

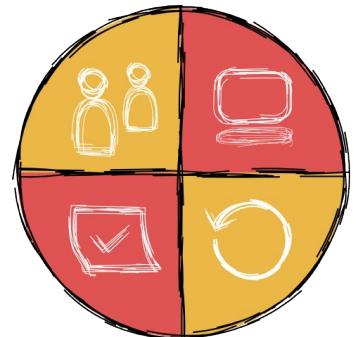
JUG Schweiz Bern, 16.10.2019

Ich packe meinen Testtoolkoffer und nehme
mit...
Testwerkzeuge für den Entwickleralltag

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Zu meiner Person

- Sandra Parsick
- Freiberuflicher Softwareentwickler und Consultant im Java-Umfeld
- Schwerpunkte:
 - Java Enterprise Anwendungen
 - Agile Methoden
 - Software Craftmanship
 - Automatisierung von Entwicklungsprozessen
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Das kann man
lokal nicht testen.

Das ist zu
aufwendig zu testen.

Das kann man
nicht testen.

Agenda

Integrierte Tests

equals, hashCode,
toString

Testcode-
Duplikierung

Testdaten

Schlecht lesbare
Assertions

Tests, die nur unter bestimmten
Bedingungen laufen

Problem: Diese Tests können nur unter bestimmten Bedingungen laufen.

JUnit 5 – Conditional Test Execution

```
3 // Operating System Conditions
4
5 @Test
6 @EnabledOnOs(OS.LINUX)
7 void testForLinux(){
8     assertTrue(true);
9 }
10
11 @Test
12 @EnabledOnOs(OS.WINDOWS)
13 void testForWindows(){
14     assertTrue(true);
15 }
16
17 @Test
18 @EnabledOnOs({OS.LINUX, OS.WINDOWS})
19 void testForLinuxAndWindows(){
20     assertTrue(true);
21 }
22
23 @Test
24 @DisabledOnOs(OS.LINUX)
25 void testNotForLinux(){
26     assertTrue(true);
27 }
```

```
29 // Java Runtime Environment Conditions
30
31 @Test
32 @EnabledOnJre(JRE.JAVA_8)
33 void onlyOnJava8() {
34     assertTrue(true);
35 }
36
37 @Test
38 @EnabledOnJre({ JRE.JAVA_9, JRE.JAVA_10 })
39 void onJava9Or10() {
40     assertTrue(true);
41 }
42
43 @Test
44 @DisabledOnJre(JRE.JAVA_8)
45 void notOnJava8() {
46     assertTrue(true);
47 }
```

JUnit 5 – Conditional Test Execution

```
50     // System Property Conditions
51
52     @Test
53     @EnabledIfSystemProperty(named = "os.arch", matches = ".*64.*")
54     void onlyOn64BitArchitectures() {
55         assertTrue(true);
56
57     }
58
59     @BeforeEach
60     void setup(){
61         System.setProperty("ci-server", "true");
62     }
63
64     @Test
65     @DisabledIfSystemProperty(named = "ci-server", matches = "true")
66     @EnabledIfSystemProperty(named = "ci-server", matches = "true")
67     void notOnCiServer() {
68         assertTrue(true);
69     }
```

JUnit 5 – Conditional Test Execution

```
71     // Environment Variable Conditions
72     // variable can be set in idea run configuration
73     // ENV1=staging-server
74     // ENV2=local.development
75
76     @Test
77     @EnabledIfEnvironmentVariable(named = "ENV1", matches = "staging-server")
78     void onlyOnStagingServer() {
79         assertTrue(true);
80     }
81
82     @Test
83     @DisabledIfEnvironmentVariable(named = "ENV2", matches = ".*development.*")
84     void notOnDeveloperWorkstation() {
85         assertTrue(true);
86     }
87
```

Problem: Testcode Duplizierung

```
public class Position {  
  
    private int xCoordinate;  
    private int yCoordinate;  
  
    public Position(int xCoordinate, int yCoordinate) {  
        this.xCoordinate = xCoordinate;  
        this.yCoordinate = yCoordinate;  
    }  
  
    public Position moveBackward(Direction facingDirection) {  
        int newX = xCoordinate;  
        int newY = yCoordinate;  
        switch (facingDirection) {  
            case NORTH:  
                newY--;  
                break;  
            case SOUTH:  
                newY++;  
                break;  
            case WEST:  
                newX++;  
                break;  
            case EAST:  
                newX--;  
                break;  
        }  
        return new Position (newX, newY);  
    }  
  
    public Position moveForward(Direction facingDirection) {  
        int newX = xCoordinate;  
        int newY = yCoordinate;  
  
        switch (facingDirection) {  
            case NORTH:  
                newY++;  
                break;  
            case SOUTH:  
                newY--;  
                break;  
            case WEST:  
                newX++;  
                break;  
            case EAST:  
                newX--;  
                break;  
        }  
  
        return new Position(newX, newY);  
    }  
}
```

Naiver Ansatz

```
7  class PositionNaiveTest {  
8  
9      @Test  
10     void moveBackward_toNorth() {  
11         Position positionUnderTest = new Position(10, 10);  
12  
13         Position newPosition = positionUnderTest.moveBackward(Direction.NORTH);  
14  
15         assertThat(newPosition).isEqualTo(new Position(10, 9));  
16     }  
17  
18     @Test  
19     void moveBackward_toEast() {  
20         Position positionUnderTest = new Position(10, 10);  
21  
22         Position newPosition = positionUnderTest.moveBackward(Direction.EAST);  
23  
24         assertThat(newPosition).isEqualTo(new Position(9, 10));  
25     }  
26 }
```

```
--  
27     @Test  
28     void moveBackward_toSouth() {  
29         Position positionUnderTest = new Position(10, 10);  
30  
31         Position newPosition = positionUnderTest.moveBackward(Direction.SOUTH);  
32  
33         assertThat(newPosition).isEqualTo(new Position(10, 11));  
34     }  
35  
36     @Test  
37     void moveBackward_toWest() {  
38         Position positionUnderTest = new Position(10, 10);  
39  
40         Position newPosition = positionUnderTest.moveBackward(Direction.WEST);  
41  
42         assertThat(newPosition).isEqualTo(new Position(11, 10));  
43     }  
44 }  
45
```

Parametrisierte Tests mit JUnit 4

```
1 @RunWith(Parameterized.class)
2 public class PositionMoveBackwardJUnit4Test {
3
4     private final Direction direction;
5     private final Position expectedPosition;
6
7     public PositionMoveBackwardJUnit4Test(Direction direction, Position expectedPosition) {
8         this.direction = direction;
9         this.expectedPosition = expectedPosition;
10    }
11
12    @Parameterized.Parameters
13    public static Collection moveBackwardParameter() {
14        return Arrays.asList(new Object[][]{
15            {Direction.NORTH, new Position(10, 9)},
16            {Direction.EAST, new Position(9, 10)},
17            {Direction.SOUTH, new Position(10, 11)},
18            {Direction.WEST, new Position(11, 10)}
19        });
20    }
21
22    @Test
23    public void moveBackward() {
24        Position positionUnderTest = new Position(10, 10);
25        Position newPosition = positionUnderTest.moveBackward(direction);
26        assertThat(newPosition).isEqualTo(expectedPosition);
27    }
28}
```

```
1 @RunWith(Parameterized.class)
2 public class PositionMoveForwardJUnit4Test {
3
4     private final Direction direction;
5     private final Position expectedPosition;
6
7     public PositionMoveForwardJUnit4Test(Direction direction, Position expectedPosition) {
8         this.direction = direction;
9         this.expectedPosition = expectedPosition;
10    }
11
12    @Parameterized.Parameters
13    public static Collection moveBackwardParameter() {
14        return Arrays.asList(new Object[][]{
15            {Direction.NORTH, new Position(10, 11)},
16            {Direction.EAST, new Position(11, 10)},
17            {Direction.SOUTH, new Position(10, 9)},
18            {Direction.WEST, new Position(9, 10)}
19        });
20    }
21
22    @Test
23    public void moveForward() {
24        Position positionUnderTest = new Position(10, 10);
25
26        Position newPosition = positionUnderTest.moveForward(direction);
27
28        assertThat(newPosition).isEqualTo(expectedPosition);
29    }
30}
```

Parametrisierte Test mit JUnit5

```
1 class PositionJUnit5Test {
2
3     @ParameterizedTest
4     @MethodSource("createMoveBackwardParameter")
5     void moveBackward(Direction direction, Position expectedPosition) {
6         Position positionUnderTest = new Position(10, 10);
7         Position newPosition = positionUnderTest.moveBackward(direction);
8         assertThat(newPosition).isEqualTo(expectedPosition);
9     }
10
11    private static Stream<Arguments> createMoveBackwardParameter() {
12        return Stream.of(
13            Arguments.of(Direction.NORTH, new Position(10, 9)),
14            Arguments.of(Direction.EAST, new Position(9, 10)),
15            Arguments.of(Direction.SOUTH, new Position(10, 11)),
16            Arguments.of(Direction.WEST, new Position(11, 10))
17        );
18    }
19
20    @ParameterizedTest
21    @MethodSource("createMoveForwardParameter")
22    void moveForward(Direction direction, Position expectedPosition) {
23        Position positionUnderTest = new Position(10, 10);
24        Position newPosition = positionUnderTest.moveForward(direction);
25        assertThat(newPosition).isEqualTo(expectedPosition);
26    }
27
28    private static Stream<Arguments> createMoveForwardParameter() {
29        return Stream.of(
30            Arguments.of(Direction.NORTH, new Position(10, 11)),
31            Arguments.of(Direction.EAST, new Position(11, 10)),
32            Arguments.of(Direction.SOUTH, new Position(10, 9)),
33            Arguments.of(Direction.WEST, new Position(9, 10))
34        );
35    }
36}
```

Weitere Möglichkeiten in JUnit5

```
@ParameterizedTest
@ValueSource(strings = {"a", "b", "c"})
void singleLetter(String candidate) {
    assertTrue(isSingleLetter(candidate));
}

private boolean isSingleLetter(String candidate) {
    return candidate.length() == 1;
}

// type for value sources:
// short
// byte
// int
// long
// float
// double
// char
// java.lang.String
// java.lang.Class

@ParameterizedTest
@EnumSource(TimeUnit.class)
void timeUnit(TimeUnit timeUnit) {
    assertThat(timeUnit).isNotNull();
}
```

```
@ParameterizedTest
@CsvSource({ "foo, 1", "bar, 2",
            "'baz, qux', 3" })
// @CsvFileSource(resources = "/test-data.csv", numLinesToSkip = 1)
void testWithCsvSource(String first, int second) {
    assertNotNull(first);
    assertEquals(0, second);
}
```

```
@ParameterizedTest
@ArgumentsSource(MyArgumentsProvider.class)
void testWithArgumentsSource(String argument) {
    assertNotNull(argument);
}
```

```
public class MyArgumentsProvider implements ArgumentsProvider {
    @Override
    public Stream<? extends Arguments> provideArguments(
            ExtensionContext extensionContext) {
        return Stream.of("foo", "bar").map(Arguments::of);
    }
}
```

Parametrisierte Test mit Spock

```
1 class PositionSpockTest extends Specification {
2
3     def "move backward" (Direction direction, Position expectedPosition){
4         Position positionUnderTest = new Position(10, 10)
5         Position newPosition = positionUnderTest.moveBackward(direction)
6
7         expect:
8             assert newPosition == expectedPosition
9
10        where:
11            direction | expectedPosition
12            Direction.NORTH | new Position(10, 9)
13            Direction.EAST | new Position(9, 10)
14            Direction.SOUTH | new Position(10, 11)
15            Direction.WEST | new Position(11, 10)
16    }
17
18    def "move forward" (Direction direction, Position expectedPosition){
19        Position positionUnderTest = new Position(10, 10)
20        Position newPosition = positionUnderTest.moveForward(direction)
21
22        expect:
23            assert newPosition == expectedPosition
24
25        where:
26            direction | expectedPosition
27            Direction.NORTH | new Position(10, 11)
28            Direction.EAST | new Position(11, 10)
29            Direction.SOUTH | new Position(10, 9)
30            Direction.WEST | new Position(9, 10)
31    }
32}
```

Problem: Testdaten

<https://www.generatedata.com>

Name für Datensatz eingeben...

SPEICHERN



LÄNDERSPEZIFISCHE DATEN

Alle Länder

DATENSATZ

Bestell	Spaltenstitel	Datentyp	Beispiele	Optionen	Hilfe	Entf
1	datum	Datum	Mon, Jan 1st, 2012	Von: 10/12/2018 <input type="button" value="..."/> To: 10/12/2020 <input type="button" value="..."/> Format-Code: D,JS,Y	<input type="button" value="?"/>	<input type="checkbox"/>
2	name	Namen, regional	John (männlich Name)	MaleName	<input type="button" value="?"/>	<input type="checkbox"/>
3	str	Straße	Keine Beispiele zur Verfügung.	Keine Optionen verfügbar.	<input type="button" value="?"/>	<input type="checkbox"/>
4	text	Beliebige Anzahl von Wörtern	Keine Beispiele zur Verfügung.	<input type="checkbox"/> Beginnen Sie mit "Lorem ipsum..." Erzeugen # 1 auf # 10 Text	<input type="button" value="?"/>	<input type="checkbox"/>

Bestell Spaltenstitel Datentyp Beispiele Optionen Hilfe Entf

Hinzufügen 1 Zeile(n)

<https://www.generatedata.com>

EXPORT-TYPEN

[CSV](#) [Excel](#) [HTML](#) [JSON](#) [LDIF](#) [Programmiersprache](#) [SQL](#) [XML](#)[- Ausblenden von Daten Format-Optionen](#) Isolieren Sie Leerzeichen aus generierten ErgebnisseDatenstruktur-Format Komplex Einfach

Erzeugen

100

Zeilen

 Hier generieren Neues Fenster / Tab Herunterladen Zip?**Erzeugen**

Daten-Typen auswählen

Human-Daten

Namen

Namen, regional

Telefon / Fax

Telefon / Fax, Regional

E-mail

Datum

Firma

SIRET

Chilean RUT number

Persönliche Nummer

Organisation Anzahl

Geo

Straße

City

Postleitzahl / PLZ

Staat / Provinz / Kreis

Land

Breite / Länge

PIN

CW

Track 1

Track 2

Text

Feste Anzahl der Worte

Beliebige Anzahl von Wörtern

Numerisch

Alphanumerisch

Auto-Inkrement

Number Range

GUID

Currency

Mathe

Standardabweichung

Andere

Konstante

Zusammengesetzt

Tree (übergeordnete Zeile ID)

Benutzerdefinierte Liste

Erstellt 100 100 Ergebnisse

abbrechen



```
1 [
2   {
3     "datum": "Wed, 1st, 2020",
4     "name": "Zachary",
5     "str": "Ap #213-6985 Molestie Straße",
6     "text": "nec mauris blandit mattis. Cras eget"
7   },
8   {
9     "datum": "Fri, 10th, 2019",
10    "name": "Macaulay",
11    "str": "Ap #891-1080 Curabitur Ave",
12    "text": "hendrerit neque. In ornare sagittis felis. Donec tempor, est ac"
13  },
14  {
15    "datum": "Sun, 24th, 2019",
16    "name": "Jonas",
17    "str": "Ap #942-7252 Quam Avenue",
18    "text": "Nam tempor diam dictum sapien. Aenean massa. Integer vitae nibh."
19  },
20  {
21    "datum": "Thu, 4th, 2019",
22    "name": "Adrian",
23    "str": "6794 Egestas, Rd.",
24    "text": "turpis. Aliquam adipiscing lobortis risus."
25  },
26  {
27    "datum": "Mon, 3rd, 2018",
28    "name": "Lev",
29    "str": "Ap #105-239 Arcu Straße",
30    "text": "Sed id risus"
31  },
```



Regenerieren

A A A

Und wenn es doch lieber Code sein soll?

Testdaten mit JavaFaker

```
@Test  
void simpleFaker() {  
    Faker dataFaker = new Faker();  
    Person person = new Person();  
    person.setFirstName(dataFaker.name().firstName());  
    person.setLastName(dataFaker.name().lastName());  
    person.setJobTitle(dataFaker.job().title());  
  
    // more test code  
}
```

- Built-In Faker (Auszug)
 - Business
 - Commerce
 - Name
 - Lorem
- Local Support (Auszug)
 - de (in vielen Varianten)
 - en (in vielen Varianten)

ObjectMother Pattern

```
class PersonTestData { // ObjectMother pattern
    static Person newPersonWithoutJobTitle() {
        Faker dataFaker = new Faker();
        Person person = new Person();
        person.setFirstName(dataFaker.name().firstName());
        person.setLastName(dataFaker.name().lastName());
        return person;
    }

    static Person newPerson() {
        Faker dataFaker = new Faker();
        Person person = new Person();
        person.setFirstName(dataFaker.name().firstName());
        person.setLastName(dataFaker.name().lastName());
        person.setJobTitle(dataFaker.job().title());
        return person;
    }
}
```

```
@Test
void objectMother(){
    Person personWithoutJobTitle =
        PersonTestData.newPersonWithoutJobTitle();
    Person fullPerson =
        PersonTestData.newPerson();

    //more test code
}
```

TestDataBuilder Pattern

```
class PersonTestDataBuilder { // test data builder pattern
    private String firstName;
    private String lastName;
    private String jobTitle;

    PersonTestDataBuilder withFirstName(String firstName){
        this.firstName = firstName;
        return this;
    }

    PersonTestDataBuilder withLastName(String lastName){
        this.lastName = lastName;
        return this;
    }

    PersonTestDataBuilder withJobTitle (String jobTitle){
        this.jobTitle = jobTitle;
        return this;
    }

    Person build() {
        Person person = new Person();
        person.setFirstName(firstName);
        person.setLastName(lastName);
        person.setJobTitle(jobTitle);
        return person;
    }
}
```

```
@Test
void testDataBuilder(){
    Faker dataFaker = new Faker();
    PersonTestDataBuilder personBuilder = new PersonTestDataBuilder();
    personBuilder.withFirstName(dataFaker.name().firstName())
        .withLastName(dataFaker.name().lastName())
        .withJobTitle(dataFaker.job().title());
    Person person = personBuilder.build();
}
```

Problem: Schlecht lesbare Assertion

Built-In Assertion in JUnit

```
@Test  
void builtInAssertion() {  
    Hero hero = new Hero("Batman", "Bruce Wayne");  
  
    assertEquals(hero.getName(), "Batman");  
    assertEquals(hero.getRealName(), "Bruce Wayne");  
}
```

AssertJ – Fluent Assertion API

```
@Test
void hasField(){
    assertThat(new Hero ("Superman", "Clark Kent"))
        .hasFieldOrPropertyWithValue("realName", "Clark Kent")
        .hasFieldOrPropertyWithValue("name", "Superman");
}
```

```
@Test
void basic() {
    assertThat("The Lord of the Rings").isNotNull()
        .startsWith("The")
        .contains("Lord")
        .endsWith("Rings");
}
```

AssertJ – List Assertion

```
@Test
void basic(){
    List<String> heros = List.of("Batman", "Superman");

    assertThat(heros)
        .hasSize(2)
        .contains("Batman")
        .containsExactly("Batman", "Superman")
        .containsAnyOf("Batman", "Superman", "Wonder woman");

    // containsNull
    // negotiation
}

@Test
void extractionSample(){
    List<Hero> heros = List.of(new Hero("Batman", "Bruce Wayne"), new Hero("Superman", "Clark Kent"));

    assertThat(heros)
        .extracting("realName")
        .contains("Bruce Wayne", "Clark Kent");
}
```

AssertJ – Exception Assertion

```
@Test
void bddStyle(){
    // GIVEN
    String[] names = { "Pier ", "Pol", "Jak" };
    // WHEN
    Throwable thrown = catchThrowable(() -> System.out.println(names[9]));
    // THEN
    assertThat(thrown)
        .isInstanceOf(ArrayIndexOutOfBoundsException.class)
        .hasMessageContaining("9");
}

@Test
void assertThatThrownByExample(){
    assertThatThrownBy(() -> { throw new Exception("boom!"); })
        .isInstanceOf(Exception.class)
        .hasMessageContaining("boom")
        .hasMessage("boom!");
}
```

AssertJ – Exception Assertion

```
@Test
void assertThatExceptionOfTypeExample(){
    assertThatExceptionOfType(IOException.class)
        .isThrownBy(() -> { throw new IOException("boom!"); })
        .withMessage("%s!", "boom")
        .withMessageContaining("boom")
        .withNoCause();

    //This later syntax has been enriched for common exceptions :
    //    assertThatNullPointerException
    //    assertThatIllegalArgumentException
    //    assertThatIllegalStateException
    //    assertThatIOException
}

@Test
void assertThatNoExceptionIsThrown(){
    assertThatCode(() -> {
        // code that should NOT throw an exception
    }).doesNotThrowAnyException();
}
```

AssertJ - Assumption

```
@Test
void assume(){
    assumeThat("Bonn").isEqualTo("Bonn");
}

@Test
void assumeMoreComplex(){
    assumeThat(new File("/starwars-testdata/star-wars-logo.png"))
        .isFile()
        .exists();
    assumeThat(List.of("Hello", "World"))
        .hasSize(2)
        .contains("Hello");
}
```

JUnit 5 – Grouped Assertion

```
@Test
void standardAssertions() {
    assertEquals(2, 2);
    assertEquals(4, 4, "The optional assertion message is now the last parameter.");
    assertTrue('a' < 'b', () -> "Assertion messages can be lazily evaluated -- "
               + "to avoid constructing complex messages unnecessarily.");
}

@Test
void groupedAssertions() {
    // In a grouped assertion all assertions are executed, and any
    // failures will be reported together.
    assertAll("person",
              () -> assertEquals("John", "John"),
              () -> assertEquals("Doe", "Doe"),
              () -> assertThat(Lists.list("foo")).isNotEmpty());
}
```

Exkurs: Migration auf JUnit 5

```
<properties>
    <junit.jupiter.version>5.4.2</junit.jupiter.version>
</properties>

<dependencies>
    <dependency>
        <groupId>org.junit.jupiter</groupId>
        <artifactId>junit-jupiter-api</artifactId>
        <scope>test</scope>
    </dependency>
    <dependency>
        <groupId>org.junit.jupiter</groupId>
        <artifactId>junit-jupiter-engine</artifactId>
        <scope>test</scope>
    </dependency>
    <dependency>
        <groupId>org.junit.vintage</groupId>
        <artifactId>junit-vintage-engine</artifactId>
        <scope>test</scope>
    </dependency>
</dependencies>
```

```
<dependencyManagement>
    <dependencies>
        <dependency>
            <groupId>org.junit</groupId>
            <artifactId>junit-bom</artifactId>
            <version>${junit.jupiter.version}</version>
            <scope>import</scope>
            <type>pom</type>
        </dependency>
    </dependencies>
</dependencyManagement>
```

Problem: Zwei Objekte sind gleich, obwohl sie
nicht gleich sein sollten

```
1 public final class Person {  
2  
3     private String firstName;  
4     private String lastName;  
5     private String jobTitle;  
6  
7     // more code like getter and setter  
8  
9     @Override  
10    public boolean equals(Object o) {  
11        if (this == o) return true;  
12        if (o == null || getClass() != o.getClass()) return false;  
13        Person person = (Person) o;  
14        return Objects.equals(firstName, person.firstName) &&  
15                Objects.equals(lastName, person.lastName) &&  
16                Objects.equals(jobTitle, person.jobTitle);  
17    }  
18  
19    @Override  
20    public int hashCode() {  
21        return Objects.hash(firstName, lastName, jobTitle);  
22    }  
23 }
```

equals() Contract

- It is *reflexive*: for any non-null reference value x , $x.equals(x)$ should return true.
- It is *symmetric*: for any non-null reference values x and y , $x.equals(y)$ should return true if and only if $y.equals(x)$ returns true.
- It is *transitive*: for any non-null reference values x , y , and z , if $x.equals(y)$ returns true and $y.equals(z)$ returns true, then $x.equals(z)$ should return true.
- It is *consistent*: for any non-null reference values x and y , multiple invocations of $x.equals(y)$ consistently return true or consistently return false, provided no information used in equals comparisons on the objects is modified.
- For any non-null reference value x , $x.equals(null)$ should return false.

Zur Erinnerung

hashCode() Contract

- *hashCode()* must return same integer consistently for the same object.
- *hashCode()* for two *a.equals(b)* object must be same, ie *a.hashCode()* is same as *b.hashCode()*.
- *hashCode()* for two *not equals()* object may not be distinct.

Zur Erinnerung

EqualsVerifier

```
1  @Test
2  void equalsContractVerySimple(){
3      Person person1 = createPerson();
4      Person person2 = createPerson();
5      person2.setJobTitle("Consultant");
6
7      assertThat(person1).isNotEqualTo(person2);
8      assertThat(person1.hashCode()).isNotEqualTo(person2.hashCode());
9  }
```

```
12  @Test
13  void equalsContractMuchBetter(){
14      EqualsVerifier.forClass(Person.class)
15          .suppress(Warning.NONFINAL_FIELDS).verify();
16  }
```



```
java.lang.AssertionError: EqualsVerifier found a problem in class Person.  
-> Mutability: equals depends on mutable field firstName.
```

For more information, go to: <http://www.jqno.nl>equalsverifier/errormessages>

```
at nl.jqno.equalsverifier.EqualsVerifierApi.verify(EqualsVerifierApi.java:305)  
at com.github.sparsick.test.tool.database.PersonTest.equalsContractMuchBetter(PersonTest.java:26)  
at java.base/jdk.internal.reflect.NativeMethodAccessorImpl.invoke0(Native Method)  
at java.base/jdk.internal.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:62)  
at  
java.base/jdk.internal.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:43)  
at java.base/java.lang.reflect.Method.invoke(Method.java:566)  
at org.junit.platform.commons.util.ReflectionUtils.invokeMethod(ReflectionUtils.java:675)  
at org.junit.jupiter.engine.execution.MethodInvocation.proceed(MethodInvocation.java:60)  
at  
org.junit.jupiter.engine.execution.InvocationInterceptorChain$ValidatingInvocation.proceed(InvocationInterceptorChain.java:125)  
at org.junit.jupiter.engine.extension.TimeoutExtension.intercept(TimeoutExtension.java:132)  
at org.junit.jupiter.engine.extension.TimeoutExtension.interceptTestableMethod(TimeoutExtension.java:124)  
at org.junit.jupiter.engine.extension.TimeoutExtension.interceptTestMethod(TimeoutExtension.java:74)  
at  
org.junit.jupiter.engine.execution.ExecutableInvoker$ReflectiveInterceptorCall.lambda$ofVoidMethod$0(ExecutableInvoker.java:115)  
at org.junit.jupiter.engine.execution.ExecutableInvoker.lambda$invoke$0(ExecutableInvoker.java:105)  
at  
org.junit.jupiter.engine.execution.InvocationInterceptorChain$InterceptedInvocation.proceed(InvocationInterceptorChain.java:104)  
.
```

Was ist mit *toString()*?

Problem: *toString()* beinhaltet nicht alle Klassenfelder

```
1 public final class Person {  
2  
3     private String firstName;  
4     private String lastName;  
5     private String jobTitle;  
6  
7     // more code like getter, setter, hashCode and equals  
8  
9  
10    @Override  
11    public String toString() {  
12        return "Person{" +  
13                "firstName='" + firstName + '\'' +  
14                ", lastName='" + lastName + '\'' +  
15                ", jobTitle='" + jobTitle + '\'' +  
16                '}';  
17    }  
18}
```

To String Verifier

```
1  @Test
2  void toStringVerifier(){
3      ToStringVerifier.forClass(Person.class)
4          .withClassName(Style.SIMPLE_NAME)
5          .verify();
6  }
```

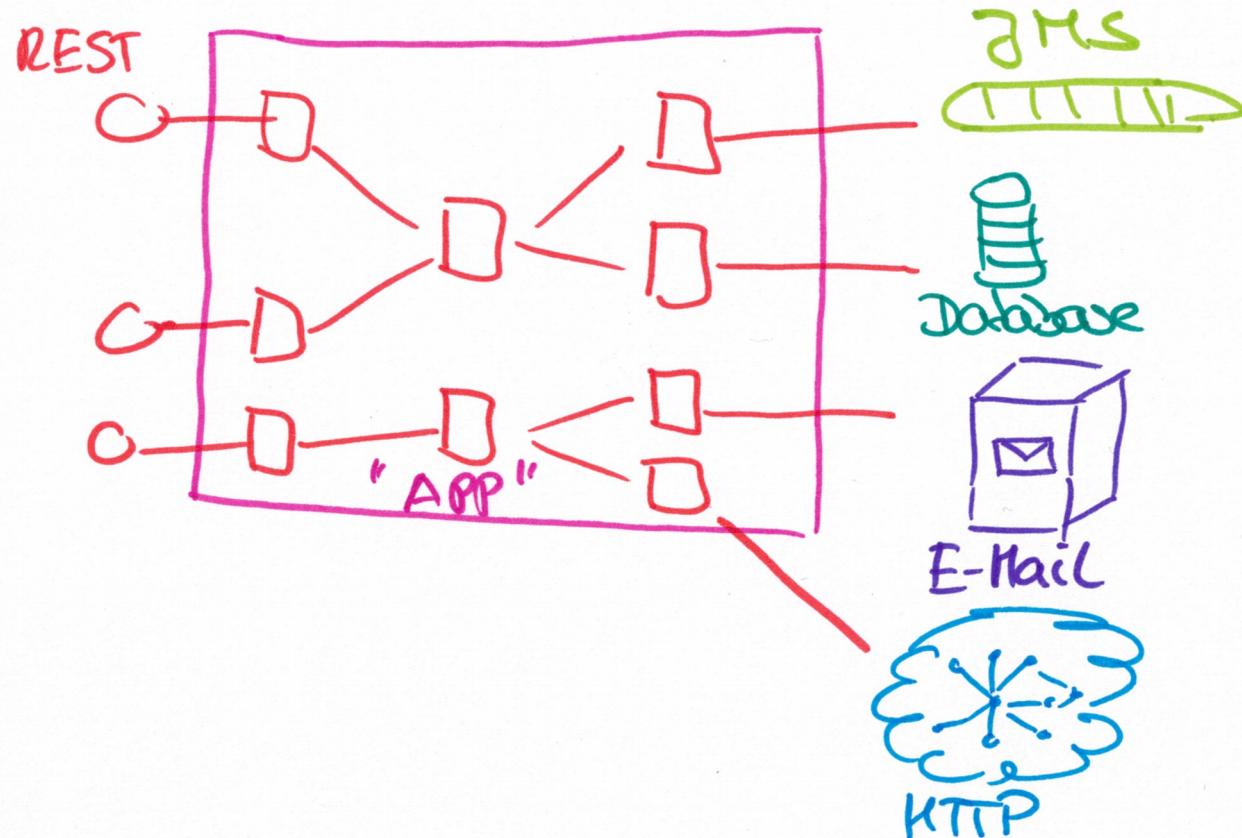


```
java.lang.AssertionError:  
  
Failed verification:  
com.github.sparsick.test.tool.database.Person  
  
Expected auto generated toString:  
Person{firstName='4b2b5d96-7d9f-46a3-a7ce-dd416c46706c', lastName='bb28f281-5cf4-43be-90ba-9dffaac274e6',  
jobTitle='a000c70c-1107-4a30-b9b9-5176222a4da6'}  
  
To start with class name: com.github.sparsick.test.tool.database.Person  
  
at com.jparams.verifier.tostring.ToStringVerifier.verify(ToStringVerifier.java:362)  
at com.github.sparsick.test.tool.database.PersonTest.toStringVerifier(PersonTest.java:33)  
at java.base/jdk.internal.reflect.NativeMethodAccessorImpl.invoke0(Native Method)  
at java.base/jdk.internal.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:62)  
at  
java.base/jdk.internal.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:43)  
at java.base/java.lang.reflect.Method.invoke(Method.java:566)  
at org.junit.platform.commons.util.ReflectionUtils.invokeMethod(ReflectionUtils.java:675)  
at org.junit.jupiter.engine.execution.MethodInvocation.proceed(MethodInvocation.java:60)  
at  
org.junit.jupiter.engine.execution.InvocationInterceptorChain$ValidatingInvocation.proceed(InvocationInterceptorChain.java:125)  
at org.junit.jupiter.engine.extension.TimeoutExtension.intercept(TimeoutExtension.java:132)  
at org.junit.jupiter.engine.extension.TimeoutExtension.interceptTestableMethod(TimeoutExtension.java:124)  
at org.junit.jupiter.engine.extension.TimeoutExtension.interceptTestMethod(TimeoutExtension.java:74)  
at  
org.junit.jupiter.engine.execution.ExecutableInvoker$ReflectiveInterceptorCall.lambda$ofVoidMethod$0(Executable
```

To String Verifier

- NameStyle
- Preset
 - Eclipse
 - IntelliJ
 - Guava
 - ApacheToStringBuilder
- Weitere Verifier (Auswahl)
 - withHashCode
 - withIgnoreFields
 - withNullField
 - withOnlyTheseFields

Problem: Integrierte Tests



Problembeschreibung

- Interaktion mit Infrastruktur wird recht spät getestet
 - Feedback bei Fehlern recht spät
- Abhängig von einer bestimmten Infrastruktur
 - Manchmal auch schon beim Build (Bad smell)
 - False negative Fehlerquote recht hoch
 - Aufwändiges Setup
 - Testausführung langsam

Integration vs Integrated Tests

Integrated Tests

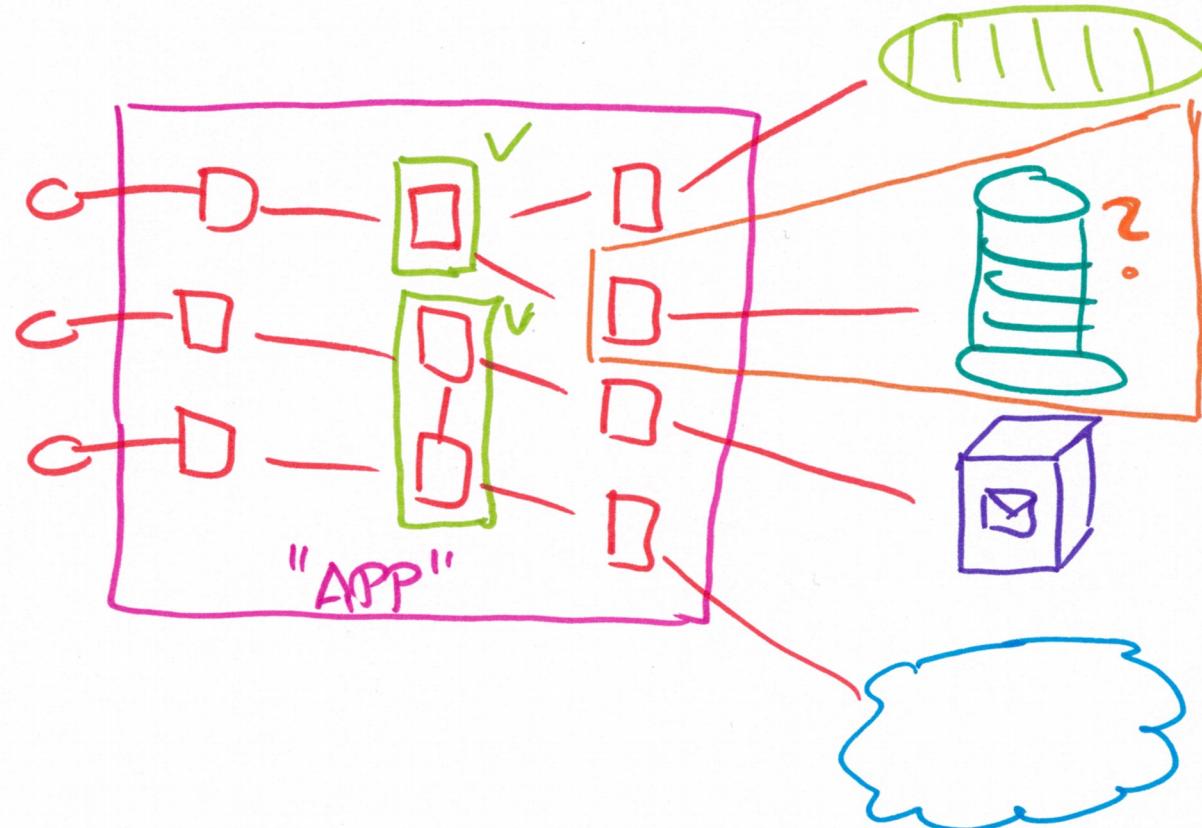
A test that will pass or fail based on the correctness of another system.

J.B.Rainsberger

Signs for having Integrated Tests:

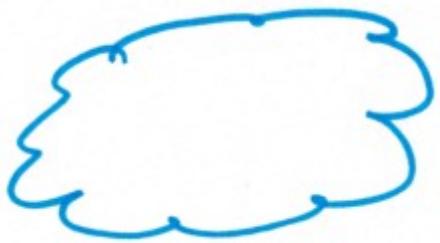
- We spin up other services in a local testing environment
- We test against other services in a shared testing environment
- Changes to your system breaks tests for other systems

from Spotify Blog Post



Anforderungen

- Build muss unabhängig von anderen Systemen sein
 - Minimierung der false negative Fehler
 - Entkopplung zwischen den Entwicklern
- Feedback bei Fehlern so schnell wie möglich
- Testausführung beschleunigen



HTTP

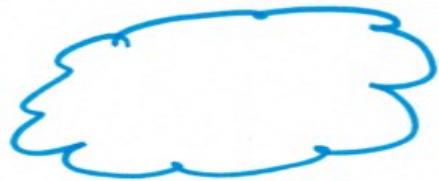


E-Mail



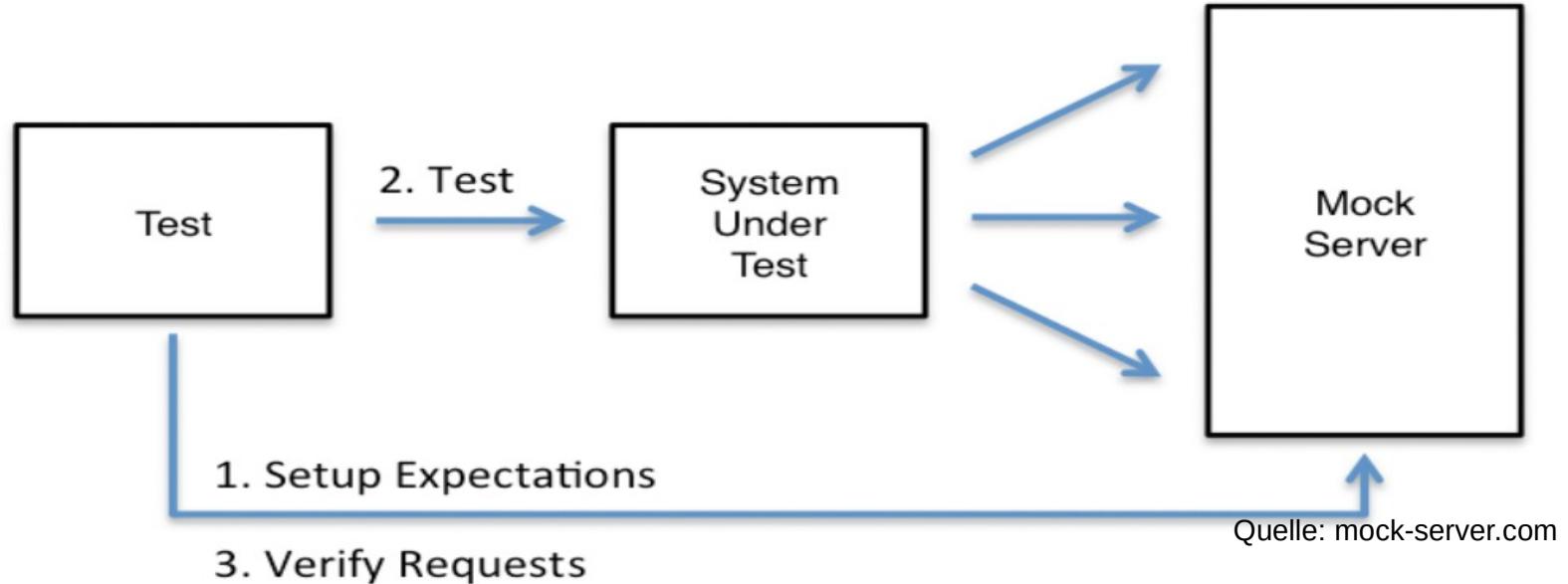
Datenbank

HTTP



Mocking HTTP Calls

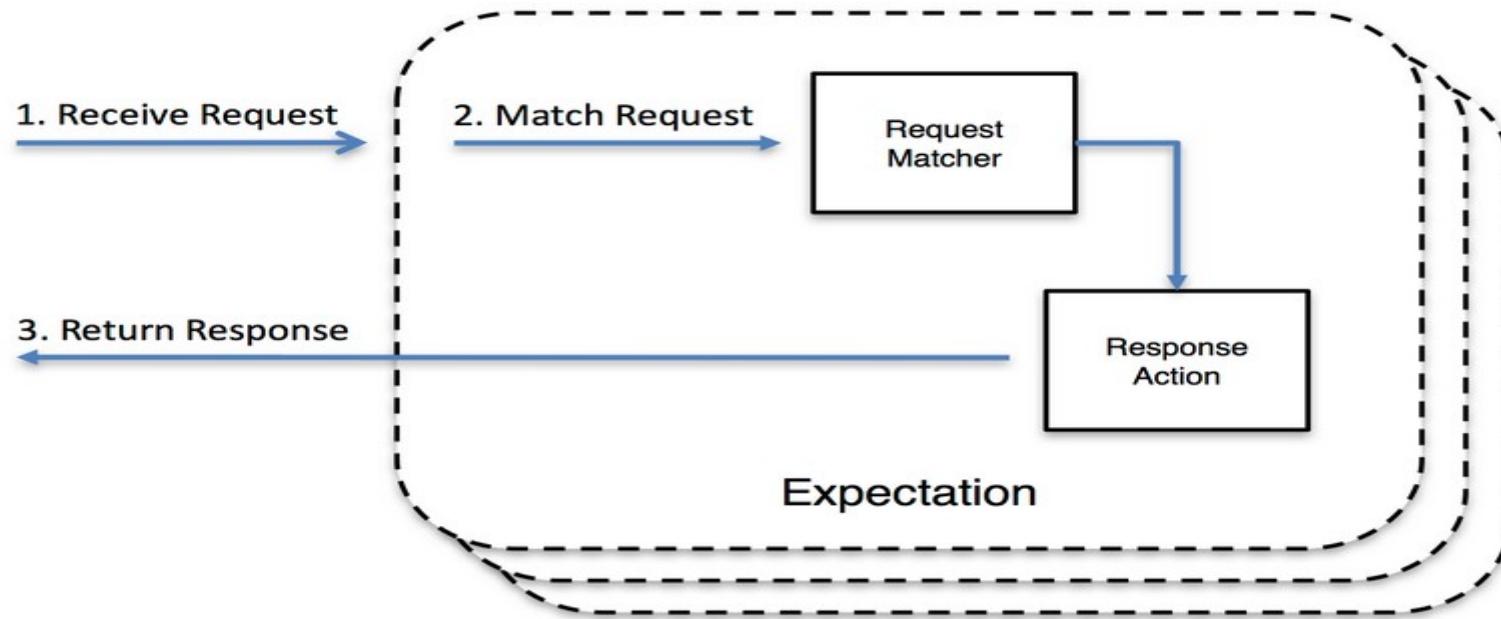
- MockServer (<http://mock-server.com/>)
- WireMock (<http://wiremock.org/>)



MockServer

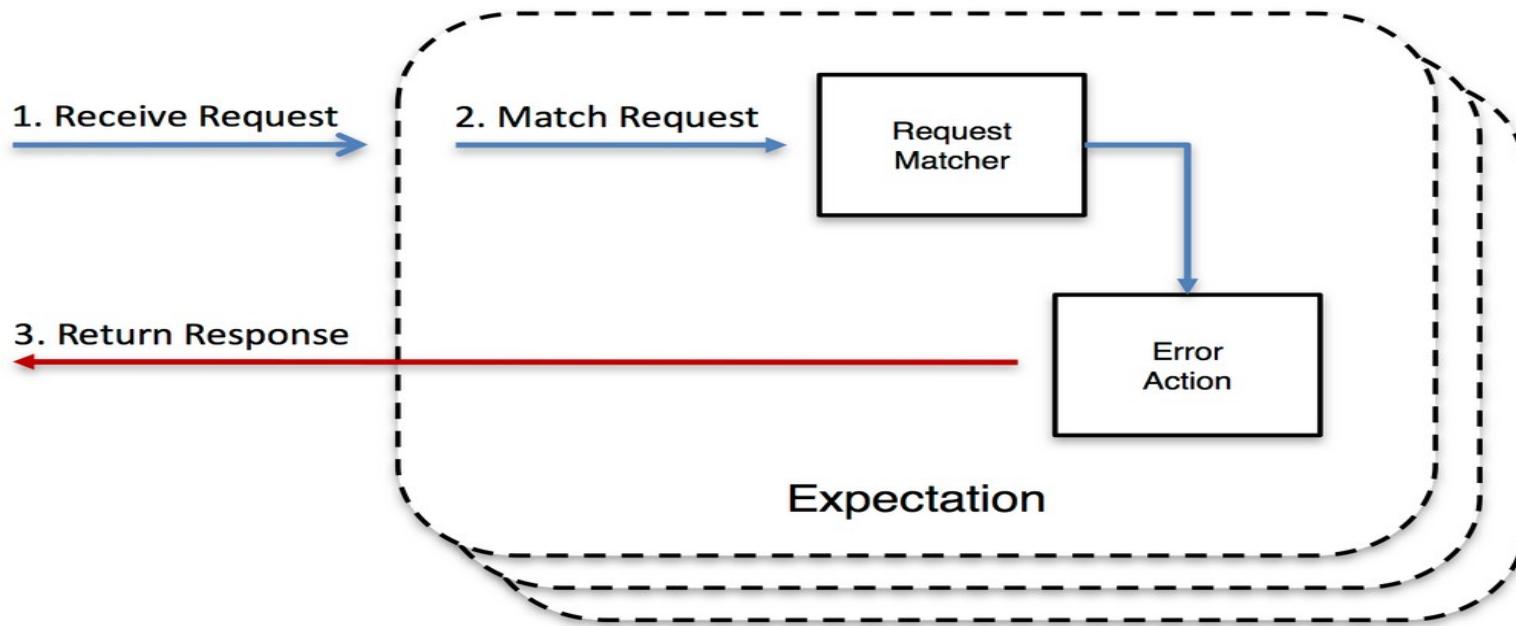
- Java und JavaScript API
- Java Rule
- Maven Plugin
- Npm Plugin
- Grunt Plugin
- Standalone (CLI)
- Docker Container

MockServer



Quelle: mock-server.com

MockServer



Quelle: mock-server.com

```
1 ▼ {
2     "count": 37,
3     "next": "https://swapi.co/api/starships/?page=2",
4     "previous": null,
5     "results": [
6         {
7             "name": "Executor",
8             "model": "Executor-class star dreadnought",
9             "manufacturer": "Kuat Drive Yards, Fondor Shipyards",
10            "cost_in_credits": "1143350000",
11            "length": "19000",
12            "max_atmosphering_speed": "n/a",
13            "crew": "279144",
14            "passengers": "38000",
15            "cargo_capacity": "2500000000",
16            "consumables": "6 years",
17            "hyperdrive_rating": "2.0",
18            "MGLT": "40",
19            "starship_class": "Star dreadnought",
20            "pilots": [],
21            "films": [
22                "https://swapi.co/api/films/2/",
23                "https://swapi.co/api/films/3/"
24            ],
25            "created": "2014-12-15T12:31:42.547000Z",
26            "edited": "2017-04-19T10:56:06.685592Z",
27            "url": "https://swapi.co/api/starships/15/"
28        },

```

http://swapi.co/api/starships

```
public class StarWarsClient {
    private final RestTemplate restTemplate;
    private final String baseUrl;

    public StarWarsClient(String protocol, String hostName, int port) {
        this.restTemplate = new RestTemplateBuilder().build();
        try {
            this.baseUrl = new URL(protocol, hostName, port, "").toString();
        } catch (MalformedURLException e) {
            throw new RuntimeException(e);
        }
    }

    public List<Starship> findAllStarships() {
        List<Starship> starships = new ArrayList<>();
        String nextPageUrl = baseUrl + "/api/starships";
        do {
            String forObject = restTemplate.getForObject(nextPageUrl, String.class);
            Map<String, Object> jsonMap = new GsonJsonParser().parseMap(forObject);
            nextPageUrl = (String) jsonMap.get("next");
            for (Map result : (List<Map>) jsonMap.get("results")) {
                starships.add(Starship.from(result));
            }
        }
        while (nextPageUrl != null);
        return starships;
    }
}
```

```
@Rule
public MockServerRule mockServerRule = new MockServerRule(this, false);

private MockServerClient mockServerClient;
private StarWarsClient clientUnderTest = new StarWarsClient("http", "localhost", mockServerRule.getPort());

@Test
public void findAllStarships() {
    mockServerClient
        .when(request()
            .withMethod("GET")
            .withPath("/api/starships"))
        )
        .respond(response()
            .withBody(testData))
    );
    mockServerClient
        .when(request()
            .withMethod("GET")
            .withPath("/api/starships2"))
        )
        .respond(response()
            .withBody(testData2))
    );

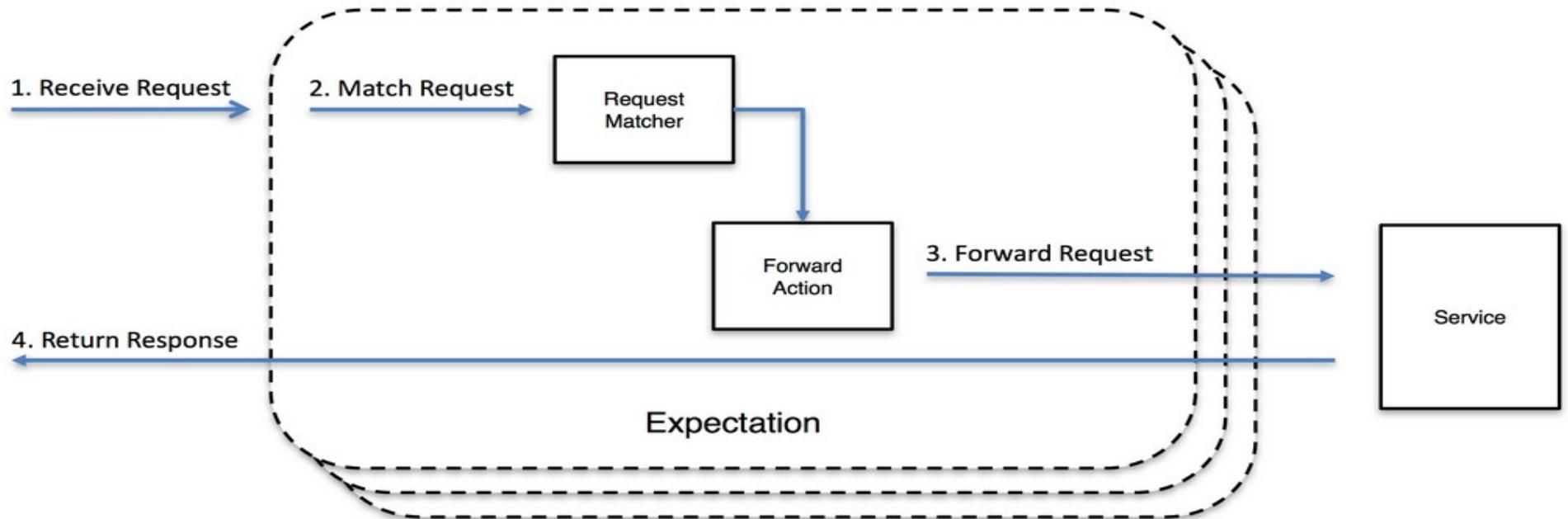
    List<Starship> allStarships = clientUnderTest.findAllStarships();
    assertThat(allStarships).hasSize(11);
}
```

Don't mock API you don't own

Verified Fakes

Tests, die die richtige API aufrufen und verifizieren ob die
Test Doubles richtig sind

MockServer – Weitere Features



Quelle: mock-server.com

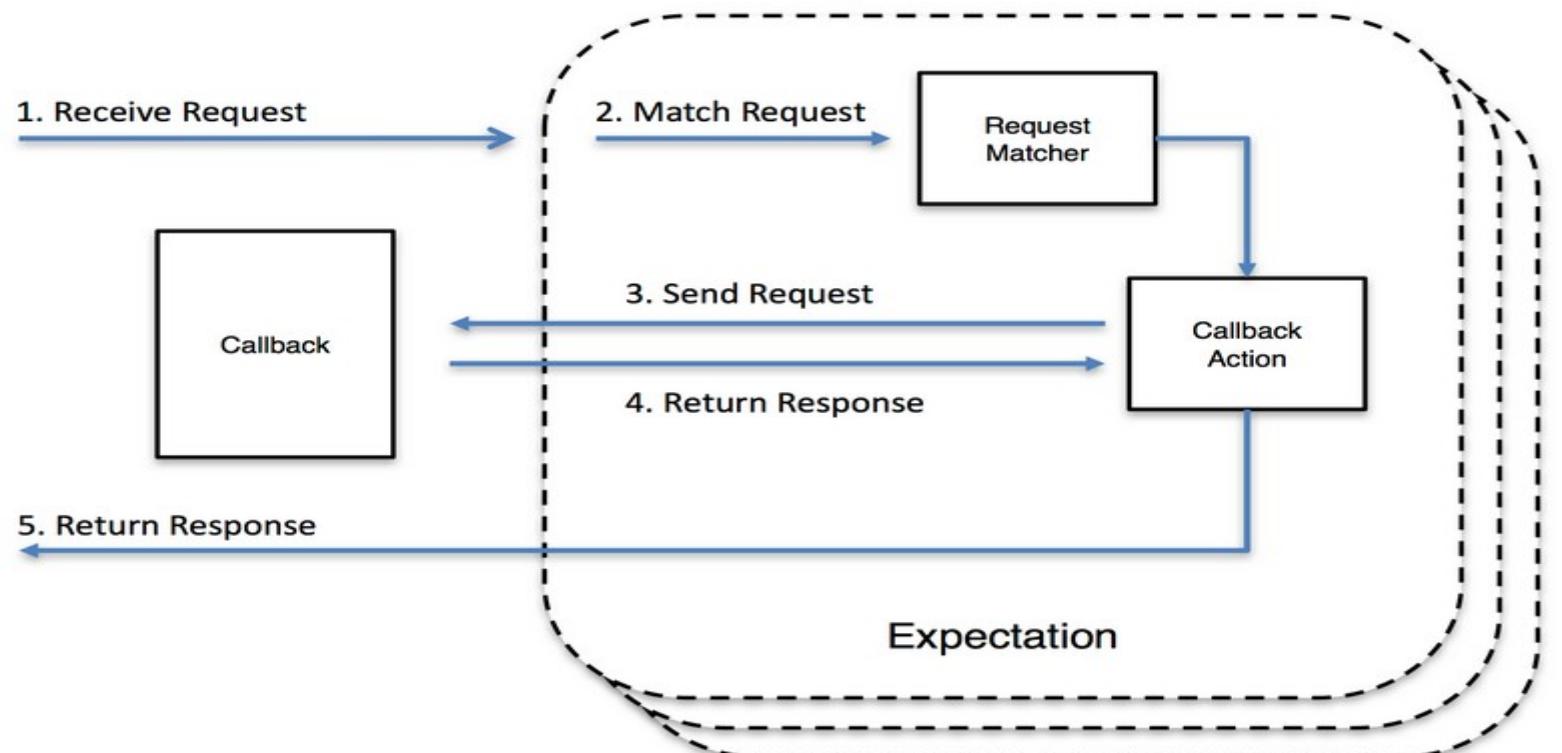
```
@Test
public void verifyfindAllStarshipsRequest(){
    mockServerClient
        .when(request())
            .withMethod("GET")
            .withPath("/api/starships")
        )
        .respond(response()
            .withBody(testData)
        );
    mockServerClient
        .when(request())
            .withMethod("GET")
            .withPath("/api/starships2")
        )
        .respond(response()
            .withBody(testData2)
        );
}

List<Starship> allStarships = clientUnderTest.findAllStarships();

assertThat(allStarships).hasSize(11);

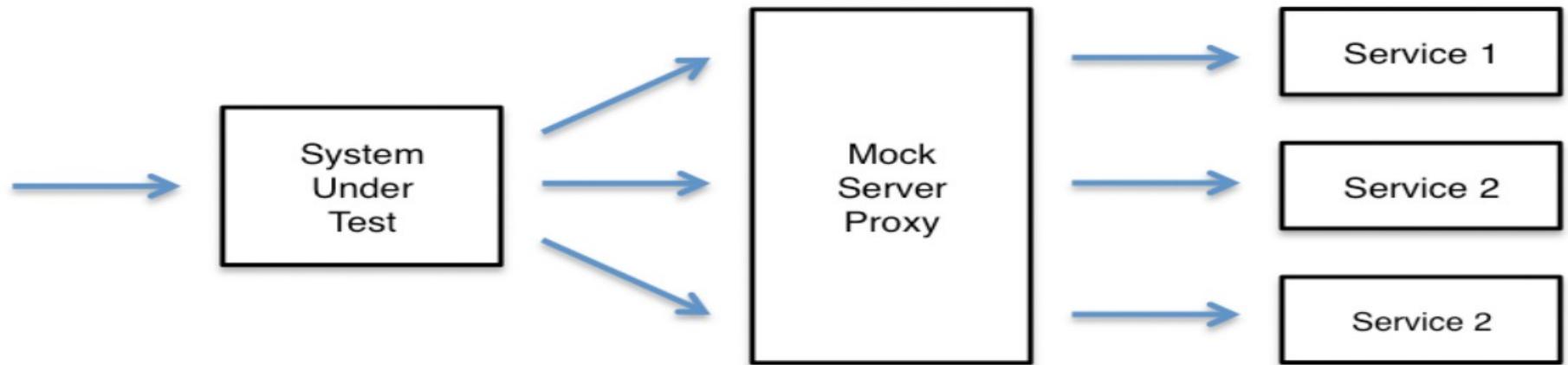
mockServerClient
    .verify(request()
        .withMethod("GET")
        .withPath("/api/starships"),
    VerificationTimes.once());
mockServerClient
    .verify(request()
        .withMethod("GET")
        .withPath("/api/starships2"),
    VerificationTimes.once());
}
```

MockServer – Weitere Features



Quelle: mock-server.com

MockServer Proxy

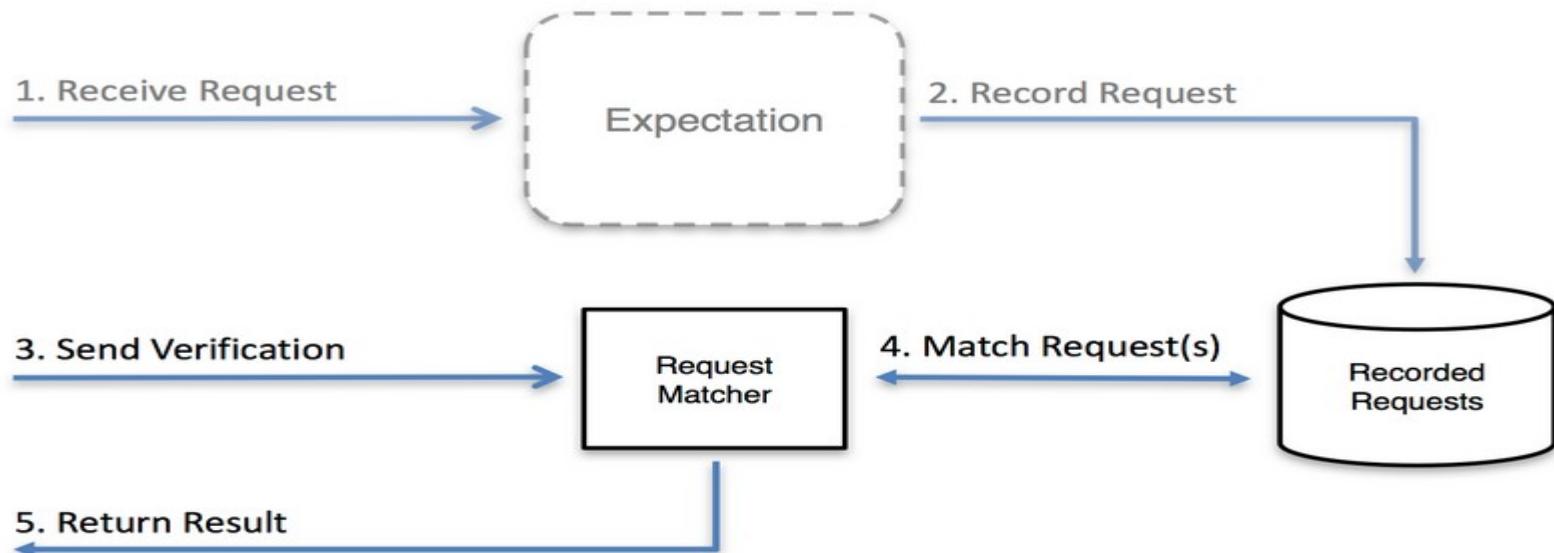


Quelle: mock-server.com

MockServer Proxy

- proxy all requests using any of the following proxying methods:
 - Port Forwarding
 - Web Proxying (i.e. HTTP proxy)
 - HTTPS Tunneling Proxying (using HTTP CONNECT)
 - SOCKS Proxying (i.e. dynamic port forwarding)
- verify requests have been sent (i.e. in a test assertion)
- record requests and responses to analyse how a system behaves

MockServer – Weitere Features



Quelle: mock-server.com

Exkurs: Wiremock

```
@ClassRule
public static WireMockClassRule serviceMock=new WireMockClassRule(options().dynamicPort());

@Test
public void findAllStarships(){
    serviceMock.stubFor(get(urlEqualTo("/api/starships"))
        .willReturn(aResponse().withBody(testData)));
    serviceMock.stubFor(get(urlEqualTo("/api/starships2"))
        .willReturn(aResponse().withBody(testData2)));

    List<Starship> allStarships=clientUnderTest.findAllStarships();

    assertThat(allStarships).hasSize(11);
}

@Test
public void verifyfindAllStarshipsRequest(){
    serviceMock.stubFor(get(urlEqualTo("/api/starships"))
        .willReturn(aResponse().withBody(testData)));
    serviceMock.stubFor(get(urlEqualTo("/api/starships2"))
        .willReturn(aResponse().withBody(testData2)));

    List<Starship> allStarships=clientUnderTest.findAllStarships();

    assertThat(allStarships).hasSize(11);

    serviceMock.verify(1,getRequestedFor(urlEqualTo("/api/starships")));
    serviceMock.verify(1,getRequestedFor(urlEqualTo("/api/starships2")));
}
```

Eigene HTTP Endpoints

- Jersey → JerseyTest
- Spring MVC → MockMvc
- Framework-unabhängig
 - REST Assured (<http://rest-assured.io/>)
 - „Killer“-Feature: JsonPath, XmlPath
 - Scala Support
 - Spring MVC Support
 - Given-when-then Struktur

Rest Assured - JsonPath

```
{  
  "lotto": {  
    "lottoId": 5,  
    "winning-numbers": [2, 45, 34, 23, 7, 5, 3],  
    "winners": [{  
      "winnerId": 23,  
      "numbers": [2, 45, 34, 23, 3, 5]  
    }, {  
      "winnerId": 54,  
      "numbers": [52, 3, 12, 11, 18, 22]  
    }]  
  }  
}
```

<http://localhost:8080/lotto>

```
get("/lotto").then().body("lotto.lottoId", equalTo(5));
```

```
get("/lotto").then().body("lotto.winners.winnerId", hasItems(23, 54));
```

Rest Assured - XMLPath

```
<greeting>
  <firstName>{params("firstName")}</firstName>
  <lastName>{params("lastName")}</lastName>
</greeting>
```

```
given().
when().
then().
```

```
parameters("firstName", "John", "lastName", "Doe").
post("/greetXML").
body("greeting.firstName", equalTo("John")).
body("greeting.lastName", equalTo("Doe"));
```

<http://localhost:8080/greetXML>

Quelle: Rest Assured Doc

Rest Assured – Spring MVC

```
@Controller
@RequestMapping("starwars")
public class StarWarsMovieController {

    @RequestMapping(value="movies", method = RequestMethod.GET, produces = "application/json")
    public @ResponseBody List<StarWarsMovie> findAllMovies(){
        return List.of(new StarWarsMovie("A New Hope", "George Lucas"),
                      new StarWarsMovie("The Force Awakens", "J. J. Abrams"));
    }
}
```

Rest Assured – Spring MVC

```
@RunWith(SpringRunner.class)
@WebMvcTest(StarWarsMovieController.class)
public class StarWarsMovieControllerITest {

    @Autowired
    private MockMvc mockMvc;

    @Test
    public void findAllMovies(){
        given().mockMvc(mockMvc).
            when().get("/starwars/movies").
            then().statusCode(200)
                .body("title", hasItems("A New Hope", "The Force Awakens"))
                .body("director", hasItems("George Lucas", "J. J. Abrams"));
    }

    @Test
    public void findAllMovies_plainMockMvc() throws Exception {
        mockMvc.perform(get("/starwars/movies"))
            .andExpect(status().isOk())
            .andExpect(jsonPath("[0].title").value("A New Hope"))
            .andExpect(jsonPath("[0].director").value("George Lucas"))
            .andExpect(jsonPath("[1].title").value("The Force Awakens"))
            .andExpect(jsonPath("[1].director").value("J. J. Abrams"));
    }
}
```

Unit Tests für Endpoints

```
class StarWarsMovieControllerTest {

    @Test
    void findAllMovies(){
        StarWarsMovieController controllerUnderTest = new StarWarsMovieController();
        List<StarWarsMovie> movies = controllerUnderTest.findAllMovies();

        assertThat(movies)
            .hasSize(2)
            .extracting("director")
            .containsExactlyInAnyOrder( "George Lucas", "J. J. Abrams" );
    }
}
```

E-Mail



E-Mail

- GreenMail (<http://www.icegreen.com/greenmail/#>)
 - Lightweight sand boxed mail server
 - Sending and Retrieving
 - SMTP, POP3, IMAP incl. SSL
 - JUnit integration (JUnit4)
 - Usage model:
 - Java API
 - Standalone
 - WAR
 - Docker Container

Greenmail

```
public class MailClient {

    private final JavaMailSender javaMailSender;

    public MailClient(JavaMailSender javaMailSender) {
        this.javaMailSender = javaMailSender;
    }

    public void sendMessage(String from, String to, String body) throws MessagingException {
        MimeMessage message = javaMailSender.createMimeMessage();
        message.setFrom(new InternetAddress(from));
        message.addRecipient(Message.RecipientType.TO, new InternetAddress(to));
        message.setText(body);
        javaMailSender.send(message);
    }
}
```

```
private static ServerSetup smtp;
private GreenMail greenMail;
private MailClient clientUnderTest;

@BeforeAll
static void setUpAll() {
    int portOffset = ThreadLocalRandom.current().nextInt(1000, 2000);
    smtp = new ServerSetup(25 + portOffset, null, ServerSetup.PROTOCOL_SMTP);
}

@BeforeEach
void setUp() {
    greenMail = new GreenMail(smtp);
    JavaMailSender javaMailSender = createJavaMailSender();
    clientUnderTest = new MailClient(javaMailSender);
    greenMail.withConfiguration(GreenMailConfiguration.aConfig().withUser("test", "xxx"));
    greenMail.start();
}

@Test
void sendMessage() throws MessagingException, IOException {
    String message = "text";
    String from = "from@example.com";
    String to = "to@example.com";
    clientUnderTest.sendMessage(from, to, message);

    MimeMessage[] receivedMessages = greenMail.getReceivedMessages();
    assertThat(receivedMessages).hasSize(1);
    String content = (String) receivedMessages[0].getContent();
    assertThat(content.trim()).isEqualTo(message);
}

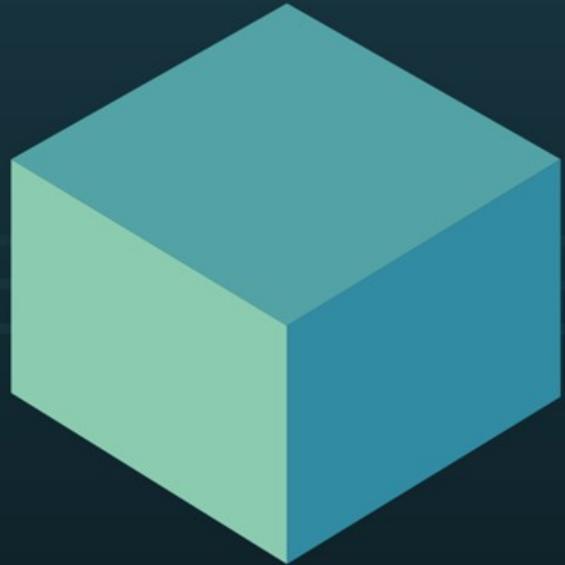
@AfterEach
void cleanUp() { greenMail.stop(); }
```

Datenbanken



Datenbanken

- Embedded Datenbanken
 - H2, Derby
 - Nicht Produktionsnah
 - Nicht alles testbar
- Standalone Datenbanken
 - Abhängigkeit zur bestimmten Infrastruktur
- Shared Datenbanken
 - Abhängigkeiten zwischen Entwickler
 - Hohe false negative Fehlerrate



TESTCONTAINERS

```
@Testcontainers
class PersonRepositoryJUnit5Test {

    @Container
    private PostgreSQLContainer postgres = new PostgreSQLContainer();

    private PersonRepository repositoryUnderTest;

    @BeforeEach
    void setup(){
        HikariConfig hikariConfig = new HikariConfig();
        hikariConfig.setJdbcUrl(postgres.getJdbcUrl());
        hikariConfig.setUsername(postgres.getUsername());
        hikariConfig.setPassword(postgres.getPassword());

        HikariDataSource ds = new HikariDataSource(hikariConfig);
        Flyway flyway = Flyway.configure().dataSource(ds).load();
        flyway.migrate();

        repositoryUnderTest = new PersonRepository(ds);
    }

    @Test
    void saveAndFindAllPerson() {
        Person person = new Person();
        person.setFirstName("firstName");
        person.setLastName("lastName");
        person.setJobTitle("jobTitle");

        repositoryUnderTest.save(person);

        List<Person> persons = repositoryUnderTest.findAllPersons();
        assertThat(persons).hasSize(1).contains(person);
    }
}
```

```
@Testcontainers
class DbMigrationJUnit5Test {

    @Container
    private MySQLContainer mysqlDb = new MySQLContainer();

    @Test
    void testDbMigrationFromTheScratch(){
        Flyway flyway = Flyway.configure()
            .dataSource(mysqlDb.getJdbcUrl(),
                       mysqlDb.getUsername(),
                       mysqlDb.getPassword()).load();

        flyway.migrate();
    }
}
```

TESTS

```
-----  
Running db.migration.DbMigrationITest  
INFO - RegistryClientProviderStrategy - Found docker client settings from environment  
INFO - DockerClientProviderStrategy - Found Docker environment with Environment variables, system properties and defaults. Resolved:  
  dockerHost=unix:///var/run/docker.sock  
  apiVersion='{UNKNOWN_VERSION}'  
  registryUrl='https://index.docker.io/v1/'  
  registryUsername='sparsick'  
  registryPassword='null'  
  registryEmail='null'  
  dockerConfig='DefaultDockerClientConfig[dockerHost=unix:///var/run/docker.sock, registryUsername=sparsick, registryPassword=<null>, registryEmail=<null>]'  
INFO - DockerClientFactory      - Docker host IP address is localhost  
INFO - DockerClientFactory      - Connected to docker:  
  Server Version: 17.05.0-ce  
  API Version: 1.29  
  Operating System: Linux Mint 18.2  
  Total Memory: 19511 MB  
    i Checking the system...  
    ✓ Docker version is newer than 1.6.0  
    ✓ Docker environment has more than 2GB free  
    ✓ File should be mountable  
    ✓ Exposed port is accessible  
INFO - [mysql:latest]           - Creating container for image: mysql:latest  
INFO - [mysql:latest]           - Starting container with ID: 2668be66c2631e49b5bcb4e180665d223525ec896ea78034326076d5f9063d53  
INFO - [mysql:latest]           - Container mysql:latest is starting: 2668be66c2631e49b5bcb4e180665d223525ec896ea78034326076d5f9063d53  
INFO - [mysql:latest]           - Waiting for database connection to become available at jdbc:mysql://localhost:32769/test using query 'SELECT  
INFO - [mysql:latest]           - Obtained a connection to container (jdbc:mysql://localhost:32769/test)  
INFO - [mysql:latest]           - Container mysql:latest started  
INFO - VersionPrinter          - Flyway 4.0.3 by Boxfuse  
INFO - DbSupportFactory         - Database: jdbc:mysql://localhost:32769/test (MySQL 5.7)  
INFO - DbValidate               - Successfully validated 2 migrations (execution time 00:00.011s)  
INFO - MetaDataTableImpl        - Creating Metadata table: `test`.`schema_version`  
INFO - DbMigrate                - Current version of schema `test`: <> Empty Schema <>  
INFO - DbMigrate                - Migrating schema `test` to version 1.0.0 - create person table  
INFO - DbMigrate                - Migrating schema `test` to version 2.0.0 - add column job title  
INFO - DbMigrate                - Successfully applied 2 migrations to schema `test` (execution time 00:00.133s).  
Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 13.9 sec
```

Testcontainers

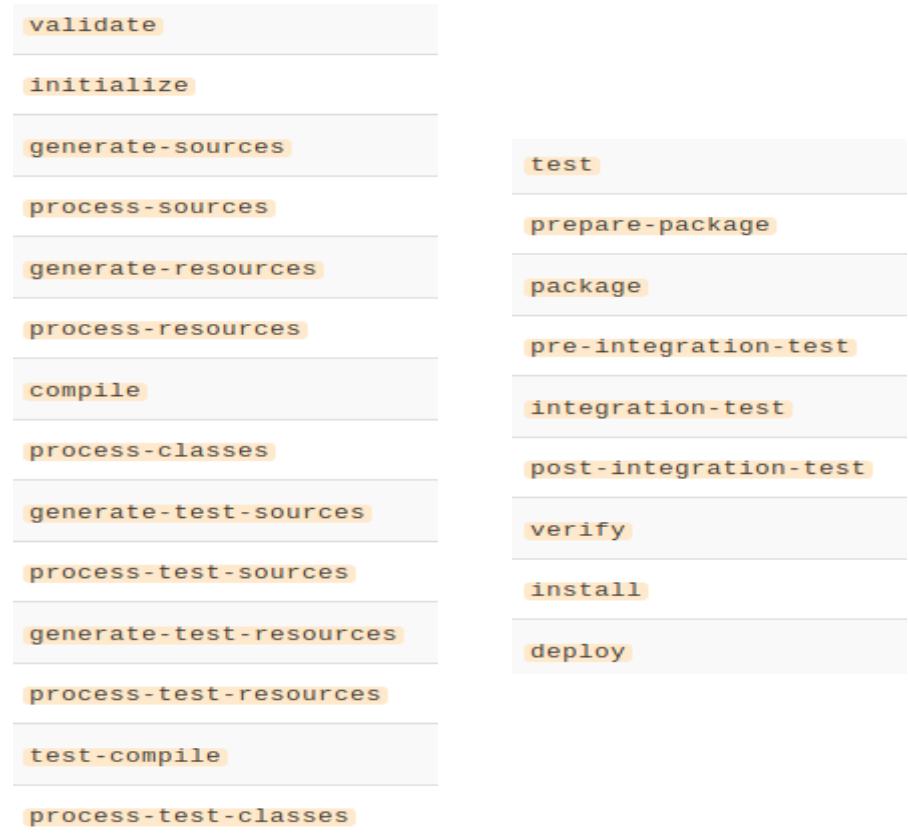
- Temporary database containers - spezielle MySQL, PostgreSQL, Oracle XE und Virtuoso container
- Webdriver containers - Dockerized Chrome oder Firefox browser für Selenium/Webdriver Operationen mit automatischer Videoaufnahme
- Weitere spezifische Container – Elasticsearch, Kafka, Apache Pulsar, Mockserver, Toxiproxy, Nginx, Hashicorp Vault
- Generic containers – irgendein Docker Container
- Docker compose – Wiederverwendung von Docker Compose YAML Datei
- Dockerfile containers – Container direkt von einem Dockerfile

Docker Maven Plugin (DMP)

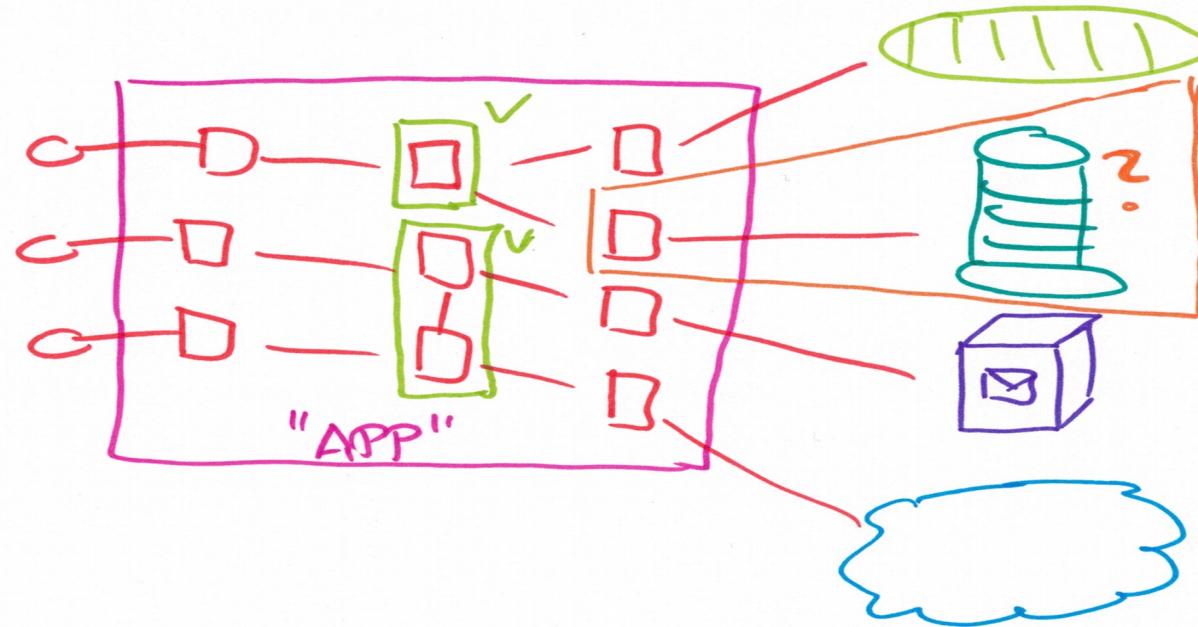
- fabric8io/docker-maven-plugin (<http://dmp.fabric8.io>)
- Kann Docker Image bauen
- Aber auch Container starten und stoppen

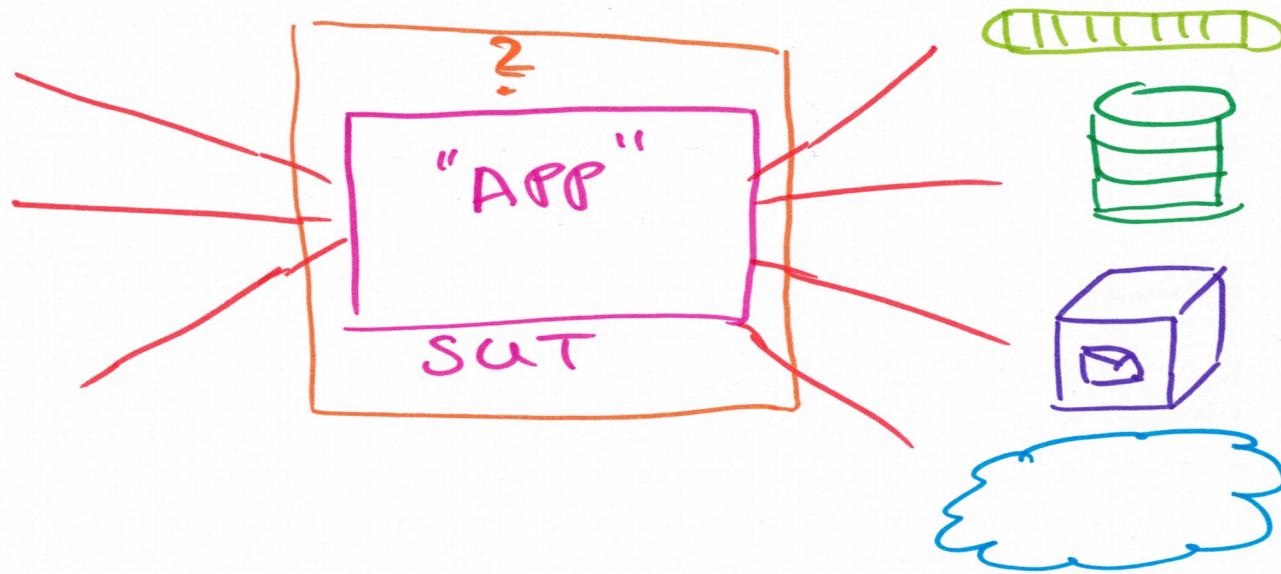
Maven Phase: Integration-Test

- Ausgangspunkt:
 - Es gibt Integrationstests gegen embedded oder standalone Datenbank
- Improvement:
 - DMP startet Container vor den Tests (*pre-integration-test*)
 - DMP stoppt Contianer nach den Tests (*post-integration-test*)



Was es noch so gibt





Citrus Integration Testing



Resilience Tests

- ToxyProxy - framework for simulating network conditions (<http://toxiproxy.io/>)
 - NEW: Testcontainers Integration
- Chaos Monkey for Spring Boot – Chaos Engineering for Spring Boot Apps (<https://codecentric.github.io/chaos-monkey-spring-boot>)

Fazit

Integration Tests
Mockserver, Wiremock,
REST Assured
Greenmail
Testcontainers

equals, hashCode, toString
EqualsVerifier, ToStringVerifier

Gut lesbare Assertions
AssertJ, JUnit5 Group Assertion

Testdaten
generatedata.com
JavaFaker
ObjectMother, TestDataBuilder

Parametrisierte
Tests
JUnit5, Spock

Tests, die nur unter bestimmten
Bedingungen laufen
JUnit5 ConditionsTest

Fragen?

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@SandraParsick

<https://github.com/sparsick/test-tool-talk>

Literatur

- <https://www.martinfowler.com/bliki/ObjectMother.html>
- <http://natpryce.com/articles/000714.html>
- <http://coding-is-like-cooking.info/2018/04/pre-tested-integration-back-to-the-basis-of-ci/>
- <http://blog.thecodewhisperer.com/permalink/integrated-tests-are-a-scam>
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- <https://martinfowler.com/bliki/IntegrationTest.html>
- <https://codewithoutrules.com/2016/07/31/verified-fakes/>