if these refer to the same object

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

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

class DemoUtilsTest {

    DemoUtils demoUtils;

    ...

    @DisplayName("Same and Not Same")
    @Test
    void testSameAndNotSame() {

        String str = "luv2code";

        assertSame(demoUtils.getAcademy(), demoUtils.getAcademyDuplicate(), "Objects should refer to same object");
        assertNotSame(str, demoUtils.getAcademy(), "Objects should not refer to same object");
    }

}
```

Object1

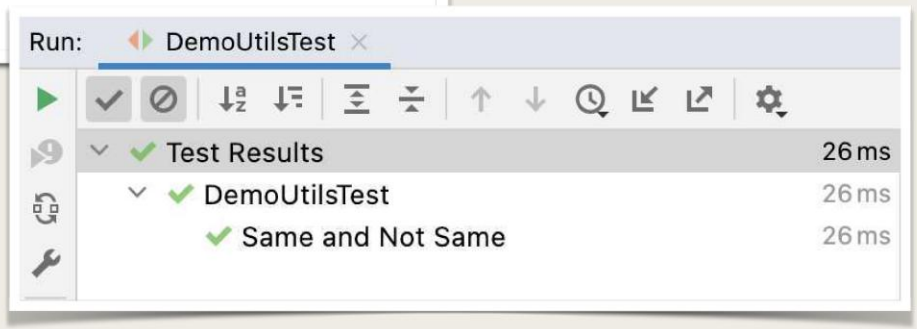
Object2

Object1

Object2

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

  private String academy = "Luv2Code Academy";
  private String academyDuplicate = academy;


  public String getAcademy() {
      return academy;
  }

  public String getAcademyDuplicate() {
      return academyDuplicate;
  }
}
```



Assertions

- Test for True and False

Method name	Description
`assertTrue`	Assert that condition is true
`assertFalse`	Assert that condition is false

DemoUtilsTest.java

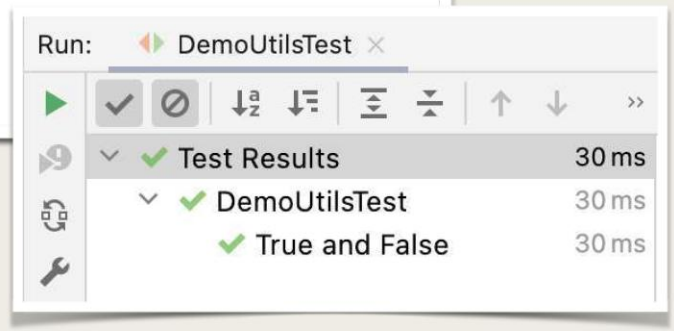
```java
package com.luv2code.junitdemo;

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

class DemoUtilsTest {

   DemoUtils demoUtils;

   ...

   @DisplayName("True and False")
   @Test
   void testTrueFalse() {
       int gradeOne = 10;
       int gradeTwo = 5;

       assertTrue(demoUtils.isGreater(gradeOne, gradeTwo), "This should return true");
       assertFalse(demoUtils.isGreater(gradeTwo, gradeOne), "This should return true");
   }
}
```

Boolean condition

Boolean condition

DemoUtils.java

```java
package com.luv2code.junitdemo;

public class DemoUtils {

  public Boolean isGreater(int n1, int n2) {
      return n1 > n2;
  }
}
```



Assertions

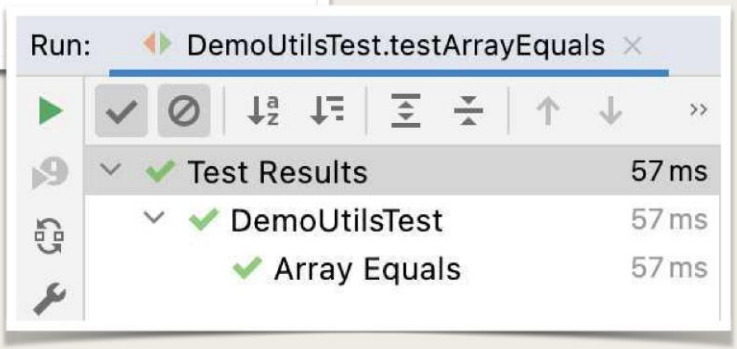
Method name	Description
`assertArrayEquals`	Assert that both object arrays are deeply equal

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

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

class DemoUtilsTest {

    DemoUtils demoUtils;

    ...

    @DisplayName("Array Equals")
    @Test
    void testArrayEquals() {
        String[] stringArray = {"A", "B", "C"};

        assertArrayEquals(stringArray, demoUtils.getFirstThreeLettersOfAlphabet(), "Arrays should be the same");
    }

}
```

DemoUtils.java

```java
package com.luv2code.junitdemo;

public class DemoUtils {

    private String[] firstThreeLettersOfAlphabet = {"A", "B", "C"};

    public String[] getFirstThreeLettersOfAlphabet() {
        return firstThreeLettersOfAlphabet;
    }
}
```



Assertions

Method name	Description
`assertIterableEquals`	Assert that both object iterables are deeply equal

An "iterable" is an instance of a class
that implements the `java.lang.Iterable` interface

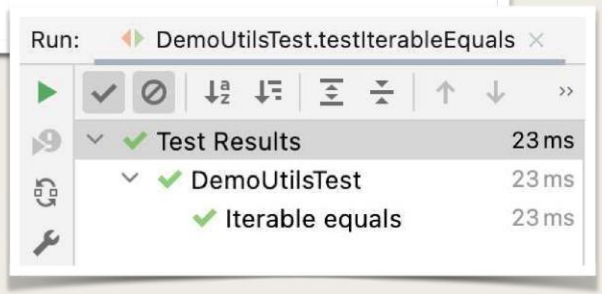
Examples: `ArrayList`, `LinkedList`, `HashSet`, `TreeSet` ...

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.*;
import static org.junit.jupiter.api.Assertions.*;
import java.util.List;

class DemoUtilsTest {

   DemoUtils demoUtils;

   ...

   @DisplayName("Iterable equals")
   @Test
   void testIterableEquals() {
       List<String> theList = List.of("luv", "2", "code");

       assertIterableEquals(theList, demoUtils.getAcademyInList(), "Expected list should be same as actual list");
   }
```

DemoUtils.java

```java
package com.luv2code.junitdemo;

import java.util.List;

public class DemoUtils {

   private List<String> academyInList = List.of("luv", "2", "code");

   public List<String> getAcademyInList() {
       return academyInList;
   }
}
```



Assertions

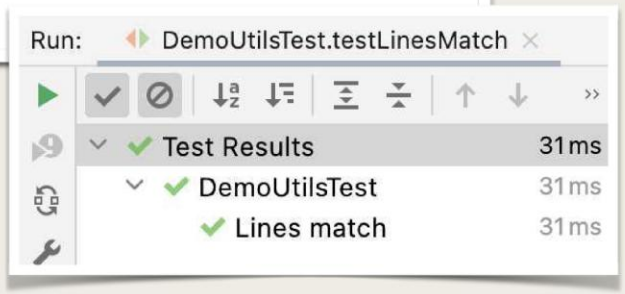
Method name	Description
`assertLinesMatch`	Assert that both lists of strings match

DemoUtilsTest.java

```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.*;
import static org.junit.jupiter.api.Assertions.*;
import java.util.List;

class DemoUtilsTest {

   DemoUtils demoUtils;

   ...

   @DisplayName("Lines match")
   @Test
   void testLinesMatch() {
       List<String> theList = List.of("luv", "2", "code");

       assertLinesMatch(theList, demoUtils.getAcademyInList(), "Lines should match");
   }
```

DemoUtils.java

```java
package com.luv2code.junitdemo;

import java.util.List;

public class DemoUtils {

   private List<String> academyInList = List.of("luv", "2", "code");

   public List<String> getAcademyInList() {
       return academyInList;
   }
}
```



Assertions

Method name	Description
`assertThrows`	Assert that an executable throws an exception of expected type

Code to Test

Verify this method
throws an exception for values < 0

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    public String throwException(int a) throws Exception {
        if (a < 0) {
            throw new Exception("Value should be greater than or equal to 0");
        }
        return "Value is greater than or equal to 0";
    }

}
```

DemoUtilsTest.java

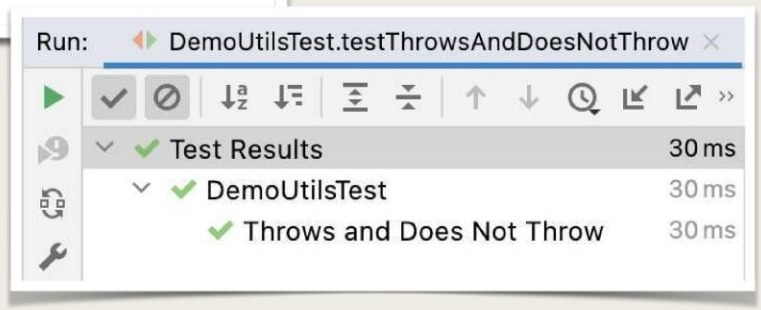
```java
package com.luv2code.junitdemo;

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

class DemoUtilsTest {

    DemoUtils demoUtils;

    ...

    @DisplayName("Throws and Does Not Throw")
    @Test
    void testThrowsAndDoesNotThrow() {
        assertThrows(Exception.class, () -> { demoUtils.throwException(-1); }, "Should throw exception");

        assertDoesNotThrow(() -> { demoUtils.throwException(5); }, "Should not throw exception");
    }
}
```

Lambda expression

Lambda expression

DemoUtils.java

```java
package com.luv2code.junitdemo;

public class DemoUtils {

    public String throwException(int a) throws Exception {
        if (a < 0) {
            throw new Exception("Value should be greater than or equal to 0");
        }
        return "Value is greater than or equal to 0";
    }

}
```



Assertions

Method name	Description
`assertTimeoutPreemptively`	Assert that an executable completes before given timeout is exceeded

Execution is preemptively aborted if timeout is exceeded

DemoUtilsTest.java

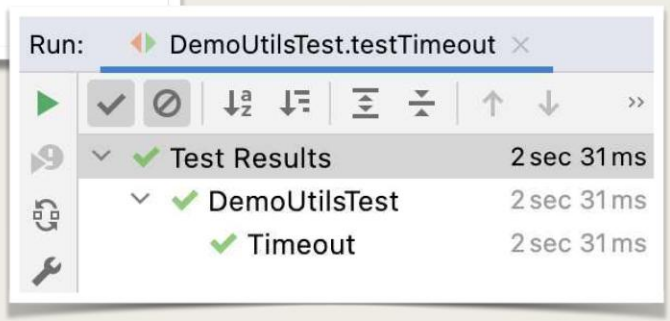
```java
package com.luv2code.junitdemo;

import org.junit.jupiter.api.*;
import static org.junit.jupiter.api.Assertions.*;
import java.time.Duration;

class DemoUtilsTest {

    DemoUtils demoUtils;

    ...

    @DisplayName("Timeout")
    @Test
    void testTimeout() {

        assertTimeoutPreemptively(Duration.ofSeconds(3), () -> { demoUtils.checkTimeout(); },
                "Method should execute in 3 seconds");
    }
}
```

Timeout duration

Lambda expression

DemoUtils.java

```java
package com.luv2code.junitdemo;

public class DemoUtils {

    public void checkTimeout() throws InterruptedException {
        System.out.println("I am going to sleep");
        Thread.sleep(2000);
        System.out.println("Sleeping over");
    }
}
```



Remember this?

Order???

- In general
  - Order should not be a factor in unit tests
  - There should be no dependency between tests
  - All tests should pass regardless of the order in which they are run

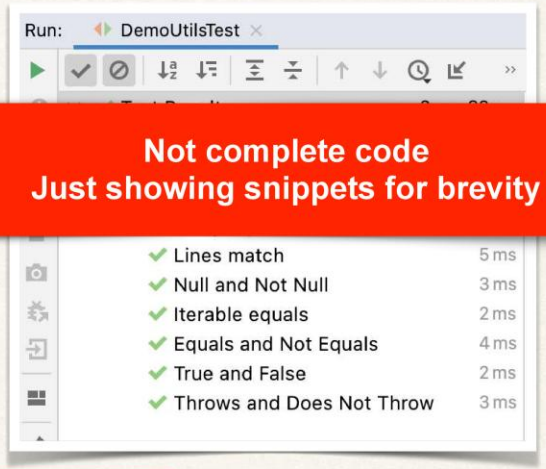
Use Cases

- However, there are some uses cases when you want to control the order
  - You want tests to appear in alphabetical order for reporting purposes
  - Sharing reports with project management, QA team etc...
  - Group tests based on functionality or requirements

Existing ... before any changes

DemoUtilsTest.java

```
class DemoUtilsTest {
    ...

    @DisplayName("Equals and Not Equals")
    void testEqualsAndNotEquals()

    @DisplayName("Null and Not Null")
    void testNullAndNotNull()

    @DisplayName("Same and Not Same")
    void testSameAndNotSame()

    @DisplayName("True and False")
    void testTrueFalse()

    @DisplayName("Array Equals")
    void testArrayEquals()

    @DisplayName("Iterable equals")
    void testIterableEquals()

    @DisplayName("Lines match")
    void testLinesMatch()

    @DisplayName("Throws and Does Not Throw")
    void testThrowsAndDoesNotThrow()

    @DisplayName("Timeout")
    void testTimeout()
}
```



Not complete code
Just showing snippets for brevity

JUnit Docs

By default, test classes and methods will be ordered using an algorithm that is deterministic but intentionally nonobvious.

https://junit.org/junit5/docs/current/user-guide/

Annotation

Annotation	Description
`@TestMethodOrder`	Configures the order/sort algorithm for the test methods

Specify Method Order

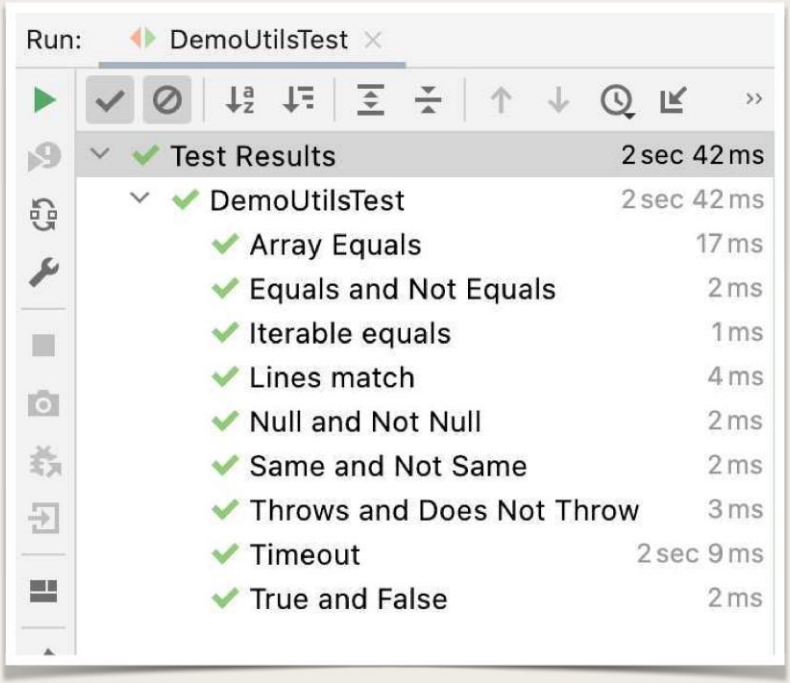
Name	Description
`MethodOrderer.DisplayName`	Sorts test methods alphanumerically based on display names
`MethodOrderer.MethodName`	Sorts test methods alphanumerically based on method names
`MethodOrderer.Random`	Pseudo-random order based on method names
`MethodOrderer.OrderAnnotation`	Sorts test methods numerically based on @Order annotation

Order by Display Name

Sorted alphanumerically

DemoUtilsTest.java

```
@TestMethodOrder(MethodOrderer.DisplayName.class)
class DemoUtilsTest {
    ...

    @DisplayName("Equals and Not Equals")
    void testEqualsAndNotEquals()

    @DisplayName("Null and Not Null")
    void testNullAndNotNull()

    @DisplayName("Same and Not Same")
    void testSameAndNotSame()

    @DisplayName("True and False")
    void testTrueFalse()

    @DisplayName("Array Equals")
    void testArrayEquals()

    @DisplayName("Iterable equals")
    void testIterableEquals()

    @DisplayName("Lines match")
    void testLinesMatch()

    @DisplayName("Throws and Does Not Throw")
    void testThrowsAndDoesNotThrow()

    @DisplayName("Timeout")
    void testTimeout()
}
```



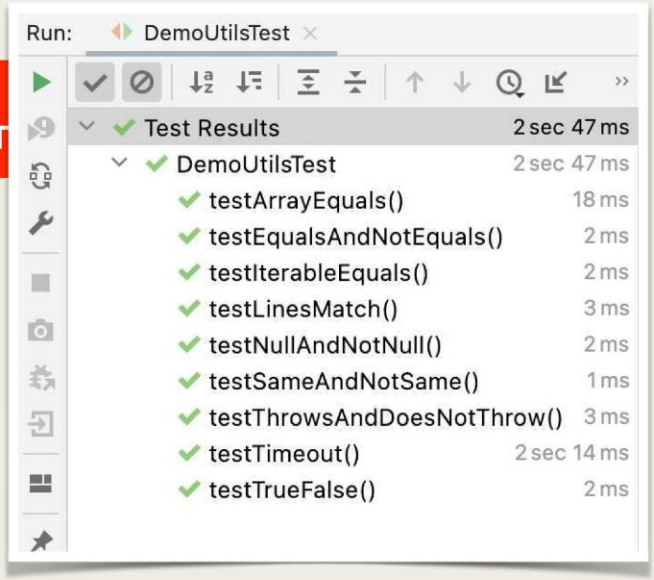
Order by Method Name

Sorted alphanumerically

DemoUtilsTest.java

```
@TestMethodOrder(MethodOrderer.MethodName.class)
class DemoUtilsTest {
    ...

    // @DisplayName("Equals and Not Equals")
    void testEqualsAndNotEquals()

    void testNullAndNotNull()

    void testSameAndNotSame()

    void testTrueFalse()

    void testArrayEquals()

    void testIterableEquals()

    void testLinesMatch()

    void testThrowsAndDoesNotThrow()

    void testTimeout()
}
```

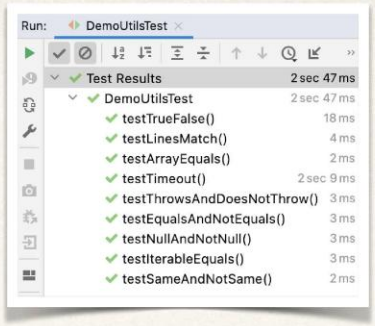
NOT

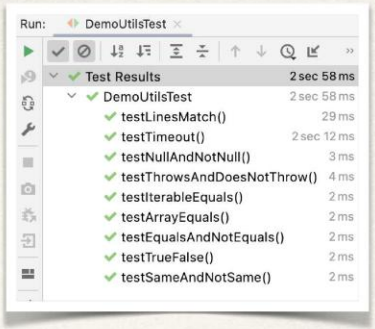


Random by Method Name

DemoUtilsTest.java

```
@TestMethodOrder(MethodOrderer.Random.class)
class DemoUtilsTest {
    ...

    void testEqualsAndNotEquals()

    void testNullAndNotNull()

    void testSameAndNotSame()

    void testTrueFalse()

    void testArrayEquals()

    void testIterableEquals()

    void testLinesMatch()

    voi

    voi
}
```





Great scenario!!!!

Make sure all of your tests pass regardless of order
Confirms no dependencies between tests

Can also use DisplayName since everything is random ... order doesn't matter

Annotation

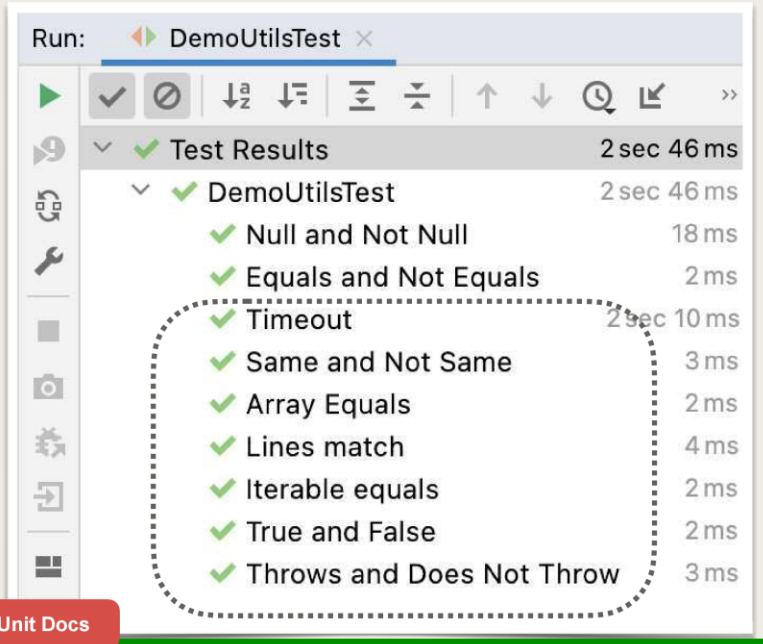
Annotation	Description
`@Order`	Manually specify the order with an `int` number - Order with lowest number has highest priority - Negative numbers are allowed

@Order

Remember
Lowest number has highest priority

DemoUtilsTest.java

```
@TestMethodOrder(MethodOrderer.OrderAnnotation.class)
class DemoUtilsTest {
    ...

    @DisplayName("Equals and Not Equals")
    @Order(3)
    void testEqualsAndNotEquals()

    @DisplayName("Null and Not Null")
    @Order(1)
    void testNullAndNotNull()

    @DisplayName("Same and Not Same")
    void testSameAndNotSame()

    @DisplayName("True and False")
    void testTrueFalse()

    @DisplayName("Array Equals")
    void testArrayEquals()

    @DisplayName("Iterable equals")
    void testIterableEquals()

    @DisplayName("Lines match")
    void testLinesMatch()

    @DisplayName("Throws and Does Not Throw")
    void testThrowsAndDoesNotThrow()

    @DisplayName("Timeout")
    void testTimeout()
}
```



JUnit Docs

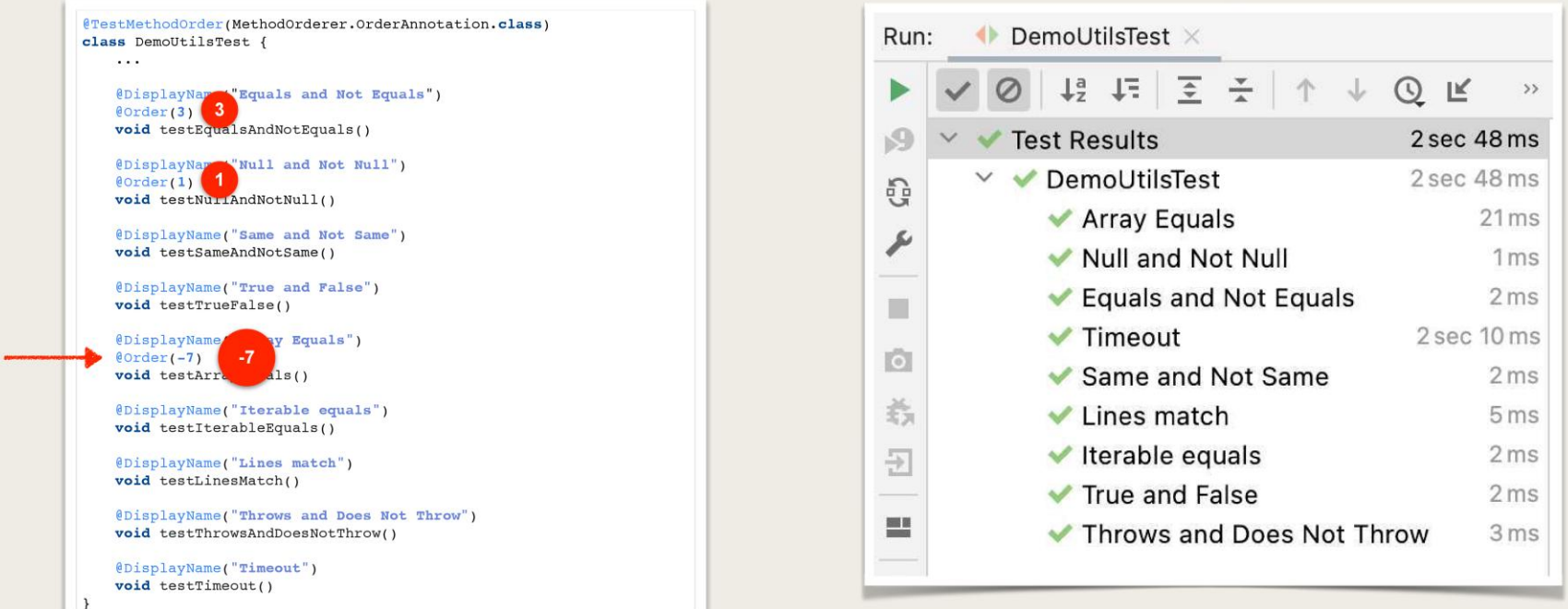
By default, test classes and methods will be ordered using an algorithm that is deterministic but intentionally nonobvious.

@Order - Negative Numbers

Remember
Lowest number has highest priority

DemoUtilsTest.java

```
@TestMethodOrder(MethodOrderer.OrderAnnotation.class)
class DemoUtilsTest {
    ...

    @DisplayName("Equals and Not Equals")
    @Order(3)
    void testEqualsAndNotEquals()

    @DisplayName("Null and Not Null")
    @Order(1)
    void testNullAndNotNull()

    @DisplayName("Same and Not Same")
    void testSameAndNotSame()

    @DisplayName("True and False")
    void testTrueFalse()

    @DisplayName("Array Equals")
    @Order(-7)
    void testArrayEquals()

    @DisplayName("Iterable equals")
    void testIterableEquals()

    @DisplayName("Lines match")
    void testLinesMatch()

    @DisplayName("Throws and Does Not Throw")
    void testThrowsAndDoesNotThrow()

    @DisplayName("Timeout")
    void testTimeout()
}
```



@Order - Duplicate Order Values

If duplicate @Order values then ...

JUnit Docs

> By default, test classes and methods will be ordered using an algorithm that is deterministic but intentionally nonobvious.

Conditional Tests - Use Cases

- Don't run a test because the method to test is broken ... and we are waiting on dev team to fix it
- A test should only run for a specific version of Java (Java 18) or range of versions (13 - 18)
- A test should only run on a given operating system: MS Windows, Mac, Linux
- A test should only run if specific environment variables or system properties are set

Why not just comment the code???

- We could do that ... but then the tests will not be displayed in reports
- Easy to forget about broken tests
- Manual process to enable/disable tests for a given operating system etc ...

- Let's report the tests ... so that management and QA are aware of the issue

Annotations

Name	Description
`@Disabled`	Disable a test method
`@EnabledOnOs`	Enable test when running on a given operating system
...	...

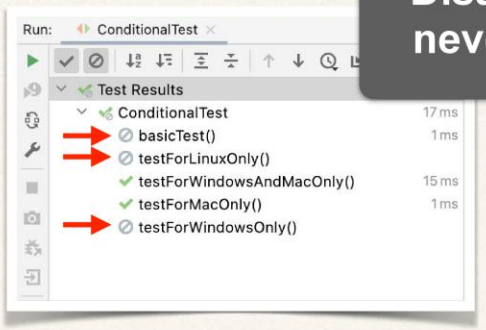
Annotations can be applied at the class level or method level

@Disabled and @EnabledOnOs

ConditionalTest.java

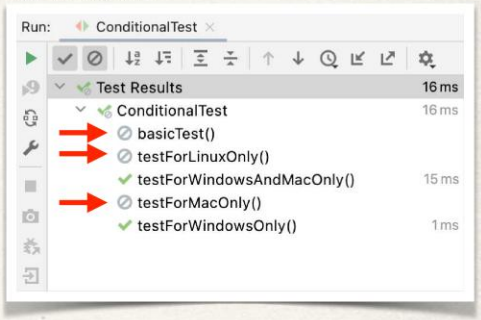
```
class ConditionalTest {

    @Test
    @Disabled("Don't run until JIRA #123 is resolved")
    void basicTest() {
        // execute method perform assertions
    }

    @Test
    @EnabledOnOs(OS.WINDOWS)
    void testForWindowsOnly() {
        // execute method and perform assertions
    }

    @Test
    @EnabledOnOs(OS.MAC)
    void testForMacOnly() {
        // execute method and perform assertions
    }

    @Test
    @EnabledOnOs({OS.WINDOWS, OS.MAC})
    void testForWindowsAndMacOnly() {
        // execute method and perform assertions
    }

    @Test
    @EnabledOnOs(OS.LINUX)
    void testForLinuxOnly() {
        // execute method and perform assertions
    }

}
```

Mac

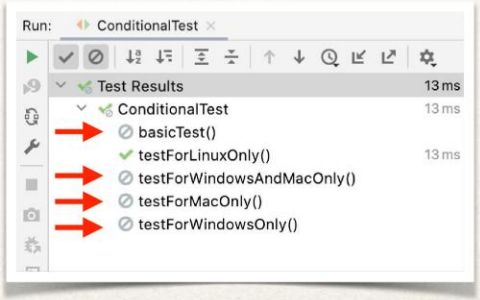


Disabled tests never execute

MS Windows



Linux



Disabled tests never execute

Annotations

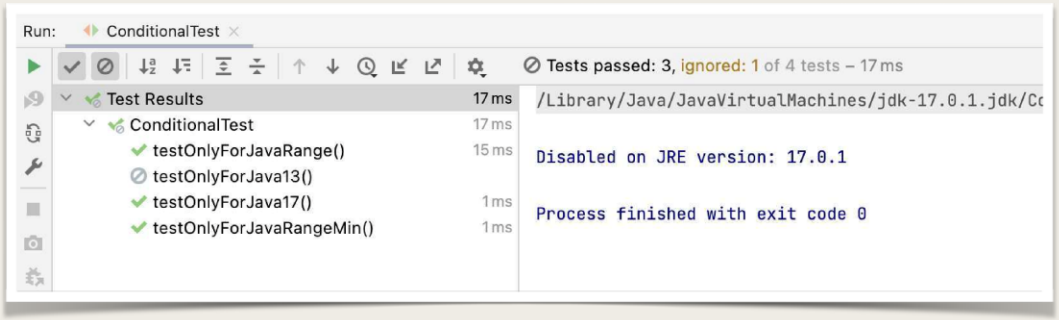
Name	Description
`@EnabledOnJre`	Enable test for a given Java version
`@EnabledForJreRange`	Enable test for a given Java version range
...	...

@EnabledOnJre @EnabledForJreRange

ConditionalTest.java

```java
class ConditionalTest {

    @Test
    @EnabledOnJre(JRE.JAVA_17)
    void testOnlyForJava17() {
        // execute method and perform assertions
    }

    @Test
    @EnabledOnJre(JRE.JAVA_13)
    void testOnlyForJava13() {
        // execute method and perform assertions
    }

    @Test
    @EnabledForJreRange(min=JRE.JAVA_13, max=JRE.JAVA_18)
    void testOnlyForJavaRange() {
        // execute method and perform assertions
    }

    @Test
    @EnabledForJreRange(min=JRE.JAVA_11)
    void testOnlyForJavaRangeMin() {
        // execute method and perform assertions
    }

}
```

Running on Java 17

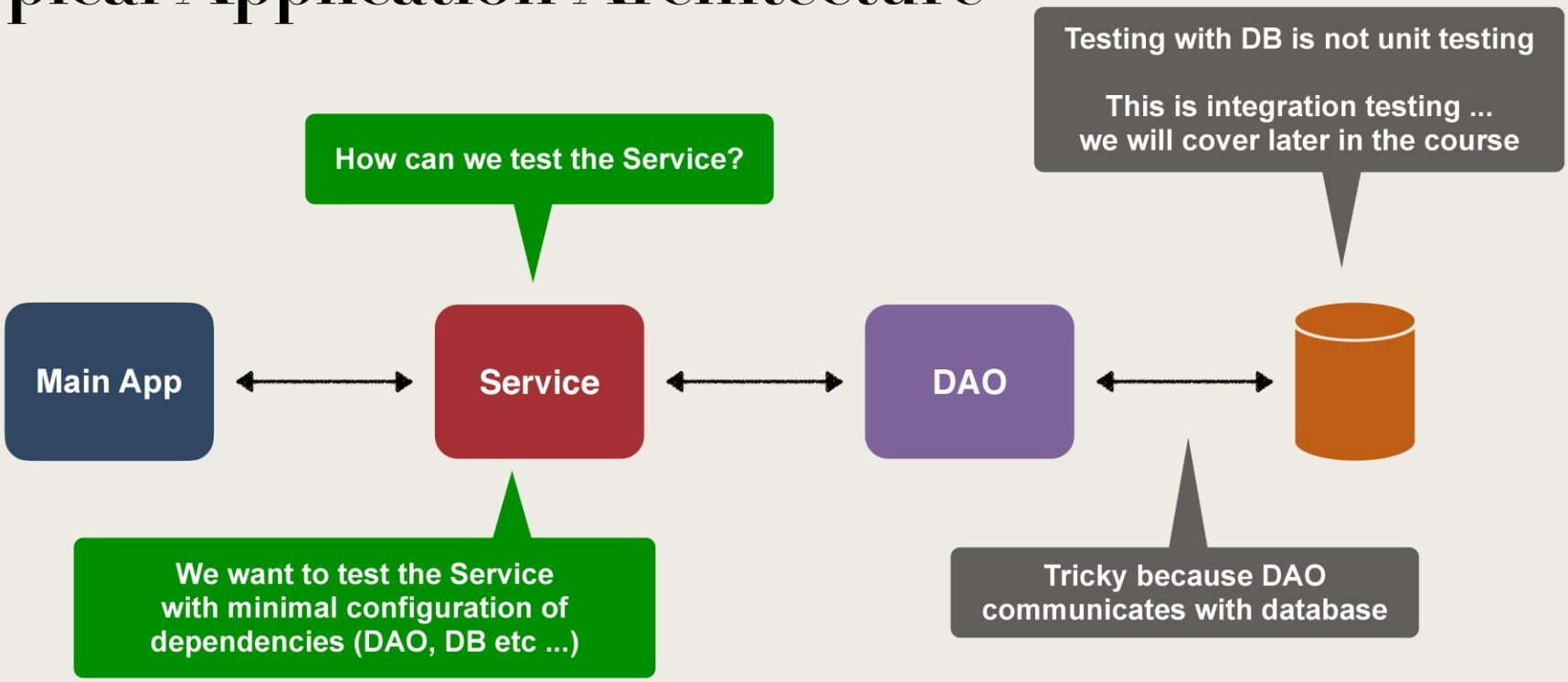


Annotations

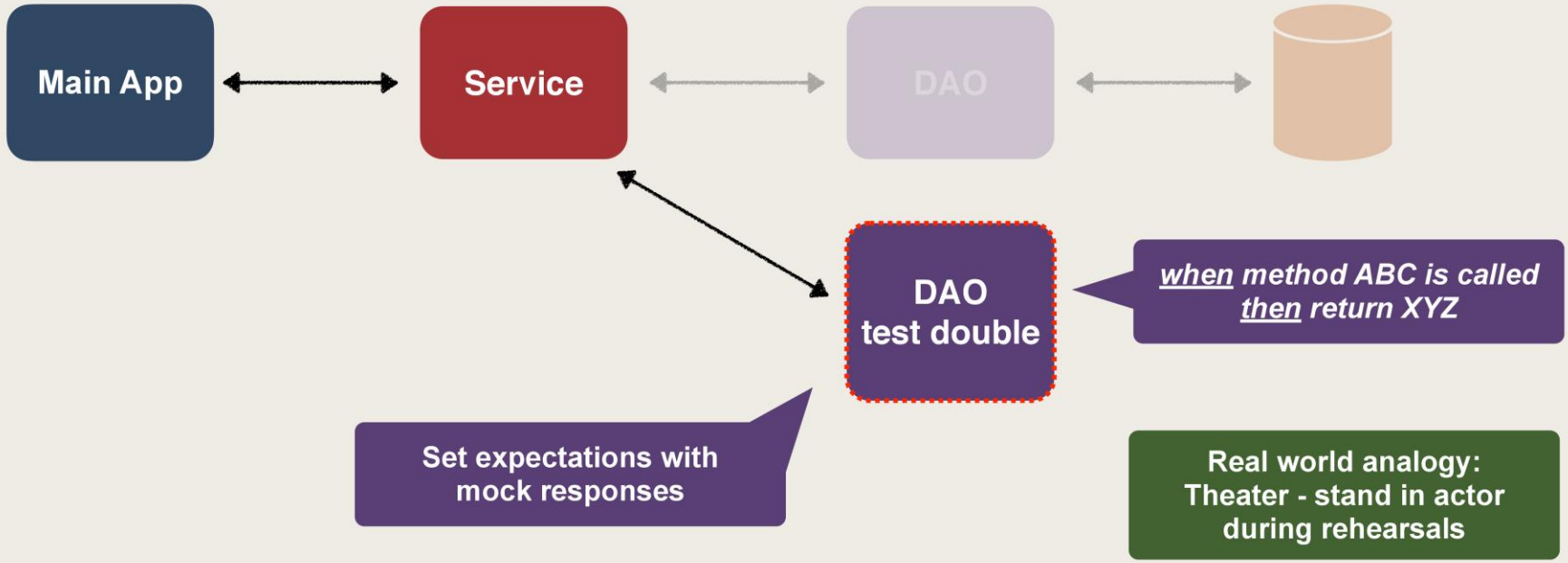
Name	Description
`@EnabledIfSystemProperty`	Enable test based on system property
`@EnabledIfEnvironmentVariable`	Enable test based on environment variable
…	…

Mockito and Spring Boot

Typical Application Architecture



Using a Test Double



The technique of using test doubles is known as "mocking"

Benefits of Mocking

- Allows us to test a given class in isolation
- Test interaction between given class and its dependencies
- Minimizes configuration / availability of dependencies
- For example DAO, DB, REST API etc
  - We can mock the DAO to give a response
  - We can mock a REST API to give a response

Real world analogy: Theater - stand in actor during rehearsals

Mocking Frameworks

- The Java ecosystem includes a number of Mocking frameworks
- The Mocking frameworks provide following features:
  - Minimize hand-coding of mocks ... leverage annotations
  - Set expectations for mock responses
  - Verify the calls to methods including the number of calls
  - Programmatic support for throwing exceptions

Mocking Frameworks

Name	Website
Mockito	site.mockito.org
EasyMock	www.easymock.org
JMockit	jmockit.github.io
...	

We will use Mockito since
Spring Boot has built-in support for Mockito

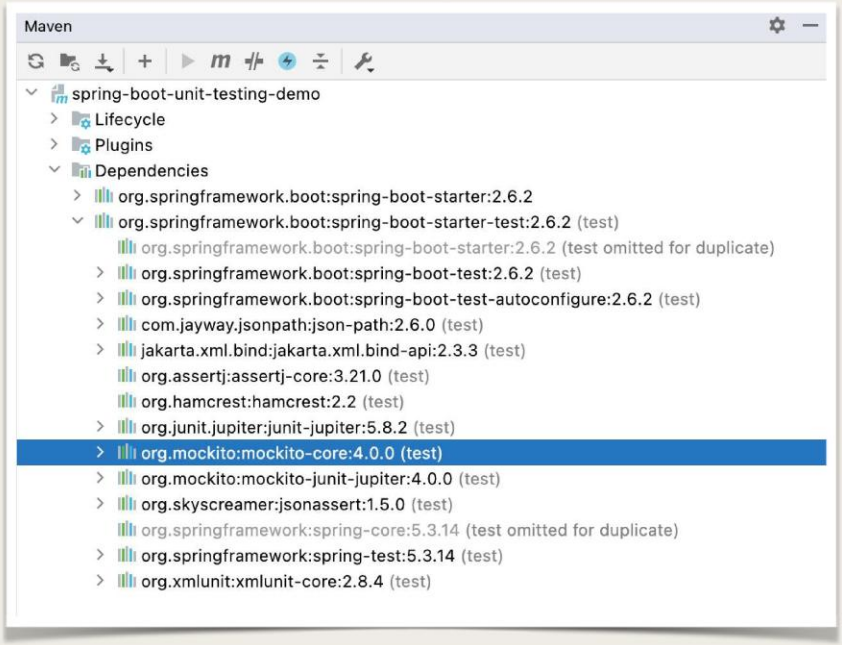
Spring Boot Starter - Transitive Dependency for Mockito

pom.xml

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-test</artifactId>
    <scope>test</scope>
</dependency>
```

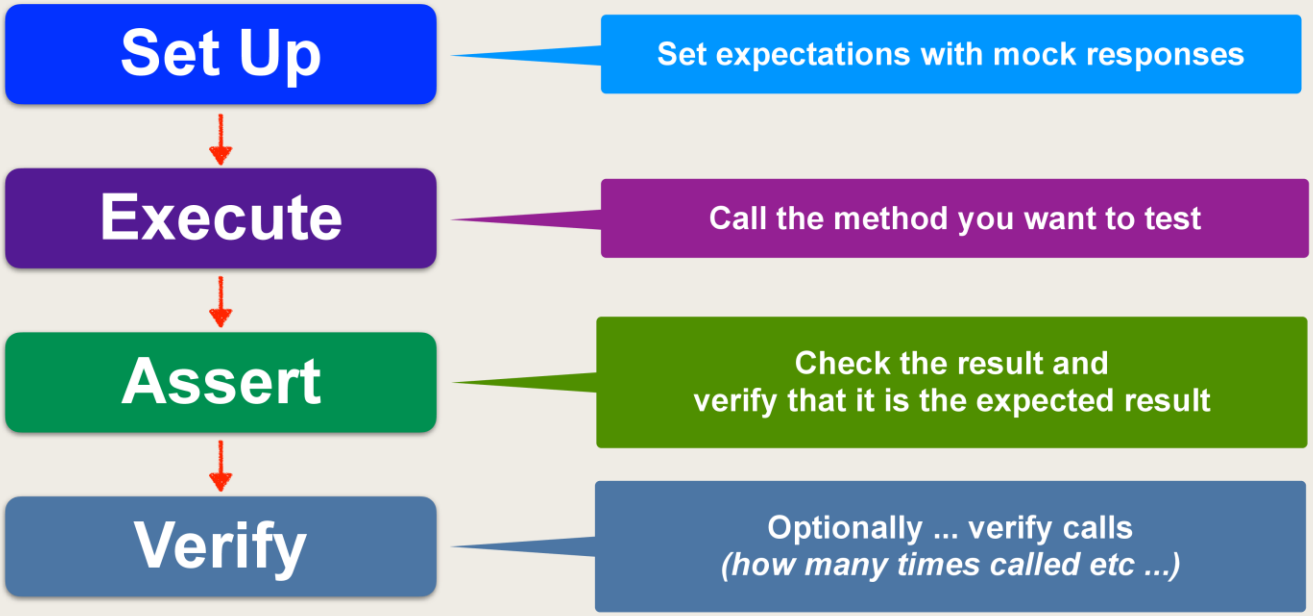
Starter includes a transitive dependency on Mockito

We get it for free :-)

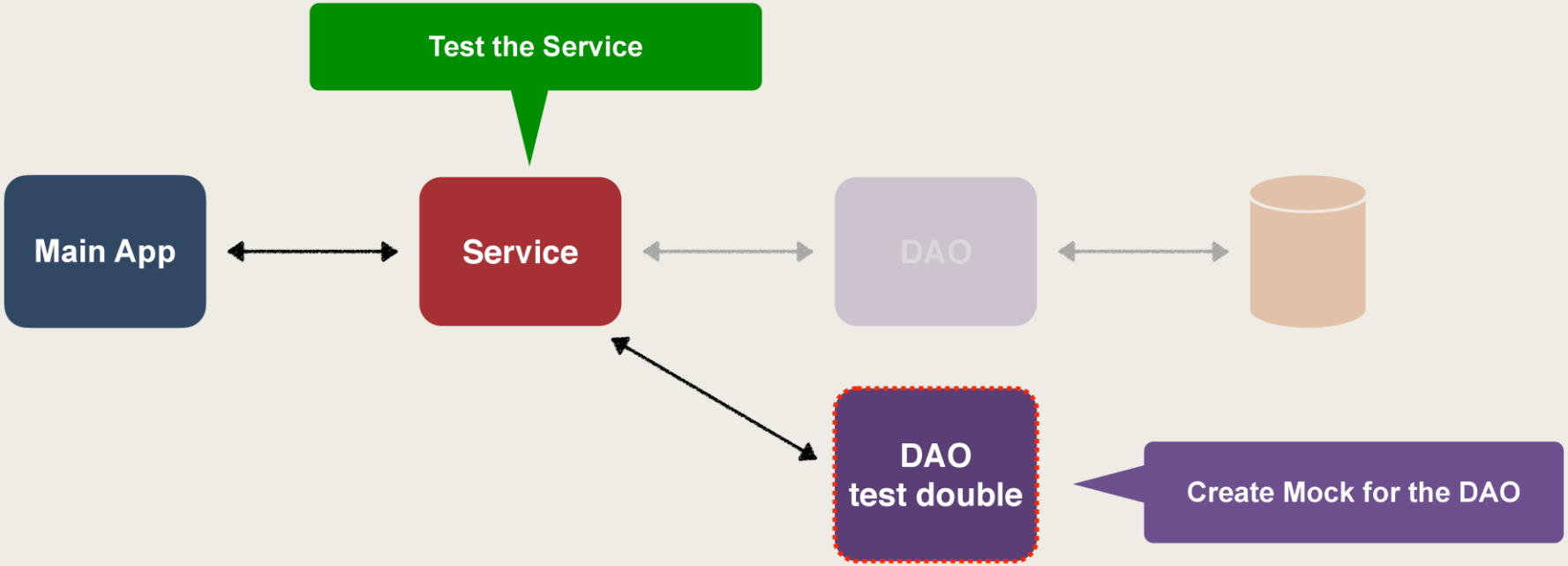


Unit testing with Mocks

- Unit tests with Mocks have the following structure



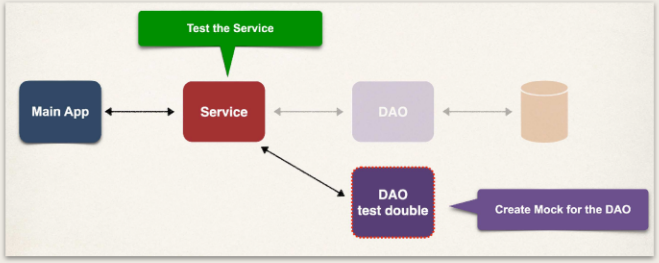
Testing Plan



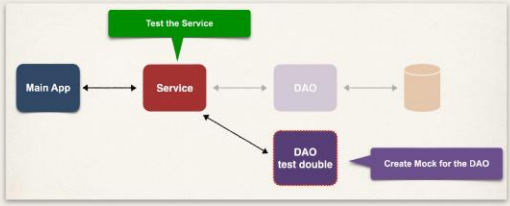
Development Process

Step-By-Step

1. Create Mock for DAO
2. Inject mock into Service
3. Set up expectations
4. Call method under test and assert results
5. Verify method calls



Step 1: Create Mock for the DAO

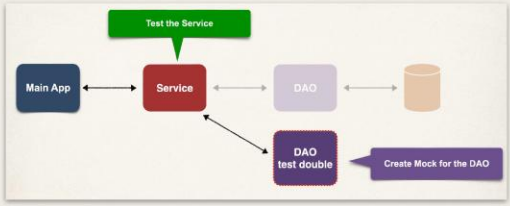


MockAnnotationTest.java

```
import org.mockito.Mock;
...

@SpringBootTest(classes=MvcTestingExampleApplication.class)
public class MockAnnotationTest {

 @Mock
 private ApplicationDao applicationDao;


 ...

}
```

Create Mock for the DAO

Step 2: Inject mock into Service



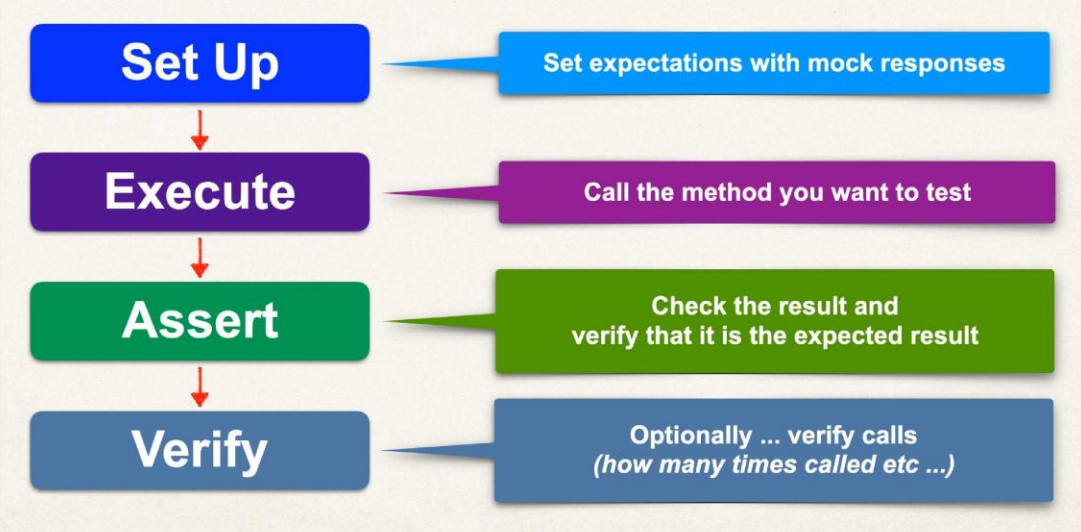
MockAnnotationTest.java

```
import org.mockito.Mock;
import org.mockito.InjectMocks;
...

@SpringBootTest(classes=MvcTestingExampleApplication.class)
public class MockAnnotationTest {

 @Mock
 private ApplicationDao applicationDao;

 @InjectMocks
 private ApplicationService applicationService;

 ...

}
```

Inject mock dependencies

Note: Will only inject dependencies annotated with @Mock or @Spy

Step 3: Set up expectations



Step 3: Set up expectations

when method
doSomeWork(...)
is called
then return "I am finished"

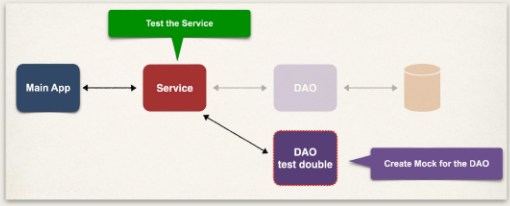
```
import static org.mockito.Mockito.when;
...

    String aResponse = "I am finished";

    when( doSomeWork() ).thenReturn( aResponse );
```

response

method

Real world analogy:
Theater - just read the script

Step 3: Set up expectations



MockAnnotationTest.java

```
import static org.mockito.Mockito.when;
import static org.junit.jupiter.api.Assertions.assertEquals;
...

@SpringBootTest(classes=MvcTestingExampleApplication.class)
public class MockAnnotationTest {

  @Mock
  private ApplicationDao applicationDao;

  @InjectMocks
  private ApplicationService applicationService;

  @Autowired
  private CollegeStudent studentOne;

  @Autowired
  private StudentGrades studentGrades;


  @DisplayName("When & Verify")
  @Test
  public void assertEqualsTestAddGrades() {
      when(applicationDao.addGradeResultsForSingleClass(
                              studentGrades.getMathGradeResults())).thenReturn(100.0);

      ...
  }
}
```

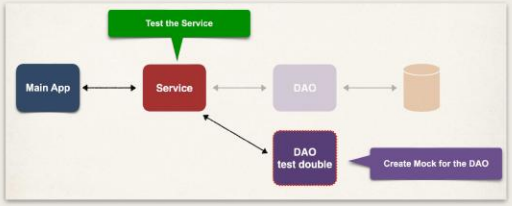
Set up expectations for mock response

when method addGradeResultsForSingleClass(...) *is called* *then return* 100.0

Step 4: Call method under test and assert results

MockAnnotationTest.java

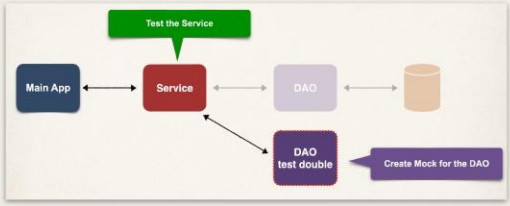
```
import static org.mockito.Mockito.when;
import static org.junit.jupiter.api.Assertions.assertEquals;
...

@SpringBootTest(classes= MvcTestingExampleApplication.class)
public class MockAnnotationTest {

  @Mock
  private ApplicationDao applicationDao;

  @InjectMocks
  private ApplicationService applicationService;

  @Autowired
  private CollegeStudent studentOne;

  @Autowired
  private StudentGrades studentGrades;


  @DisplayName("When & Verify")
  @Test
  public void assertEqualsTestAddGrades() {
      when(applicationDao.addGradeResultsForSingleClass(
                              studentGrades.getMathGradeResults())).thenReturn(100.0);

      assertEquals(100.0, applicationService.addGradeResultsForSingleClass(
                              studentOne.getStudentGrades().getMathGradeResults()));

  }
}
```



Assert results

The service uses the DAO ...
that has been set up to return 100.0

Step 5: Verify method calls

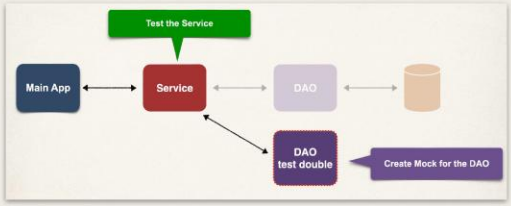


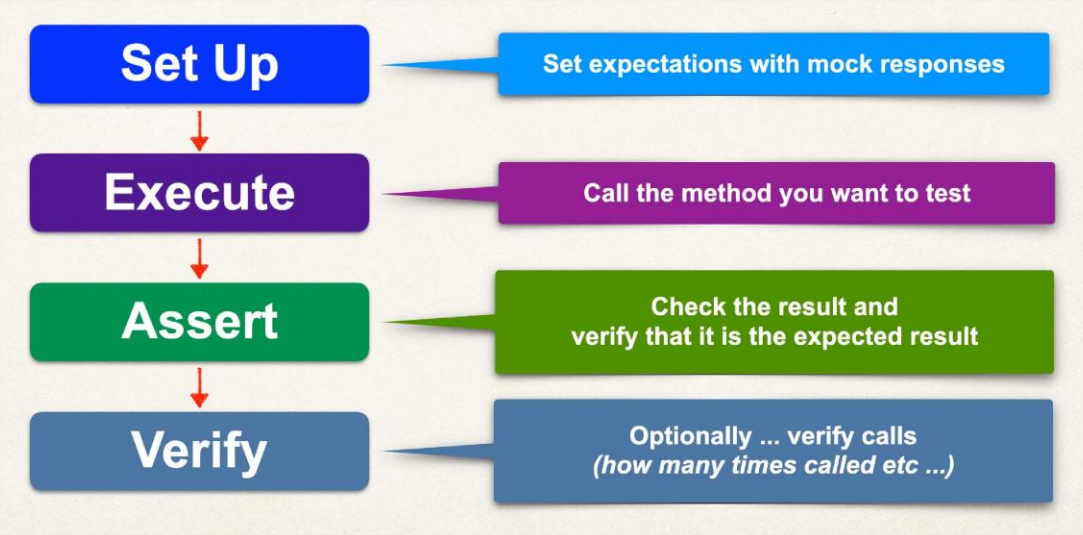
MockAnnotationTest.java

```
import static org.mockito.Mockito.when;
import static org.mockito.Mockito.verify;
import static org.mockito.Mockito.times;
...

@SpringBootTest(classes= MvcTestingExampleApplication.class)
public class MockAnnotationTest {

  @Mock
  private ApplicationDao applicationDao;

  @InjectMocks
  private ApplicationService applicationService;

  ...

  @DisplayName("When & Verify")
  @Test
  public void assertEqualsTestAddGrades() {
      when(applicationDao.addGradeResultsForSingleClass(
                              studentGrades.getMathGradeResults())).thenReturn(100.0);

      assertEquals(100.0, applicationService.addGradeResultsForSingleClass(
                              studentOne.getStudentGrades().getMathGradeResults()));

     verify(applicationDao,
              times(1)).addGradeResultsForSingleClass(studentGrades.getMathGradeResults());

  }
}
```

Verify the DAO method was called 1 time

Recap


Test the Service
Main App
Service
DAO
DAO
test double
Create Mock for the DAO


Set Up
Set expectations with mock responses
Execute
Call the method you want to test
Assert
Check the result and
verify that it is the expected result
Verify
Optionally ... verify calls
(how many times called etc ...)

Mockito Resources

- Additional features
  - Stubs, spies
  - Argument matchers, Answers
  - ...

site.mockito.org

MockAnnotationTest.java

```
import org.mockito.Mock;
import org.mockito.InjectMocks;
...

@SpringBootTest(classes=MvcTestingExampleApplication.class)
public class MockAnnotationTest {

 @Mock
 private ApplicationDao applicationDao;

 @InjectMocks
 private ApplicationService applicationService;

 ...

}
```

Inject mock dependencies

Note: Will only inject dependencies annotated with @Mock or @Spy

Spring Boot @MockBean

- Instead of using Mockito: `@Mock` and `@InjectMocks`
- Use Spring Boot support: `@MockBean` and `@Autowired`

- `@MockBean`
  - includes Mockito `@Mock` functionality
  - also adds mock bean to Spring ApplicationContext
    - if existing bean is there, the mock bean will replace it
  - thus making the mock bean available for injection with `@Autowired`

Use Spring Boot @MockBean
when you need to inject mocks
AND
inject regular beans from app context

BEFORE

MockAnnotationTest.java

```
import org.mockito.Mock;
import org.mockito.InjectMocks;
...

@SpringBootTest(classes=MvcTestingExampleApplication.class)
public class MockAnnotationTest {

  @Mock
  private ApplicationDao applicationDao;

  @InjectMocks
  private ApplicationService applicationService;

  ...

}
```

AFTER

MockAnnotationTest.java

```
import org.springframework.boot.test.mock.mockito.MockBean;
import org.springframework.beans.factory.annotation.Autowired;
...

@SpringBootTest(classes=MvcTestingExampleApplication.class)
public class MockAnnotationTest {

  @MockBean
  private ApplicationDao applicationDao;

  @Autowired
  private ApplicationService applicationService;

  ...

}
```

Create Mock for the DAO

Inject dependencies

No longer a limitation ...
can inject any dependency ...
mock or regular bean

Spring Boot support for Unit Testing

What do you need for Spring Boot unit testing?

- Access to the Spring Application Context
- Support for Spring dependency injection
- Retrieve data from Spring application.properties
- Mock object support for web, data, REST APIs etc ...

Unit Testing support in Spring Boot

- Spring Boot provides rich testing support

- `@SpringBootTest`
  - Loads the application context
  - Support for Spring dependency injection
  - You can access data from Spring application.properties
  - ...

Spring Boot Starter - for Testing support

- Add Maven dependency

pom.xml

```
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-test</artifactId>
  <scope>test</scope>
</dependency>
```

Starter includes a transitive dependency on JUnit 5

We get it for free :-)

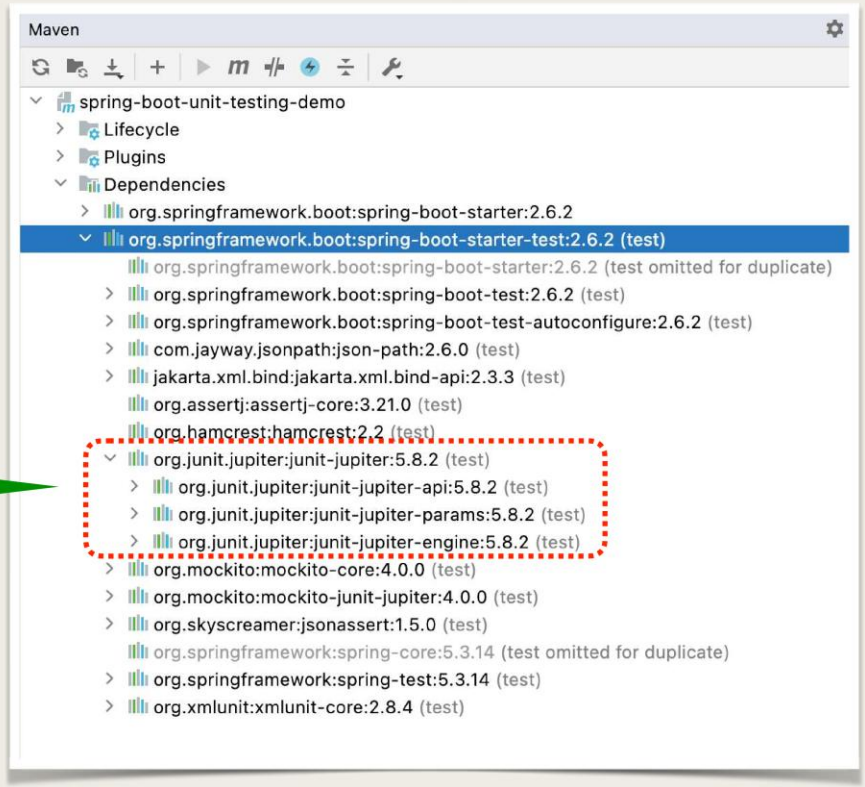
Spring Boot Starter - Transitive Dependency for JUnit 5

pom.xml

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-test</artifactId>
    <scope>test</scope>
</dependency>
```

Starter includes a transitive dependency on JUnit 5

We get it for free :-)



Spring Boot Starter - Transitive Dependency for JUnit 5

At command-line, type:

```
mvn dependency:tree

[INFO] Scanning for projects...
[INFO]
[INFO] -------------< com.luv2code:spring-boot-unit-testing-demo >-------------
[INFO] Building spring-boot-unit-testing-demo 1.0.0
[INFO] --------------------------------[ jar ]---------------------------------
[INFO]
[INFO] --- maven-dependency-plugin:3.2.0:tree (default-cli) @ spring-boot-unit-testing-demo ---
[INFO] com.luv2code:spring-boot-unit-testing-demo:jar:1.0.0
...
[INFO] \- org.springframework.boot:spring-boot-starter-test:jar:2.6.2:test
[INFO]    \- org.junit.jupiter:junit-jupiter:jar:5.8.2:test
[INFO]       +- org.junit.jupiter:junit-jupiter-api:jar:5.8.2:test
[INFO]       +- org.junit.jupiter:junit-jupiter-params:jar:5.8.2:test
[INFO]       \- org.junit.jupiter:junit-jupiter-engine:jar:5.8.2:test

...
```

Starter includes a transitive dependency on JUnit 5

We get it for free :-)

Spring Boot Test

ApplicationExampleTest.java

```
import org.junit.jupiter.api.Test;
import org.springframework.boot.test.context.SpringBootTest;

@SpringBootTest
public class ApplicationExampleTest {

    @Test
    void basicTest() {
        // ...
    }

}
```

Loads Spring Application Context

Inject Spring Beans

ApplicationExampleTest.java

```
import org.junit.jupiter.api.Test;
import org.springframework.boot.test.context.SpringBootTest;
import org.springframework.beans.factory.annotation.Autowired;

@SpringBootTest
public class ApplicationExampleTest {

    @Autowired
    StudentGrades studentGrades;

    @Test
    void basicTest() {
        // ...
    }
```

Injection

```
@Component
public class StudentGrades {

  ...

}
```

Access Application Properties

application.properties

```
info.school.name=luv2code
info.app.name=My Super Cool Gradebook
```

ApplicationExampleTest.java

```
import org.junit.jupiter.api.Test;
import org.springframework.boot.test.context.SpringBootTest;
import org.springframework.beans.factory.annotation.Value;

@SpringBootTest
public class ApplicationExampleTest {

    @Value("${info.school.name}")
    private String schoolName;

    @Value("${info.app.name}")
    private String appInfo;

    @Test
    void basicTest() {
        // ...
    }

}
```

Access data from application.properties

Access Application Context

ApplicationExampleTest.java

```
import org.junit.jupiter.api.Test;
import org.springframework.boot.test.context.SpringBootTest;
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.context.ApplicationContext;

@SpringBootTest
public class ApplicationExampleTest {

    @Autowired
    ApplicationContext context;

    @Test
    void basicTest() {
        // ...
    }

}
```

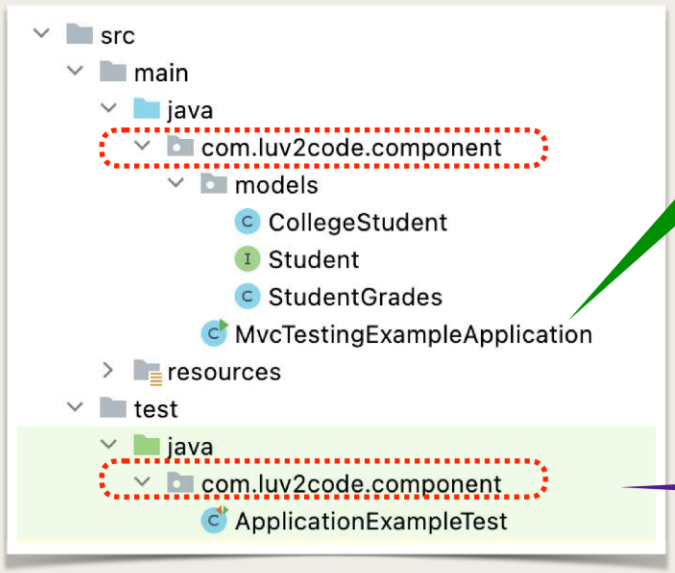
Access Spring Application Context

@SpringBootTest configuration

Place your test class in `test` package same as your `main` package

- This implicitly defines a base search
  - Allows you to leverage default configuration
  - No need to explicitly reference the main Spring Boot application class

More on Configuration



Main Spring Boot application class

Automatically component scans sub-packages

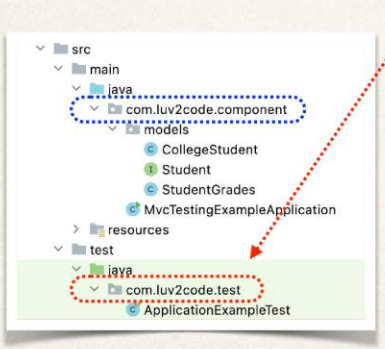
Same package names

... no additional config required ...

More on Configuration

- Default configuration is fine if everything is under
  - **`com.luv2code.component`**

- But what if test class is in a different package???
  - **`com.luv2code.test`**



Explicitly reference main SpringBoot class

```
package com.luv2code.test;
…
@SpringBootTest(classes = MvcTestingExampleApplication.class)
public class ApplicationExampleTest {
   …
}
```

REST API Testing - Overview

Technical Stack

- Spring Boot
- Spring Data JPA
- Spring @RestController

Existing Code (partial)

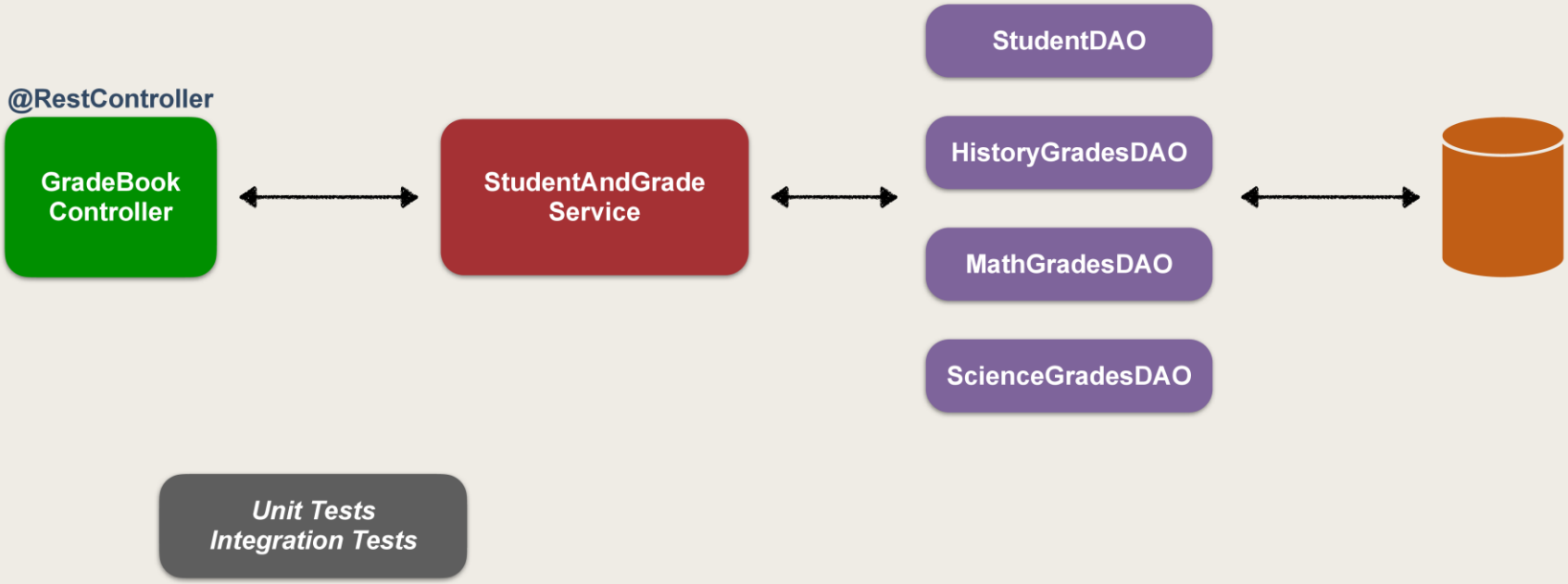
@RestController

GradeBookController.java

Model

CollegeStudent.java
Grade.java
Gradebook.java
GradebookCollegeStudent.java
HistoryGrade.java
MathGrade.java
ScienceGrade.java
Student.java
StudentGrades.java

Application Architecture



Problem

- How can we test REST API developed with Spring REST Controllers?
- How can we create HTTP requests and send to the Spring REST controller?
- How can we verify HTTP response?
  - status code
  - content type
  - JSON response body

Spring Testing Support

- For testing Spring REST controllers, you can use `MockMvc`
- Provides Spring REST processing of request / response
- There is no need to run a server (embedded or external)

In general, the process is VERY similar to Spring MVC testing

Slight differences for content-type and checking JSON results

Preliminary Set Up

- For GradebookControllerTest
- Stub out the test class
- Define fields that we'll use later: MockMvc, Service, DAOs etcs
- @BeforeAll, @BeforeEach, @AfterEach

GradebookControllerTest.java

```
...
@TestPropertySource("/application-test.properties")
@AutoConfigureMockMvc
@SpringBootTest
public class GradebookControllerTest {

   // inject support utils

   // inject Service and DAOs

   // inject SQL strings

   // @BeforeAll, @BeforeEach and @AfterEach

}
```

Get Students Endpoint

- Get a list of students as a JSON array

http://localhost:1500/

Web browser will send a GET request


```
[
  {
    "id": 10,
    "firstname": "David",
    "lastname": "Adams",
    "emailAddress": "david@luv2code.com",
    "studentGrades": {
      "mathGradeResults": [],
      "scienceGradeResults": [],
      "historyGradeResults": []
    },
    "fullName": "David Adams"
  },
  {
    "id": 11,
    "firstname": "John",
    "lastname": "Doe",
    "emailAddress": "john@luv2code.com",
    "studentGrades": {
      "mathGradeResults": [],
      "scienceGradeResults": [],
      "historyGradeResults": []
    },
    "fullName": "John Doe"
  },
  ...
]
```

GradebookController

```java
@RestController
public class GradebookController {

   @Autowired
   private StudentAndGradeService studentService;

   @Autowired
   private Gradebook gradebook;

   @RequestMapping(value = "/", method = RequestMethod.GET)
   public List<GradebookCollegeStudent> getStudents() {
      gradebook = studentService.getGradebook();
      return gradebook.getStudents();
   }

   ...
}
```


```
[
  {
    "id": 10,
    "firstname": "David",
    "lastname": "Adams",
    "emailAddress": "david@luv2code.com",
    "studentGrades": {
      "mathGradeResults": [],
      "scienceGradeResults": [],
      "historyGradeResults": []
    },
    "fullName": "David Adams"
  },
  {
    "id": 11,
    "firstname": "John",
    "lastname": "Doe",
    "emailAddress": "john@luv2code.com",
    "studentGrades": {
      "mathGradeResults": [],
      "scienceGradeResults": [],
      "historyGradeResults": []
    },
    "fullName": "John Doe"
  },
  ...
]
```

Verifying the HTTP Response

- How can we verify HTTP response?
  - status code
  - content type
  - JSON response body

Verifying HTTP Status and Content Type

```
import static org.springframework.test.web.servlet.result.MockMvcResultMatchers.content;
import static org.springframework.test.web.servlet.result.MockMvcResultMatchers.status;
...

@TestPropertySource("/application-test.properties")
@AutoConfigureMockMvc
@SpringBootTest
public class GradebookControllerTest {

   ...

   @Test
   public void getStudentsHttpRequest() throws Exception {

      mockMvc.perform(MockMvcRequestBuilders.get("/"))
             .andExpect(status().isOk())
             .andExpect(content().contentType(APPLICATION_JSON_UTF8));

   }

   ...

}
```

HTTP status of 200 (OK)

application/json

Verifying JSON Response Body

- How can we verify JSON response body?
  - Access specific JSON element (even for nested elements)
  - Size of the JSON array

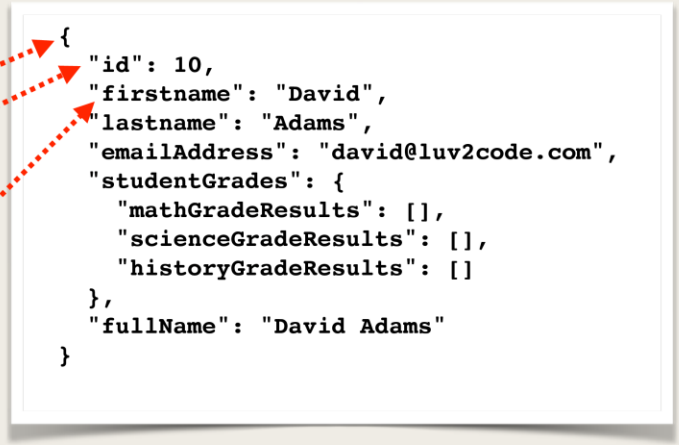
Solution: JsonPath

- **JsonPath** allows you to access elements of JSON
- Open-source project

https://github.com/json-path/JsonPath

JsonPath Examples

JsonPath	Result
`$`	The root element to query. Starts all path expressions
`$.id`	Access the **`id`** element of the JSON element
`$.firstname`	Access the **`firstname`** element of the JSON element
`...`	`...`



```
{
  "id": 10,
  "firstname": "David",
  "lastname": "Adams",
  "emailAddress": "david@luv2code.com",
  "studentGrades": {
    "mathGradeResults": [],
    "scienceGradeResults": [],
    "historyGradeResults": []
  },
  "fullName": "David Adams"
}
```

https://github.com/json-path/JsonPath

JsonPath - Verifying Array Size

```
import static org.springframework.test.web.servlet.result.MockMvcResultMatchers.jsonPath;
import static org.hamcrest.Matchers.hasSize;
...

@TestPropertySource("/application-test.properties")
@AutoConfigureMockMvc
@SpringBootTest
public class GradebookControllerTest {

   ...

   @Test
   public void getStudentsHttpRequest() throws Exception {

      mockMvc.perform(MockMvcRequestBuilders.get("/"))
             .andExpect(status().isOk())
             .andExpect(content().contentType(APPLICATION_JSON_UTF8))
             .andExpect(jsonPath("$", hasSize(2));

   }

   ...
}
```

Root element

Verify JSON array size is 2

```
[
  {
    "id": 10,
    "firstname": "David",
    "lastname": "Adams",
    "emailAddress": "david@luv2code.com",
    "studentGrades": {
      "mathGradeResults": [],
      "scienceGradeResults": [],
      "historyGradeResults": []
    },
    "fullName": "David Adams"
  },
  {
    "id": 11,
    "firstname": "John",
    "lastname": "Doe",
    "emailAddress": "john@luv2code.com",
    "studentGrades": {
      "mathGradeResults": [],
      "scienceGradeResults": [],
      "historyGradeResults": []
    },
    "fullName": "John Doe"
  }
]
```

Thank You

Spring AOP: Enhancing Modularity and Cross-Cutting Concerns

Spring Aspect-Oriented Programming (AOP) is a powerful paradigm addressing common enterprise application challenges. It significantly improves code reusability and maintainability

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What is AOP?

- AOP is **Aspect Oriented Programming** which helps to decouple the cross-cutting concerns like logging, security, transaction management, etc., from the business logic.
- The class containing the methods that define cross-cutting concerns is known as **Aspect**.
- These methods are known as **Advice**.
- Every method is annotated with a **Pointcut Expression**.
- Depending on these Pointcut Expressions, advices will be invoked automatically at runtime.

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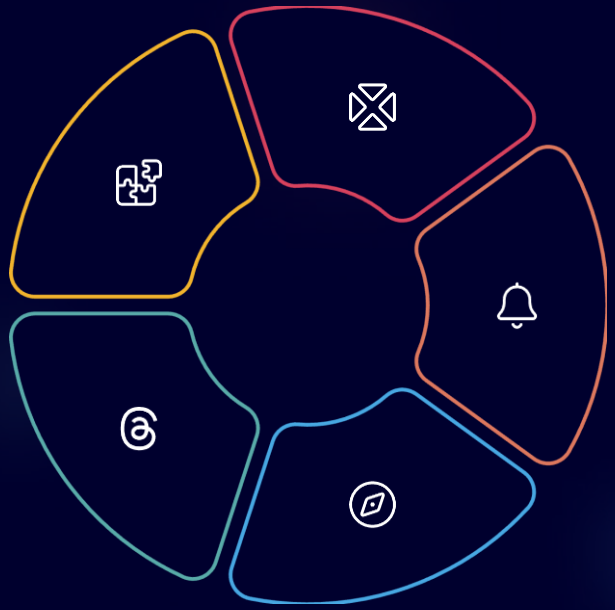
Understanding Aspect-Oriented Programming (AOP)

Aspects

Modularize cross-cutting concerns (e.g., logging, security, exceptions).

Weaving

The process of linking aspects with target objects, typically at runtime via proxies in Spring AOP.



Join Points

Specific execution points in the application (method calls, exceptions).

Advice

Action taken at a join point (e.g., @Before, @Around, @After).

Pointcuts

Define where advice applies, typically using expressions (e.g., specific package or method pattern).

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Why Spring AOP? Solving Cross-Cutting Concerns

Separates Concerns

Isolates core business logic from boilerplate code like logging or security, making the codebase cleaner.

Avoids Scattering

Eliminates repetitive code scattered across multiple modules, centralizing common functionalities.

Enables Modular Development

Facilitates building large, complex systems with highly decoupled and manageable components.

Boosts Productivity

Can improve developer productivity by up to 20% by reducing boilerplate and simplifying code maintenance.

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Simplifying AOP with Annotations

@Aspect

Marks a class as an aspect, containing advice and pointcut definitions.

@Before

Executes before a join point, suitable for pre-conditions or logging.

@After

Executes after a join point, regardless of its outcome (success or exception).

@Around

Wraps a join point, allowing custom behavior before, during, and after its execution. Offers maximum control.

@Pointcut

Defines reusable pointcut expressions, making advice more organized.

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Types of Advise

- **Before Advice**

```
@Before("execution(expression)")
public void logBefore(JoinPoint joinPoint) {
  System.out.println("Before method: " + joinPoint.getSignature());
}
```

- **After Advice**

```
@After("execution(expression)")
public void logAfter(JoinPoint joinPoint) {
  System.out.println("After method: " + joinPoint.getSignature());
}
```

- **After Returning Advice**

```
@AfterReturning(pointcut="execution(expression)", returning="result")
public void logAfterReturning(JoinPoint joinPoint, Object result) {
  System.out.println("AfterReturning method returned: " + result);
}
```

- **After Throwing Advice**

```
@AfterThrowing(pointcut="execution(expression)", throwing="exception")
public void logAfterThrowing(JoinPoint joinPoint, Throwable exception) {
  System.out.println("AfterThrowing method threw: " + exception);
}
```

- **Around Advice**

```
@Around("execution(expression)")
public Object logAround(ProceedingJoinPoint proceedingJoinPoint) throws Throwable {
  System.out.println("Around method: ", proceedingJoinPoint.getSignature());
  System.out.println("Before proceeding part of the Around advice.");
  Object object = proceedingJoinPoint.proceed();
  System.out.println("After proceeding part of the Around advice.");
  return object;
}
```

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Common Use Cases: Transaction Management and Logging

Declarative Transactions

- Uses **@Transactional** annotation to ensure ACID properties for database operations.
- Automatically commits on success or rolls back on failure, simplifying data consistency.
- Eliminates manual transaction demarcation in business logic.

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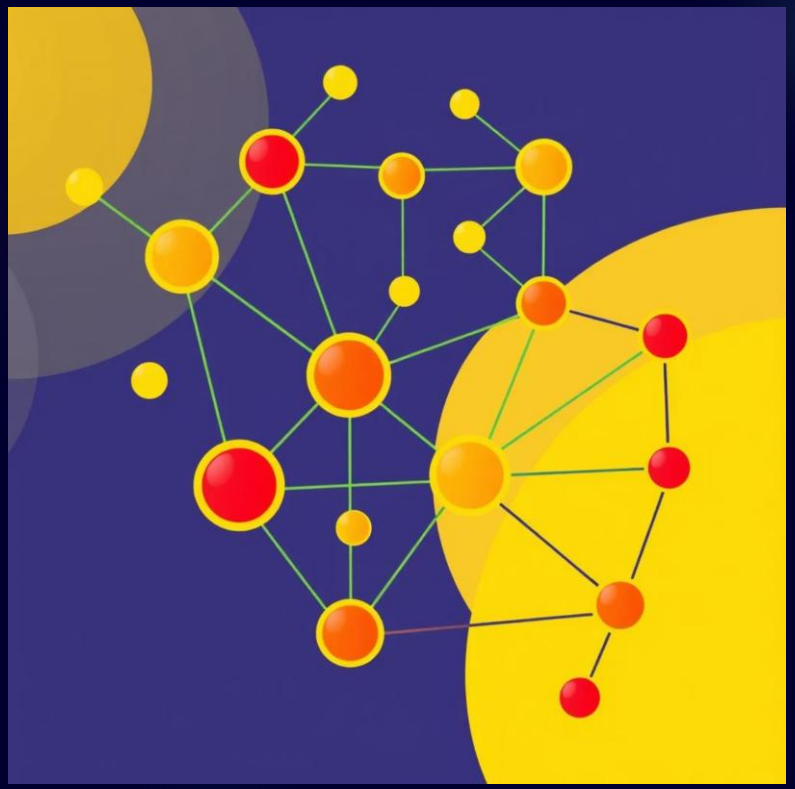
Using Aspects for Robust Exception Handling

Aspects can centralize exception handling logic, preventing scattered try-catch blocks and ensuring consistent error management across an application.

- **@AfterThrowing:** This advice type runs only if a method exits by throwing an exception. It's ideal for logging specific exceptions, notifying administrators, or performing cleanup operations.
- **Global Error Handling:** Implement a single aspect to catch and process exceptions from multiple layers (e.g., service, repository), mapping them to user-friendly messages or specific error codes.
- **Retry Mechanisms:** Use **@Around** advice to implement retry logic for transient errors (e.g., network timeouts, database deadlocks), enhancing application resilience.



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Key Benefits of Spring AOP

Modularity

Encapsulates distinct concerns into reusable aspects, promoting a clean architecture.

Maintainability

Easier to update and manage, as changes to cross-cutting concerns have minimal impact on core code.

Reusability

Aspects can be applied consistently across diverse modules and applications, saving development time.

Testability

Decouples components, allowing for isolated testing of business logic without concern for cross-cutting details.

Declarative

Simplifies application development through easy configuration via annotations or XML, reducing verbose code.

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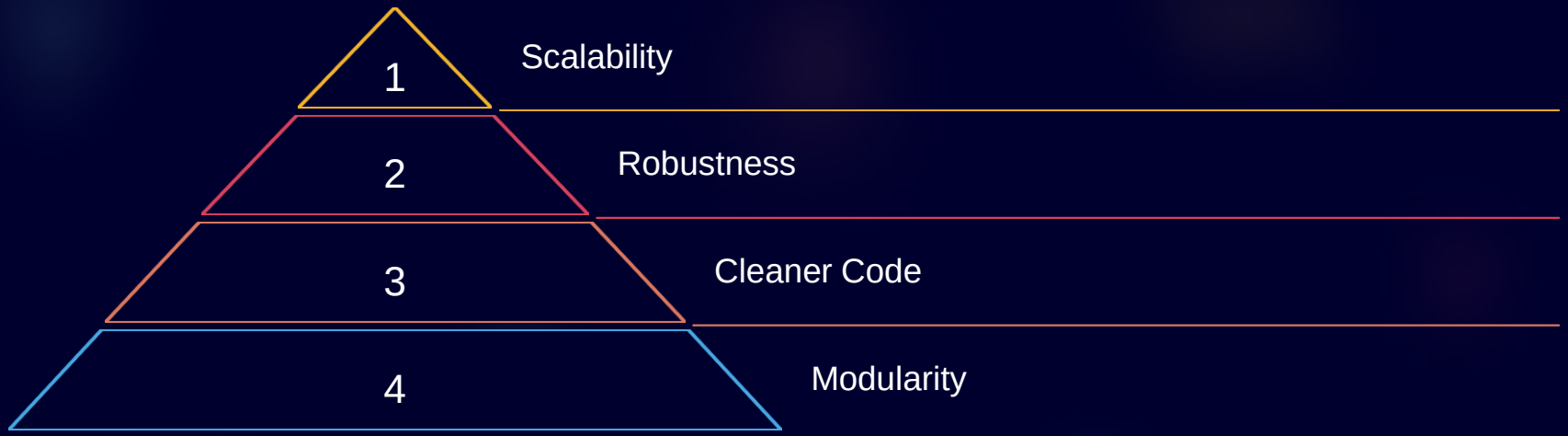
Conclusion: A Powerful Tool for Enterprise Applications



Spring AOP is essential for managing complexities in modern applications, driving cleaner, more robust, and scalable codebases. It enhances core functionality without intrusive changes, making it invaluable for improved system architecture.

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All the best