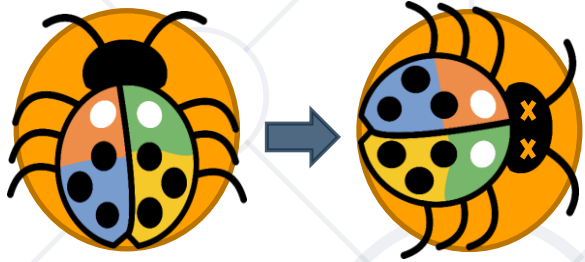


Unit Testing

Building Rock-Solid Software



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Technical Trainers



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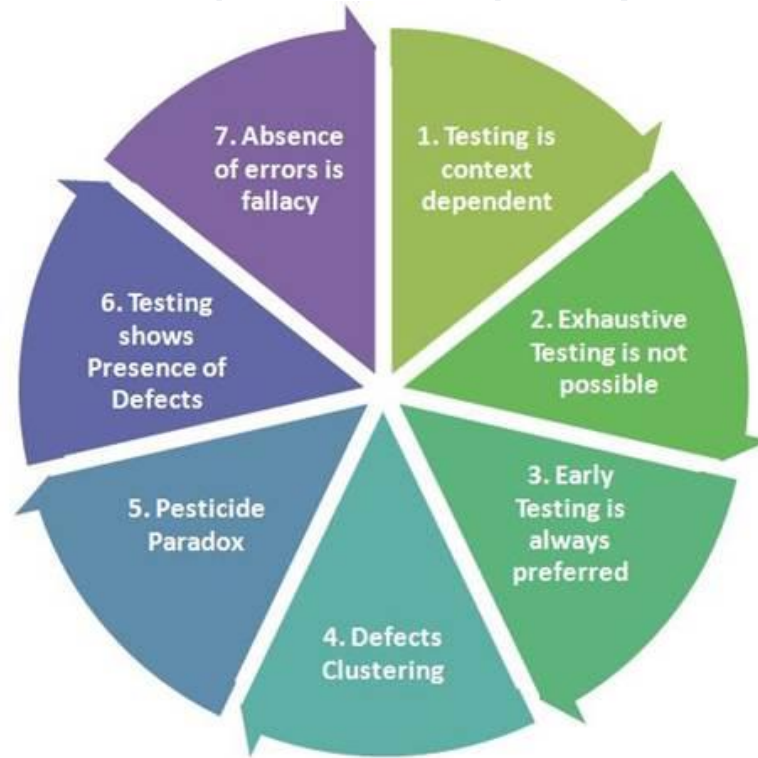
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#java-advanced

1. Seven Testing Principles
2. What Is Unit Testing?
 - Unit Testing Frameworks - JUnit
 - 3A Pattern
3. Best Practices
4. Dependency Injection
5. Mocking and Mock Objects

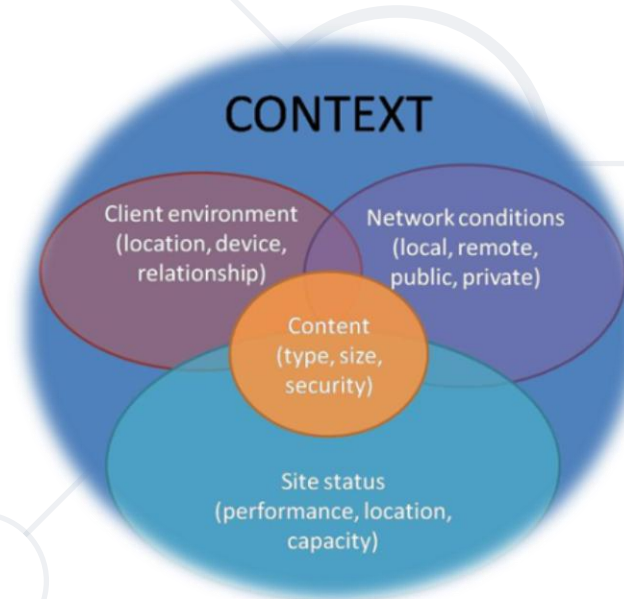




Seven Testing Principles

Seven Testing Principles (1)

- Testing is context dependent
 - Testing is done differently in **different contexts**
- Example:
 - Safety-critical software is tested **differently** from an e-commerce site



Seven Testing Principles (2)

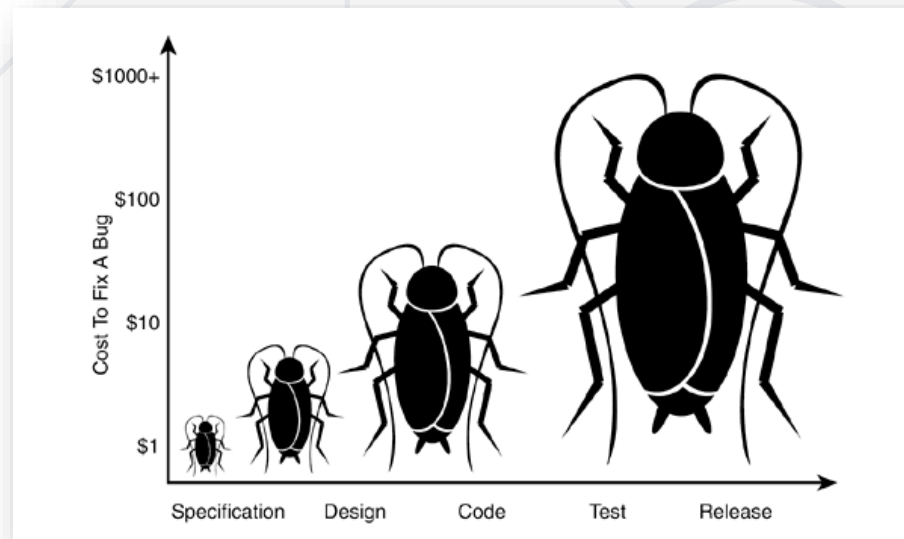
- Exhaustive testing is **impossible**
 - All combinations of inputs and preconditions are usually an almost **infinite number**
 - Testing everything is not feasible
 - Except for trivial cases
- Risk analysis and priorities should be used to focus testing efforts

Seven Testing Principles (3)

- Defect clustering
 - Testing effort shall be focused **proportionally**
 - To the expected and later observed defect density of modules
 - A **small number** of modules usually contains **most of the defects** discovered
 - Responsible for most of the operational failures

Seven Testing Principles (4)

- Early testing is **always preferred**
 - Testing activities shall be started as early as possible
 - And shall be focused on defined objectives
 - The later a bug is found – the more it costs!



Seven Testing Principles (5)

- Pesticide paradox
 - Same tests repeated **over and over again** tend to **lose their effectiveness**
 - Previously **undetected** defects remain **undiscovered**
 - New and modified test cases should be developed

Seven Testing Principles (6)

- Testing shows presence of defects
 - Testing can **show that defects are present**
 - Cannot prove that there are no defects
 - Appropriate testing **reduces** the probability for defects

Seven Testing Principles (7)

- Absence-of-errors fallacy
 - **Finding** and **fixing** defects itself does not help in these cases:
 - The system built is unusable
 - Does not fulfill the users needs and expectations



What is Unit Testing

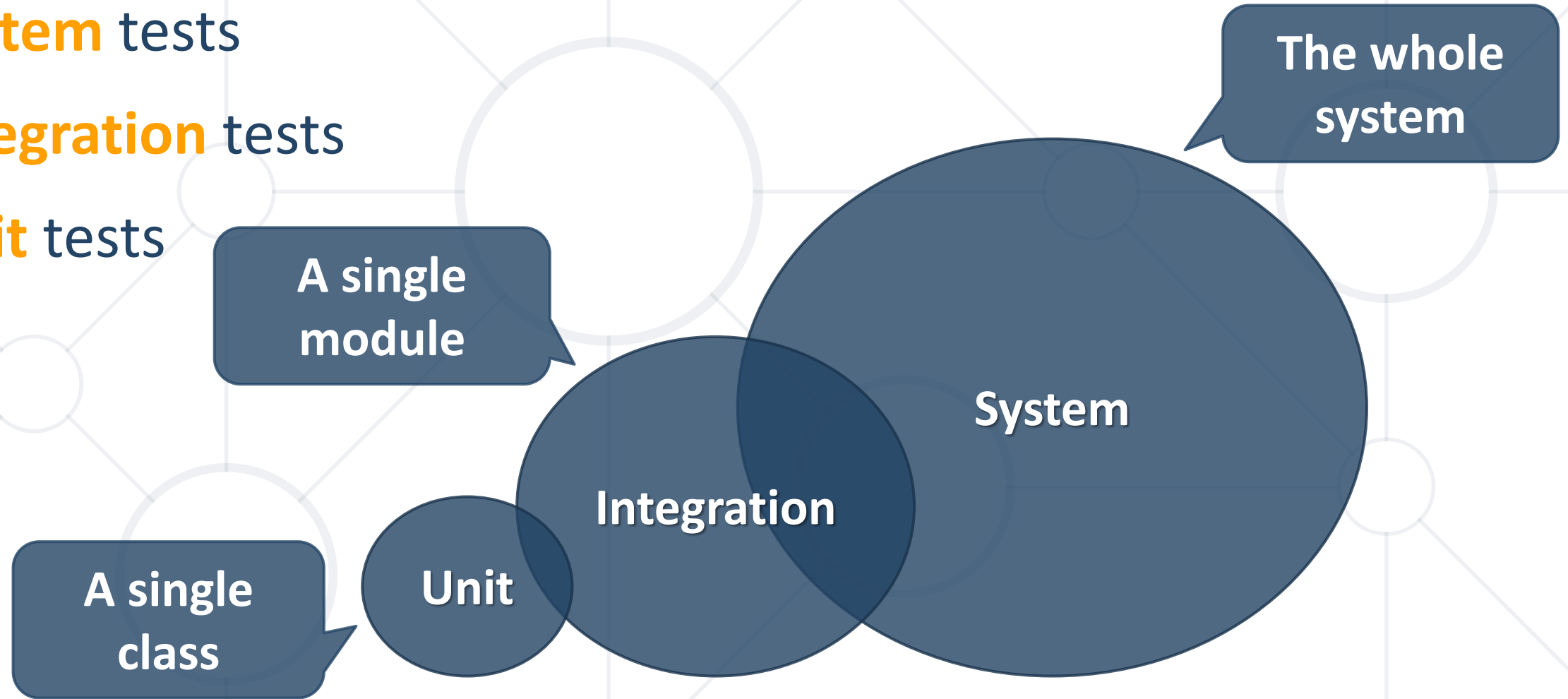
Manual Testing (1)

- 
- Not **structured**
 - Not **repeatable**
 - Can't **cover** all of the code
 - **Not** as **easy** as it should be

```
void testSum() {  
    if (this.sum(1, 2) != 3) {  
        throw new Exception("1 + 2 != 3");  
    }  
}
```

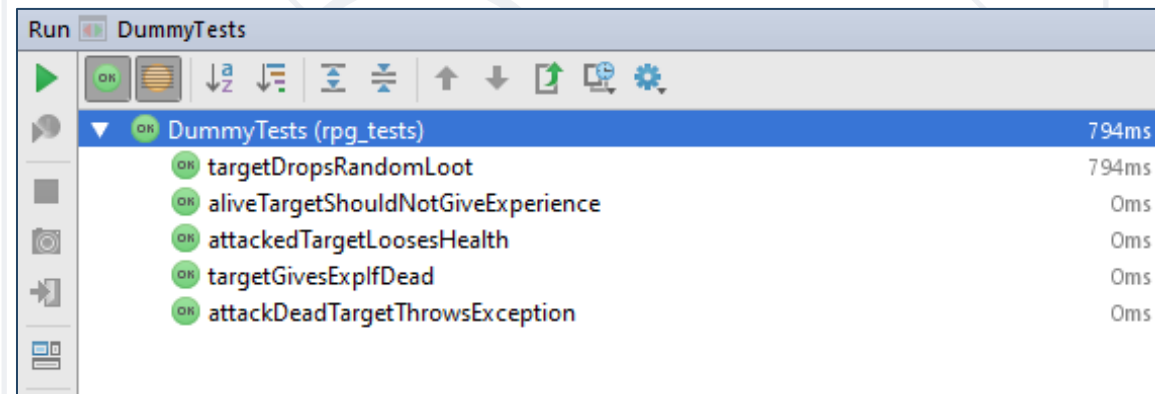
- We need a **structured approach** that:
 - Allows **refactoring**
 - Reduces the **cost of change**
 - **Decreases** the number of **defects** in the code
- Bonus:
 - Improves **design**

- **System** tests
- **Integration** tests
- **Unit** tests



Junit (1)

- The first popular unit testing **framework**
- Most popular for Java development
- Based on Java, written by Kent Beck & Co.

The JUnit logo, featuring the word "JUnit" in a stylized font. The "J" is green and the "Unit" is red, all on a dark blue background.

- Maven Repository – Junit 4.13
- Copy JUnit repository and paste in **pom.xml**

```
<project ...>
...
<dependency>
  <groupId>junit</groupId>
  <artifactId>junit</artifactId>
  <version>4.13</version>
  <scope>test</scope>
</dependency>
</project>
```

- Create new package (e.g. **tests**)
- Create a class for test methods (e.g. **BankAccountTests**)
- Create a **public void** method annotated with **@Test**

```
@Test  
public void depositShouldAddMoney() {  
    /* magic */  
}
```

- **Arrange** - Preconditions
- **Act** - Test a **single behavior**
- **Assert** - Postconditions

@Test

```
public void depositShouldAddMoney() {  
    BankAccount account = new BankAccount();  
    account.deposit(50);  
    Assert.assertTrue(account.getBalance() == 50)  
}
```

Each test should test
a **single behavior**!

- Sometimes **throwing** an exception is the **expected behavior**

```
@Test(expected = IllegalArgumentException.class)
public void depositNegativeShouldNotAddMoney() {
    BankAccount account = new BankAccount();
    account.deposit(-50);
}
```

Assert

Act

Arrange

Problem: Test Axe

- Create a **Maven** project
- Add provided classes (**Axe**, **Dummy**, **Hero**) to project
- In **test/java** folder, create a package **rpg_tests**
- Create a class **AxeTests**
- Create the following tests:
 - Test if weapon **loses durability** after attack
 - Test attacking with a **broken weapon**



Solution: Test Axe (1)

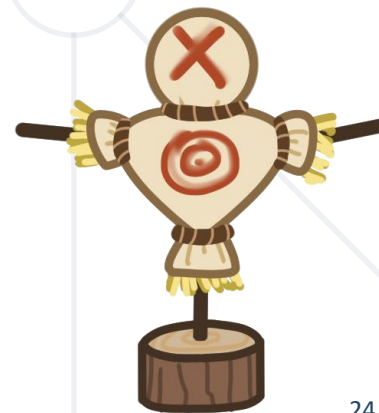
```
@Test
public void weaponLosesDurabilityAfterAttack() {
    // Arrange
    Axe axe = new Axe(10, 10);
    Dummy dummy = new Dummy(10, 10);
    // Act
    axe.attack(dummy);
    // Assert
    Assert.assertTrue(axe.getDurabilityPoints() == 9);
}
```

Solution: Test Axe (2)

```
@Test(expected = IllegalStateException.class) // Assert
public void brokenWeaponCantAttack() {
    // Arrange
    Axe axe = new Axe(10, 1);
    Dummy dummy = new Dummy(10, 10);
    // Act
    axe.attack(dummy);
    axe.attack(dummy);
}
```

Problem: Test Dummy

- Create a class **DummyTests**
- Create the following tests
 - Dummy **loses health** if attacked
 - Dead Dummy **throws an exception** if attacked
 - Dead Dummy **can give** XP
 - Alive Dummy **can't give** XP



Solution: Test Dummy

```
@Test
public void attackedTargetLoosesHealth() {
    // Arrange
    Dummy dummy = new Dummy(10, 10);
    // Act
    dummy.takeAttack(5);
    // Assert
    Assert.assertTrue(dummy.getHealth() == 5);
}

// TODO: Write the rest of the tests
```

There is a better solution...



Unit Testing Best Practices

- **assertTrue()** vs **assertEquals()**

- **assertTrue()**

```
Assert.assertTrue(account.getBalance() == 50);
```

```
java.lang.AssertionError <3 internal calls>
```

- **assertEquals(expected, actual)**

```
Assert.assertEquals(50, account.getBalance());
```

Better description when
expecting value

```
java.lang.AssertionError:  
Expected :50  
Actual   :35  
<Click to see difference>
```

- Assertions can **show messages**
 - Helps with **diagnostics**
- **Hamcrest** is useful tool for test diagnostics

```
Assert.assertEquals(  
    "Wrong balance", 50, account.getBalance());
```

Helps finding
the problem

```
java.lang.AssertionError: Wrong balance  
Expected :50  
Actual   :35  
<Click to see difference>
```

- Avoid using magic numbers (use **constants** instead)

```
private static final int AMOUNT = 50;

@Test
public void depositShouldAddMoney() {
    BankAccount account = new BankAccount();
    account.deposit(AMOUNT);
    Assert.assertEquals("Wrong balance",
        AMOUNT, account.getBalance());
}
```

- Use **@Before** annotation

```
private BankAccount account;  
@Before  
public void createAccount() {  
    this.account = new BankAccount();  
}  
@Test  
public void depositShouldAddMoney() { ... }
```

Executes before
each test

- Test names
 - Should use **business domain terminology**
 - Should be **descriptive** and **readable**

```
incrementNumber() {}
```

```
test1() {}
```

```
testTransfer() {}
```



```
depositAddsMoneyToBalance() {}
```

```
depositNegativeShouldNotAddMoney() {}
```

```
transferSubtractsFromSourceAddsToDestAccount() {}
```



Problem: Refactor Tests

- Refactor the tests for **Axe** and **Dummy** classes
- Make sure that:
 - **Names** of test methods are **descriptive**
 - You use **appropriate assertions** (assert equals vs assert true)
 - You use **assertion messages**
 - There are **no magic numbers**
 - There is no **code duplication** (Don't Repeat Yourself)

Solution: Refactor Tests (1)

```
private static final int AXE_ATTACK = 10;
private static final int AXE_DURABILITY = 1;
private static final int DUMMY_HEALTH = 20;
private static final int DUMMY_XP = 10;
private Axe axe;
private Dummy dummy;
@Before
public void initializeTestObjects() {
    this.axe = new Axe(AXE_ATTACK, AXE_DURABILITY);
    this.dummy = new Dummy(DUMMY_HEALTH, DUMMY_XP); }
}
```

Solution: Refactor Tests (2)

@Test

```
public void weaponLosesDurabilityAfterAttack() {  
    this.axe.attack(this.dummy);  
    Assert.assertEquals("Wrong durability",  
        AXE_DURABILITY - 1,  
        axe.getDurabilityPoints()); }  

```

@Test(expected = IllegalStateException.class)

```
public void brokenWeaponCantAttack() {  
    this.axe.attack(this.dummy);  
    this.axe.attack(this.dummy); }  

```



Dependencies

- Consider testing the following code:
 - We want to test a **single behavior**

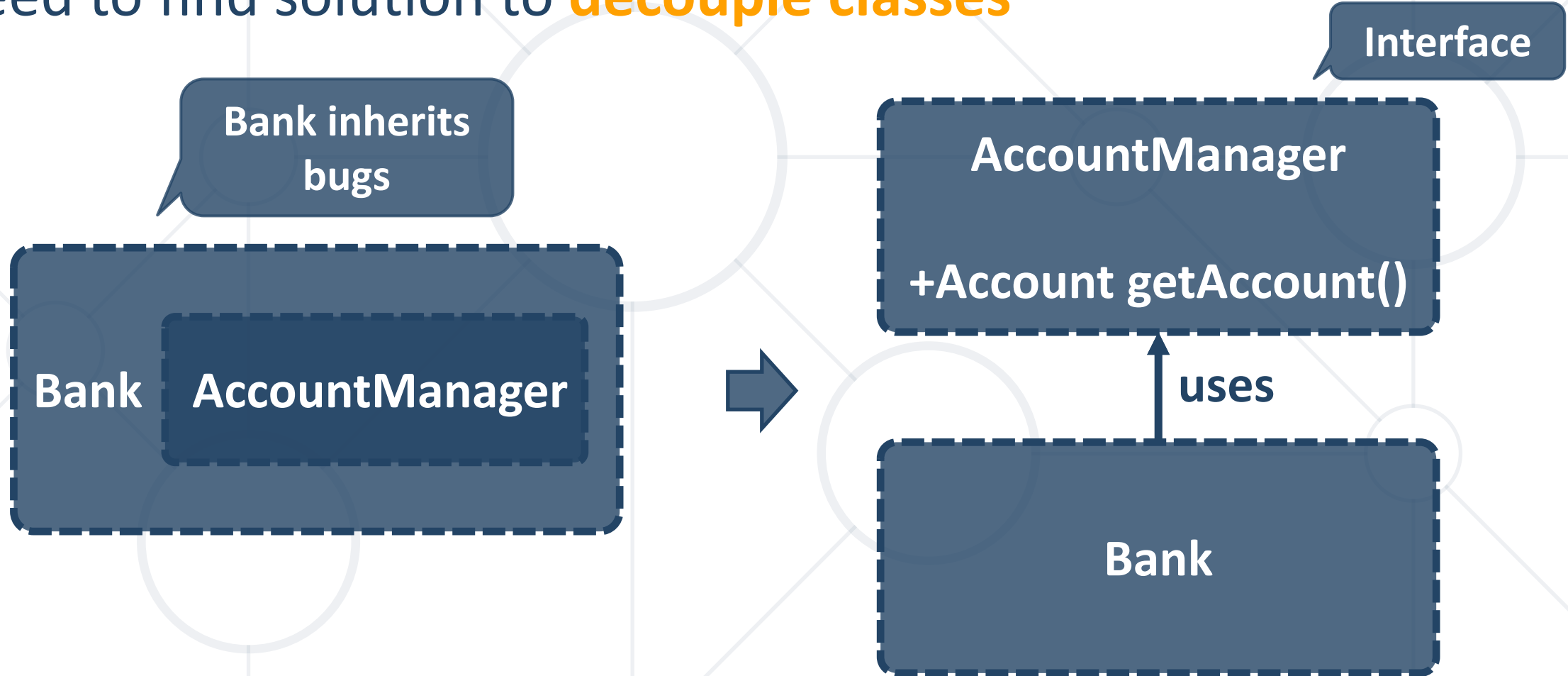
```
public class Bank {  
    private AccountManager accountManager;  
    public Bank() {  
        this.accountManager = new AccountManager();  
    }  
    public AccountInfo getInfo(String id) { ... }  
}
```

Concrete
Implementation

Bank depends on
AccountManager

Coupling and Testing (2)

- Need to find solution to **decouple classes**



Dependency Injection

- Decouples classes and **makes code testable**

```
interface AccountManager {  
    Account getAccount();  
}  
  
public class Bank {  
    private AccountManager accountManager;  
    public Bank(AccountManager accountManager) {  
        this.accountManager = accountManager;  
    }  
}
```

Using Interface

Independent from
Implementation

Injecting
dependencies



Goal: Isolating Test Behavior

- In other words, to **fixate** all **moving parts**

```
@Test
public void testGetInfoById() {
    // Arrange
    AccountManager manager = new AccountManager() {
        public Account getAccount(String id) { ... }
    }
    Bank bank = new Bank(manager);
    AccountInfo info = bank.getInfo(ID);
    // Assert... }
```

Anonymous class

Fake interface implementation
with fixed behavior

Problem: Fake Axe and Dummy

- Test if hero **gains XP** when a **target dies**
- To do this, first:
 - Make **Hero** class **testable** (use **Dependency Injection**)
 - Introduce **Interfaces** for Axe and Dummy
 - Interface Weapon
 - Interface Target
 - Create a test using a **fake Weapon** and **fake Dummy**

Solution: Fake Axe and Dummy (1)

```
public interface Target {  
    void takeAttack(int attackPoints);  
    int getHealth();  
    int giveExperience();  
    boolean isDead();  
}
```

```
public interface Weapon {  
    void attack(Target target);  
    int getAttackPoints();  
    int getDurabilityPoints(); }  
}
```

Solution: Fake Axe and Dummy (2)

// Hero: Dependency Injection through constructor

```
public Hero(String name, Weapon weapon) {  
    this.name = name;           /* Hero: Dependency Injection */  
    this.experience = 0;        /* through constructor */  
    this.weapon = weapon; }  

```

```
public class Axe implements Weapon {  
    public void attack(Target target) { ... }  
}
```

// Dummy: implement Target interface

```
public class Dummy implements Target { }
```

Solution: Fake Axe and Dummy (3)

@Test

```
public void heroGainsExperienceAfterAttackIfTargetDies() {  
    Target fakeTarget = new Target() {  
        public void takeAttack(int attackPoints) { }  
        public int getHealth() { return 0; }  
        public int giveExperience() { return TARGET_XP; }  
        public boolean isDead() { return true; }  
    };  
    // Continues on next slide...
```

Solution: Fake Axe and Dummy (4)

```
// ...  
Weapon fakeWeapon = new Weapon() {  
    public void attack(Target target) {}  
    public int getAttackPoints() { return WEAPON_ATTACK; }  
    public int getDurabilityPoints() { return 0; }  
};  
Hero hero = new Hero(HERO_NAME, fakeWeapon);  
hero.attack(fakeTarget);  
// Assert...  
}
```

- Not **readable**, cumbersome and boilerplate

```
@Test
public void testRequiresFakeImplementationOfBigInterface() {
    // Arrange
    Database db = new BankDatabase() {
        // Too many methods...
    };
    AccountManager manager = new AccountManager(db);
    // Act & Assert...
}
```

Not suitable for
big interfaces

- Mock objects **simulate behavior** of real objects
 - Supplies data** exclusively for the test - e.g. **network** data, **random** data, **big** data (database), etc.

@Test

```
public void testAlarmClockShouldRingInTheMorning() {  
    Time time = new Time();  
    AlarmClock clock = new AlarmClock(time);  
    if (time.isMorning()) {  
        Assert.assertTrue(clock.isRingin());  
    }  
}
```

Test will pass only in the morning!



- [Mockito Web Site](#) - [Mockito 3.0.0](#) dependency
- Copy dependency in **pom.xml**

```
<dependency>  
  <groupId>org.mockito</groupId>  
  <artifactId>mockito-core</artifactId>  
  <version>3.0.0</version>  
  <scope>test</scope>  
</dependency>
```

- Framework for mocking objects

```
@Test
```

```
public void testAlarmClockShouldRingInTheMourning() {  
    Time mockedTime = Mockito.mock(Time.class);  
    Mockito.when(mockedTime.isMorning()).thenReturn(true);  
    AlarmClock clock = new AlarmClock(mockedTime);  
    if (mockedTime.isMorning()) {  
        Assert.assertTrue(clock.isRinging());  
    }  
}
```

Always true



Problem: Mocking

- Include **Mockito** in the project dependencies
- Mock fakes from previous problem
- Implement Hero **Inventory**, holding unequipped weapons
 - method - **Iterable<Weapon> getInventory()**
- Implement Target giving random weapon upon death
 - field - **private List<Weapon> possibleLoot**
- Test Hero killing a target getting loot in his inventory
- Test Target drops random loot

Solution: Mocking (1)

@Test

```
public void attackGainsExperienceIfTargetIsDead() {  
    Weapon weaponMock = Mockito.mock(Weapon.class);  
    Target targetMock = Mockito.mock(Target.class);  
    Mockito.when(targetMock.isDead()).thenReturn(true);  
    Mockito.when(targetMock.giveExperience()).thenReturn(TARGET_XP);  
    Hero hero = new Hero(HERO_NAME, weaponMock);  
    hero.attack(targetMock);  
  
    Assert.assertEquals("Wrong experience", TARGET_XP,  
        hero.getExperience());  
}
```

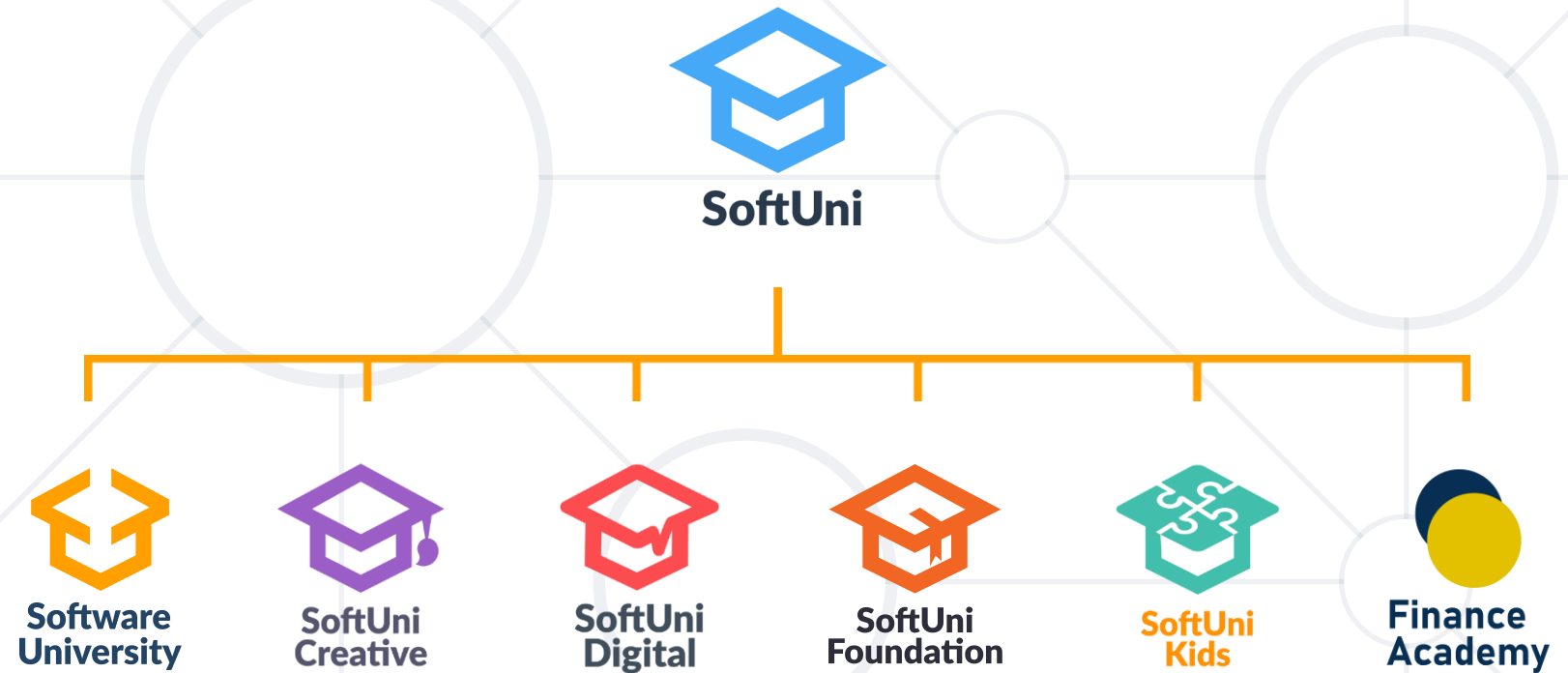
Solution: Mocking (2)

- Create **RandomProvider** Interface
- Hero method
 - **attack(Target target, RandomProvider rnd)**
- Target method
 - **dropLoot(RandomProvider rnd)**
- Mock weapon, target and random provider for test

- **Unit Testing** helps us build **solid code**
- **Structure** your unit tests – **3A Pattern**
- Use **descriptive names** for your tests
- Use different **assertions** depending on the situation
- **Dependency Injection**
 - makes your classes **testable**
 - **Looses coupling** and **improves design**
- **Mock** objects to **isolate tested behavior**



Questions?



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