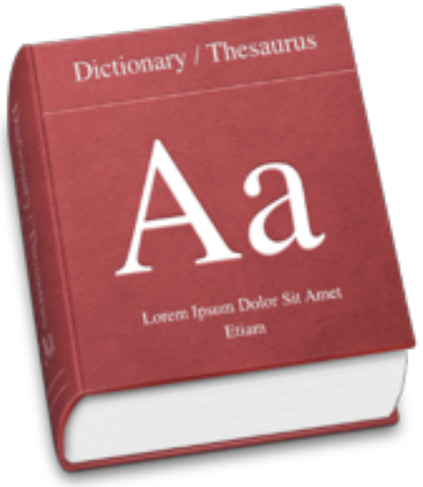
Software Engineering and Architecture
Behavior Driven Development (BDD)

Olivier Liechti
HEIG-VD
olivier.liechti@heig-vd.ch

MSE | MASTER OF SCIENCE IN ENGINEERING

Reminder: Building Value

- When we presented agile development concepts, we insisted on the notion of “**value**”.
- **Building the right system** is at least as important as **building the system right**.
- When requirements are managed with a **product backlog**, the order of items in the backlog should reflect their value.
- On paper, this sounds like common sense. In practice, it is not obvious for the **whole team** to have this **mindset**.
- **Therefore, anything that can reinforce this principle is useful. It has a lot to do with communication and collaboration.**



Reminder: Are we Done?

- Agile methodologies rely on the definition of "done" for stories (or other **units of delivery**).
- From a **development** perspective, we have seen that a story is done when it has been **implemented**, **tested** and **documented**.
- With **continuous delivery**, the scope of "done" has been extended. A feature is "done" when it is in production and available to users.
- In practice, it is challenging for developers to **be sure that they are done** at the end of the sprint. Are all the scenario variations covered?
- **Practices and tools that help clarify, track and validate the acceptance criteria are important.**

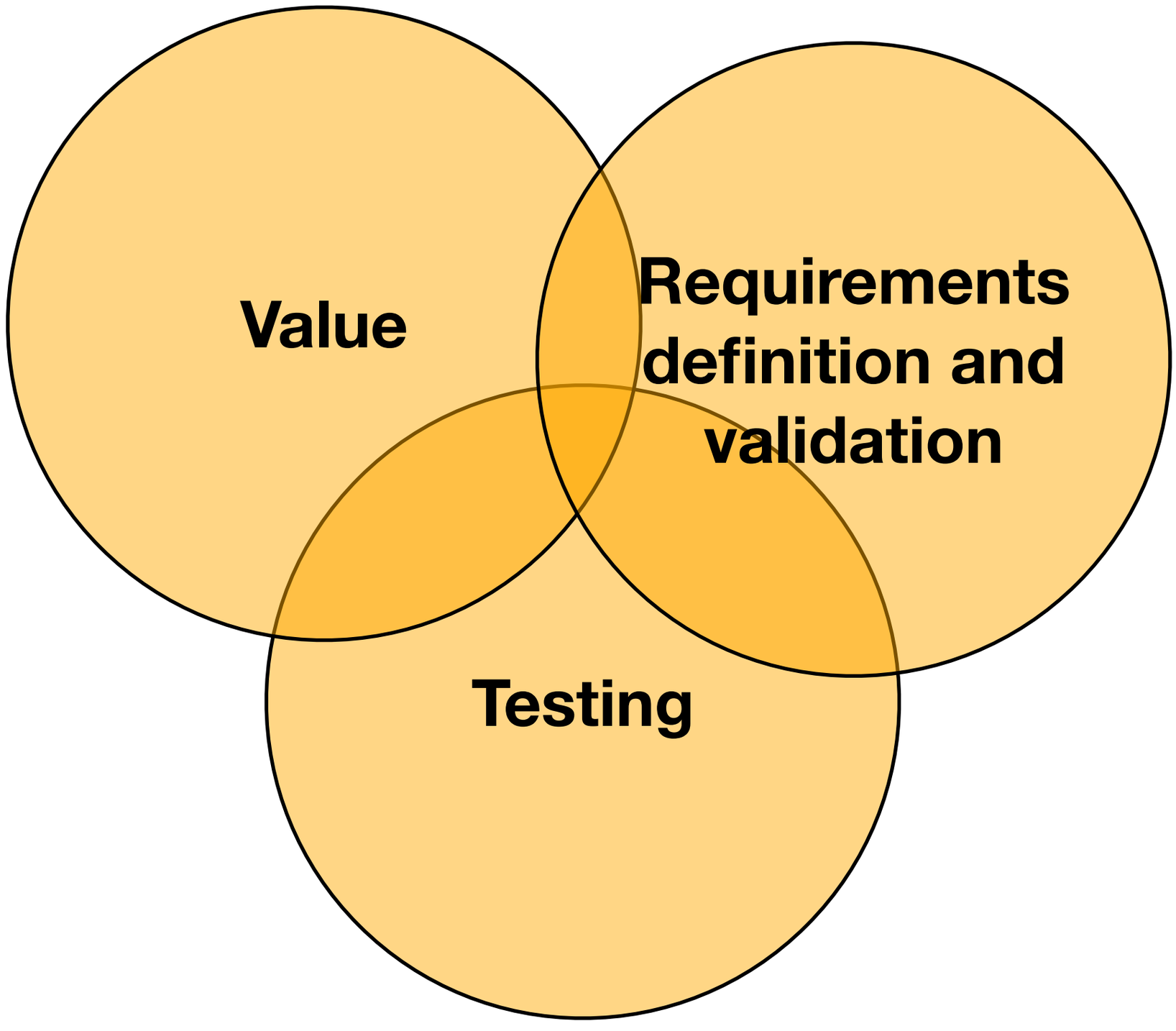
The Testing Onion

- There are **different types of tests**. They need to be run very, very often (along the delivery pipeline). The results must be broadcasted to the team.
- **Unit tests** must be **extremely fast** (no network, no DB access, no file access). They must be run before committing changes.
- **Integration tests** are slower and test **end-to-end** flows in the entire system. They are typically run after commit, on an integration server
- **Automated acceptance tests** validate the **behavior** of the system, from an **end-user perspective**. They also need to be run on a frequent basis, but they usually take a long time to execute.
- **User acceptance tests** give feedback that is difficult to get with an automated approach (subjective evaluation, exploratory testing, usability, etc.)
- **What kind of tools can we use to manage automated acceptance tests?**

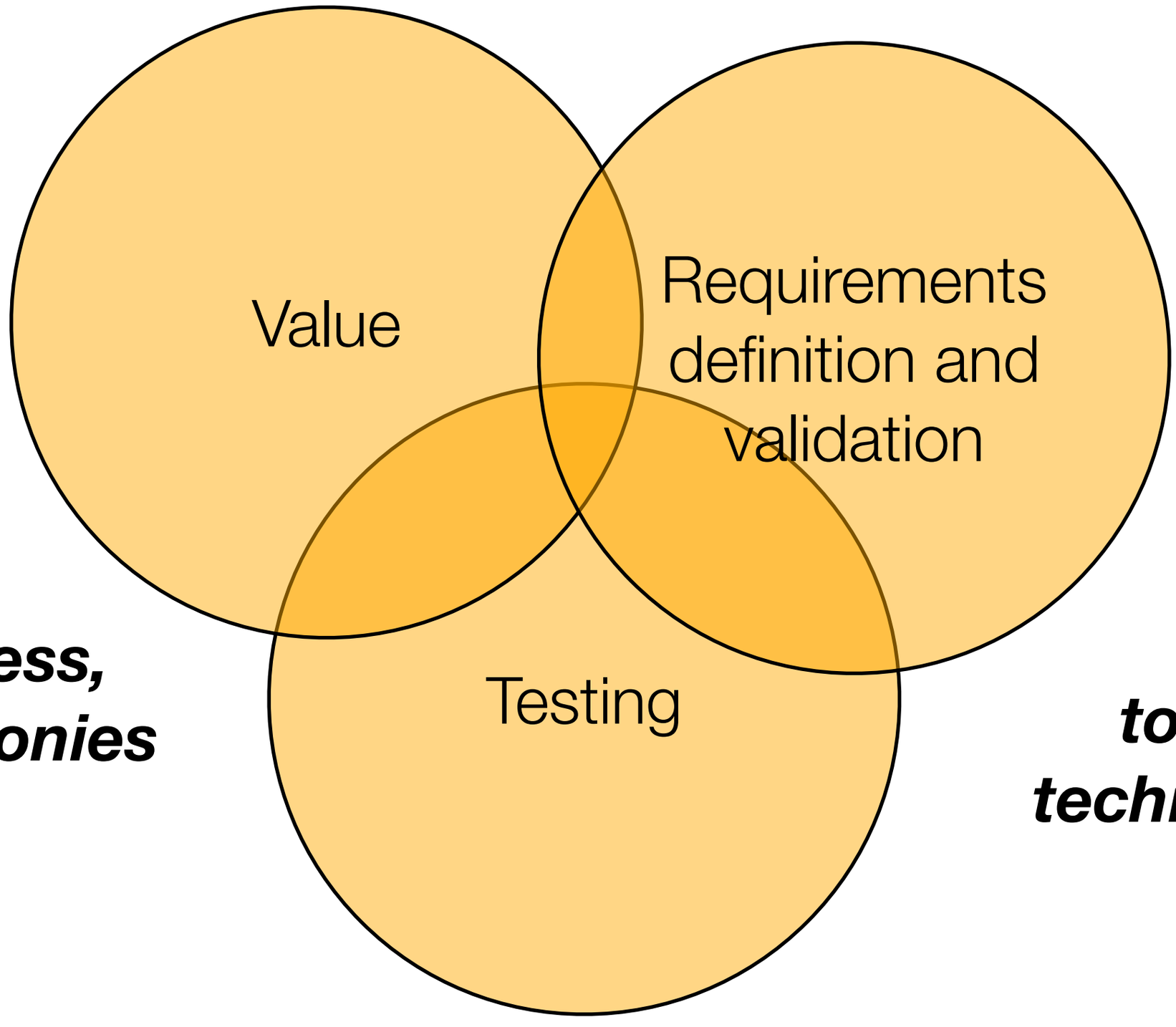
Testing is not an After-the-Fact Activity

- **Writing tests** if not only about checking that a piece of code is doing what it is supposed to do.
- **Writing unit tests** helps us **design** better software (more modular, easier to maintain, easier to evolve). This is the core idea of Test-Driven Development (TDD).
- Writing unit tests, i.e. building a **test harness**, allows us to **refactor** our code with confidence.
- **If unit tests help us design, could other tests help us specify the... behavior of our system? Could they also give us confidence that we don't impact end-users with our changes?**

A harness can be useful and cool.


Value
Requirements definition and validation
Testing

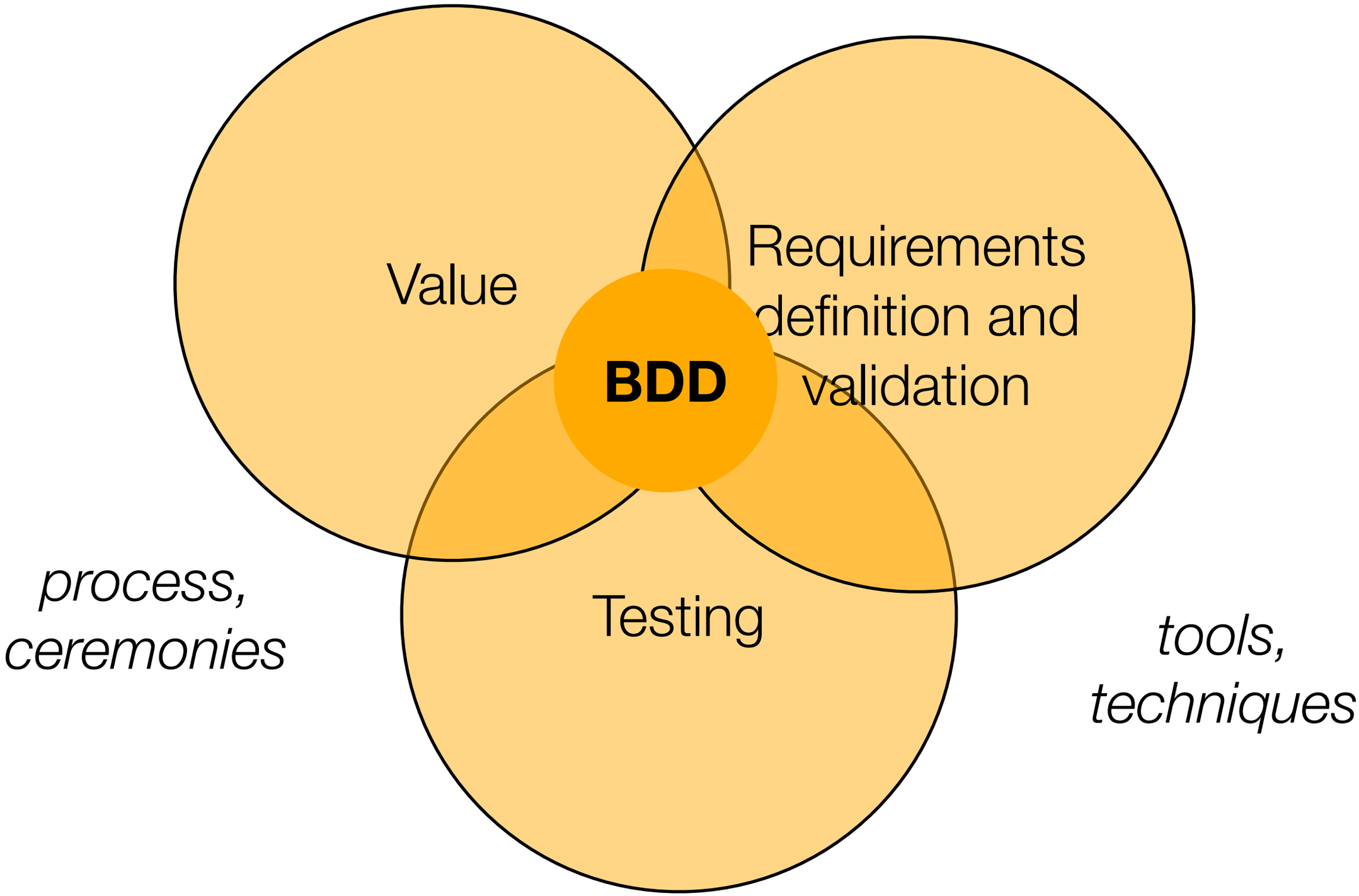
mindset,
common language



process,
ceremonies

tools,
techniques

mindset,
common language



process,
ceremonies

tools,
techniques

*"My response is **behaviour-driven development** (BDD). It has evolved out of established agile practices and is designed to make them more accessible and effective for teams new to agile software delivery.*

*Over time, BDD has grown to **encompass the wider picture of agile analysis and automated acceptance testing**."*

Dan North, 2006

BDD: Naming & Vocabulary Matters

- “Test method names should be sentences”.
- Compare the two representations of the same “specification”. It suggests that tools can support communication by emphasizing a common language for the domain.

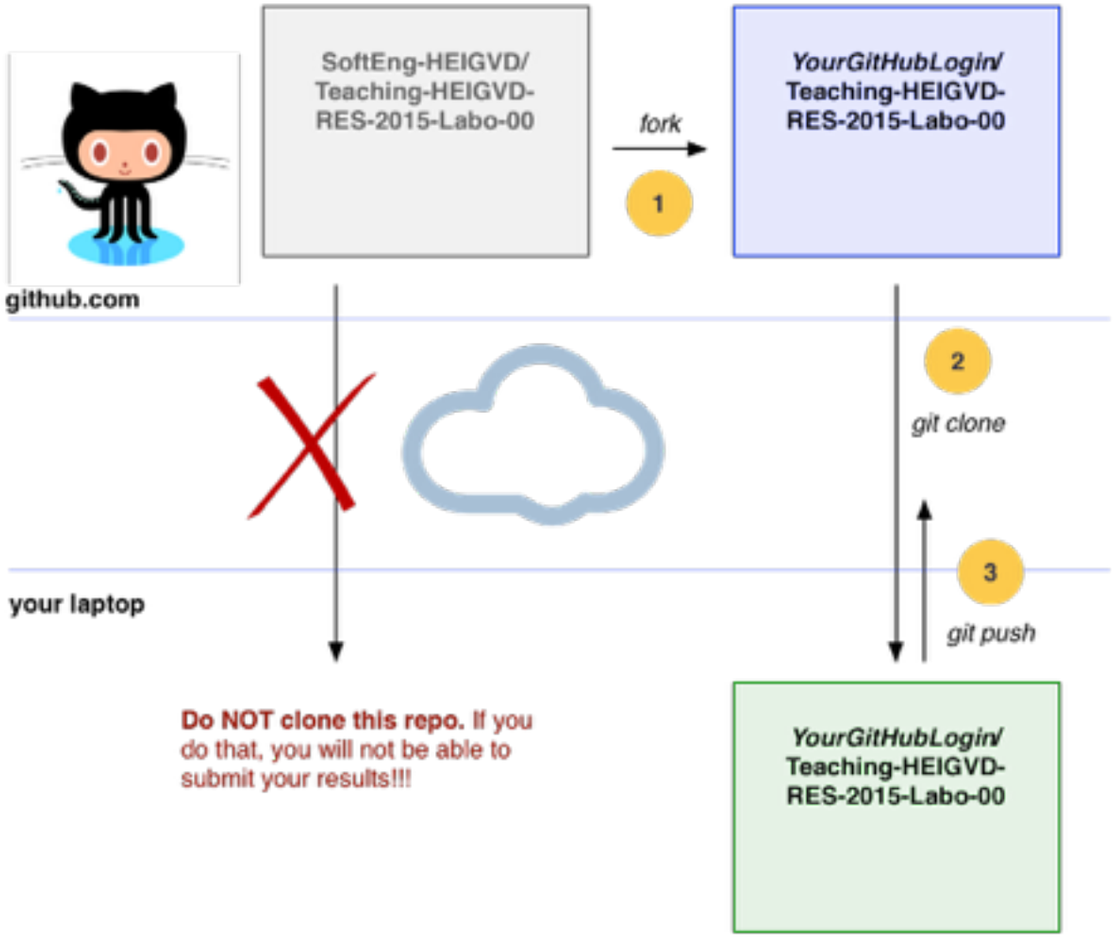
see http://agiledox.sourceforge.net/

```
public class FooTest extends TestCase {
    public void testIsASingleton() {}
    public void testAReallyLongNameIsAGoodThing() {}
}
```

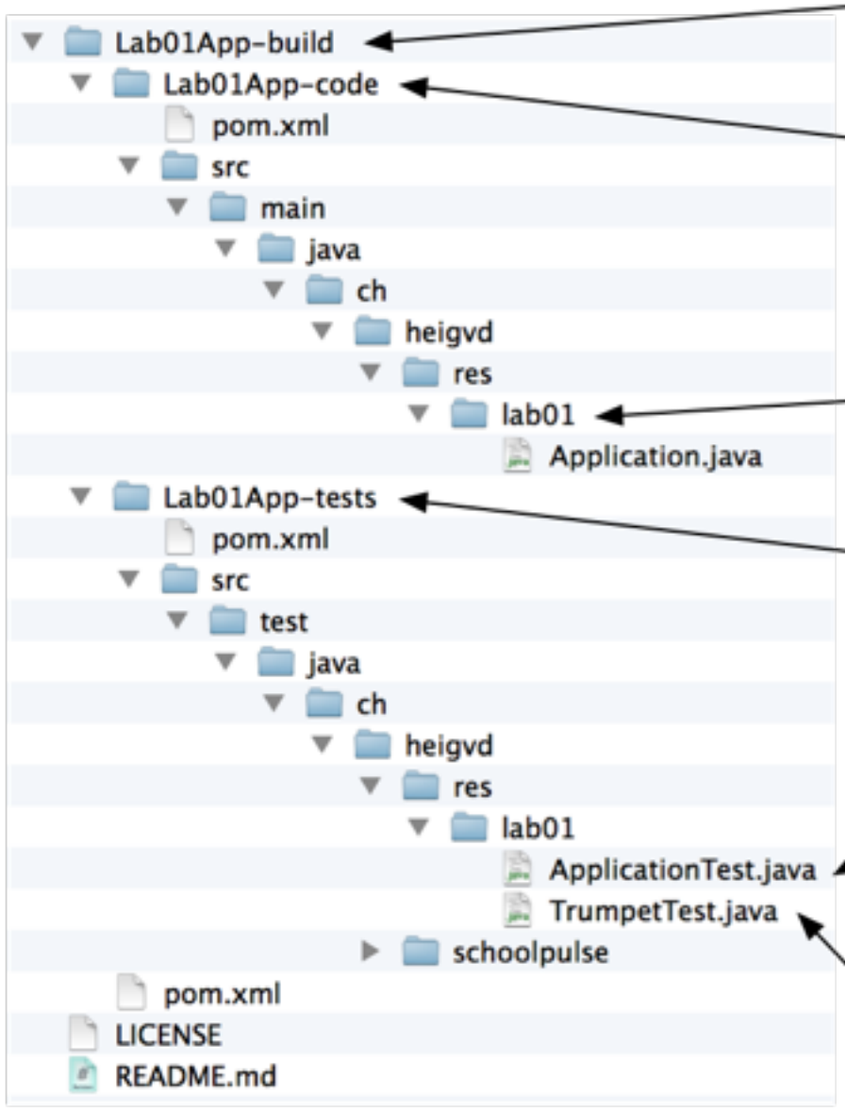
```
Foo
- is a singleton
- a really long name is a good thing
```

Example

- https://github.com/SoftEng-HEIGVD/Teaching-HEIGVD-RES-2015-Labo-00
  - https://www.youtube.com/watch?v=uqIva5-mKMs&list=PLfKkysTy70Qb_mfkkqa5OUMqsOPNEYZIa&index=1
  - https://www.youtube.com/watch?v=uqIva5-mKMs&list=PLfKkysTy70Qb_mfkkqa5OUMqsOPNEYZIa&index=1
  - https://www.youtube.com/watch?v=P3aMCCuAFv0&list=PLfKkysTy70Qb_mfkkqa5OUMqsOPNEYZIa&index=3



Example



This is a "parent" project, which contains the two others. It is what we use to build and test our application. You can open this project in Netbeans.

This is a project that you can open in Netbeans. It is the project that contains the sources for your application.

We give you a partial implementation. At the beginning, there is only one source file, with one bug. ***You will add code here.***

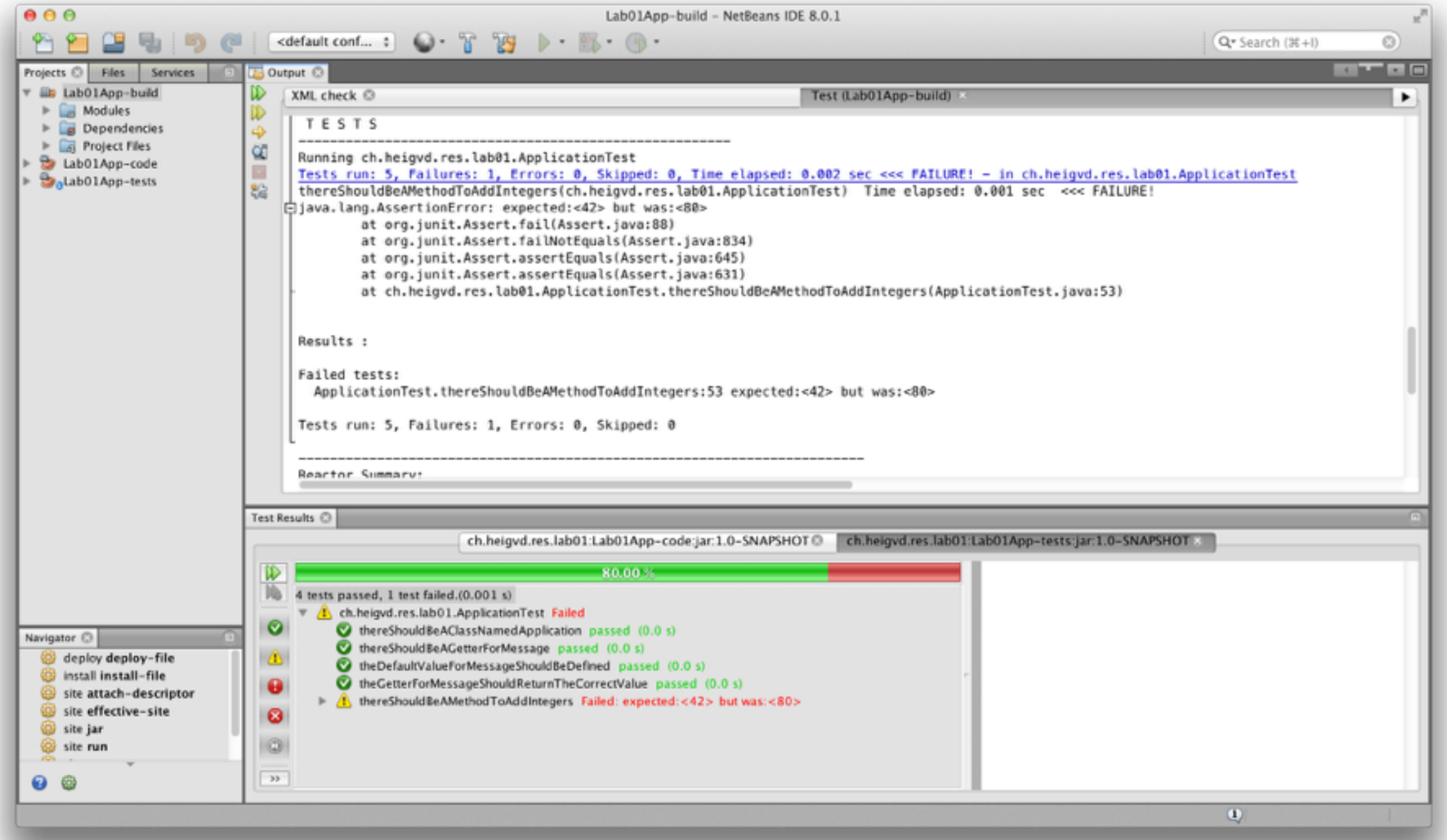
This is also a project that you can open in Netbeans. It contains the unit tests that specify what your application should do. The tests are used to validate your code.

This class contains unit tests to specify and validate the behavior of Application.java. At the beginning, one unit test fails (because we have one bug in Application.java).

This class contains unit tests for code that you have to write. The tests are commented so that you can compile the project after the clone.

```
public class ApplicationTest {

  @Test
  public void thereShouldBeAClassNamedApplication() {
    Application application = new Application();
    assertNotNull(application);
  }

  @Test
  public void thereShouldBeAGetterForMessage() {
    Application application = new Application();
    String message = application.getMessage();
    assertNotNull(message);
  }

  @Test
  public void theGetterForMessageShouldReturnTheCorrectValue() {
    String testValue = "does it work?";
    Application application = new Application(testValue);
    String message = application.getMessage();
    assertEquals(testValue, message);
  }

  @Test
  public void theDefaultValueForMessageShouldBeDefined() {
    Application application = new Application();
    String message = application.getMessage();
    assertEquals("HEIG-VD rocks!", message);
  }

  @Test
  public void thereShouldBeAMethodToAddIntegers() {
    Application application = new Application();
    int sum = application.add(40, 2);
    assertEquals(42, sum);
  }

}
```

```
@Test
public void thereShouldBeAnIInstrumentInterfaceAndATrumpetClas
  IInstrument trumpet = new Trumpet();
  assertNotNull(trumpet);
}

@Test
public void itShouldBePossibleToPlayAnInstrument() {
  IInstrument trumpet = new Trumpet();
  String sound = trumpet.play();
  assertNotNull(sound);
}

@Test
public void aTrumpetShouldMakePouet() {
  IInstrument trumpet = new Trumpet();
  String sound = trumpet.play();
  Assert.assertEquals("pouet", sound);
}

@Test
public void aTrumpetShouldBeLouderThanAFlute() {
  IInstrument trumpet = new Trumpet();
  IInstrument flute = new Flute();
  int trumpetVolume = trumpet.getSoundVolume();
  int fluteVolume = flute.getSoundVolume();
  Assert.assertTrue(trumpetVolume > fluteVolume);
}
@Test
public void aTrumpetShouldBeGolden() {
  IInstrument trumpet = new Trumpet();
  String color = trumpet.getColor();
  Assert.assertEquals("golden", color);
}
```


Lab01App-build - NetBeans IDE 8.0.1
<default conf...
Search (⌘+I)
Projects
Files
Services
Lab01App-build
Modules
Dependencies
Project Files
Lab01App-code
Lab01App-tests
Output
XML check
Test (Lab01App-build)
T E S T S
Running ch.heigvd.res.lab01.ApplicationTest
Tests run: 5, Failures: 1, Errors: 0, Skipped: 0, Time elapsed: 0.002 sec <<< FAILURE! - in ch.heigvd.res.lab01.ApplicationTest
thereShouldBeAMethodToAddIntegers(ch.heigvd.res.lab01.ApplicationTest) Time elapsed: 0.001 sec <<< FAILURE!
java.lang.AssertionError: expected:<42> but was:<80>
at org.junit.Assert.fail(Assert.java:88)
at org.junit.Assert.failNotEquals(Assert.java:834)
at org.junit.Assert.assertEquals(Assert.java:645)
at org.junit.Assert.assertEquals(Assert.java:631)
at ch.heigvd.res.lab01.ApplicationTest.thereShouldBeAMethodToAddIntegers(ApplicationTest.java:53)
Results :
Failed tests:
ApplicationTest.thereShouldBeAMethodToAddIntegers:53 expected:<42> but was:<80>
Tests run: 5, Failures: 1, Errors: 0, Skipped: 0
Reactor Summary:
Test Results
ch.heigvd.res.lab01:Lab01App-code:jar:1.0-SNAPSHOT
ch.heigvd.res.lab01:Lab01App-tests:jar:1.0-SNAPSHOT
80.00 %
4 tests passed, 1 test failed.(0.001 s)
ch.heigvd.res.lab01.ApplicationTest Failed
thereShouldBeAClassNamedApplication passed (0.0 s)
thereShouldBeAGetterForMessage passed (0.0 s)
theDefaultValueForMessageShouldBeDefined passed (0.0 s)
theGetterForMessageShouldReturnTheCorrectValue passed (0.0 s)
thereShouldBeAMethodToAddIntegers Failed: expected:<42> but was:<80>
Navigator
deploy deploy-file
install install-file
site attach-descriptor
site effective-site
site jar
site run

BDD: “Ubiquitous Language” for Analysis

- BDD proposes a template to describe the intended behavior of a system. The template is used to specify the acceptance criteria for a given user story.

```
Given some initial context (the givens),
When an event occurs,
then ensure some outcomes.
```

USER STORY
As a customer,
I want to withdraw cash from an ATM,
so that I don’t have to wait in line at the bank.

ACCEPTANCE CRITERIA
Given the account is in credit
And the card is valid
And the dispenser contains cash
When the customer requests cash
Then ensure the account is debited
And ensure cash is dispensed
And ensure the card is returned

BDD: Executable Specifications

- “Acceptance criteria should be executable”
- We need tools that allow:
  - **analysts** to write the acceptance criteria in plain english, following the previous template;
  - **developers** to write test fixtures that act as intermediary between the specification and the system to test;
  - the **continuous delivery pipeline** to execute the specifications automatically, to integrate the test results in the “live” specification, to notify the team about the results.

Process : When will be done?

```
Scenario:  trader is not alerted below threshold

Given a stock of symbol STK1 and a threshold of 10.0
When the stock is traded at 5.0
Then the alert status should be OFF
```

Executable Specifications

Acceptance criteria for stories are defined as scenarios.

Process : linking the specs with the system

Executable Specifications

```
Scenario:  trader is not alerted below threshold

Given a stock of symbol STK1 and a threshold of 10.0
When the stock is traded at 5.0
Then the alert status should be OFF
```

Test Fixtures

System Under Test (SUT)

```
public class TraderSteps { // look, Ma, I'm a POJO!!

    private Stock stock;

    @Given("a stock of symbol $symbol and a threshold
of $threshold")
    public void aStock(String symbol, double threshold)
{
        stock = new Stock(symbol, threshold);
    }

    @When("the stock is traded at $price")
    public void theStockIsTradedAt(double price) {
        stock.tradeAt(price);
    }

    @Then("the alert status should be $status")
    public void theAlertStatusShouldBe(String status) {
        ensureThat(stock.getStatus().name(),
equalTo(status));
    }

}
```

Process : let's see if we are done...

```
Scenario:  trader is not alerted below threshold

Given a stock of symbol STK1 and a threshold of 10.0
When the stock is traded at 5.0
Then the alert status should be OFF
```

Executable Specifications

The test results are displayed directly in the "living" specs (other reports and notifications are also useful!)

Process : yeah!!!!!!

```
Scenario:  trader is not alerted below threshold

Given a stock of symbol STK1 and a threshold of 10.0
When the stock is traded at 5.0
Then the alert status should be OFF
```

Executable Specificati

The test results are displayed directly in the "living" specs (other reports and notifications are also useful!)

Process : nooooooooooo....

```
Scenario:  trader is not alerted below threshold

Given a stock of symbol STK1 and a threshold of 10.0
When the stock is traded at 5.0
Then the alert status should be OFF
```

Executable Specifications

The test results are displayed directly in the "living" specs (other reports and notifications are also useful!)

I can't wait to get started... what should I do?

Tools

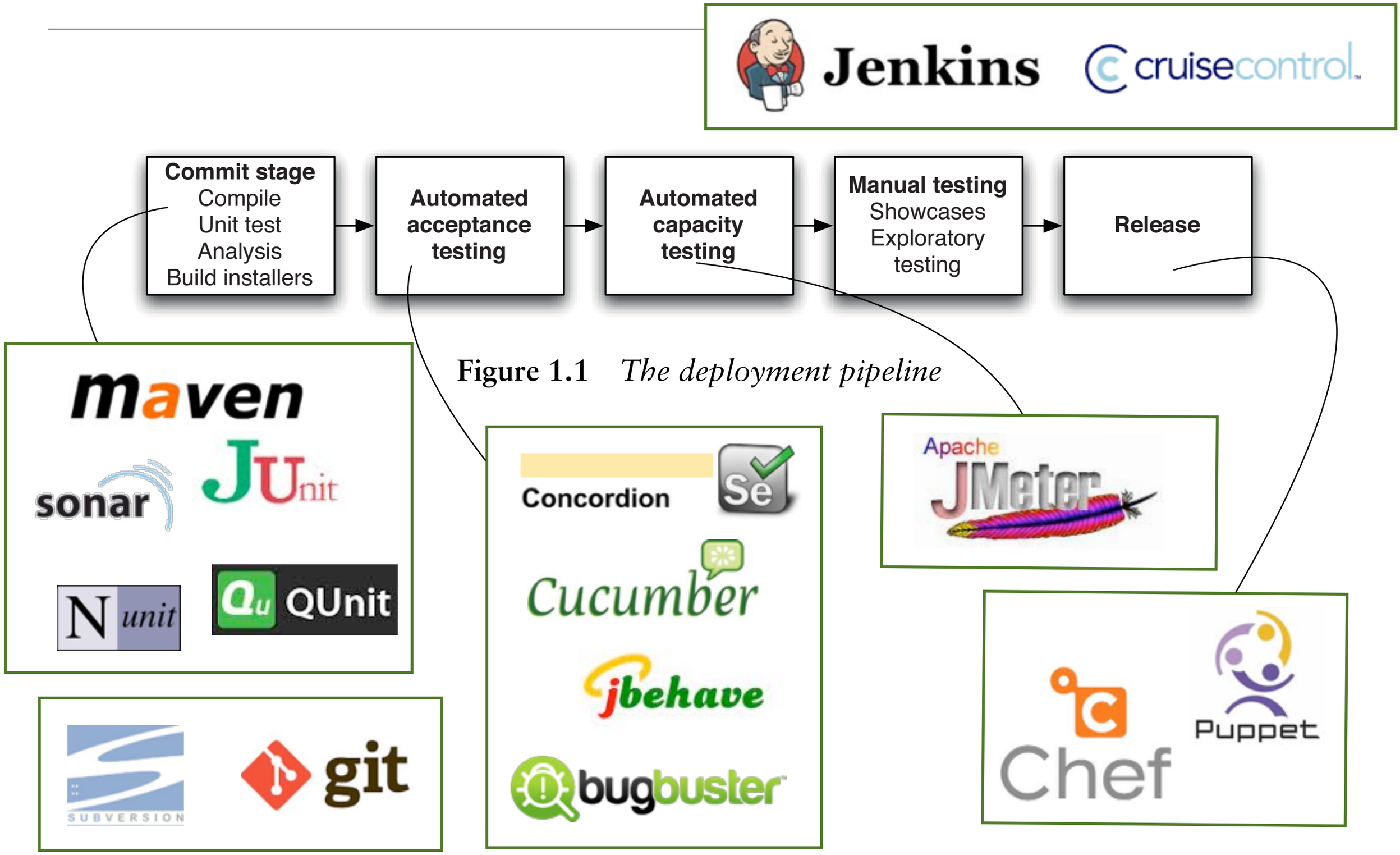


Figure 1.1 *The deployment pipeline*

Tools

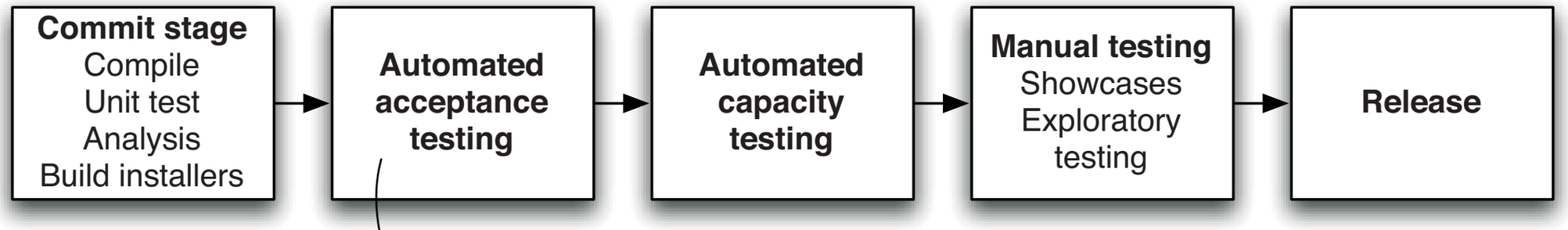
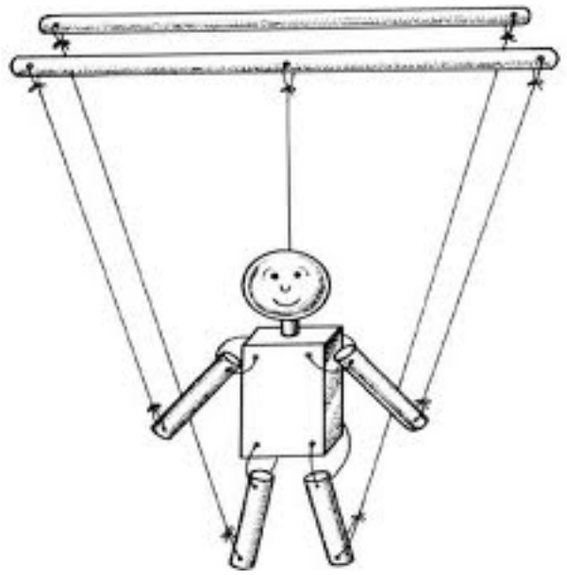


Figure 1.1 *The deployment pipeline*

Selenium

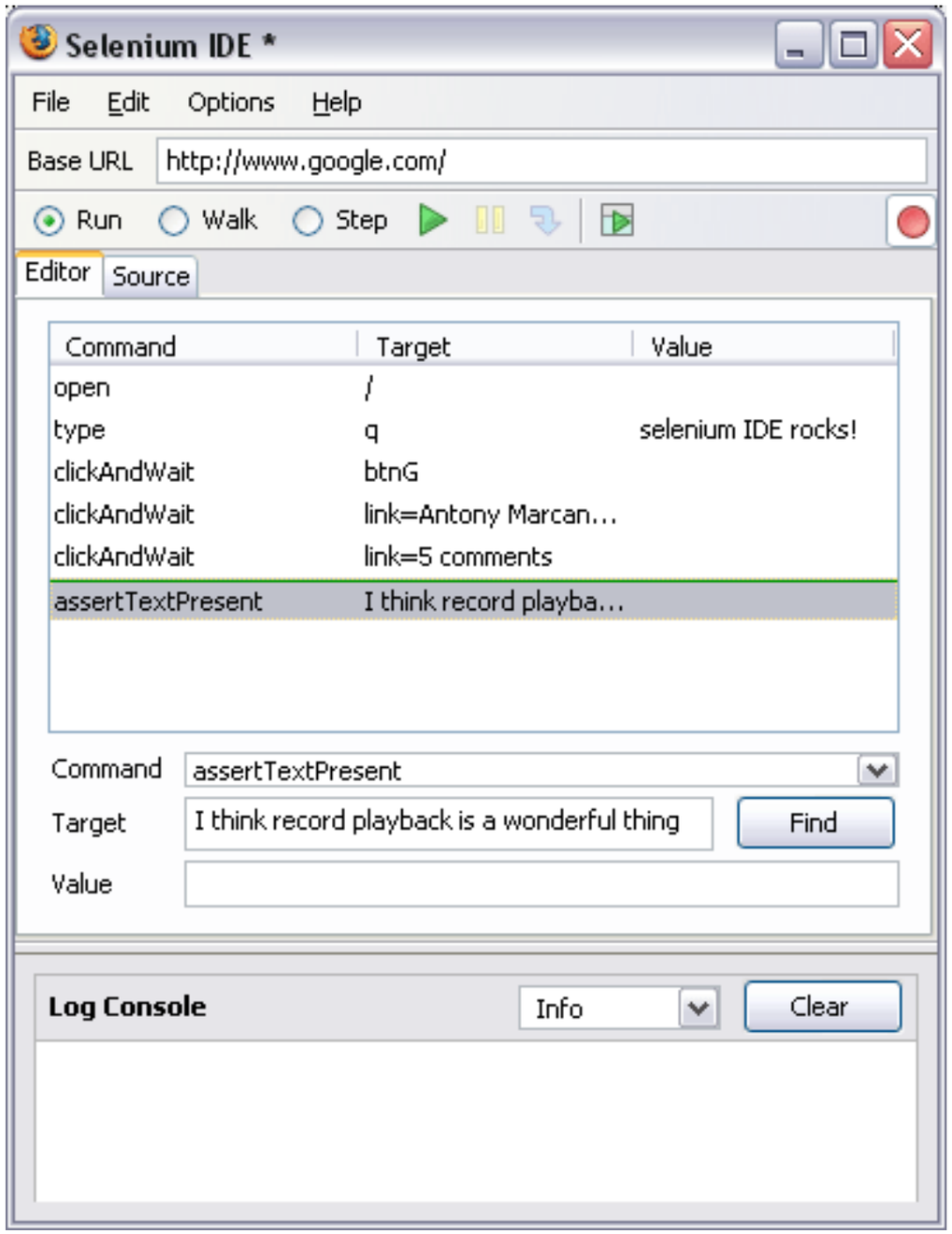
- Selenium provides means to **control web browsers** and to automate tasks, including testing.
- Selenium is a **suite of tools**: Selenium IDE, Selenium Web Driver, Selenium Server.
- With Selenium, it is possible to **record** browsing sessions and to **replay** them. An **API** is also available.
- Selenium is one of the most popular tools for **automated testing of web applications**.



http://seleniumhq.org/

Selenium IDE

- With Selenium IDE, you can record web browsing sessions.
- You can then replay them (Selenium is actually controlling the web browser, so this is testing the real user experience).
- You can also edit your scripts and add tests and assertions.



Selenium Web Driver

- Web Driver provides you with an API to write automated web tests.
- In this case, Selenium still controls a real web browser.
- There are patterns to write good, maintainable tests (in particular, the “Page Object” pattern)
- This is important, because the Web UI is often very dynamic (in the sense that it changes often). You don’t want to have to rewrite all of your tests when a page layout is redone...

```
public class Selenium2Example  {
    public static void main(String[] args) {
        // Create a new instance of the Firefox driver
        WebDriver driver = new FirefoxDriver();

        // And now use this to visit Google
        driver.get("http://www.google.com");

        // Find the text input element by its name
        WebElement element = driver.findElement(By.name("q"));

        // Enter something to search for
        element.sendKeys("Cheese!");

        // Now submit the form. WebDriver will find the form for us from
the element
        element.submit();

        // Check the title of the page
        System.out.println("Page title is: " + driver.getTitle());

        // Google's search is rendered dynamically with JavaScript.
        // Wait for the page to load, timeout after 10 seconds
        (new WebDriverWait(driver, 10)).until(new
ExpectedCondition<Boolean>() {
            public Boolean apply(WebDriver d) {
                return d.getTitle().toLowerCase().startsWith("cheese!");
            }
        });

        // Should see: "cheese! - Google Search"
        System.out.println("Page title is: " + driver.getTitle());

        //Close the browser
        driver.quit();
    }
```

```
public class Selenium2Example  {
    public static void main(String[] args) {
        // Create a new instance of the Firefox driver
        WebDriver driver = new FirefoxDriver();

        // And now use this to visit Google
        driver.get("http://www.google.com");

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        // Enter something to search for
        element.sendKeys("Cheese!");

        // Now submit the form. WebDriver will find the form for us from the element
        element.submit();

        // Check the title of the page
        System.out.println("Page title is: " + driver.getTitle());

        // Google's search is rendered dynamically with JavaScript.
        // Wait for the page to load, timeout after 10 seconds
        (new WebDriverWait(driver, 10)).until(new ExpectedCondition<Boolean>() {
            public Boolean apply(WebDriver d) {
                return d.getTitle().toLowerCase().startsWith("cheese!");
            }
        });

        // Should see: "cheese! - Google Search"
        System.out.println("Page title is: " + driver.getTitle());

        //Close the browser
        driver.quit();
    }
```
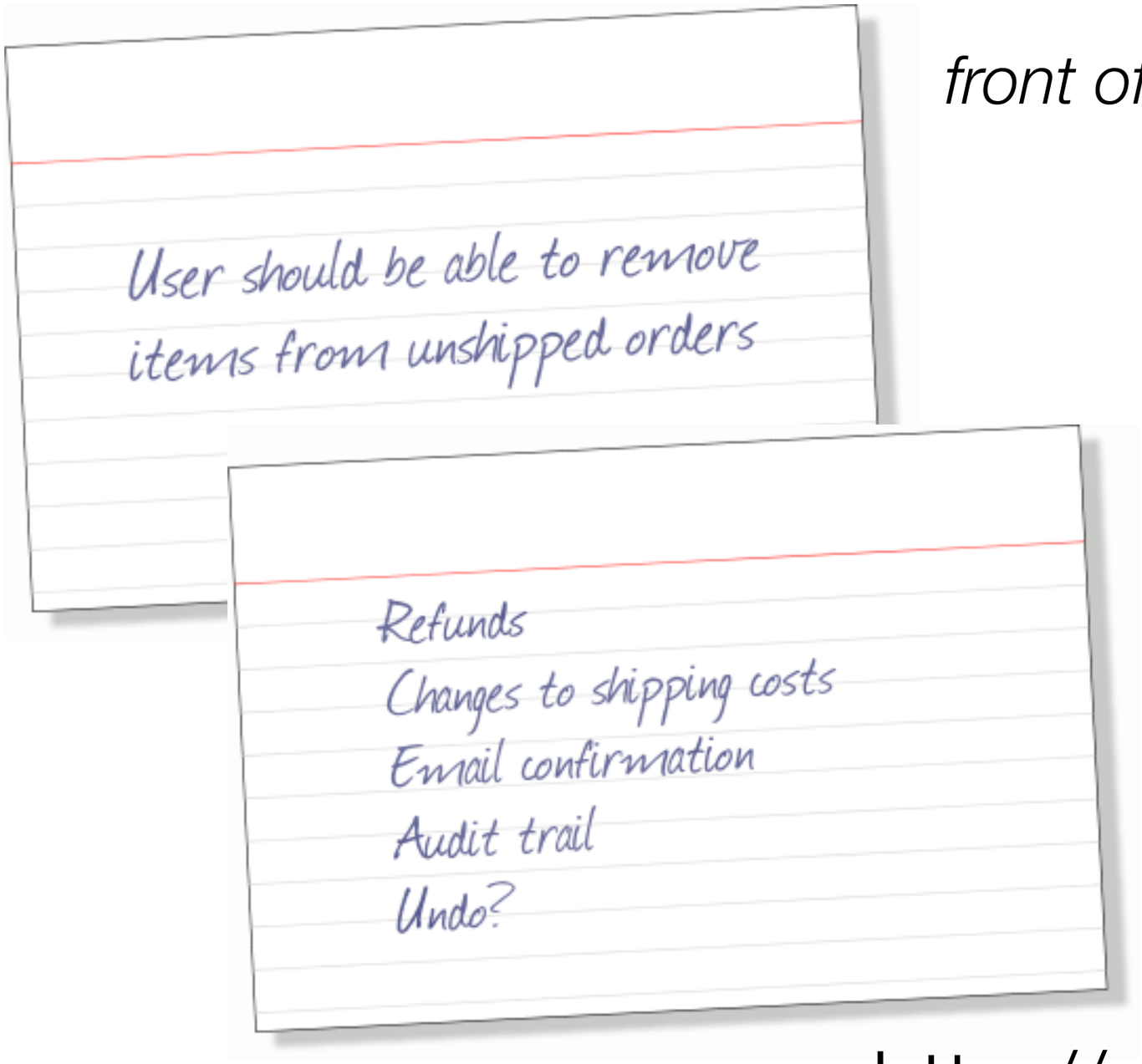

Concordion

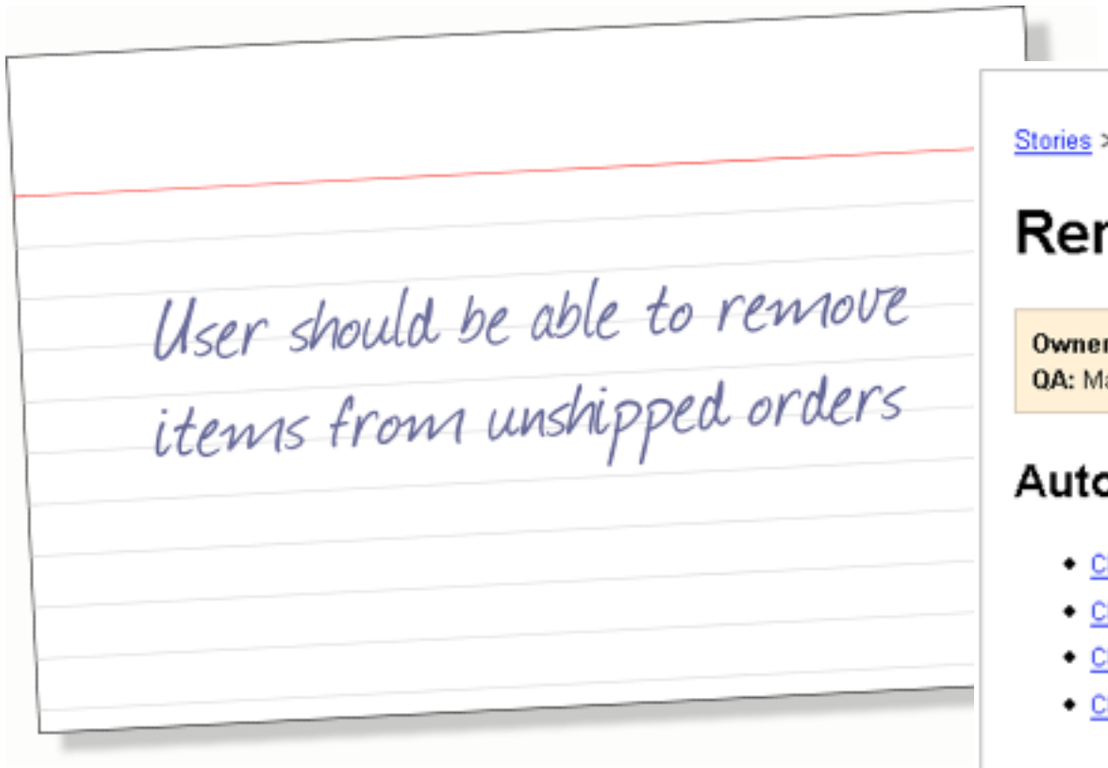


front of the story card

back of the story card (acceptance criteria)

http://www.concordion.org/

Concordion



Stories > Iteration 19 >

Removing Items From Unshipped Orders

Owner: Sharon Hargreaves
QA: Manish Gupta

Automated

- Check item removal is only available for unshipped orders
- Check price is updated (refunds / shipping costs)
- Check e-mail confirmation is sent
- Check changes are audited

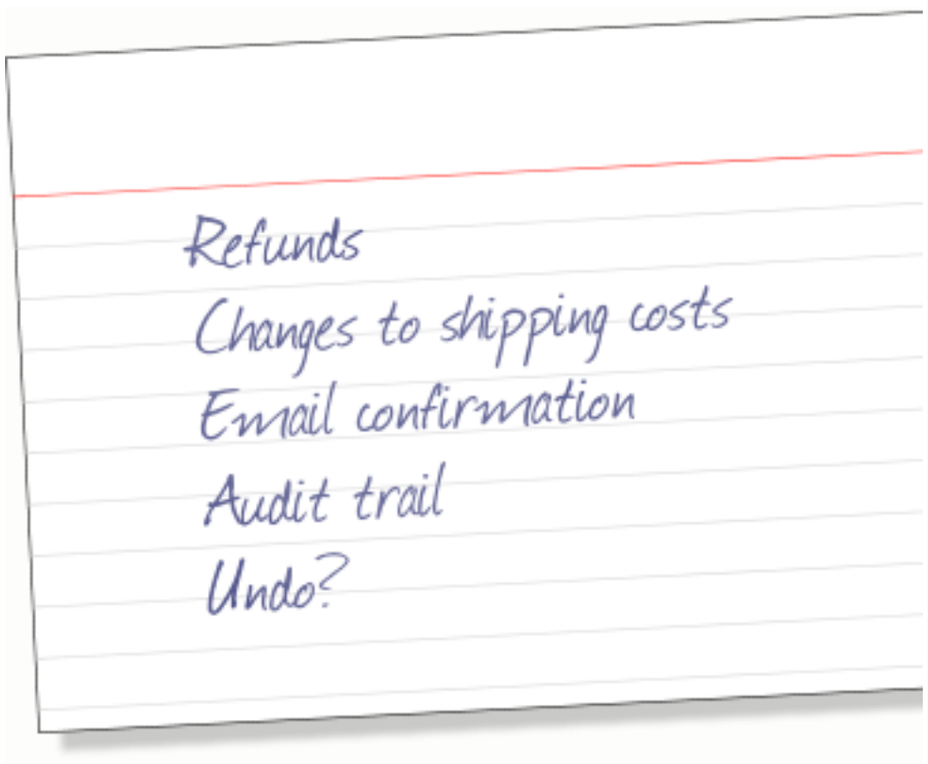
Manual

- Check user-interface changes are consistent with rest of system
- Attempt to remove items from a shipped order (incl. URL manipulation)

Out of Scope

- "Undo" functionality
- Analysis / reporting of suspicious activity
- Handling bounced e-mail

Concordion



Online Shop > Orders > Unshipped > Item Removal >

Item Refund

For orders that are not subject to shipping charges, removal of an item results in a refund of the item's price.

Example

Given an unshipped order with no shipping charges, containing the following items:

Item Description	Price Incl. Tax (£)
Kettle	33.25
Dictionary	18.49
Camera	249.95

If the shopper removes the **Dictionary** from her order then she will be refunded **£18.49**.

The order now contains:

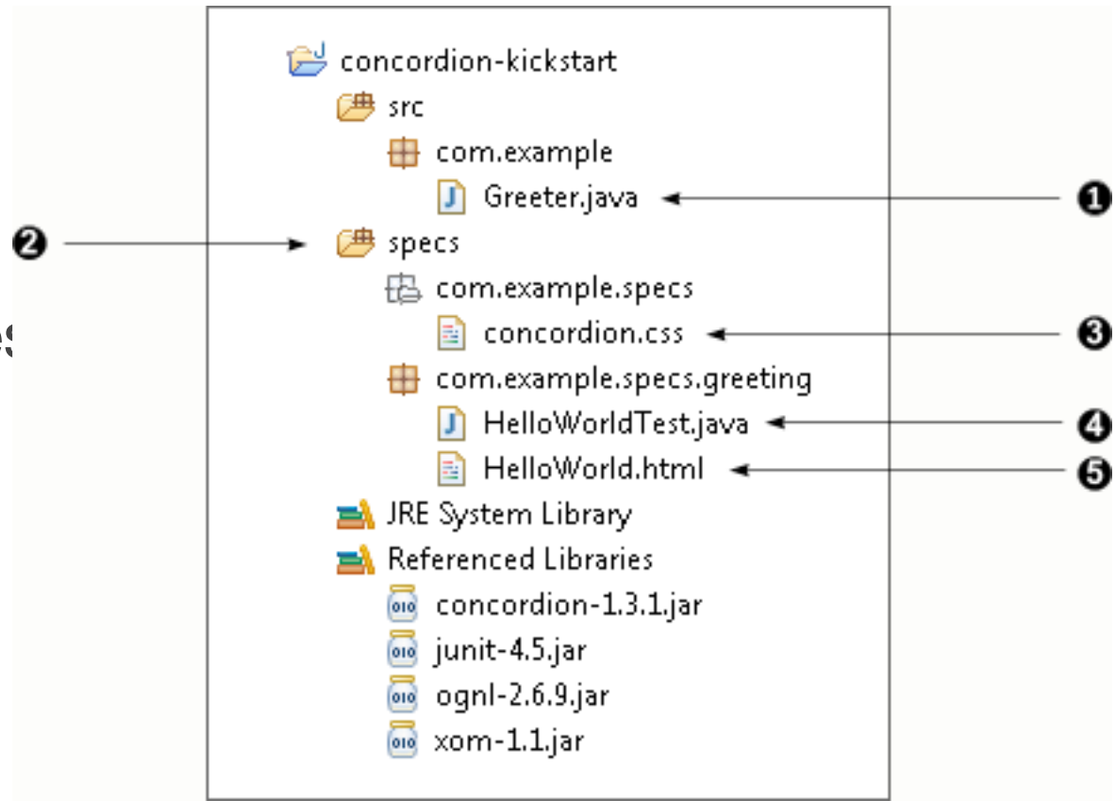
Item Description	Price Incl. Tax (£)
Kettle	33.25
Camera	249.95

Further details

- How are shipping charges handled?
- What happens if the order only contains one item?
- How are the refunds processed?

Concordion

- You write **acceptance tests in HTML** documents.
- You use **special HTML tags** to invoke te fixtures and to make assertions.
- You write **text fixtures as JUnit** tests.
- Executing the JUnit tests generates standard reports AND generates a collection of HTML documents (the living spec).
- You can use (and write) extensions to integrate **Selenium tests** (and even include snapshots in the living specs!)



Acceptance Test & Fixture

Hello World!

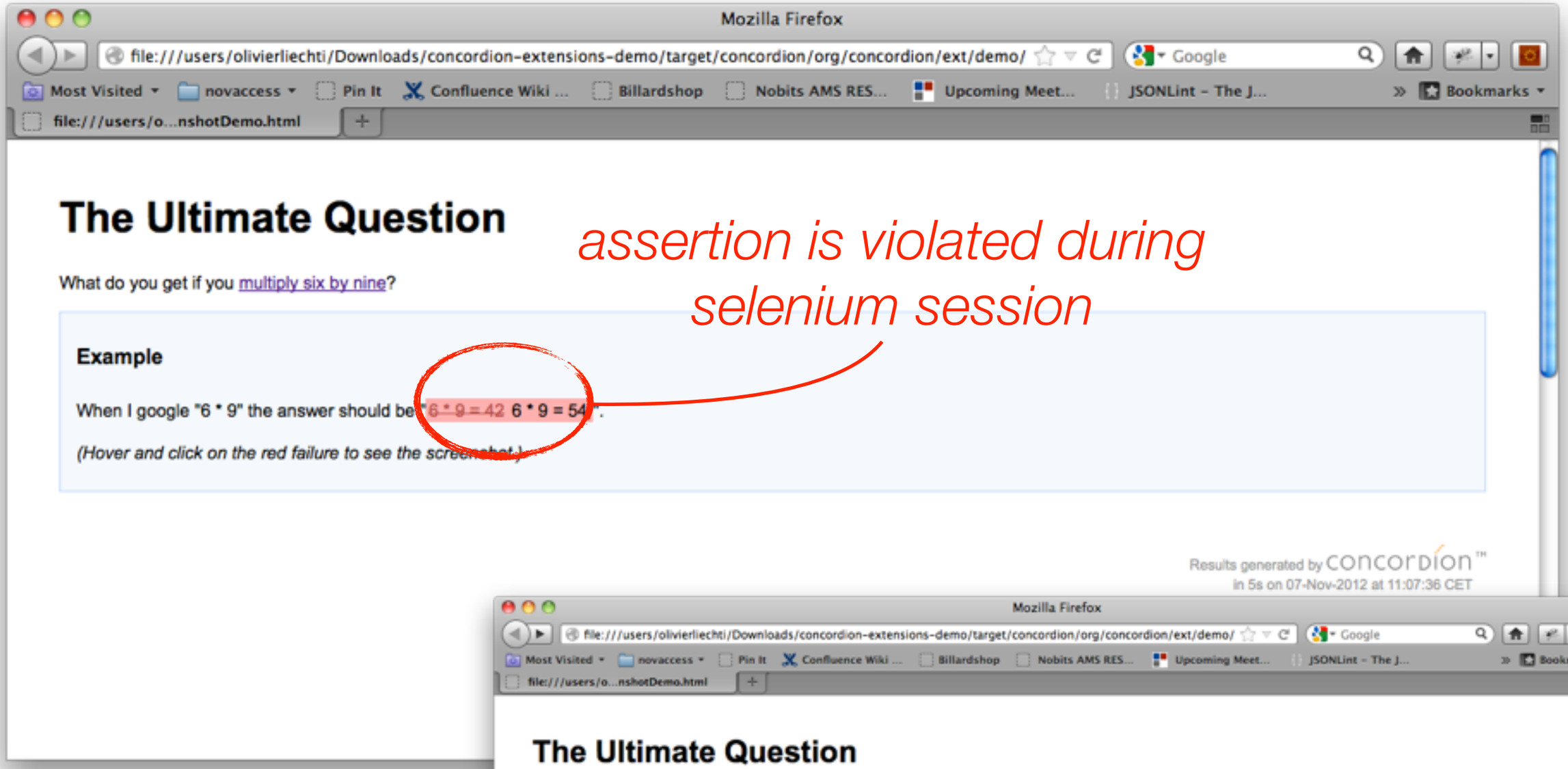
Results generated by concordion™
in 97 ms on 18-Sep-2007 at 16:20:49 BST

HelloWorld.html

```
<html xmlns:concordion="http://www.concordion.org/2007/concordion">
    <body>
        <p concordion:assertEquals="getGreeting()">Hello World!</p>
    </body>
</html>
```

HelloWorldTest.java

```
package example;

import org.concordion.integration.junit3.ConcordionTestCase;

public class HelloWorldTest extends ConcordionTestCase {

    public String getGreeting() {
        return "Hello World!";
    }
}
```



assertion is violated during selenium session

snapshot recorded during selenium session is displayed on mouse-over

jbehave

1. Write story

Plain text

```
Scenario: A trader is alerted of status

Given a stock and a threshold of 15.0
When stock is traded at 5.0
Then the alert status should be OFF
When stock is traded at 16.0
Then the alert status should be ON
```

2. Map steps to Java

POJO

```
public class TraderSteps {
    private TradingService service;   // Injected
    private Stock stock; // Created

    @Given("a stock and a threshold of $threshold")
    public void aStock(double threshold) {
        stock = service.newStock("STK", threshold);
    }
    @When("the stock is traded at price $price")
    public void theStockIsTraded(double price) {
        stock.tradeAt(price);
    }
    @Then("the alert status is $status")
    public void theAlertStatusIs(String status) {
        assertThat(stock.getStatus().name(), equalTo(status));
    }
}
```

jbehave

3. Configure Stories

Only once

```
public class TraderStories extends JUnitStories {

    public Configuration configuration() {
        return new MostUsefulConfiguration()
            .useStoryLoader(new LoadFromClasspath(this.getClass()))
            .useStoryReporterBuilder(new StoryReporterBuilder()
                .withCodeLocation(codeLocationFromClass(this.getClass()))
                .withFormats(CONSOLE, TXT, HTML, XML));
    }

    public List<CandidateSteps> candidateSteps() {
        return new InstanceStepsFactory(configuration(),
              new TraderSteps(new TradingService())).createCandidateSteps();
    }

    protected List<String> storyPaths() {
        return new StoryFinder().findPaths(codeLocationFromClass(this.getClass()),
"**/*.story");
    }
}
```

4. Run Stories

With any of

<APACHE ANT>

eclipse THE ECLIPSE PROJECT

JUnit

IntelliJIDEA

maven

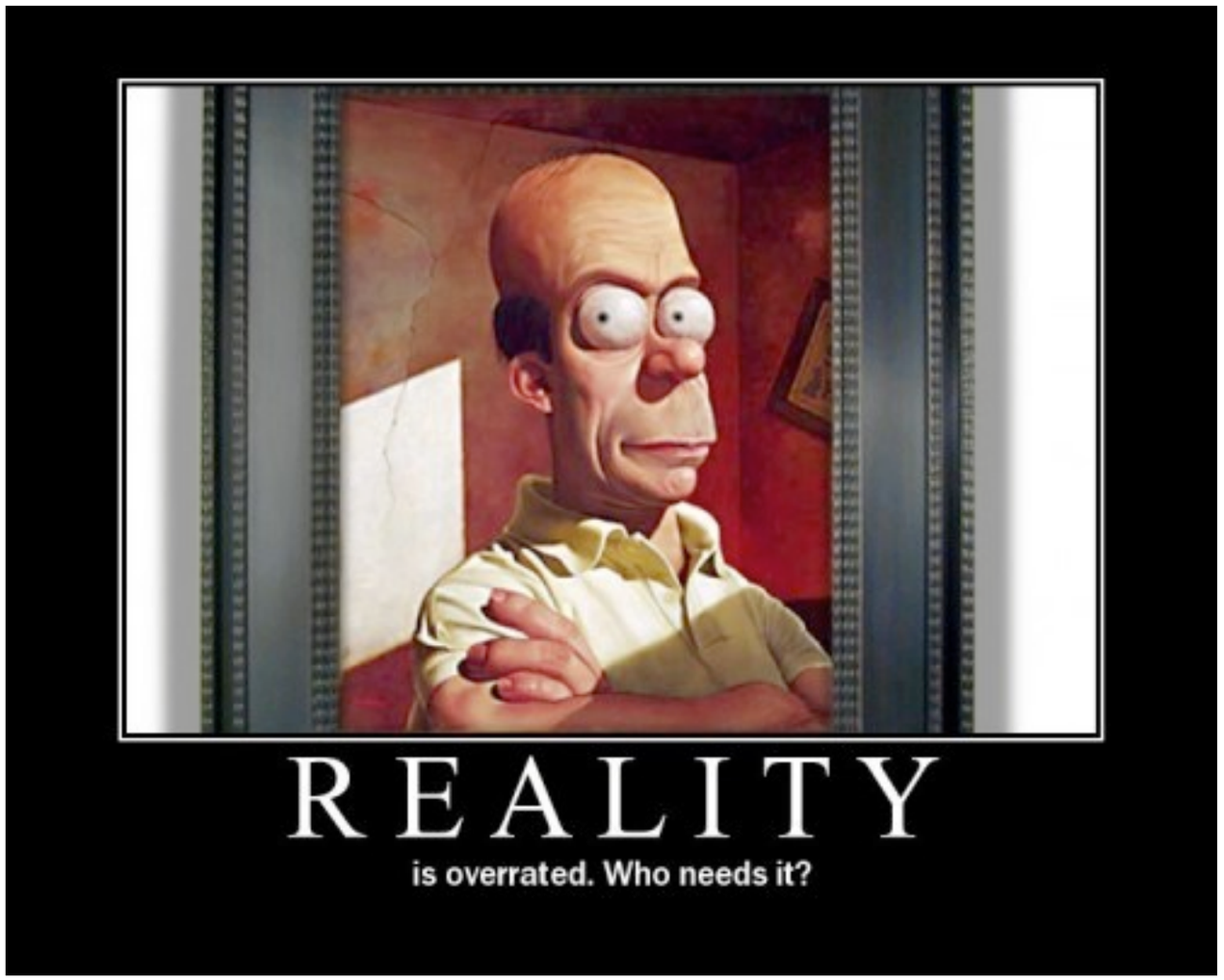
5. View Reports

HTML

Scenario: A trader is alerted of status

Given a stock and a threshold of 15.0
When stock is traded at 5.0
Then the alert status is OFF
When stock is traded at 16.0
Then the alert status is ON

To be continued...



https://github.com/kowalcj0/tech-test-selenium-jbehave