POWERING
POTENTIAL

TESTING

TEST DOUBLES

WHAT ARE TEST DOUBLES?

- Your code interacts with other things
  - Network resource – database, web service, etc.
  - Code being developed in parallel by another person/team
  - Container (e.g. objects with lifecycle methods)

- **Collaborators**: objects with which the class under test interacts with
- If the collaborator doesn't exist yet or isn't available, use a substitute called a **test double**

Test doubles allow you to…

- Run the test in its real environment
- Test interactions between your class and the rest

WHAT IS MOCKING?

- A method for testing your code functionality in isolation
- Does not require:
  - Database connections
  - File server reads
  - Web services
- The mock object itself does the 'mocking' of the real service, returning dummy data
- The mock object simulates the behaviour of a real method, external component

MOCK OBJECTS

Mock: 'an object created to stand in for an object that your code will be collaborating with. Your code can call methods on the mock object, which will deliver results as set up by your tests'

– Massol, p. 141

To mock a database ResultSet:

- You are not creating an object with state, you are creating an object which will respond to method calls from your code as if it had a certain state

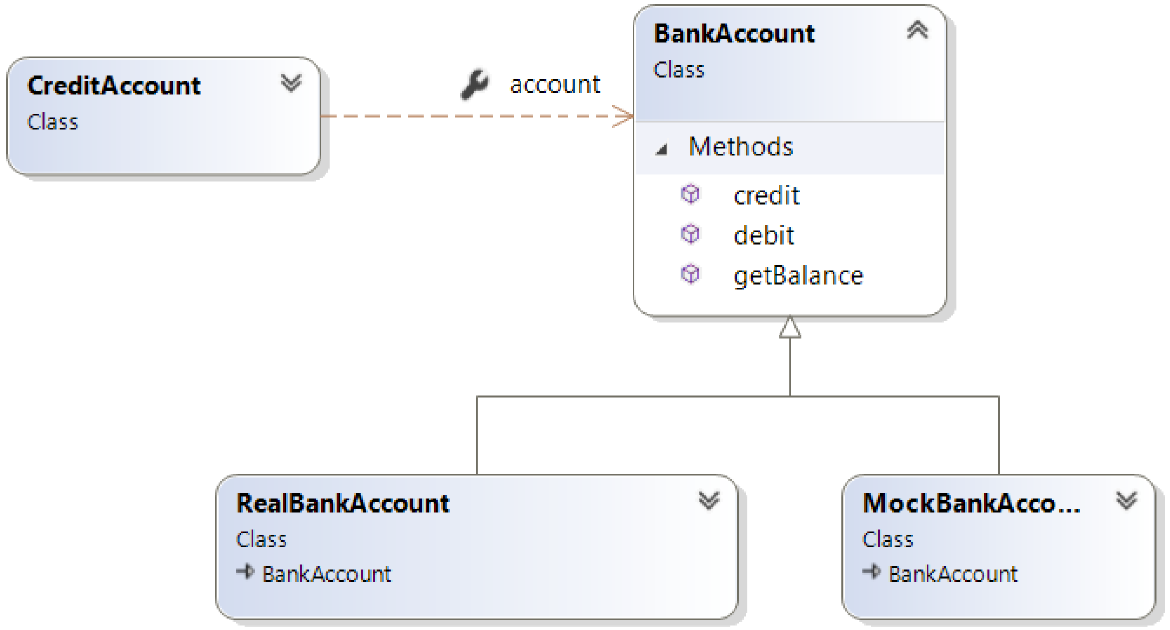
Several Dynamic Mock Frameworks in Java:

- EasyMock
- JMock
- Mockito
- Powermock
- JMockit and more

WHEN TO USE MOCK OBJECTS

When the real object...

- Has non-deterministic behaviour
- Is difficult to set up
- Has behaviour that is hard to cause (such as network error)
- Is slow
- Has (or is) a UI
- Uses a callback (tests need to query the object, but the queries are not available in the real object (for example, ‘was this callback called?’)
- Does not yet exist



From *Endo-testing: Unit Testing with Mock Objects*, Mackinnon, Freeman and Craig

DRAWBACKS OF MOCK OBJECTS

1. Mocks don’t test interactions with container or between the components.
2. Tests are coupled very tightly to implementation.
3. Mocks don’t test the deployment part of components.
4. Most frameworks can’t mock static methods, final classes and methods

The first three points here are adapted from Massol, *JUnit In Action*, p. 171.

STUBS

Stub: controllable replacement for existing dependency

- A class which is (ideally) the simplest possible implementation of the logic in the real code
- Provide pre-programmed answers to calls they receive
- Won't respond to anything outside of what you've programmed

Good for:

- Coarse-grained testing, e.g. replacing a complete external system

Drawbacks:

- Often complex to write
- Introduce their own debugging & maintenance issues

MOCKS VS STUBS

- Not mutually exclusive; you can combine their use
- Both can be handwritten, simple classes – simplicity and readability are at an advantage over frameworks
- **Stubs** enable tests by replacing external dependencies
- Asserts are against the Class Under Test, not the stub

$$\begin{tikzcd}
\text{Test} \arrow[r, leftrightarrow, "\text{asserts}"'] & \textbf{CUT} \arrow[r, leftrightarrow, "\text{interacts}"'] & \text{Stub}
\end{tikzcd}$$

- Using a **mock** is much like using a stub, except that the mock will record the interactions, which can be verified
- Asserts are verified against the mock

$$\begin{tikzcd}
\text{CUT} \arrow[r, leftrightarrow, "\text{interacts}"'] & \textbf{Mock} \arrow[r, leftrightarrow, "\text{asserts}"'] & \text{Test}
\end{tikzcd}$$

WHAT IS DEPENDENCY INJECTION (DI)?

- Injecting dependencies means setting relations between instances
- It helps to remove tight coupling
- Use interfaces instead of concrete classes to illustrate a dependency:

```
public interface IEngine { }
public class FastEngine implements IEngine { }
```

tight coupling

-
```
public class FastEngine {
    private IEngine engine;
    public FastEngine(IEngine engine) {
        this.engine = engine;
    }
}
```

Dependency Injection Methodology

- Rather than creating concrete instances, inject them at runtime
- Need a way to manage (or wire) the dependencies

  Java's Spring framework

- Two ways to perform dependency injection:

```java
public class Owner {
    Pet pet;

    public Owner(Pet pet)  {
        this.pet = pet;
    }
}
```

Constructor

```java
public class Owner {
    Pet pet;

    public void setPet(Pet pet)  {
        this.pet = pet;
    }
}
```

Setter

DEPENDENCY INJECTION EXAMPLE

Without injection:

```
public void print() {
    Owner owner = new Owner();
    owner.setName("Bob");
    owner.setId(98765);
    System.out.println("Owner " +owner.getId()
        + " is " +owner.getName());
}
```

Using injection:

```
public void print(Owner owner) {
    System.out.println("Owner " +owner.getId()
        + " is " +owner.getName());
}
```

DEPENDENCY INJECTION CONTAINERS

- Containers inject the mock objects into your unit tests during unit testing
- Some DI containers include:
  - Spring DI
  - Butterfly DI Container
  - Dagger
  - Guice
  - PicoContainer
- Many unit tests don’t require a DI container if their dependencies are simple to mock out

CODE EXAMPLES

Code example are offered in your next lab but for more examples of using **mocks** and **stubs** please see:

04-B Testing Mocks and stubs.pptx

LAB

"Test Doubles" Lab

Creating Mocks and Stubs

Revision material

Stubs and Mocks

Stub:

→ Used to create a class that returns data to a test

→ Data should be easily created and will always stay the same.

→ They don't show how a class interacts with the system.

→ Just provides data.

→ MOQ frameworks can create Stubs.

Stubs and Mocks

Mock:

→ When your class interacts with the system.

→ Created using MOQ frameworks.

→ Can provide the same functionality as the Stub
but Stubs are easier to create.

→ They could create the same functionality as the class under test.

Creating mocks and stubs with C#

Using a hand-crafted Stub – Using an interface

```
public interface IFileReader
{
    string ReadFirstLine();
}
```

```
public class StubFileReader : IFileReader {
    public string ReadFirstLine()  {
        return "10 Pen 60p";
    }
}
```

```
public class Order {
    public string ProcessOrder(IFileReader fileReader)  {
        string line= fileReader.ReadFirstLine();
        // process information
        // if(process OK) {
                   email();
                   return true;
           }
           return false;
    }
    public virtual void email() {
        // code to email a message
    }
}
```

```
[TestMethod]
public void TestOrder() {
    Order ord = new Order();
    Assert.IsTrue(ord.ProcessOrder(new StubFileReader());
}
```

Using Moq to mock objects

```
public interface IFileReader
{
    string ReadLine(int ln);
}
```

```
[TestMethod]
public void TestMethod1()
{
    var moqFileReader = new Mock<IFileReader>();

    moqFileReader.Setup(f => f.ReadLine(1)).Returns("10 Pen 60p");
    moqFileReader.Setup(f => f.ReadLine(2)).Returns("15 Ruler 120p");
    var oReader = new Order();
    bool res = oReader.ProcessOrder(moqFileReader.Object);
    Assert.IsTrue(res);
}
```

Using TestInitialize (Moq with MsTest)

```
[TestClass]
public class Temp {

    Order oReader;
    IFileReader fileReader;

    [TestInitialize]
    public void Initialize()
    {
        var moqFileReader = new Mock<IFileReader>();
        moqFileReader.Setup(f => f.ReadFirstLine()).Returns("10 Pen 60p");
        fileReader = moqFileReader.Object;
        oReader = new Order();
    }

    [TestMethod]
    public void TestMethod1()
    {
        bool res = oReader.ProcessOrder(fileReader);
        Assert.IsTrue(res);
    }
}
```

```
public interface IFileReader
{
    string ReadFirstLine();
}
```

Creating mocks and stubs with Java

Using Mockito with Java

- Mockito is a very useful app for java developers to mock external dependencies.
- To use **Mockito**, you need to set it up for you application.
- See here for a Maven project's POM file.

```
<dependencies>
       <dependency>
              <groupId>org.junit.jupiter</groupId>
              <artifactId>junit-Jupiter-api</artifactId>
              <version>5.9.1</version>
              <scope>test</scope>
       </dependency>
       <dependency>
              <groupId>org.mockito</groupId>
              <artifactId>mockito-core</artifactId>
              <version>4.6.1</version>
              <scope>test</scope>
       </dependency>
```

```
       <dependency>
              <groupId>org.mockito</groupId>
              <artifactId>mockito-junit jupiter</artifactId>
              <version>4.6.1</version>
              <scope>test</scope>
       </dependency>
</dependencies>
```

Using Mockito - setting expectations

- Create an interface for the actual system that your application depends on.
- Then ask Mockito to create a mock and setup the methods' expected values.
- You can create a Stub, but you will have to code it and maintain it in your project.

```
public class StubDatabase implements QADatabase {
  public String getUsernameByID(int id) {
    String[] names = {"Bob","Anna","Mike","David","Lily", "Fred", "Kimberly"};

    if (id < names.length)
        return names[id];
    else
        return null;
    }
}
```

So, how do we get Mockito to do all this for us? Let’s see…

Mocking an object using Mockito

```
public interface QADatabase {
    public String getUsernameByID(int id);
}
```

Object to mock

Class requiring the mock

```
public class QAController {
  private QADatabase qaDb;

  public QAController(QADatabase db) {
      this.qaDb = db;
  }
}
```

```
@ExtendWith(MockitoExtension.class)
public class FirstTest {

   @Mock
   QADatabase db;

   @InjectMocks
   QAController controller;

   @Before
   public void setUp() {
       Mockito.when(db.getUsernameByID(1)).thenReturn("Bob");
    }
}
```

SUMMARY

- In this chapter you learn how to create a Stub and how to create a mock

C# EXTRA MATERIAL

- Let’s explore using mock objects in more detail

MOQ –Another example

```
public interface ILogin {
          bool isValidUser(string uname, string pass, int userType);
}
```

```
public class Company {
    public bool registerEmployee(string uname, string password, ILogin login, int userType) {
        // ... some code
        if (!isValidUser(uname, password, login, userType))
            return false;
        //... Register the user
        return true;
    }

    public bool isValidUser(string uname, string password, int userType) {
        return login.isValidUser(uname, password, userType);
    }
}
```

```
[TestMethod]
public void StockInformationTestTDD_GetStockInfoIsCalled() {
    Mock<ILogin> mockLogin = new Mock<ILogin>();
    mockLogin.Setup(log => log.isValidUser("mike", "password123", 1)).Returns(true);
    mockLogin.Setup(log => log.isValidUser("Bob", "pass1", 1)).Returns(false);
    Company qa = new Company();

    Assert.IsTrue(qa.registerEmployee("mike", "password123", mockLogin.Object, 1));
}
```

MOQ – Parameter type of Any

```
public interface Ilogin {
    bool VerifyUser(string userName, string password, int userType);
}
```

```
Mock<ILogin> mockLogin;

[TestInitialize]
public void testInitialize() {
    mockLogin = new Mock<ILogin>();
    mockLogin.Setup(x => x.VerifyUser("Bob", "Password123", It.IsAny<int>())).Returns(true);
    mockLogin.Setup(x => x.VerifyUser("Steve", "sa", 2)).Returns(true);

    login.Setup(x => x.VerifyUser(It.IsAny<string>(), It.IsAny<string>(),
                                                        It.IsNotIn(1, 2))).
                                                        Throws<ArgumentException>();
}

[TestMethod]
public void TestRegisterEmployeeWithValidUserType() {
    var qa = new Company();
    Assert.IsTrue( qa.registerEmployee("mike", "password123", mockLogin.Object, 1) );
}
```

MOQ – Mock Exceptions

```
public interface Ilogin {
    bool Verify(string userName, string password, int userType);
}
```

```
[TestInitialize]
public void testInitialize() {
    mockLogin = new Mock<ILogin>();
    mockLogin.Setup(x => x.VerifyUser("Bob", "Password123", It.IsAny<int>())).Returns(true);
    mockLogin.Setup(x => x.VerifyUser("Steve", "sa", 2)).Returns(true);

    login.Setup(x => x.VerifyUser(It.IsAny<string>(), It.IsAny<string>(),
                                                       It.IsNotIn(1, 2))).
                                                       Throws<ArgumentException>();
}

[TestMethod]
[ExpectedException(typeof(ArgumentException))]
public void TestNullUserName()
{
    var qa = new Company();
    qa.registerEmployee("mike", "password123", mockLogin.Object, 99) );
}
```

MOQ – verify a method was called

```
public interface ILogWriter  {
    void Write(string message);
}
public class LogWriter : ILogWriter
{
    public void Write(string message)  {
        Console.WriteLine(message);
    }
}
```

```
public class MyProcessor
{
    public void Start(ILogWriter _writer)
    {
        _writer.Write("my message");
    }
}
```

```
[TestClass]
public class MyProcessorTest {
    private Mock<ILogWriter> _writer;

    [TestInitialize]
    public void SetUp() {
        _writer = new Mock<ILogWriter>();
        _writer.Setup(x => x.Write(It.IsAny<string>()));
    }
    [TestMethod]
    public void Succesfully_writeLog()
    {
        new MyProcessor().Start(_writer.Object);
        _writer.Verify(x => x.Write(It.IsAny<string>()), Times.Once());
    }
}
```

Real-life example of a Stub

The following code example shows a practical example of using a Stub.

There are cases when the data modules are not available or it is undesirable to use.

Repository example – The Interface

First define an interface

All data operation which the business layer wish to perform

```
public interface INorthwindRepository
{
    IEnumerable<Customer> GetCustomers();
    IEnumerable<Customer> GetCustomersByCity(string city);
    Customer GetCustomerByID(string id);
    void DeleteCustomer(Customer cus);
    void DeleteCustomerByID(string id);
    void AddCustomer(Customer cus);
}
```

You may then add real business methods in another layer which uses this interface

Repository Classes – Implement the interface

```
public class SQLNorthwindRepository : INorthwindRepository  {
    Northwind context = new Northwind();       // better in a constructor
    public void AddCustomer(Customer cus) {
        context.Customers.Add(cus);
        context.SaveChanges();
    }
    public void DeleteCustomer(Customer cus) {
        context.Customers.Remove(cus);
        context.SaveChanges();
    }
    public void DeleteCustomerByID(string id) {
        context.Customers.Remove(GetCustomerByID(id));
        context.SaveChanges();
    }
    public IEnumerable<Customer> GetCustomers() {
        return context.Customers;
    }
    public IEnumerable<Customer> GetCustomersByCity(string city) {
        return context.Customers.Where(c => c.City == city);
    }
    public Customer GetCustomerByID(string id) {
        return context.Customers.Single(c => c.CustomerID == id);
    }
}
```

Refactor

When many Controller's Actions need to use a repository consider:

→ Creating class level variable (based on the repository interface)

→ Instantiate the object in constructor chain

```
public class HomeController : Controller
{
    INorthwindRepository northwindRepository;
    public HomeController() : this(new SQLNorthwindRepository())  {
    }
    public HomeController(INorthwindRepository repository) {
        this.northwindRepository = repository;
    }
    public ActionResult Index()  {
        return View(northwindRepository.GetCustomers().ToList());
    }
}
```

But why?

Testing Your Controller – Building a Stub

By basing the repository on an interface, it’s easy to implement a “stub” for testing:

```
public class StubNorthwindRepository : INorthwindRepository
{
        IEnumerable<Customer> customers;
        public StubNorthwindRepository ()  {
            customers = new List<Customer>() {
new Customer(){CompanyName="QA", ContactName="Mike", City="London", CustomerID="AAAAA" },
new Customer(){CompanyName="BA", ContactName="Dean", City="London", CustomerID="BBBBB" },
new Customer(){CompanyName="QA", ContactName="Steve", City="Leeds", CustomerID="CCCCC" },
new Customer(){CompanyName="QA", ContactName="Victor", City="London",CustomerID="DDDDD"}
        };
        }
        public IEnumerable<Customer> GetCustomers() {
            return customers;
        }
        public IEnumerable<Customer> GetCustomersByCity(string city)   {
            return customers.Where(c => c.City == city);
        }
   // other methods
}
```

Testing Your Controller – Using the Stub

Use the overloaded constructors to pass in your test repository

and test the returned object

```
 [TestClass]
 public class HomeControllerTest     {
    [TestMethod]
    public void Index() {
       // Arrange
       HomeController controller = new HomeController( new StubNorthwindRepository());

       // Act
       ViewResult result = controller.Index() as ViewResult;
       IEnumerable<Customer> model = (IEnumerable<Customer>)result.Model;


       // Assert
       Assert.AreEqual(96, model.Count());
   }
}
```

Use the Stub

Cast

Check the Model