DZone Refcardz

CONTENTS INCLUDE:

- About JUnit and EasyMock
- JUnit Lifecycle
- JUnit 4 Annotations
- EasyMock Object Lifecycle
- Recording Behavior in EasyMock
- Hot Tips and more...

JUnit and EasyMock

By Michael T Minella

ABOUT JUNIT AND EASYMOCK

Unit testing and test driven development are proven ways to improve both the productivity of a developer and the quality of their software. JUnit and EasyMock are the predominant choices for testing tools in the Java space. This reference card will guide you through the creation of unit tests with JUnit and EasyMock. It contains detailed definitions for unit testing and mock objects as well as a description of the lifecycle of each. The APIs for both JUnit and EasyMock are covered thoroughly so you can utilize these tools to their fullest extent.

UNIT TESTING

A unit test is a test of a single isolated component in a repeatable way. A test consists of four phases:

Prepare	Sets up a baseline for testing and defines the expected results.
Execute	Running the test.
Validate	Validates the results of the test against previously defined expectations.
Reset	Resets the system to the way it was before Prepare.

JUnit is a popular framework for creating unit tests for Java. It provides a simple yet effective API for the execution of all four phases of a unit test.

TEST CASE

A test case is the basic unit of testing in JUnit and is defined by extending `junit.framework.TestCase`. The `TestCase` class provides a series of methods that are used over the lifecycle of a test. When creating a test case, it is required to have one or more test methods. A test method is defined by any method that fits the following criteria:

- It must be public.
- It must return void.
- The name must begin with "test".

Optional lifecycle methods include `public void setUp()` and `public void tearDown()`. `setUp()`is executed before each test method, `tearDown()`is executed after each test method and the execution of both `setUp()` and `tearDown()` are guaranteed.

Figure 1

```
import junit.framework.TestCase;
public class FooTest extends TestCase {
   private Foo fooInstance;

   @Override
   public void setUp() {
      fooInstance = new Foo();
   }
```

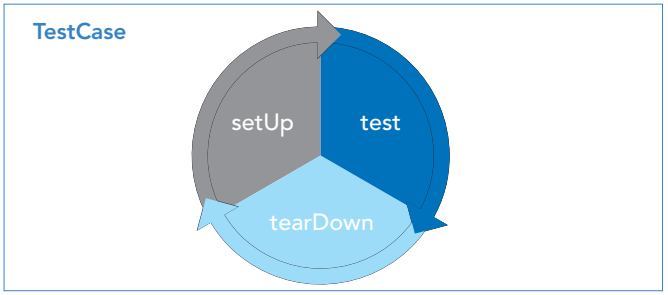
Test Case, continued

```
public void testBar() {
   assertNotNull("fooInstance was null", fooInstance);

   String results = fooInstance.bar();
   assertNotNull("Results was null", results);
   assertEquals("results was not 'success'",
      "success", results);
   }

   @Override
   public void tearDown(){
      fooInstance.close();
   }
}
```

Hot Tip Place test classes in the same package but different source folder as the class they are testing. That allows the test to have access to protected methods and attributes.

JUNIT LIFECYCLE

A JUnit test case can contain many test methods. Each method identified as a test will be executed within the JUnit test lifecycle. The lifecycle consists of three pieces: setup, test and teardown, all executed in sequence.



JUnit Lifecycle, continued

Lifecycle stage	Method called	Method description
Setup	`public void setUp()`	Called to do any required preprocessing before a test. Examples include instantiating objects and inserting test data into a database
Test	`public void testXYZ()`	Each test method is called once within the test lifecycle. It performs all required testing. Test results are recorded by JUnit for reporting to the test runner upon completion.
Teardown	`public void tearDown()`	Called to do any required post processing after a test. Examples include cleaning up of database tables and closing database connections.

Table 1. Lifecycle stage

All of the test methods are guaranteed to be executed. In JUnit 4 two more phases of the lifecycle were added, `beforeClass()` and `afterClass()`. These methods are executed once per test class (instead of once per test method as `setUp` and `tearDown` are), before and after respectively.

ASSERTIONS

Assertion	What it does
`assertNull(Object x)`	Validates that the parameter is `null`
`assertNotNull(Object x)`	Validates that the parameter is not `null`
`assertTrue(boolean x)`	Validates that the parameter is `true`
`assertFalse(boolean x)`	Validates that the parameter is `false`
`assertEquals(Object x, Object y)`	Validates that the two objects passed are equal based on the `.equals(Object obj1, Object obj2)` method
`assertSame(Object x, Object y)`	Validates that the two objects passed are equal based on the == operator
`assertNotSame(Object x, Object y)`	Validates that the two objects passed are not equal based on the == operator
`fail()`	Programmatically fail the test.

Table 2. Assertions

TESTS

Testing is about running code with a predictable set of inputs and verifying that the set of outputs you receive are as expected. JUnit is used to execute the code to be tested in an isolated manor so that those validations can be made.

Figure 2

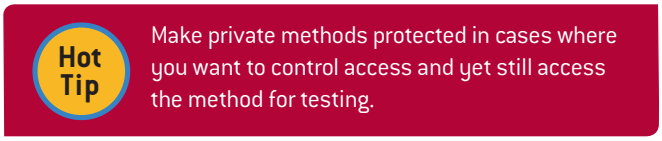
```
public void testGoodResultsBar() {
   String param1 = "parameter1";

   String results = foo.bar(param1);

   assertNotNull("results was null", results);
   assertEquals("results was not 'good'", "good",
    results);
}

public void testBadResultsBar() {
   try {
      String results = foo.bar(null);
   } catch (NullPointerException npe) {
      return;
   }
   fail();
}
```

`testGoodResultsBar()` tests a positive scenario. It passes in an expected value ("`parameter1`") into the method to be tested (`foo.bar()`) and validates that the results are as expected (the String "`good`").

The second test is an example of a negative test. It tests that an

Tests, continued

error condition is handled correctly. In `testBadResultsBar()`, `foo.bar()` is passed null expecting that a `NullPointerException` will be thrown. If it is not thrown, the test is considered a failure (indicated by the `fail()` call).



JUNIT 4 ANNOTATIONS

JUnit 4 added annotations to the framework and eliminated the need to extend `TestCase`. You can direct both the lifecycle events and other aspects of the test execution with the provided annotations.

Annotation	Parameters	Use
`@After`	None	Method will be executed after each test method (similar to the `tearDown()` method in JUnit 3.x). Multiple methods may be tagged with the `@After` annotation, however no order is guaranteed.
`@AfterClass`	None	Method will be executed after all of the test methods and teardown methods have been executed within the class. Multiple methods may be tagged with the `@AfterClass` annotation, however no order is guaranteed.
`@Before`	None	Method will be executed before each test method (similar to the `setUp()` method in JUnit 3.x). Multiple methods may be tagged with the `@Before` annotation, however no order is guaranteed.
`@BeforeClass`	None	Executed before any other methods are executed within the class. Multiple methods may be tagged with the `@BeforeClass` annotation, however no order is guaranteed.
`@Ignore`	String (optional)	Used to temporarily exclude a test method from test execution. Accepts an optional String reason parameter.
`@Parameters`	None	Indicates a method that will return a Collection of objects that match the parameters for an available constructor in your test. This is used for parameter driven tests.
`@RunWith`	Class	Used to tell JUnit the class to use as the test runner. The parameter must implement the interface `junit.runner.Runner`.
`@SuiteClasses`	Class []	Tells JUnit a collection of classes to run. Used with the `@RunWith(Suite.class)` annotation is used.
`@Test`	▪ Class(optional) ▪ Timeout(optional)	Used to indicate a test method. Same functionality as naming a method `public void testXYZ()` in JUnit 3.x. The class parameter is used to indicate an exception is expected to be thrown and what the exception is. The timeout parameter specifies in milliseconds how long to allow a single test to run. If the test takes longer than the timeout, it will be considered a failure.

Table 3. Annotations

Figure 3 shows two test cases, one using JUnit 3.x method names and one using JUnit 4 annotations.

Figure 3

JUnit 3.x

```
import junit.framework.TestCase;
public class FooTestCase extends TestCase {
   private Foo foo;
   @Override
```

JUnit 4 Annotations, continued

```
   public void setUp() {
      foo = new Foo();
   }
   public void testGoodResultsBar() {
      String param1 = “parameter1”;
      String results = foo.bar(param1);
      assertNotNull(“results was null”, results);
      assertEquals(“results was not ‘good’”, “good”,
       results);
   }
   public void testBadResultsBar() {
      try {
         String results = foo.bar(null);
      } catch (NullPointerException npe) {
         return;
      }
   fail();
   }
   @Override
   public void tearDown() {
      foo.close();
   }
}
```

JUnit 4

```
public class FooTestCase {
   private Foo foo;
   @Before
   public void buildFoo() {
      foo = new Foo();
   }
   @Test
   public void testGoodResultsBar() {
      String param1 = “parameter1”;
      String results = foo.bar(param1);
      assertNotNull(“results was null”, results);
      assertEquals(“results was not ‘good’”, “good”,
       results);
   }
   @Test
   public void testBadResultsBar() {
      try {
           String results = foo.bar(null);
      } catch (NullPointerException npe) {
           return;
      }
      fail();
  }
   @After
   public void closeFoo() {
      foo.close();
   }
}
```

Hot Tip When using JUnit 4, you do not need to extend **`junit.framework.TestCase`**. Any plain old java object (POJO) can be run as a test with the appropriate annotations.

Test Suites

A test suite is a collection of tests cases. It is used to run a collection of tests and aggregate the results. In JUnit 3.x., test suites can be used to parameterize test cases (parameterized tests are handled with annotations in JUnit 4) as well as group test cases together (in functional groups for example). There are two ways to create a test suite, programmatically and with annotations.

Test Suites, continued

Programmatically:

```
TestSuite suite = new TestSuite();
suite.addTest(new MyFirstTest());
suite.addTest(new MySecondTest());
suite.addTest(new MyThirdTest());
suite.run();
```

Annotations:

```
@RunWith(Suite.class)
@SuiteClasses({FooTest.class, BarTest.class})
public class AllTests{
   public static Test suite() {
      return new JUnit4TestAdapter(AllTests.class);
   }
}
```

Fixtures

A test fixture is a baseline environment used for testing. For example, if the method bar is to be tested on the object foo, the test should create a new instance of foo for each test. This will prevent any state related issues from interfering with future tests (variables left initialized from previous tests, objects left with invalid data, etc). Figure 1 is an example of a fixture. It creates a new instance of foo for each test and closes it after the execution of each test. This prevents any carryover issues from affecting the current test.

MOCK OBJECTS

Unit testing is the testing of a component in isolation. However, in most systems objects have many dependencies. In order to be able to test code in isolation, those dependencies need to be removed to prevent any impact on test code by the dependant code. To create this isolation, mock objects are used to replace the real objects.

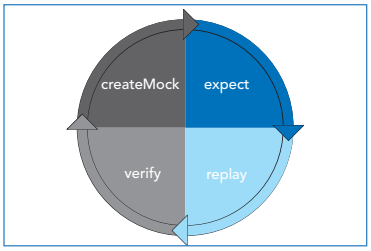
EASYMOCK

EasyMock is a framework for creating mock objects using the `java.lang.reflect.Proxy` object. When a mock object is created, a proxy object takes the place of the real object. The proxy object gets its definition from the interface or class you pass when creating the mock.

EasyMock has two sets of APIs. One is intended for creation and manipulation of mock objects that are based on interfaces, the other on classes (`org.easymock.EasyMock` and `org.easymock.classextensions.EasyMock` respectively). Both provide the same basic functionality; however classextensions does not have quite as extensive as an API as the regular EasyMock does.

EASYMOCK MOCK OBJECT LIFECYCLE

EasyMock has a lifecycle similar to JUnit. It contains four stages.



EasyMock mock object lifecycle, continued

Stage	Description
Create Mock	This phase creates the mock object.
Expect	This phase records the expected behaviors of the mock object. These will be verified at the end.
Replay	Replays the previously recorded expectations.
Verify	In order for a test to pass, the expected behaviors must have been executed. The verify phase confirms the execution of the expected calls.

Table 4. EasyMock stages

OBJECTS IN EASYMOCK

Type	Description
Regular	A test fails if a method is called that is not expected or if a method that is expected is not called. Order of method calls does not matter.
Nice	A test fails if a method is expected but not called. Methods that are called but are not expected are returned with a type appropriate default value (0, null or false). Order of method calls does not matter.
Strict	A test fails if a method is called that is not expected or if a method that is expected is not called. Order of method calls does matter.

Table 5. Types of mock objects in EasyMock

Hot Tip Use strict mocks if the order of processing matters.

Creating objects with EasyMock

There are two main ways to create a mock object using EasyMock, directly and thru a mock control. When created directly, mock objects have no relationship to each other and the validation of calls is independent. When created from a control, all of the mock objects are related to each other. This allows for validation of method calls across mock objects (when created with the `EasyMock.createStrictControl()` method).

Direct creation of mock objects

```
…
@Override
public void setUp() {
   UserDAO userDAO = EasyMock.createMock(UserDAO.class);
   CustomerDAO customerDAO =
   EasyMock.createMock(CustomerDAO.class);
}
…
```

Creation of a mock object thru a control

```
…
@Override
public void setUp() {
   IMocksControl mockCreator = EasyMock.createControl();
   UserDAO userDAO = mockCreator.createMock(UserDAO.
    class);
   CustomerDAO customerDAO =
mockCreator.createMock(CustomerDAO.class);
}
…
```

Table 6 describes the API available for creating mock objects. These are static methods that are available on both versions of EasyMock (regular and classextension). `createMock(MyInterface.class)` is also available from a mock control.

Creating objects with EasyMock, continued

Method	Description
`EasyMock.createMock(MyInterface.class)`	Creates a mock object based on the passed interface
`EasyMock.createNiceMock(MyInterface.class)`	Creates a nice mock object based on the passed interface
`EasyMock.createStrictMock(MyInterface.class)`	Creates a strict mock object based on the passed interface

Table 6. EasyMock method

RECORDING BEHAVIOR IN EASYMOCK

There are three groups of scenarios that exist when recording behavior: void methods, non void methods and methods that throw exceptions. Each of which is handled slightly different.

Void methods

Void methods are the easiest behavior to record. Since they do not return anything, all that is required is to tell the mock object what method is going to be called and with what parameters. This is done by calling the method just as you normally would.

Code being tested

```
…
foo.bar();
String string = “Parameter 2”;
foo.barWithParameters(false, string);
…
```

Mocking the behavior

```
…
Foo fooMock = EasyMock.createMock(Foo.class);
fooMock.bar();
fooMock.barWithParameters(false, “Parameter 2”);
…
```

Methods that return values

When methods return values a mock object needs to be told the method call and parameters passed as well as what to return. The method `EasyMock.expect()` is used to tell a mock object to expect a method call.

Code to be tested

```
…
String results = foo.bar();
String string = “Parameter 2”;
BarWithParametersResults bwpr = foo.
barWithParameters(false, string);
…
```

Mocking the behavior

```
…
Foo fooMock = EasyMock.createMock(Foo.class);
EasyMock.expect(foo.bar()).andReturn(“results”);
EasyMock.expect(foo.barWithParameters(false, “Parameter
2”))
   .andReturn(new BarWithParametersResults());
…
```

Methods that throw Exceptions

Negative testing is an important part of unit testing. In order to be able to test that a method throws the appropriate exceptions when required, a mock object must be able to throw an exception when called.

Methods that throw Exceptions, continued

Code to be tested

```
…
try {
   String fileName = “C:\tmp\somefile.txt”;
   foo.bar(fileName);
} catch (IOException ioe) {
   foo.close();
}
…
```

Mocking the behavior

```
…
Foo fooMock = EasyMock.createMock(Foo.class);
EasyMock.expect(fooMock.bar(“C:\tmp\somefile.txt”))
   .andThrow(new IOException());
foo.close();
…
```

Repeated Calls

There are times where a method will be called multiple times or even an unknown number of times. EasyMock provides the ability to indicate those scenarios with the `.times()`, `.atleastOnce()` and `.anyTimes()` methods.

```
…
Foo fooMock = EasyMock.createMock(Foo.class);
EasyMock.expect(foo.bar()).andReturn(“results”).
anyTimes();
EasyMock.expect(foo.barWithParameters(false, “Parameter
2”))
   .andReturn(new BarWithParametersResults()).
atLeastOnce();
…
```

Method	Description
`.atLeastOnce()`	Requires that the method call be executed 1 or more times.
`.times(int min, int max)`	The number of times the method is called must fall within the specified range (inclusive).
`.anyTimes()`	Requires that the method be called 0 or more times.

Table 7. Time methods

Matchers in EasyMock

When replaying recorded behavior in EasyMock, EasyMock uses the `.equals()` to compare if the passed parameters are what are expected or not. On many objects, this may not be the desired behavior (arrays are one example). EasyMock has a collection of matchers to solve this issue. Matchers are used to compare things in ways other than the `.equals()` method. Custom matchers can be created by implementing the `org.easymock.IArgumentMatcher` interface.

Matcher in action

```
...
String [] array1 = {“one”, “two”, “three”};
Foo fooMock = EasyMock.createMock(Foo.class);
EasyMock.expect(fooMock.getMiddleElement(
EasyMock.aryEq(array1)).andReturn(“two”);
…
```

Method	Description
`eq(Object obj)`	Accepts a value that is equal to obj
`anyBooelan(),anyByte(), anyChar(), anyDouble(), anyFloat(), anyInt(), anyLong(), anyObject, anyShort()`	Accepts any value of the corresponding type.

Matchers In EasyMock, continued

Method	Description
`eq(float x, float range), eq(double x, double range)`	Accepts any value of a float or double within the appropriate ± range.
`aryEq(Array x)`	Compares the array based on the `Array.equals()` method.
`isNull()`	Accepts only `null`
`notNull()`	Accepts any object that is not `null`
`same(Object x)`	Compares x based on the == method instead of `.equals()`
`isA(Class clazz)`	Accepts any object if it is an instance of, descendant of or implements clazz.
`lt(NumericPrimitave x), leq(NumericPrimitave x), geq(NumericPrimitave x), gt(NumericPrimitave x)`	Accepts a numeric primitive <, ≤, ≥, > the number provided.
`startsWith(String x), contains(String x), endsWith(String x)`	Accepts any String that starts with, contains or ends with the specified String. x is an actual value not a regular expression.
`and(x, y), or(x, y), not(x)`	Accepts an object that is either equal to x and y, x or y, or not x respectively

Table 8. Matcher in action

REPLAYING BEHAVIOR WITH EASYMOCK

Once the behavior of the mock objects has been recorded with expectations, the mock objects must be prepared to replay those expectations. Mock objects are prepared by calling the `replay()` method and passing it all of the mock objects to be replayed.

Replaying expectations in EasyMock

```
…
Foo fooMock = EasyMock.createMock(Foo.class);
EasyMock.expect(fooMock.doSomething(parameter1,
parameter2)).andReturn(new Object());
EasyMock.replay(fooMock);
…
```

VALIDATION OF EXPECTATIONS WITH EASYMOCK

The final step in the mock object lifecycle is to validate that all expectations were met. That includes validating that all methods that were expected to be called were called and that any calls that were not expected are also noted. To do that, `EasyMock.verify()` is called after the code to be tested has been executed. The `verify()` method takes all of the mock objects that were created as parameters, similar to the `replay()` method.

Validating method call expectations

```
…
Foo fooMock = EasyMock.createMock(Foo.class);
EasyMock.expect(fooMock.doSomething(parameter1,
Parameter2)).andReturn(new Object());
EasyMock.replay(fooMock);
Bar bar = new Bar();
bar.setFoo(fooMock);
EasyMock.replay(fooMock);
bar.runFoo();
EasyMock.verify(fooMock);
…
```

JUNIT EXTENSIONS

JUnit provides a basic set of functionality that is applicable to all types of testing. JUnit extensions are projects that add on features that are specific to a particular type of testing. Table 9 shows a list of the more popular extensions.

Add-on	URL	Use
DbUnit	http://dbunit.sourceforge.net/	Provides functionality relevant to database testing including data loading and deleting, validation of data inserted, updated or removed from a database, etc.
HttpUnit	http://httpunit.sourceforge.net/	Impersonates a browser for web based testing. Emulation of form submission, JavaScript, basic http authentication, cookies and page redirection are all supported.
EJB3Unit	http://ejb3unit.sourceforge.net/	Provides necessary features and mock objects to be able to test EJB 3 objects out of container.
JUnitPerf	http://clarkware.com/software/JUnitPerf.html	Extension for creating performance and load tests with JUnit.

Table 9. JUnit Extensions

USEFUL ONLINE RESOURCES

The internet holds a large collection of resources on test driven development, JUnit and EasyMock. Table 10 lists just a few of the more popular resources.

Technology	URL
Mock Objects	http://www.mockobjects.com
EasyMock	http://www.easymock.org
JUnit	http://www.junit.org
JUnit	http://junit.sourceforge.net
Test Driven Development	http://www.testdriven.com
Yahoo EasyMock Group	http://groups.yahoo.com/group/easymock
Yahoo JUnit Group	http://tech.groups.yahoo.com/group/junit

Table 10. Resources

ABOUT THE AUTHOR

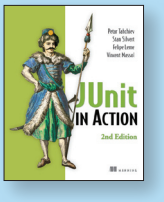
Michael T Minella

Michael Minella's technical background runs the gambit. From the first programming language he ever learned, mainframe Assembler, to the languages he is using now (Java and Ruby) he has been all over the map. His passion is in quality software development and the sharing of knowledge with others thru mentoring and formal teaching.

Blog and Tutorials

http://www.michaelminella.com

RECOMMENDED BOOK



JUnit in Action, Second Edition is an up-to-date guide to unit testing Java applications (including Java EE applications) using the JUnit framework and its extensions. This book provides techniques for solving real-world problems such as testing AJAX applications, using mocks to achieve testing isolation, in-container testing for Java EE and database applications, and test automation.

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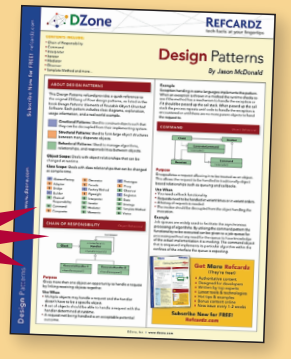

Design Patterns
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