Scaffolding with JMock

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Valerio Maggio, PhD Student
Prof. Adriano Peron

Outline

- Brief Recap
  - Unit Testing
  - JUnit (case study)
- Test Scaffolding
  - Stubs
  - Mocks
- JMock Example

Example Scenario

(… not properly related to Computer Science :)

- Please, imagine that you have to test a building
  - Test if it has been constructed properly
  - Test if it is able to resist to earthquake
  - ….

- **Q:** What types of "testing" would you do?
- **Q:** What should be the "starting point"?
  - Make an educated guess

Unit Testing

- Testing of the smallest pieces of a program
  - Individual functions or methods

- Keyword: **Unit**
  - **(def) Something is a unit if it there's no meaningful way to divide it up further**

- Buzz Word:
  - **Testing in isolation**

Unit Testing (cont.)

- Unit test are used to test a single *unit* in isolation
  - Verifying that it works as expected
  - No matter the rest of the program would do

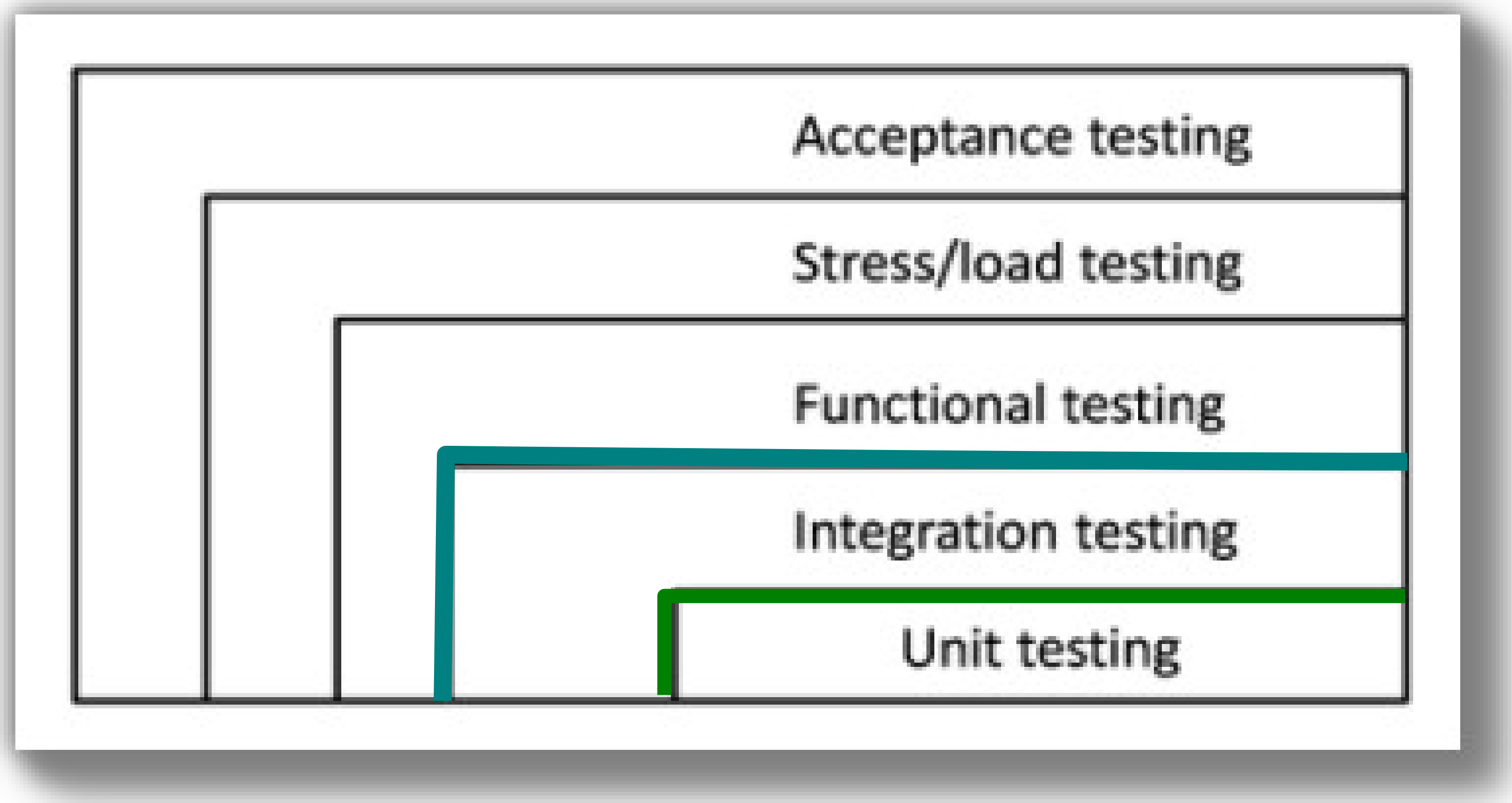
- Possible advantages ?
  - (Possibly) No inheritance of bugs of mistakes from made elsewhere
  - Narrow down on the actual problem

Unit Testing (cont.)

- Is it enough ?
  - No, by itself, but...
- … it is the foundation upon which everything is based!

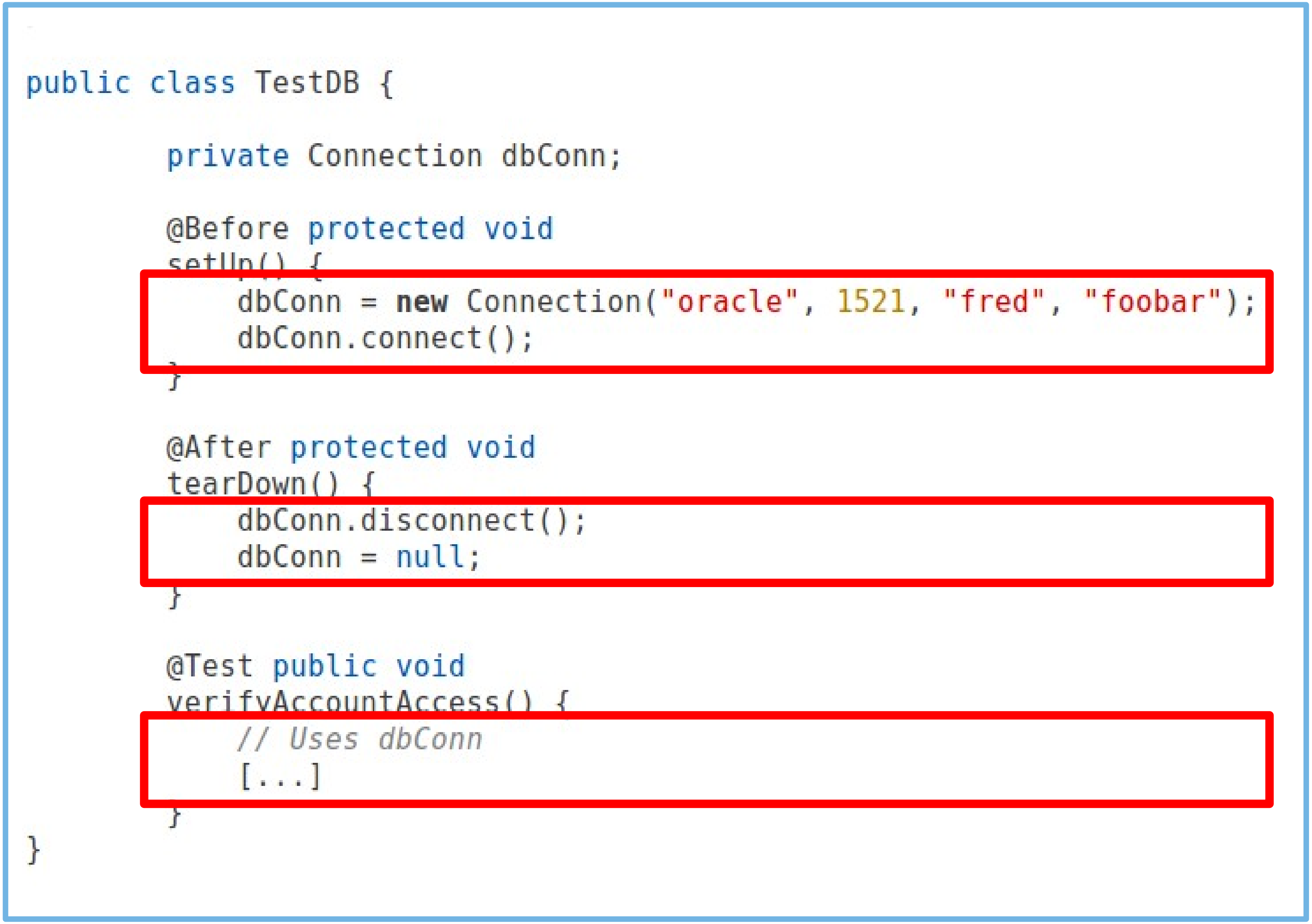
- (Back to the example)
  - You can't build a house without solid materials.
  - You can't build a program without units that works as expected.

Testing RoadMap



Test Scaffolding

Integration Testing Example



```
public class TestDB {

        private Connection dbConn;

        @Before protected void
        setUp() {
            dbConn = new Connection("oracle", 1521, "fred", "foobar");
            dbConn.connect();
        }

        @After protected void
        tearDown() {
            dbConn.disconnect();
            dbConn = null;
        }

        @Test public void
        verifyAccountAccess() {
            // Uses dbConn
            [...]
        }
}
```

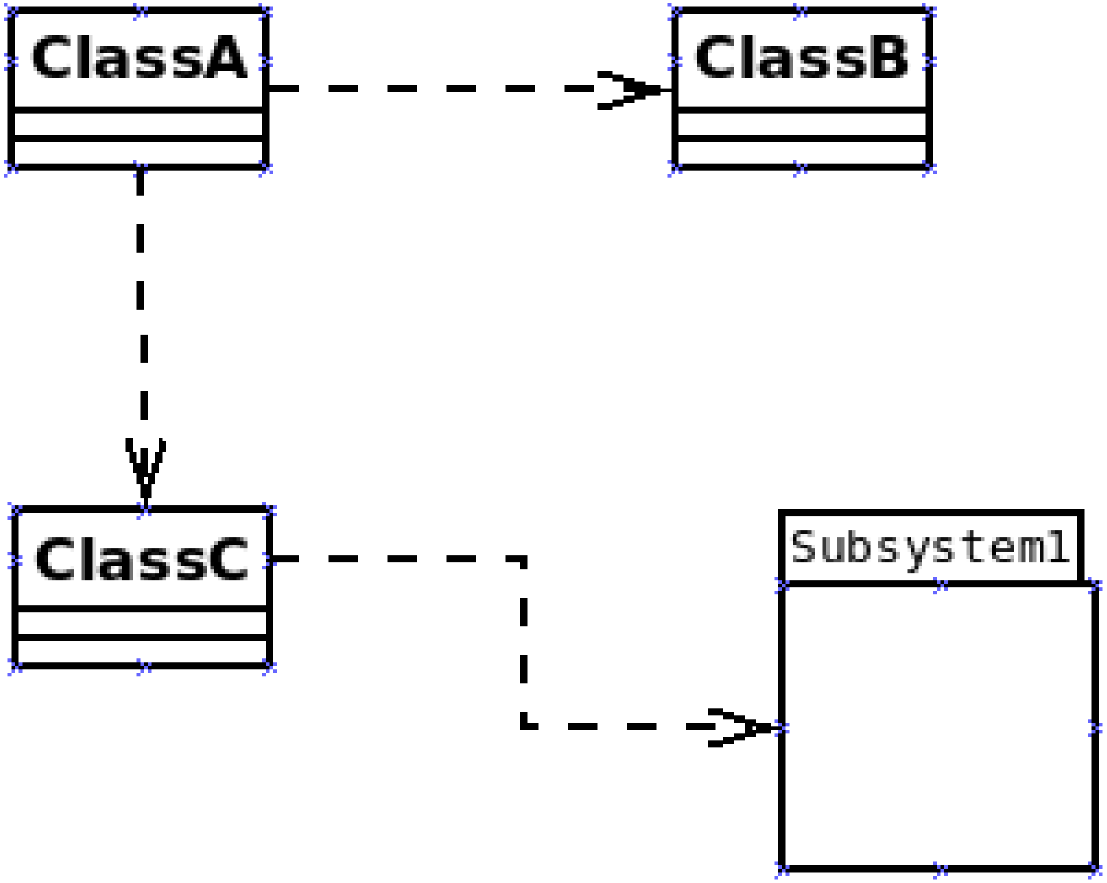
Integration testing problem

- Integrate multiple components implies to decide in which order classes and subsystems should be integrated and tested

- **CITO** Problem
  - *Class Integration Testing Order* Problem

- Solution:
  - Topological sort of dependency graph

Integration testing example

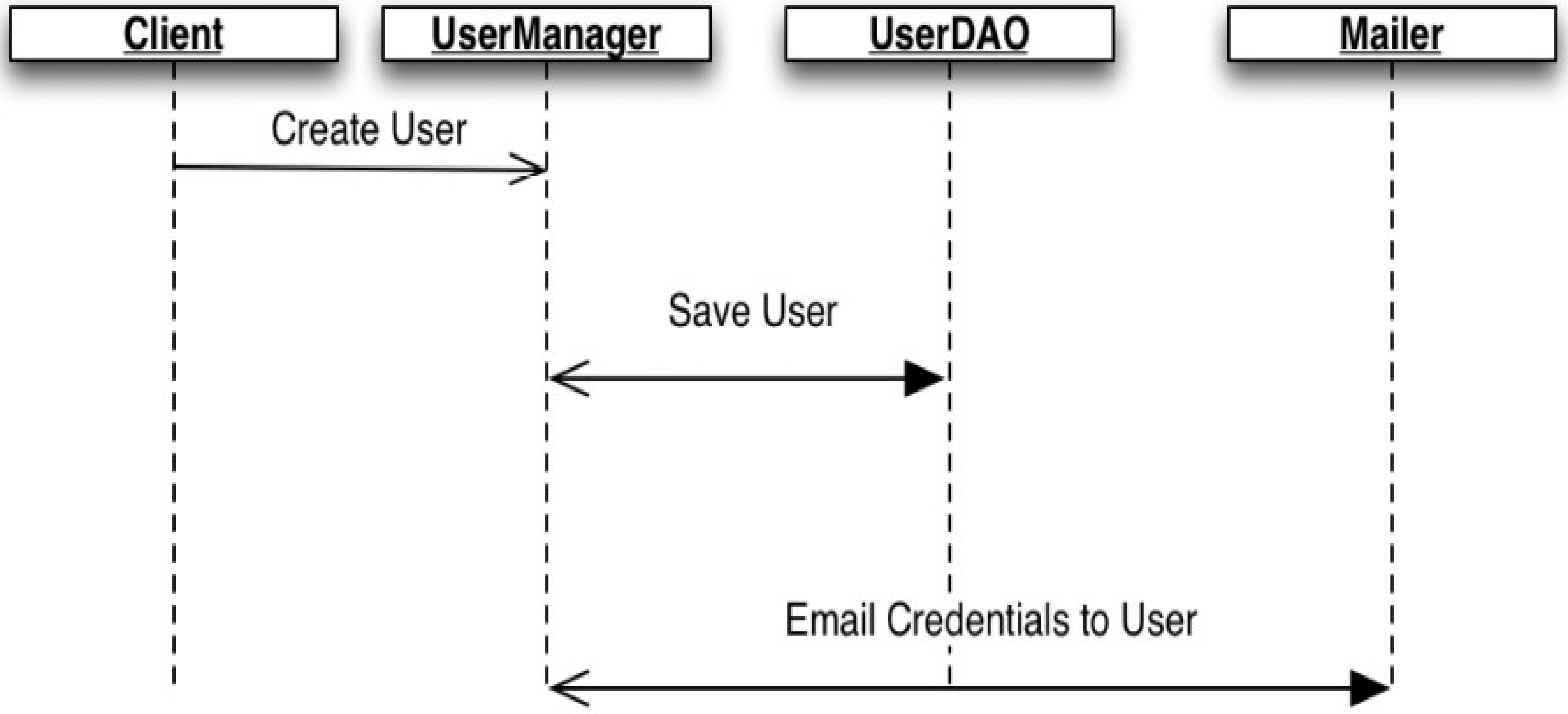


Testing in isolation

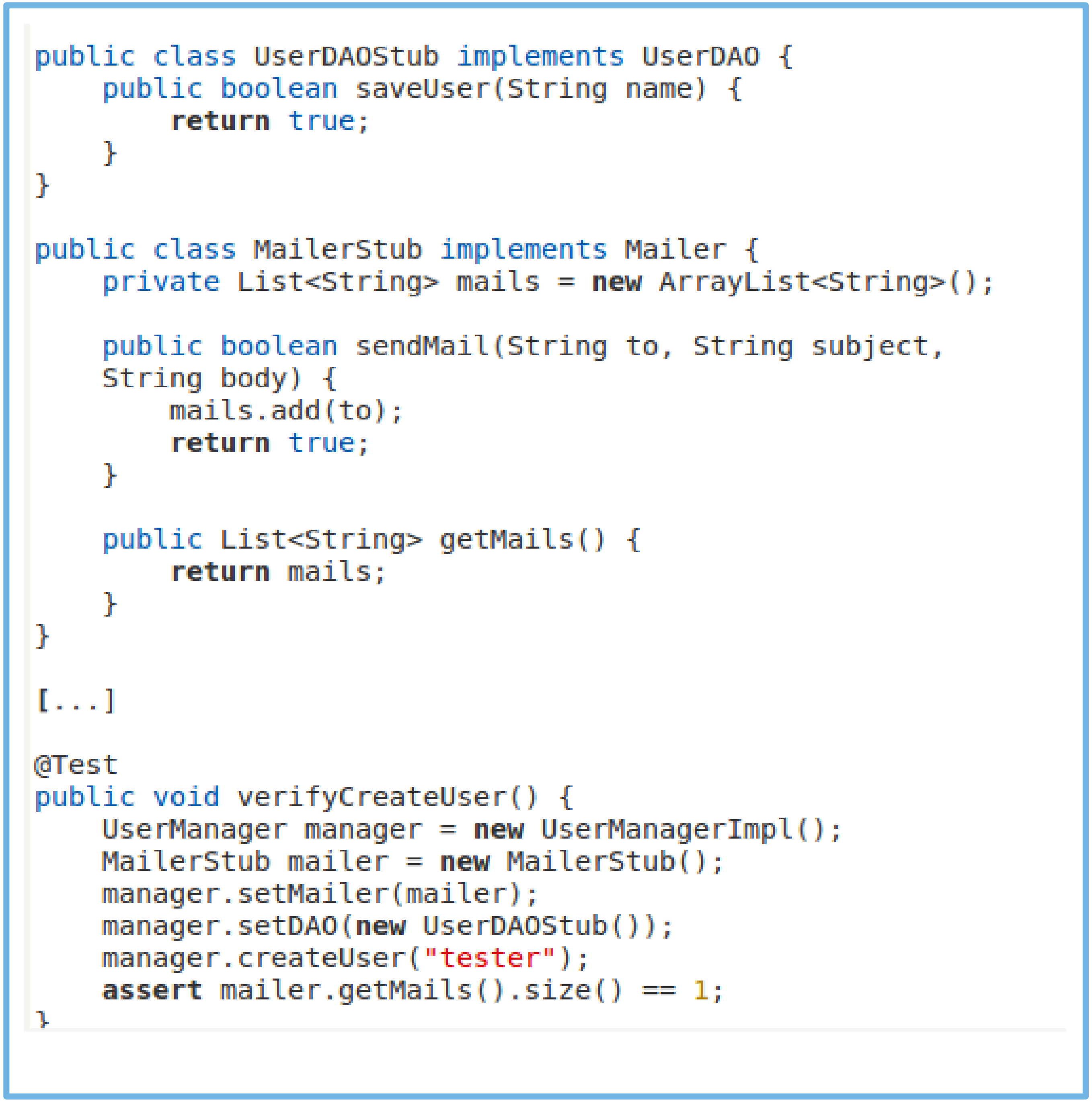
- Testing in isolation offers strong benefits
  - Test code that have not been written
  - Test only a single method (behavior) without side effects from other objects

- Solutions ?
  - Stubs
  - Mocks
  - …

Testing in Isolation: example

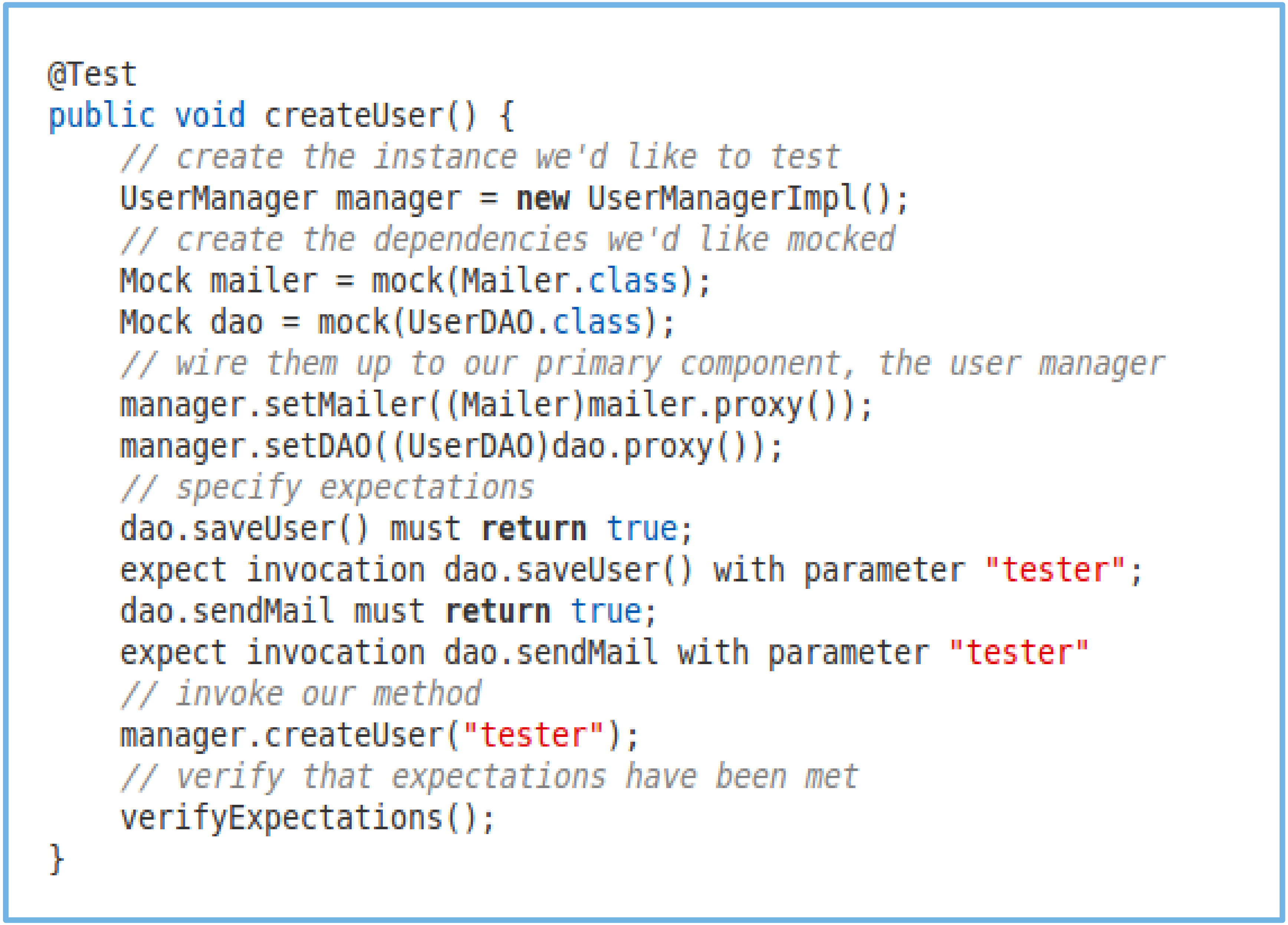


Solution with stubs



```java
public class UserDAOStub implements UserDAO {
    public boolean saveUser(String name) {
        return true;
    }
}

public class MailerStub implements Mailer {
    private List<String> mails = new ArrayList<String>();

    public boolean sendMail(String to, String subject,
    String body) {
        mails.add(to);
        return true;
    }

    public List<String> getMails() {
        return mails;
    }
}

[...]

@Test
public void verifyCreateUser() {
    UserManager manager = new UserManagerImpl();
    MailerStub mailer = new MailerStub();
    manager.setMailer(mailer);
    manager.setDAO(new UserDAOStub());
    manager.createUser("tester");
    assert mailer.getMails().size() == 1;
}
```

Solution with (Pseudo) Mocks



```
@Test
public void createUser() {
    // create the instance we'd like to test
    UserManager manager = new UserManagerImpl();
    // create the dependencies we'd like mocked
    Mock mailer = mock(Mailer.class);
    Mock dao = mock(UserDAO.class);
    // wire them up to our primary component, the user manager
    manager.setMailer((Mailer)mailer.proxy());
    manager.setDAO((UserDAO)dao.proxy());
    // specify expectations
    dao.saveUser() must return true;
    expect invocation dao.saveUser() with parameter "tester";
    dao.sendMail must return true;
    expect invocation dao.sendMail with parameter "tester"
    // invoke our method
    manager.createUser("tester");
    // verify that expectations have been met
    verifyExpectations();
}
```

Key Ideas

(Ignoring the specifics of codes)

- ► Mocks do not provide our own implementation of the components we'd like to swap in

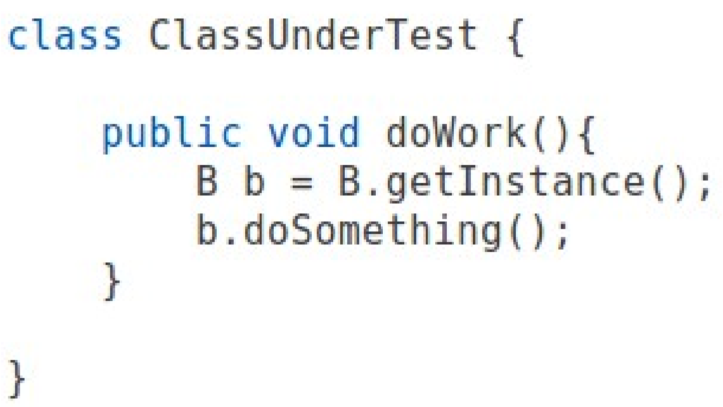
- ► Main Difference:
  - Mocks test behavior and interactions between components
  - Stubs replace heavyweight process that are not relevant to a particular test with simple implementations

Mock Objects Observations

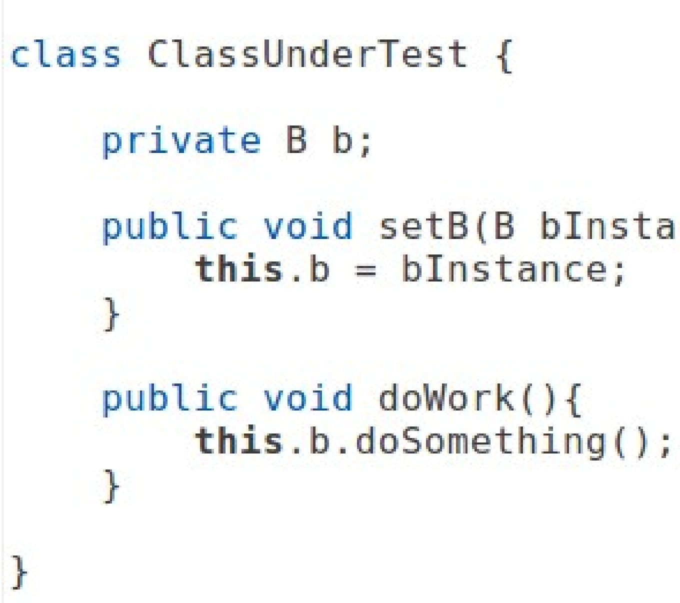
- Powerful way to implement Behavior Verification
  - while avoiding Test Code Duplication between similar tests.
- It works by delegating the job of verifying the indirect outputs of the SUT
- Important Note: **Design for Mockability**
  - **Dependency Injection Pattern**

Design for Mockability

- Dependency Injection



```
class ClassUnderTest {

    public void doWork(){
        B b = B.getInstance();
        b.doSomething();
    }

}
```

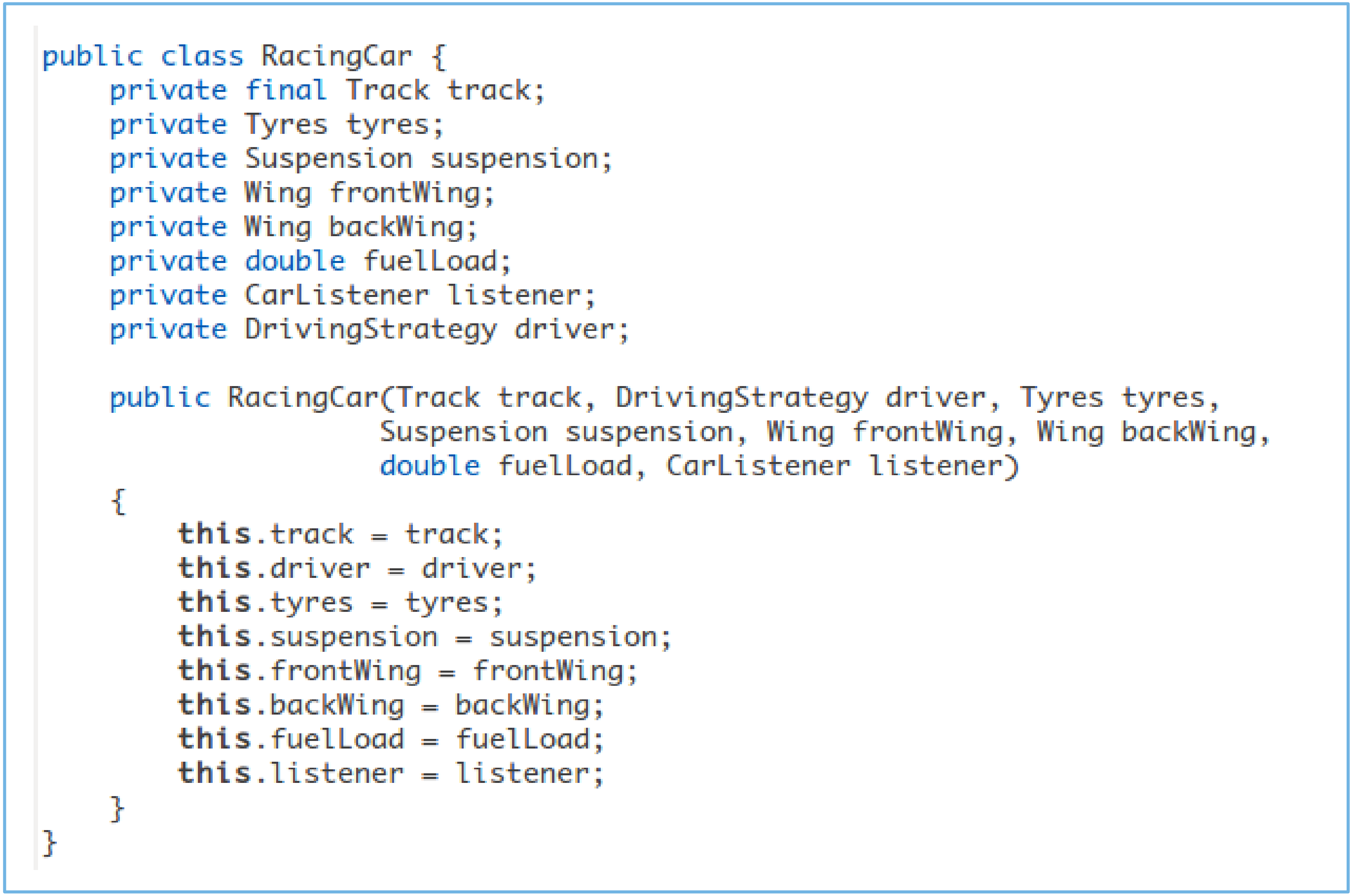


```
class ClassUnderTest {

    private B b;

    public void setB(B bInstance){
        this.b = bInstance;
    }

    public void doWork(){
        this.b.doSomething();
    }

}
```

Dependency injection issues?

►Too Many Dependencies

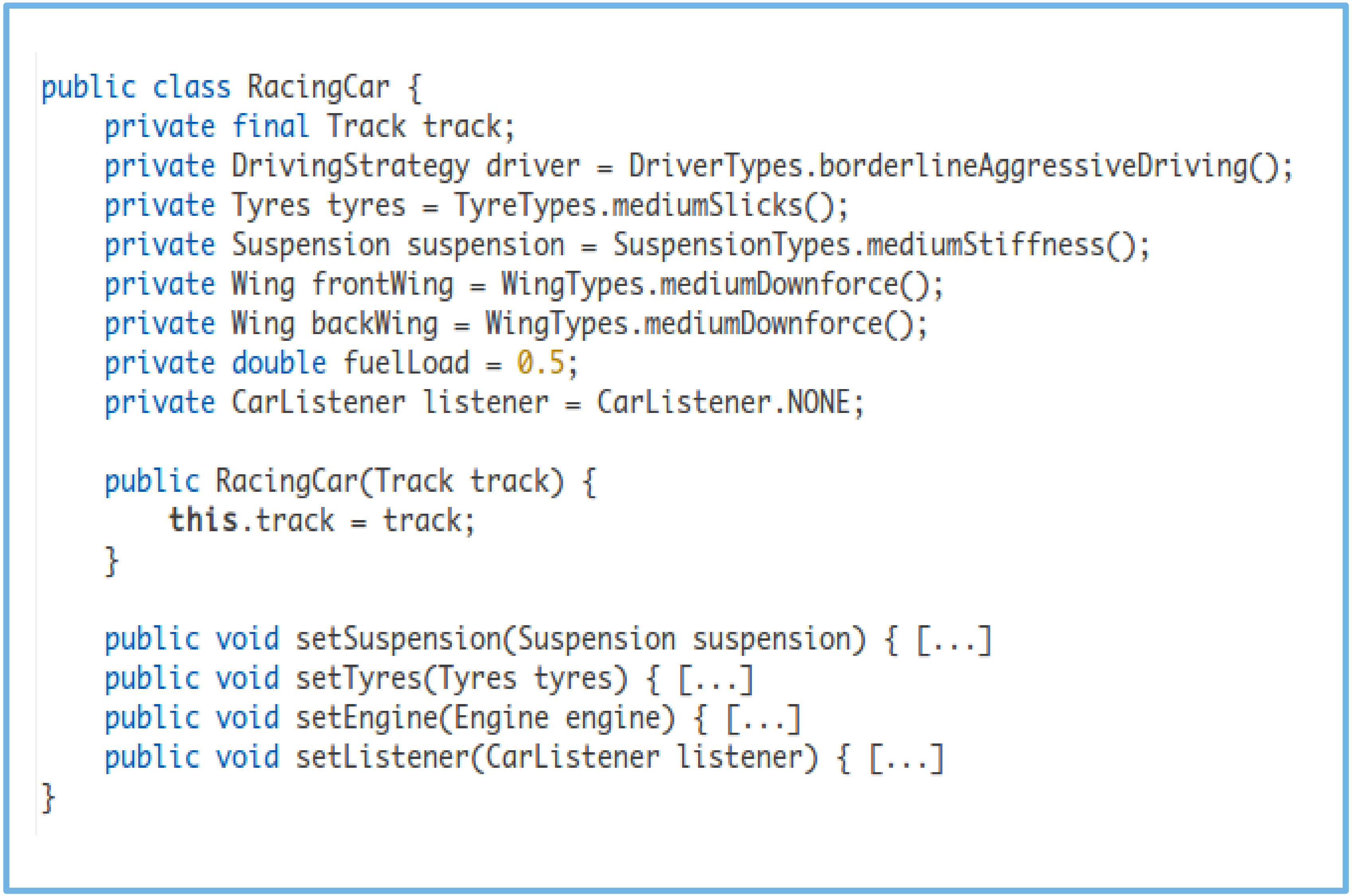
- Ideas??



```java
public class RacingCar {
    private final Track track;
    private Tyres tyres;
    private Suspension suspension;
    private Wing frontWing;
    private Wing backWing;
    private double fuelLoad;
    private CarListener listener;
    private DrivingStrategy driver;

    public RacingCar(Track track, DrivingStrategy driver, Tyres tyres,
                     Suspension suspension, Wing frontWing, Wing backWing,
                     double fuelLoad, CarListener listener)
    {
        this.track = track;
        this.driver = driver;
        this.tyres = tyres;
        this.suspension = suspension;
        this.frontWing = frontWing;
        this.backWing = backWing;
        this.fuelLoad = fuelLoad;
        this.listener = listener;
    }
}
```

Dependency injection issues?

- ►Dependency injection for mockability



```
public class RacingCar {
    private final Track track;
    private DrivingStrategy driver = DriverTypes.borderlineAggressiveDriving();
    private Tyres tyres = TyreTypes.mediumSlicks();
    private Suspension suspension = SuspensionTypes.mediumStiffness();
    private Wing frontWing = WingTypes.mediumDownforce();
    private Wing backWing = WingTypes.mediumDownforce();
    private double fuelLoad = 0.5;
    private CarListener listener = CarListener.NONE;

    public RacingCar(Track track) {
        this.track = track;
    }

    public void setSuspension(Suspension suspension) { [...]
    public void setTyres(Tyres tyres) { [...]
    public void setEngine(Engine engine) { [...]
    public void setListener(CarListener listener) { [...]
}
```

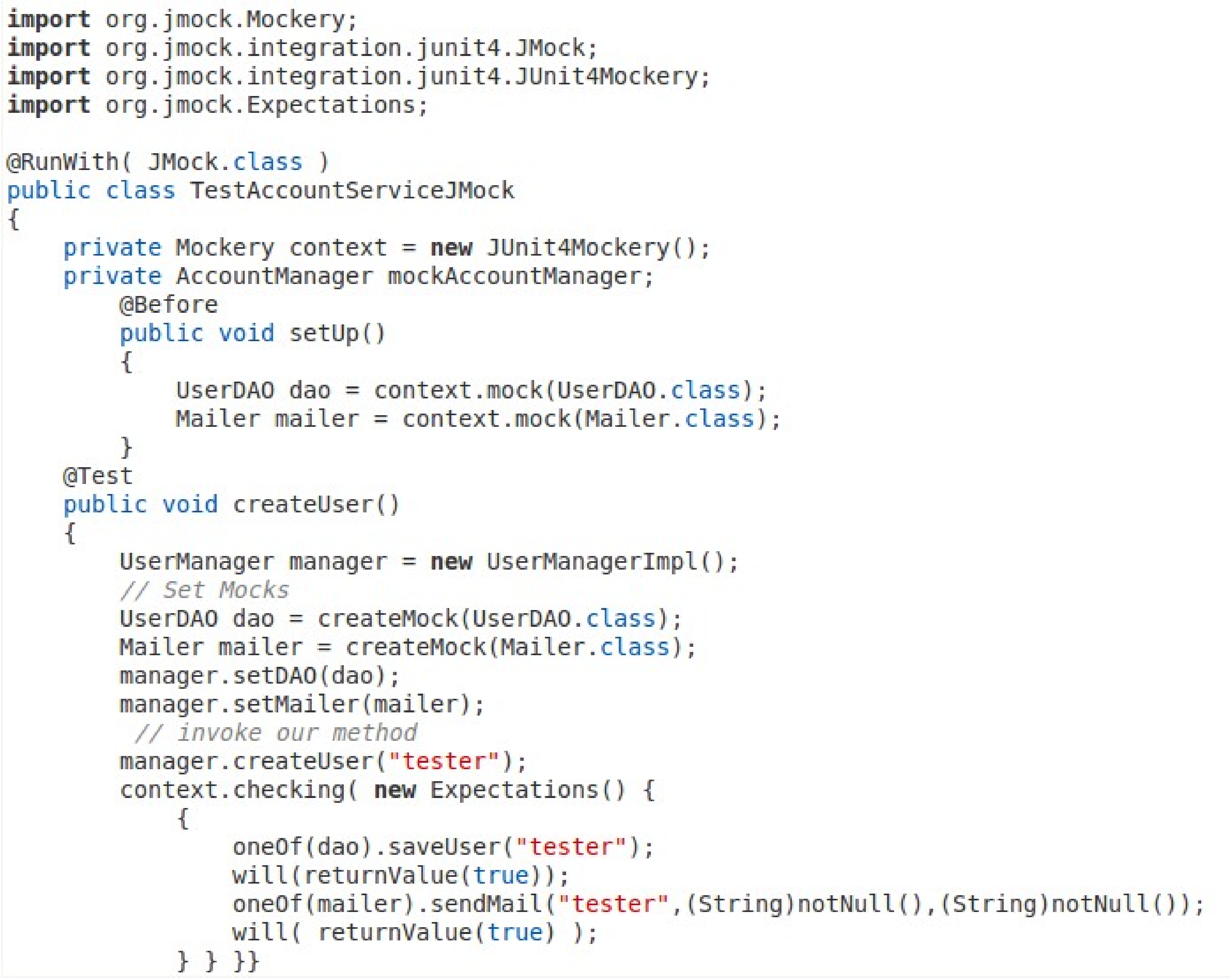
Mock Libraries

- Two main design philosphy:
  - DSL Libraries
  - Record/Replay Models Libraries

- Record Replay Frameworks
  - First train mocks and then verify expectations

- DSL Frameworks
  - Domain Specific Languages
  - Specifications embedded in “Java” Code

JMock Example



```
import org.jmock.Mockery;
import org.jmock.integration.junit4.JMock;
import org.jmock.integration.junit4.JUnit4Mockery;
import org.jmock.Expectations;

@RunWith( JMock.class )
public class TestAccountServiceJMock
{
    private Mockery context = new JUnit4Mockery();
    private AccountManager mockAccountManager;
        @Before
        public void setUp()
        {
            UserDAO dao = context.mock(UserDAO.class);
            Mailer mailer = context.mock(Mailer.class);
        }
    @Test
    public void createUser()
    {
        UserManager manager = new UserManagerImpl();
        // Set Mocks
        UserDAO dao = createMock(UserDAO.class);
        Mailer mailer = createMock(Mailer.class);
        manager.setDAO(dao);
        manager.setMailer(mailer);
         // invoke our method
        manager.createUser("tester");
        context.checking( new Expectations() {
            {
                oneOf(dao).saveUser("tester");
                will(returnValue(true));
                oneOf(mailer).sendMail("tester",(String)notNull(),(String)notNull());
                will( returnValue(true) );
            } } }}
```

JMock features

- JMock syntax relies heavily on chained method calls
  - Sometimes difficult to decipher and to debug

- **Common Patterns:**

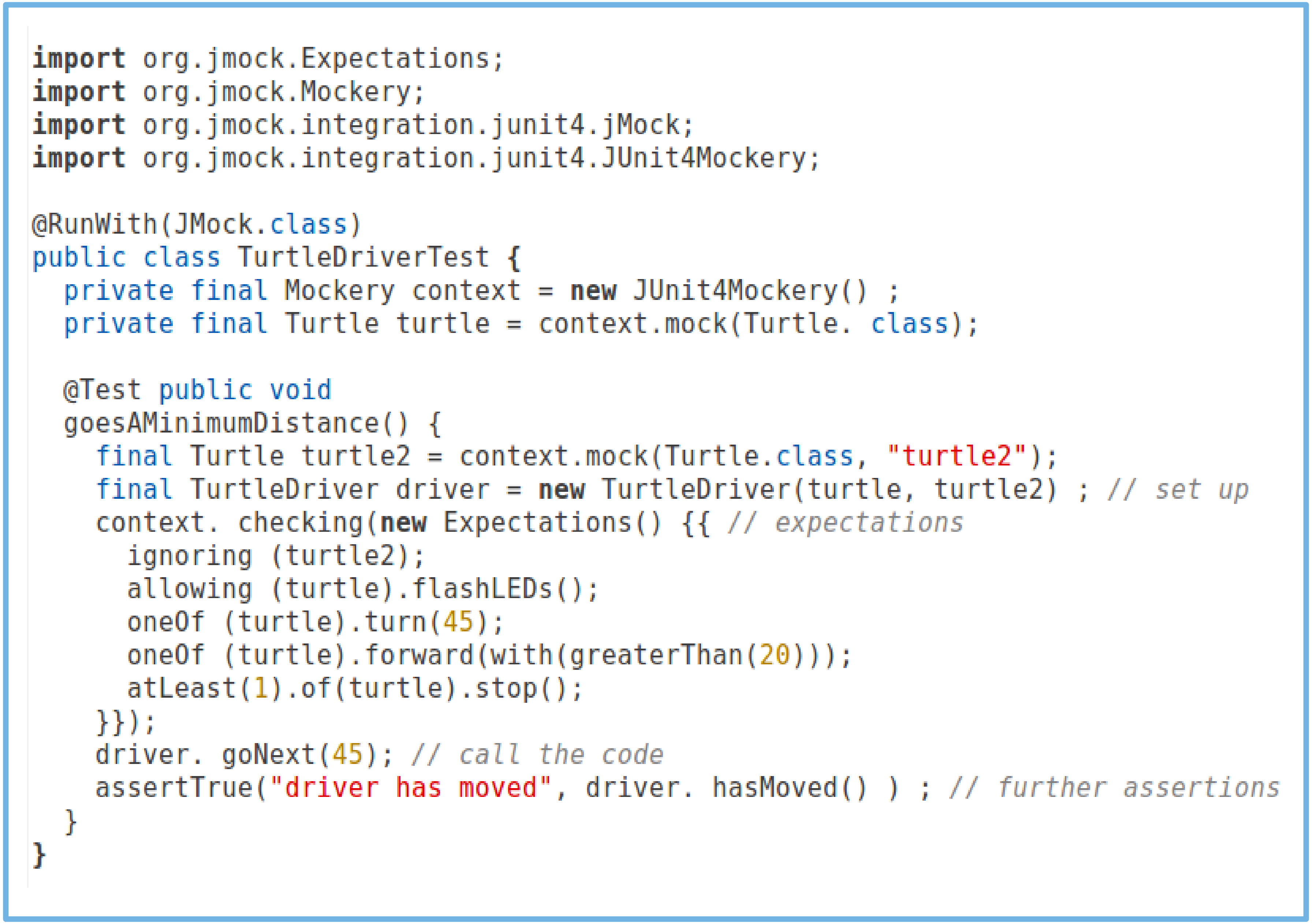
```
invocation-count
(mockobject).method(arguments);
inSequence(sequence-name);
when(state-machine.is(state-name));
will(action);
then(state-machine.is(new-state name));
```

JMock Working Example

JMock features (intro)

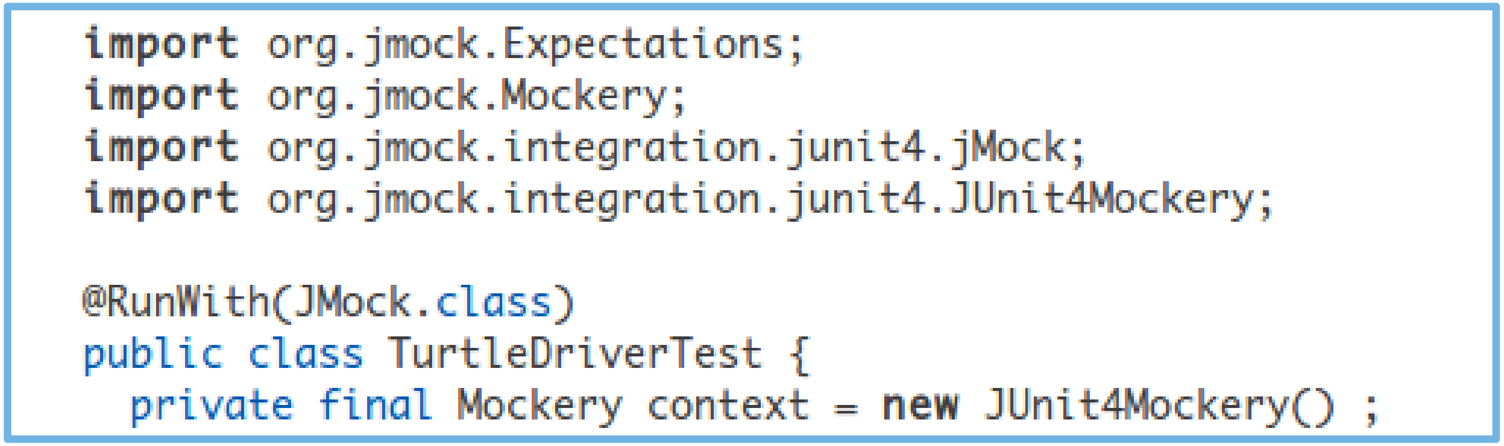
- JMock previsous versions required subclassing
  - Not so smart in testing
  - Now directly integrated with Junit4
  - JMock tests requires more typing
- JMock API is extensible

JMock Example



```java
import org.jmock.Expectations;
import org.jmock.Mockery;
import org.jmock.integration.junit4.jMock;
import org.jmock.integration.junit4.JUnit4Mockery;

@RunWith(JMock.class)
public class TurtleDriverTest {
  private final Mockery context = new JUnit4Mockery() ;
  private final Turtle turtle = context.mock(Turtle. class);

  @Test public void
  goesAMinimumDistance() {
    final Turtle turtle2 = context.mock(Turtle.class, "turtle2");
    final TurtleDriver driver = new TurtleDriver(turtle, turtle2) ; // set up
    context. checking(new Expectations() {{ // expectations
      ignoring (turtle2);
      allowing (turtle).flashLEDs();
      oneOf (turtle).turn(45);
      oneOf (turtle).forward(with(greaterThan(20)));
      atLeast(1).of(turtle).stop();
    }});
    driver. goNext(45); // call the code
    assertTrue("driver has moved", driver. hasMoved() ) ; // further assertions
  }
}
```

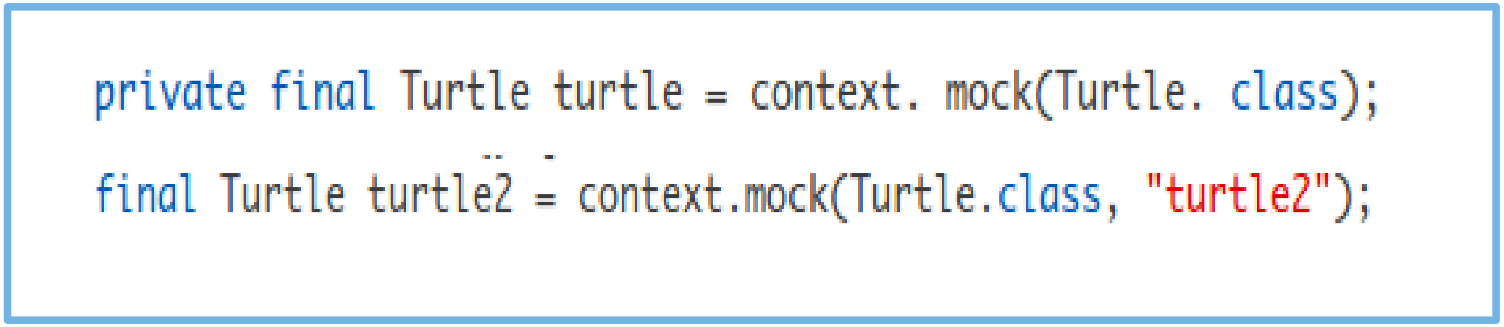
1. Test Fixture



```
import org.jmock.Expectations;
import org.jmock.Mockery;
import org.jmock.integration.junit4.jMock;
import org.jmock.integration.junit4.JUnit4Mockery;

@RunWith(JMock.class)
public class TurtleDriverTest {
  private final Mockery context = new JUnit4Mockery() ;
```

- ►Mockery represents the *context*
  - Neighboring objects it will communicate with
  - By convention the mockery is stored in an istance variable named context
- ►@RunWith(JMock.class) annotation
- ►JUnit4Mockery reports expectation failures as JUnit4 test failures

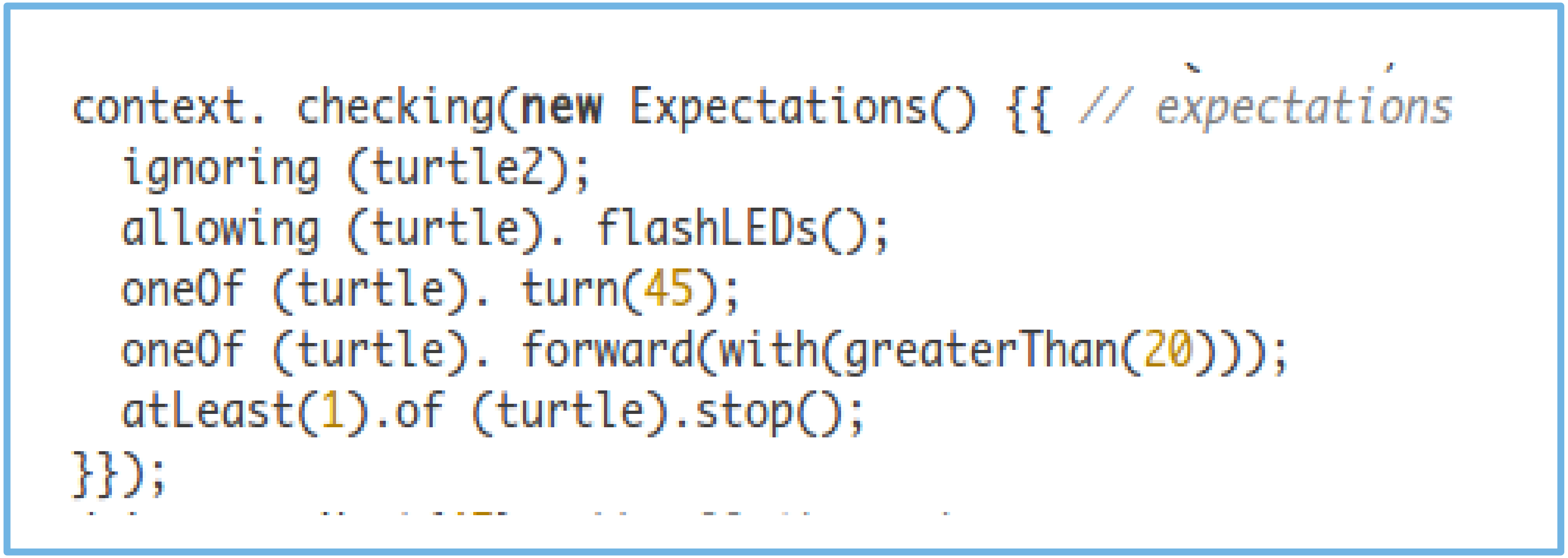
2. Create Mock Objects



```
private final Turtle turtle = context. mock(Turtle. class);

final Turtle turtle2 = context.mock(Turtle.class, "turtle2");
```

- ►The tests has two mock turtles
  - The first is a field in the test class
  - The second is local to the test
- ►References (fields and Vars) have to be `final`
  - Accessible from Anonymous Expectations
- ►The second mock has a specified name
  - JMock enforces usage of names except for the first (default)
  - This makes failures reporting more clear

3. Tests with Expectations

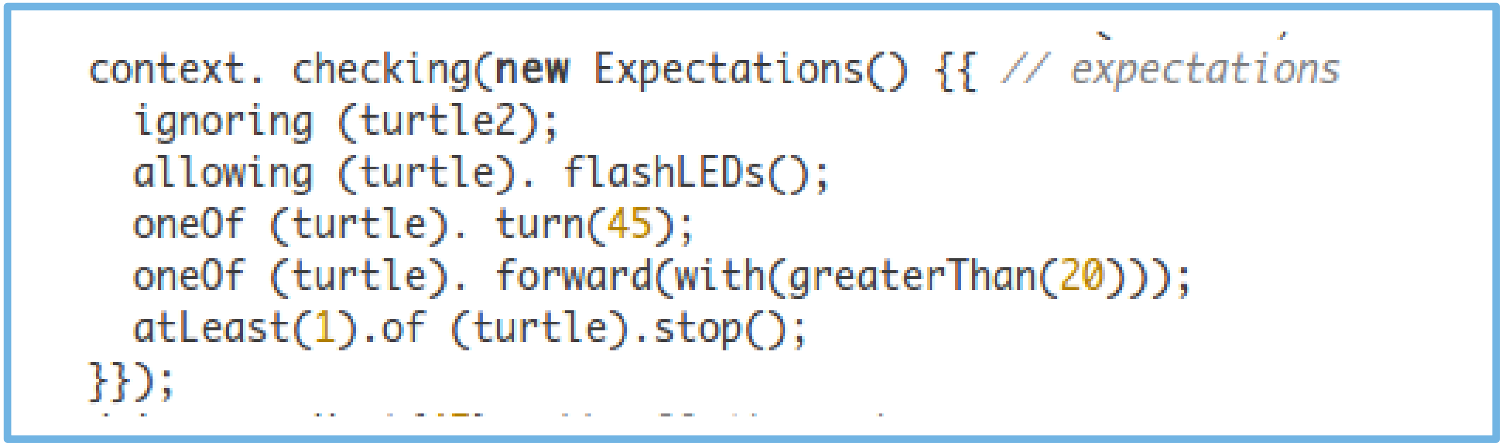


```
context. checking(new Expectations() {{ // expectations
  ignoring (turtle2);
  allowing (turtle). flashLEDs();
  oneOf (turtle). turn(45);
  oneOf (turtle). forward(with(greaterThan(20)));
  atLeast(1).of (turtle).stop();
}});
```

► A test sets up it expectations in one or more *expectation blocks*

- An expectation block can contain any number of expectations
- Expectation blocks can be interleaved with calls to the code under test.

3. Tests with Expectations



```
context. checking(new Expectations() {{ // expectations
  ignoring (turtle2);
  allowing (turtle). flashLEDs();
  oneOf (turtle). turn(45);
  oneOf (turtle). forward(with(greaterThan(20)));
  atLeast(1).of (turtle).stop();
}});
```

- Expectations have the following structure:

```
invocation-count
(mockobject).method(arguments);
inSequence(sequence-name);
when(state-machine.is(state-name));
will(action);
then(state-machine.is(new-state name));
```

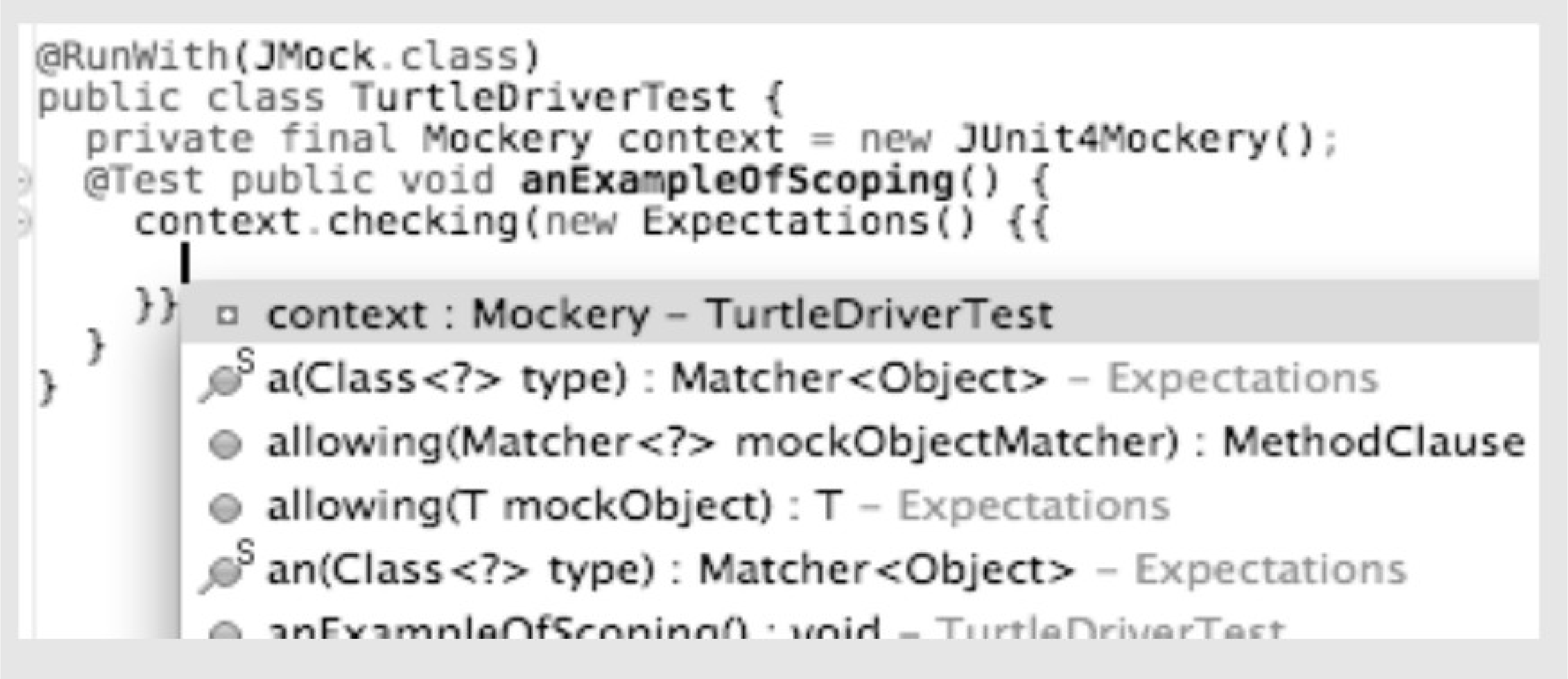
What are those double braces?

```
context.checking(new Expectations(){{
       oneOf(turtle).turn(45);
   }});
```

- Anonymous subclass of `Expectations`
- Baroque structure to provide a scope for building up expectations
  - Collection of expectation components
  - Is an example of **Builder Pattern**
  - Improves code completion

What are those double braces?

```
context.checking(new Expectations(){{
          oneOf(turtle).turn(45);
    }});
```



```
@RunWith(JMock.class)
public class TurtleDriverTest {
  private final Mockery context = new JUnit4Mockery();
  @Test public void anExampleOfScoping() {
    context.checking(new Expectations() {{

    }}
  }
}
```

context : Mockery – TurtleDriverTest
a(Class<?> type) : Matcher<Object> – Expectations
allowing(Matcher<?> mockObjectMatcher) : MethodClause
allowing(T mockObject) : T – Expectations
an(Class<?> type) : Matcher<Object> – Expectations
anExampleOfScoping() : void – TurtleDriverTest

Allowances and Expectations

```
context.checking(new Expectations(){{
   ignoring (turtle2);
   allowing (turtle).flashLEDs();
   oneOf(turtle).turn(45);
}});
```

- *Expectations* describe the interactions that are **essential** to the protocol we're testing
- *Allowances* **support** the interaction we're testing
  - `ignoring()` clause says that we don't care about messages sent to `turtle2`
  - `allowing()` clause matches any call to `flashLEDs` of `turtle`

Allowances and Expectations

```
context.checking(new Expectations(){{
   ignoring (turtle2);
   allowing (turtle).flashLEDs();
   oneOf(turtle).turn(45);
}});
```

- Distintion between *allowances* and *expectations* is not rigid
- **Rule of Thumb:**
  - ***Allow queries; Expect Commands***
- **Why?**
  - Commands could have side effects;
  - Queries don't change the world.

References

- ► Professional Java JDK 5 Edition
  - *Richardson et. al.*, Wrox Publications 2006
- ► Growing Object-Oriented Software, Guided By Tests
  - *Freeman and Pryce*, Addison Wesley 2010
- ► Jmock project site
  - http://jmock.org