Demystify
Instant
Destroy target enchantment.
Behind every mage is a trail of shattered lies.
Véronique Meignaud

Testing Spring Boot Applications Demystified

Full-Day Workshop

DATEV Coding Festival 09.10.2025

Philip Riecks - PragmaTech GmbH - @rieckpil

Organization

- Slides & code will be shared: check PragmaTech GitHub in the linked resources within Zoom
- Workshop lab requirements
  - Java JDK 21
  - Docker for Testcontainers, consider Podman
  - GitHub Account (preferably a personal) to use GitHub Codespaces if the local setup is not possible

(Planned) Timeline

- 9:00 - 10:30: **Lab 1 - Introduction and Spring Boot Testing Basics** (90 minutes)
- 10:30 - 11:00: **Coffee Break** (30 minutes)
- 11:00 - 12:30: **Lab 2 - Sliced Testing** (90 minutes)
- 12:30 - 13:30: **Lunch** (60 minutes)
- 13:30 - 15:00: **Lab 3 - Integration Testing** (90 minutes)
- 15:00 - 15:30: **Coffee Break** (30 minutes)
- 15:30 - 16:30: **Lab 4 - Pitfalls, Best Practices, AI & Outlook** (60 minutes)
- 16:30 - 17:00: **Final Q&A and Wrap-Up**

Workshop Instructor: Philip

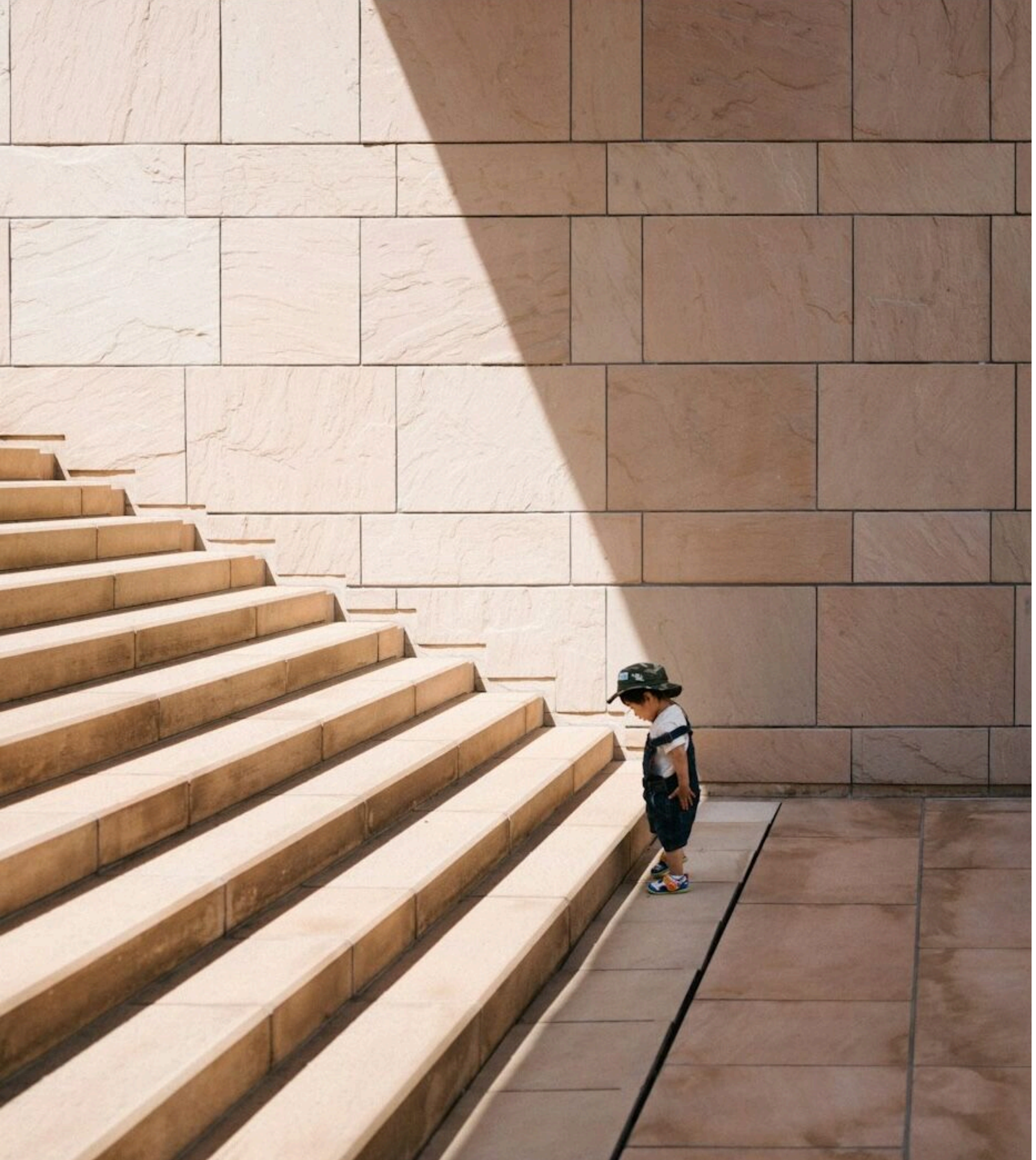
- Self-employed IT consultant from Herzogenaurach, Germany (Bavaria) 🍻
- Blogging & content creation for more than five years. Since three years with a focus on testing Java and specifically Spring Boot applications 🍃
- Founder of PragmaTech GmbH - Enabling Developers to Frequently Deliver Software with More Confidence 🚤
- Enjoys writing tests 🧪
- @rieckpil on various platforms

Getting to Know Each Other

- What's your name and your role?
- What's one word that describes how you're feeling about automated testing?
- What's your expectation for this workshop?

Lab 1

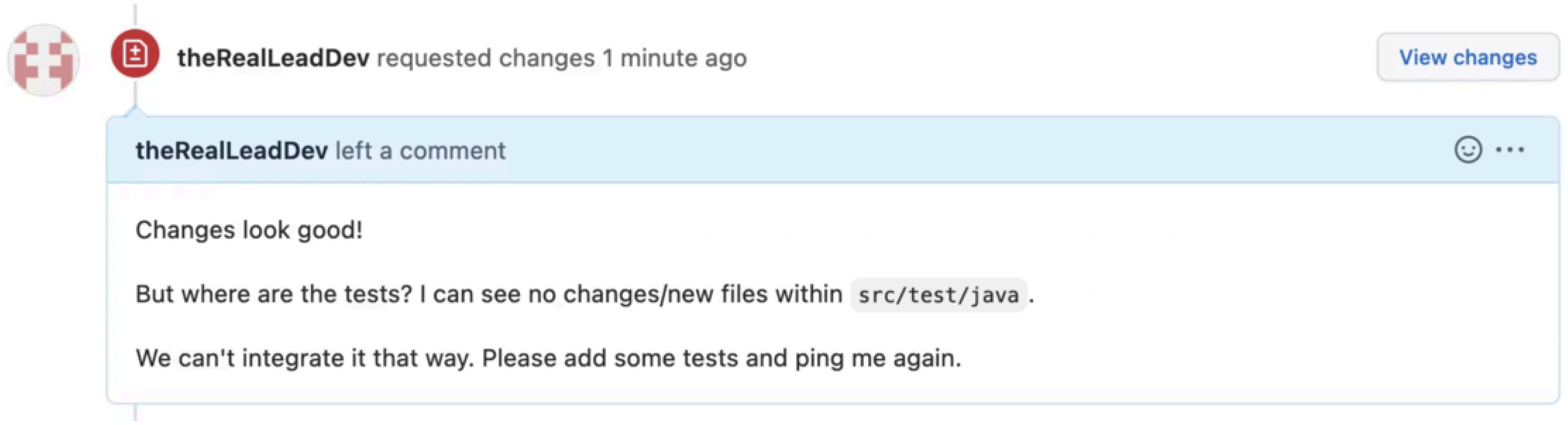
Introduction and Spring Boot Testing Basics



Getting Started with Testing

How It Started

Getting Used To Testing At Work



theRealLeadDev requested changes 1 minute ago

theRealLeadDev left a comment

Changes look good!

But where are the tests? I can see no changes/new files within `src/test/java`.

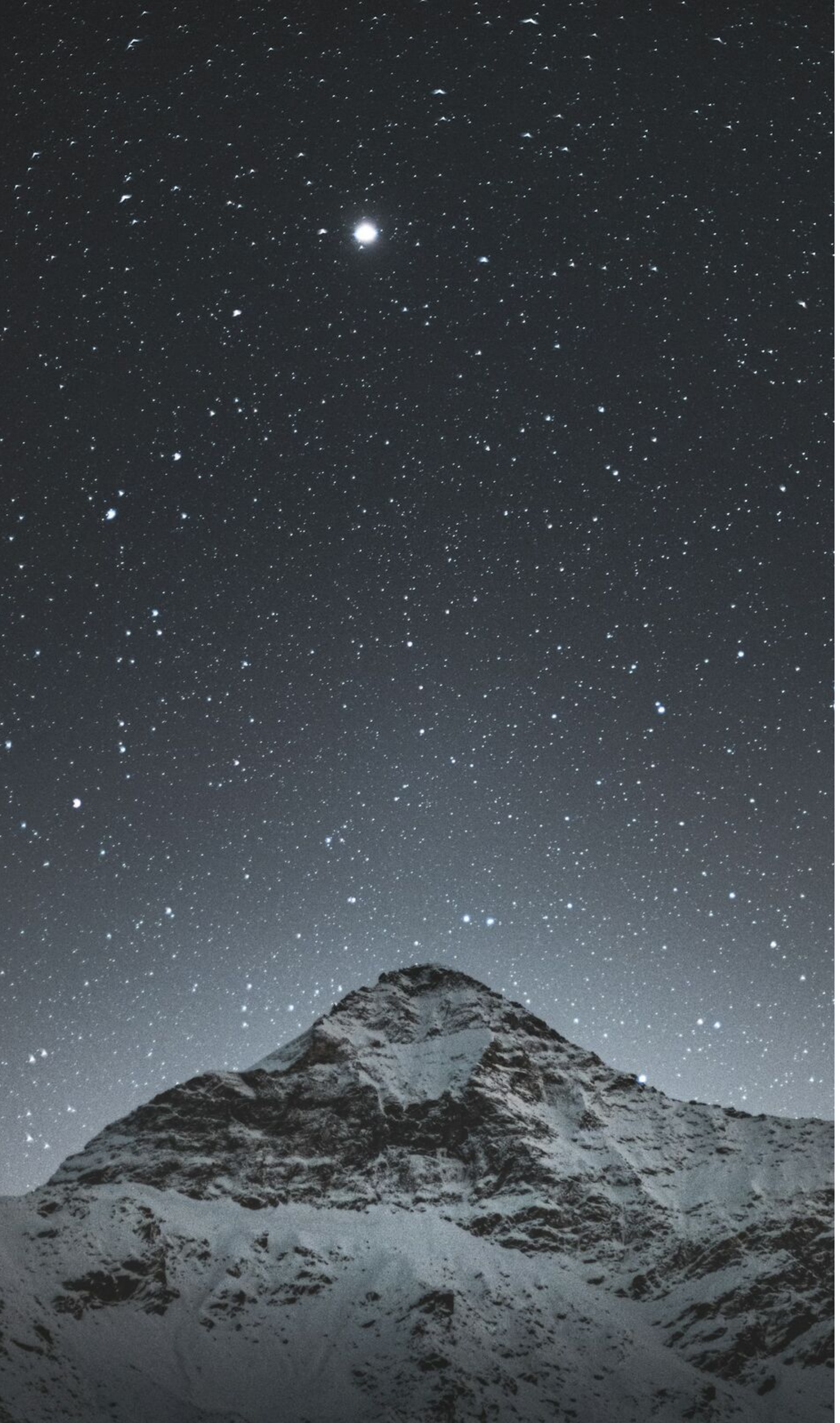
We can't integrate it that way. Please add some tests and ping me again.

Goals of this Workshop

1. Demystify the complexities of testing Spring Boot applications

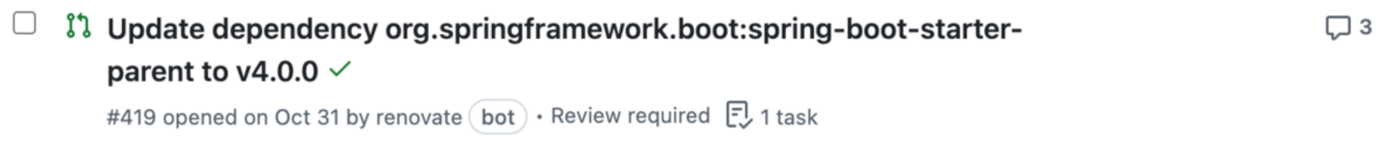
2. Provide clear explanations, practical insights, and actionable best practices

3. Become more productive and confident in your development and testing efforts



My Overall Northstar

Imagine seeing this pull request on a Friday afternoon:



Update dependency org.springframework.boot:spring-boot-starter-parent to v4.0.0 ✓

#419 opened on Oct 31 by renovate bot · Review required 1 task

3

How confident are you to merge this major Spring Boot upgrade and deploy it to production once the pipeline turns green?

Good tests don't just catch bugs - they give you the confidence to say "yes" without hesitation.

Why Do We Test Software

- Shift Left
- Catch Bugs Early
- Confidence in Code Changes
- Documentation
- Regression Prevention
- Become more Productive
- Use Tests as a Playground to Explore New Technologies

Spring Boot Testing Basics

Spring Boot Starter Test, Build Tools, Conventions, Unit Testing

Naming Things Is Hard

Black Box Test

Unit Tests

Integrated Test

White Box Test

Integration Tests

Fast Test

User Acceptance Tests

E2E Tests

Mutation Tests

Smoke Tests

Contract Tests

Regression Test

Load Tests

Property-based Tests

Functional Test

Stress Tests

Boundary Value Testing

System Tests

Exploratory Tests

Performance Tests

My Pragmatic Test Name Approach

1. **Unit Tests**: Tests that verify the functionality of a single, isolated component (like a method or class) by mocking or stubbing all external dependencies.

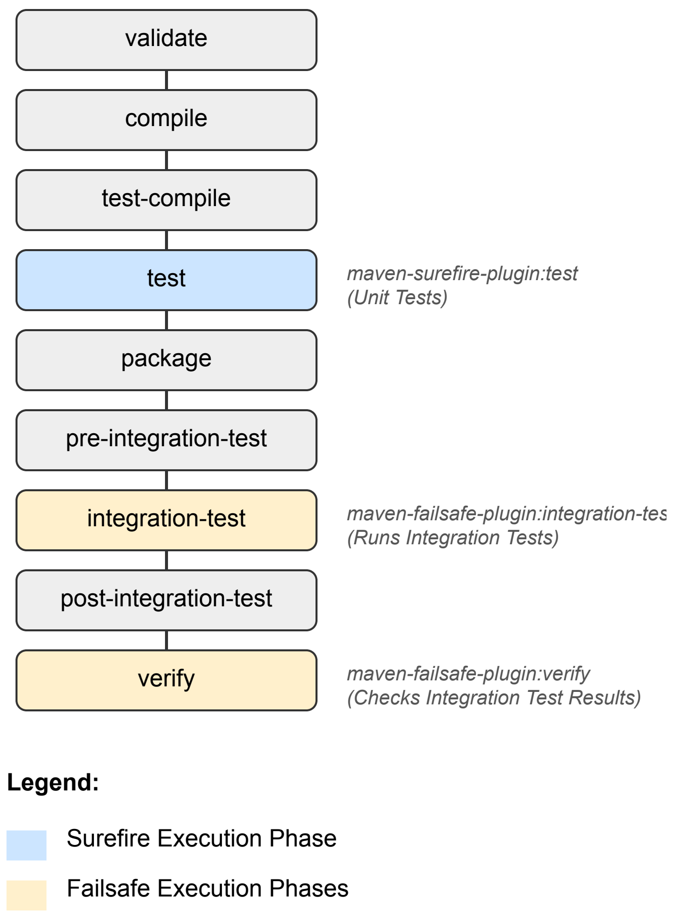
2. **Integration Tests**: Tests that verify interactions between two or more components work correctly together, with real implementations replacing some mocks.

3. **E2E**: Tests that validate the entire application workflow from start to finish, simulating real user scenarios across all components and external dependencies.

Maven Build Lifecycle

- **Maven Surfire Plugin** for unit tests: default postfix `*Test` (e.g. `CustomerTest`)
- **Maven Failsafe Plugin** for integration tests: default postfix `*IT` (e.g. `CheckoutIT`)
- Reason for splitting: different **parallelization** options, better **organisation**

Running ./mvnw verify



Spring Boot Starter Test

- aka. "Testing Swiss Army Knife"
- Batteries-included for testing
- Dependency management for:
  - JUnit Jupiter
  - Mockito
  - AssertJ
  - Awaitility
  - etc.
- We can manually override the dependency versions

```
[INFO] +- org.springframework.boot:spring-boot-starter-test:jar:3.5.6:test
[INFO] |  +- org.springframework.boot:spring-boot-test:jar:3.5.6:test
[INFO] |  +- org.springframework.boot:spring-boot-test-autoconfigure:jar:3.5.6:test
[INFO] |  +- com.jayway.jsonpath:json-path:jar:2.9.0:test
[INFO] |  +- jakarta.xml.bind:jakarta.xml.bind-api:jar:4.0.2:test
[INFO] |  |  \- jakarta.activation:jakarta.activation-api:jar:2.1.3:test
[INFO] |  +- net.minidev:json-smart:jar:2.5.2:test
[INFO] |  |  \- net.minidev:accessors-smart:jar:2.5.2:test
[INFO] |  |     \- org.ow2.asm:asm:jar:9.7.1:test
[INFO] |  +- org.assertj:assertj-core:jar:3.26.3:test
[INFO] |  |  \- net.bytebuddy:byte-buddy:jar:1.15.11:test
[INFO] |  +- org.awaitility:awaitility:jar:4.3.0:test
[INFO] |  +- org.hamcrest:hamcrest:jar:2.2:test
[INFO] |  +- org.junit.jupiter:junit-jupiter:jar:5.11.4:test
[INFO] |  |  +- org.junit.jupiter:junit-jupiter-api:jar:5.11.4:test
[INFO] |  |  |  +- org.junit.platform:junit-platform-commons:jar:1.11.4:test
[INFO] |  |  |  \- org.apiguardian:apiguardian-api:jar:1.1.2:test
[INFO] |  |  +- org.junit.jupiter:junit-jupiter-params:jar:5.11.4:test
[INFO] |  |  \- org.junit.jupiter:junit-jupiter-engine:jar:5.11.4:test
[INFO] |  |     \- org.junit.platform:junit-platform-engine:jar:1.11.4:test
[INFO] |  +- org.mockito:mockito-core:jar:5.17.0:test
[INFO] |  |  +- net.bytebuddy:byte-buddy-agent:jar:1.15.11:test
[INFO] |  |  \- org.objenesis:objenesis:jar:3.3:test
[INFO] |  +- org.mockito:mockito-junit-jupiter:jar:5.17.0:test
[INFO] |  +- org.skyscreamer:jsonassert:jar:1.5.3:test
[INFO] |  |  \- com.vaadin.external.google:android-json:jar:0.0.20131108.vaadin1:test
[INFO] |  +- org.springframework:spring-core:jar:6.2.6:compile
[INFO] |  |  \- org.springframework:spring-jcl:jar:6.2.6:compile
[INFO] |  +- org.springframework:spring-test:jar:6.2.6:test
[INFO] |  \- org.xmlunit:xmlunit-core:jar:2.10.0:test
```

Transitive Test Dependency: JUnit 5

- Modern testing framework for Java applications
- Rewrite of JUnit 4
- JUnit 5 = JUnit Jupiter + JUnit Vintage + JUnit Platform
- Key features: parameterized tests, nested tests, extensions, parallelization

```java
@Test
void shouldCreateNewBook() {
  Book book = new Book("1234", "Spring Boot Testing", "Test Author");

  assertEquals("1234", book.getIsbn());
}
```

Transitive Test Dependency: Mockito

- Mocking framework for unit tests
- Used to isolate the class under test from its dependencies
- Allows verification of interactions between objects
- Golden Mockito Rules:
    - Don't mock what you don't own
    - Don't mock value objects
    - Don't mock everything
    - Show some love with your tests

```java
@ExtendWith(MockitoExtension.class)
class BookServiceTest {

  @Mock
  private BookRepository bookRepository;

  @InjectMocks
  private BookService bookService;

  @Test
  void shouldReturnBookWhenFound() {
    when(bookRepository.findByIsbn("1234")).thenReturn(Optional.of(expectedBook));

    Optional<Book> result = bookService.getBookByIsbn("1234");

    verify(bookRepository).findByIsbn("1234");
  }
}
```

Transitive Test Dependency: AssertJ

- Fluent assertion library for Java tests
- Provides more readable, chain-based assertions
- Rich set of assertions for collections, exceptions, and more

```java
@Test
void shouldProvideFluentAssertions() {
  List<Book> books = List.of(
    new Book("1234", "Spring Boot Testing", "Test Author"),
    new Book("5678", "Advanced Spring", "Another Author")
  );

  assertThat(books)
    .hasSize(2)
    .extracting(Book::getTitle)
    .containsExactly("Spring Boot Testing", "Advanced Spring");
}
```

Transitive Test Dependency: Hamcrest

- Fluent assertion library
- Occasionally used within Spring Test, e.g. `MockMvc` verifications
- Implementation for many other programming languages

```
@Test
void shouldMatchWithHamcrest() {
  Book book = new Book("1234", "Spring Boot Testing", "Test Author");

  assertThat(book.getIsbn(), is("1234"));
  assertThat(book.getTitle(), allOf(
    startsWith("Spring"),
    containsString("Testing"),
    not(emptyString())
  ));
}
```

Transitive Test Dependency: Awaitility

- Library for testing asynchronous code
- Provides a DSL for expressing expectations on async operations
- Great for testing concurrent code and background tasks

```java
@Test
void shouldEventuallyCompleteAsyncOperation() {
  CompletableFuture<Book> futureBook = CompletableFuture.supplyAsync(() -> {
    try {
      Thread.sleep(300);
      return new Book("1234", "Async Testing", "Author");
    } catch (InterruptedException e) {
      return null;
    }
  });

  await()
    .atMost(1, TimeUnit.SECONDS)
    .until(futureBook::isDone);
}
```

Transitive Test Dependency: JsonPath

- Library for parsing and evaluating JSON documents
- Used for extracting and asserting on JSON structures
- Especially useful in REST API testing

```java
@Test
void shouldParseAndEvaluateJson() throws Exception {
  String json = """
    { "book": {"isbn": "1234", "title": "JSON Testing", "author": "Test Author"}}""";

  DocumentContext context = JsonPath.parse(json);

  assertThat(context.read("$.book.isbn", String.class)).isEqualTo("1234");
  assertThat(context.read("$.book.title", String.class)).isEqualTo("JSON Testing");
}
```

Transitive Test Dependency: JSONAssert

- Assertion library for JSON data structures
- Provides powerful comparison of JSON structures
- Supports strict and lenient comparison modes

```java
@Test
void shouldAssertJsonEquality() throws Exception {
  String actual = """
    { "isbn": "1234", "title": "JSON Testing", "author": "Test Author"}""";

  String expected = """
    { "isbn": "1234", "title": "JSON Testing"}""";

  // Strict mode would fail as expected is missing the author field
  JSONAssert.assertEquals(expected, actual, false);
}
```

Transitive Test Dependency: XMLUnit

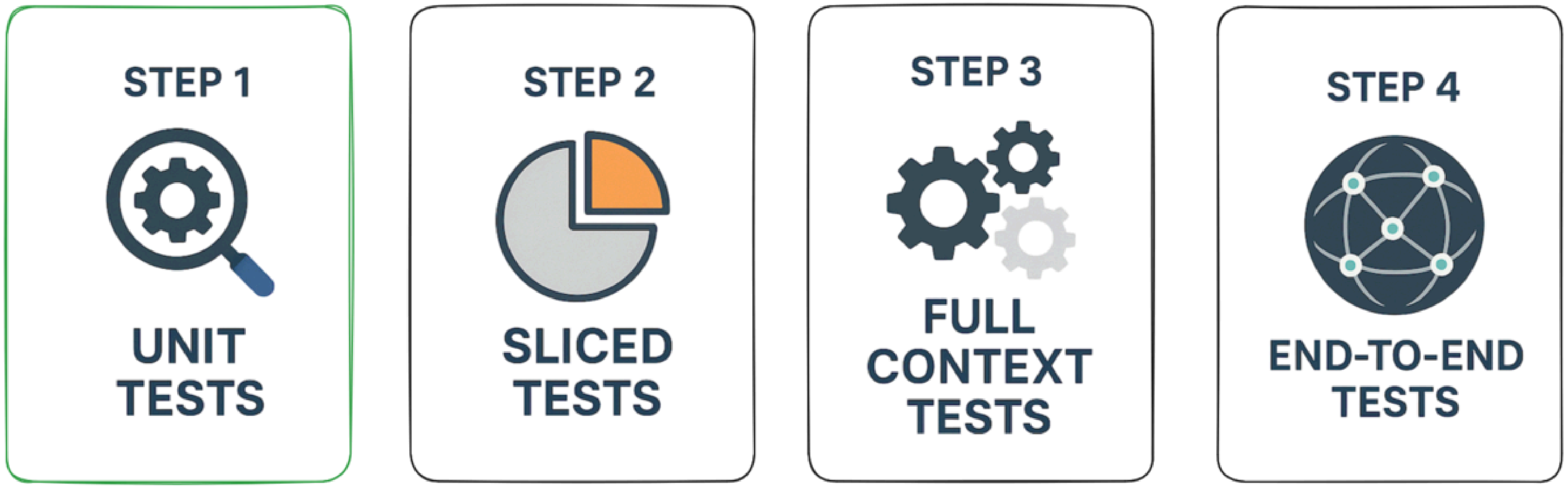
- Library for testing XML documents
- Provides comparison and validation of XML
- Useful for testing SOAP services or XML outputs

```java
@Test
void shouldCompareXmlDocuments() {
  String control = "<book><isbn>1234</isbn><title>XML Testing</title></book>";
  String test = "<book><isbn>1234</isbn><title>XML Testing</title></book>";

  Diff diff = DiffBuilder.compare(Input.fromString(control))
    .withTest(Input.fromString(test))
    .build();

  assertFalse(diff.hasDifferences(), diff.toString());
}
```

Testing Types for Spring Boot Applications



Unit Testing Spring Boot Applications 101

- **Core Concept**: Test individual components (classes, methods) in complete isolation from their dependencies.
- **Confidence Gained**: Provides logarithmic verifications, ensuring that the smallest parts of your code work as expected under various conditions.
- **Best Practices**: Focus on a single unit of work.
- **Pitfalls**: Requires a well-thought-out class design. Poor design can lead to testing overly complex "god classes," making tests difficult to write and maintain.
- **Tools**: JUnit (or Spock, TestNG, etc.), Mockito and assertion libraries like AssertJ or Hamcrest.

Design For (Unit) Testability with Spring Boot

- Provide collaborators from outside (dependency injection) -> no `new` inside your code
- Develop small, single responsibility classes
- Test only the public API of your class
- Verify behavior not implementation details
- TDD can help design (better) classes

Avoid Static Method Access

```java
@Service
public class BirthdayService {

  public boolean isTodayBirthday(LocalDate birthday) {
    LocalDate today = LocalDate.now();

    return today.getMonth() == birthday.getMonth()
      && today.getDayOfMonth() == birthday.getDayOfMonth();
  }
}
```

Better Alternative

```
@Service
public class BirthdayServiceWithClock {

  private final Clock clock;

  public BirthdayServiceWithClock(Clock clock) {
    this.clock = clock;
  }

  public boolean isTodayBirthday(LocalDate birthday) {
    LocalDate today = LocalDate.now(clock);

    return today.getMonth() == birthday.getMonth()
      && today.getDayOfMonth() == birthday.getDayOfMonth();
  }
}
```

```java
@Test
void shouldReturnTrueWhenTodayIsBirthday() {
  // Arrange
  LocalDate fixedDate = LocalDate.of(2025, 5, 15);
  Clock fixedClock = Clock.fixed(
    fixedDate.atStartOfDay(ZONE_ID).toInstant(),
    ZONE_ID
  );

  BirthdayServiceWithClock cut = new BirthdayServiceWithClock(fixedClock);
  LocalDate birthday = LocalDate.of(1990, 5, 15); // Same month and day

  // Act
  boolean result = cut.isTodayBirthday(birthday);

  // Assert
  assertThat(result).isTrue();
}
```

Check Your Imports

- Nothing Spring-related here
- Rely only on JUnit, Mockito and an assertion library

```java
import org.junit.jupiter.api.DisplayName;
import org.junit.jupiter.api.Nested;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.CsvSource;
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;

import static org.assertj.core.api.Assertions.assertThat;
```

Unify Test Structure

- Use a consistent test method naming: givenWhenThen, shouldWhen, etc.
- Structure test for the Arrange/Act/Assert test setup

```java
@Test
void should_When_() {

  // Arrange
  // ... setting up objects, data, collaborators, etc.

  // Act
  // ... performing the action to be tested on the class under test

  // Assert
  // ... verifying the expected outcome
}
```

A Standard Unit Test

```java
@Test
void testBookService() {
    // Given
    Book book = new Book("123", "Test Book", "Test Author");
    when(bookRepository.findById("123")).thenReturn(Optional.of(book));

    // When
    Optional<Book> result = bookService.getBookById("123");

    // Then
    assertTrue(result.isPresent());
    assertEquals("Test Book", result.get().getTitle());
    verify(bookRepository).findById("123");
}
```

JUnit Jupiter Extension API

- Important concept to understand
- Makes JUnit Jupiter extensible
- `SpringExtension` provides Spring integration
- Successor of JUnit 4's `@RunWith` / `@Rule` API

```java
@ExtendWith(MockitoExtension.class)
class BookServiceTest {

}
```

JUnit Jupiter Extension Points

- Lifecycle Callbacks: `BeforeEachCallback`, `AfterAllCallback`, etc.
- Parameter Resolution: `ParameterResolver`
- Exception Handling: `TestExecutionExceptionHandler`
- Conditional Test Execution: `ExecutionCondition`
- Test Instance Factories: `TestInstanceFactory`, `TestInstancePostProcessor`

Create a Custom Extension

```java
public class TimingExtension implements BeforeTestExecutionCallback, AfterTestExecutionCallback {

    private static final Logger logger = LoggerFactory.getLogger(TimingExtension.class);

    @Override
    public void beforeTestExecution(ExtensionContext context) {
        getStore(context).put("start", System.currentTimeMillis());
    }

    @Override
    public void afterTestExecution(ExtensionContext context) {
        long start = getStore(context).remove("start", Long.class);
        long duration = System.currentTimeMillis() - start;
        logger.info("Test {} took {} ms", context.getDisplayName(), duration);
    }

    private Store getStore(ExtensionContext context) {
        return context.getStore(Namespace.create(getClass(), context.getRequiredTestMethod()));
    }
}
```

Time For Some Exercises

Lab 1

- Check out the repository locally and open it at the project root inside your IDE
- Work locally (requires Podman and Java 21) or use GitHub Codespaces (120 hours/month free)
- For Codespaces, pick at least 4-Cores (16 GB RAM) and region `Europe West`
- Navigate to the `labs/lab-1` folder in the repository and complete the tasks as described in the `README` file of that folder
- Time boxed until the end of the coffee break (11:00 AM)