Unit Testing with JUnit

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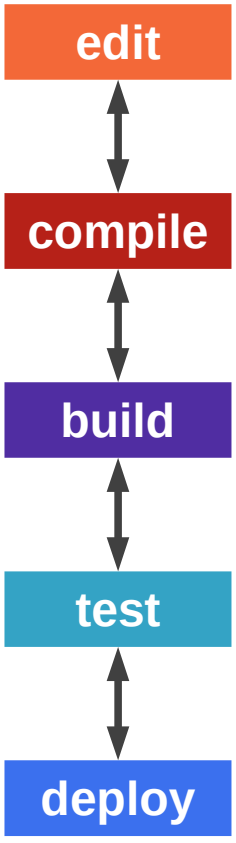
ADAP B02

Simple Development Cycle



- Developer
  - Edit: Implements new feature
    - Iterates over the code until it looks right
  - Compile: Compiles the code
    - Iterates over the code until it compiles (no syntax error)
  - Build: Puts classes, build path together
    - Packages jar, if any, by hand
  - Test: Tests the program
    - Keeps going until “behavior looks right” i.e. no bugs
  - Deploy: Puts code into production
    - If a student, submits homework

What’s Wrong with “Test-by-hand”?

- Manual testing
  - takes time that can be saved by automation
  - is not as reliable as programmed tests
  - tends to be selective, not comprehensive
- But: Human intuition can see problems that computers cannot

Tests and Testing

- Testing is a process
  - that tests some concern (the concern “under test”)
  - for correct and expected operation
  - according to a specification
  - usually as part of quality assurance
- Tests can be manual or automated
- Tests verify against a given specification
- Tests increase confidence in correct functioning
- However, tests can never proof a program correct

Types of Tests [1]

- **Components tests** (a.k.a. unit tests)
  - Focus on testing one component out of context
- **Acceptance tests** (a.k.a. functional tests)
  - Focus on testing one cross-cutting functionality
- **Integration tests** (a.k.a. system tests)
  - Focus on testing end-to-end system integrity

Test Types by other Dimensions

- Inner vs. outer perspective
  - Black-box tests
    - Tests are written to test outside observable behavior
  - White-box tests
    - Tests are written to test the innards of a component
- Static vs. dynamic perspective
  - Static-analysis based
    - Tests are written based on static code analysis
  - Run-time analysis based
    - Tests are written based on simulated behavior
- Other dimensions (see dedicated courses)

Tests and Testing Terminology

- **Test (Case)**
  - A single test for some particular aspect of the software, succeeds or fails
- **Test Suite**
  - A set of related tests that cover a particular domain of the software
- **Test Set-up**
  - The data and preparation necessary to run a test as intended
- **Test Result**
  - The result of running a test, typically succeeds/fails or error
- **Test Harness**
  - A software, like JUnit, that is used to run test suites

Example of Test Harness

- JUnit (Java Unit Testing Framework)
  - A test harness implemented as an object-oriented testing framework
  - Supports tests and test suites, set-ups, tear-downs, etc.
  - Small and simple, easy to learn
  - Well-supported by tools / integrated into IDEs like Eclipse

JUnit popularized unit testing: “Never in the field of software development have so many owed so much to so few lines of code.” [M07]

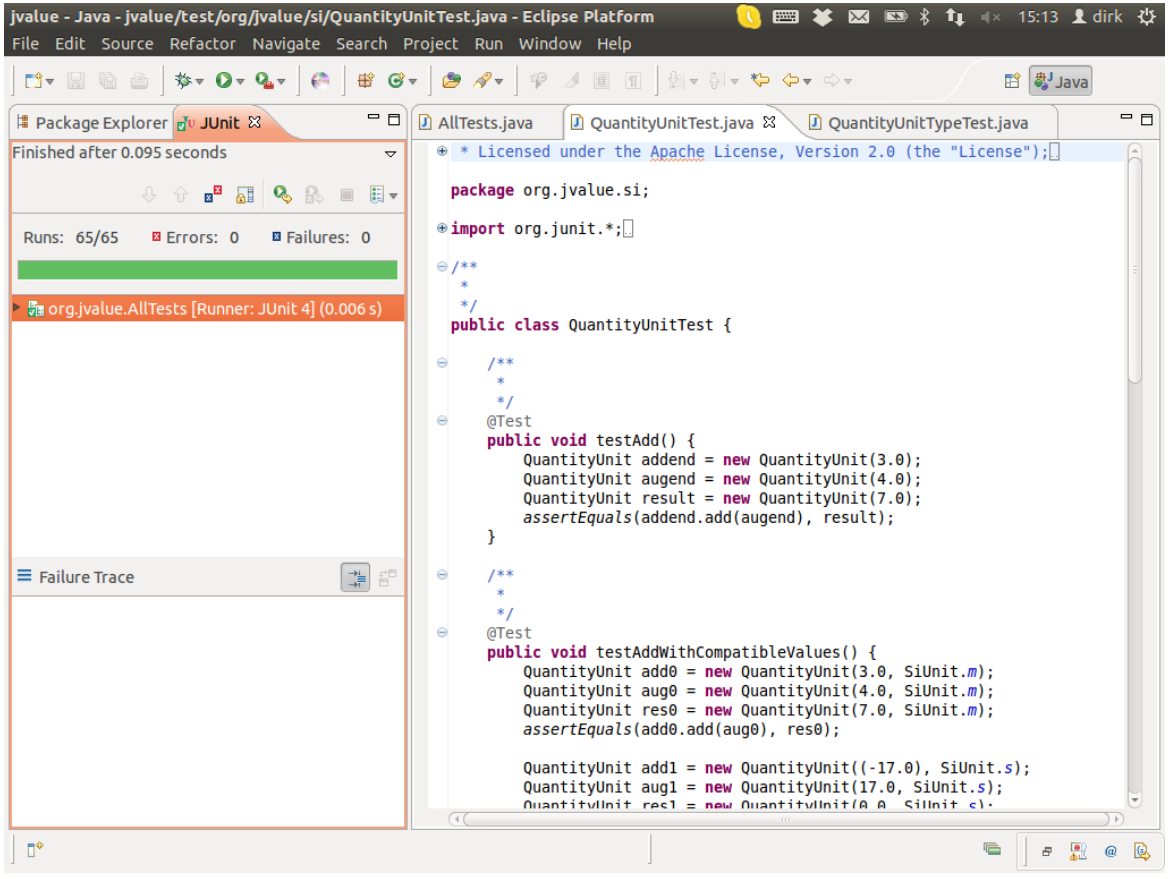
JUnit Information

- Available from http://junit.org
  - Comes as pre-installed plug-in with Eclipse and most other IDEs
  - See course literature for an introduction to JUnit
- Version history of JUnit
  - Prior to JUnit 4 conventions rather than annotations
  - Wahlzeit uses JUnit 4
- JUnit 5
  - Is the new major version of the testing framework
  - Is a complete rewrite of JUnit 4 to
  - Provides new foundation for developer-side testing on the JVM
  - Uses Java 8 features, for example, lambdas
  - Has a modular concept, imports only what is needed

Example for Unit Testing

- JValue Value Objects
  - A framework for value objects in Java (more on value objects later)
    - Examples are names, currencies, SI units, etc.
  - Is a small self-contained library → good for unit testing
  - Available at https://github.com/jvalue/value-objects

JUnit for JValue using Eclipse Plug-In



Test Cases in JUnit

- Tests are implemented in test classes
  - JUnit 5
    - Annotate test method with @Test
    - **Annotate set-up methods with @BeforeEach and @BeforeAll**
    - **Annotate tear-down methods with @AfterEach and @AfterAll**
    - End class name with Test (optional)
  - JUnit 4
    - Annotate test method with @Test
    - **Annotate set-up methods with @Before and @BeforeClass**
    - **Annotate tear-down methods with @After and @AfterClass**
    - End class name with Test (optional)
  - JUnit 3.8 or before
    - Start test method name with “test”
    - End test class name with “Test”

Two Example Test Cases

```
@Test
public void testEquality1() {
   String[] helloWorld = { "hello", "world", "!" };
   Name defaultName = new DefaultName(helloWorld);
   Name compactName = new CompactName(helloWorld);
   Assert.assertEquals(defaultName, compactName);
}

@Test
public void testEquality2() {
   String[] charMalaise = { "\\###\\", "#", "\\", "\\\\\\\\#", "#" };
   Name defaultName = new DefaultName(charMalaise);
   Name compactName = new CompactName(charMalaise);
   Assert.assertEquals(defaultName, compactName);
}
```

How to Write a Test (3A Pattern)

1. Arrange
2. Act (execute)
3. Assert (check)

Example of 3A

```
import org.junit.*;
import static org.junit.Assert.*;

public class QuantityUnitTest {

   @Test
   public void testAdd() {
      QuantityUnit addend = new QuantityUnit(3.0, SIUnit.s);
      QuantityUnit augend = new QuantityUnit(4.0, SIUnit.s);
      QuantityUnit result = new QuantityUnit(7.0, SIUnit.s);
      assertEquals(addend.add(augend), result);
   }
   ...
```

1. Arrange

2. Act

3. Assert

By-Test-Case Test Set-ups in JUnit

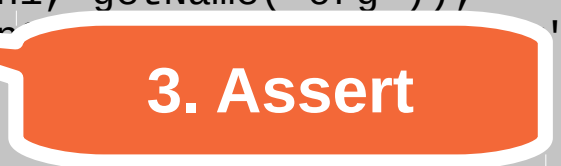
- Annotation @before implements set-up method
  - Is executed before each test case (method) in a given class
  - Used to be (naming convention) setUp
- Annotation @after implements tear-down method
  - Is executed after each test case (method) in a given class
  - Used to be (naming convention) tearDown

Example of a Test Set-up

```
protected Name ne; // empty name
protected Name n0; // ("")
protected Name n1; // ("org", '.')
protected Name n2; // ("jvalue.org", '.')

@Before
public void setUp() {
    ne = Name.EMPTY_NAME;
    n0 = getName("");
    n1 = getName("org", '.');
    n2 = getName("jvalue.org", '.');
}

@Test
public void testEquals() {
    assertEquals(n0, getName(""));
    assertEquals(n1, getName("org"));
    assertEq                        "));
}
...
```



Test Results

1. Pass / fail
2. Test execution error

Checking for Pass / Fail

- Explicit assertions / failures in code
  - assert(...)
  - fail(...)
- Annotations with expected results
  - @Test(expected = SomeException.class)
  - @Test(timeout = 500)

Another Example of 3A

```
public class FlagReasonTest {
   private Map<FlagReason, TestEntry> entries;

   @Before
   public void setUp() {
      entries = new HashMap<FlagReason, TestEntry>();
      addEntry(FlagReason.MISMATCH, "mismatch", 0);
      addEntry(FlagReason.OFFENSIVE, "offensive", 1);
      ...
   }

   protected void addEntry(FlagReason reason, String str, int i) {
      entries.put(reason, new TestEntry(str, i));
   }

   @Test(expected = IllegalArgumentException.class)
   public void tooBigIndexShouldCauseException() {
      FlagReason.getFromInt(FlagReason.MAX_VALUE + 1);
   }

   ...
```

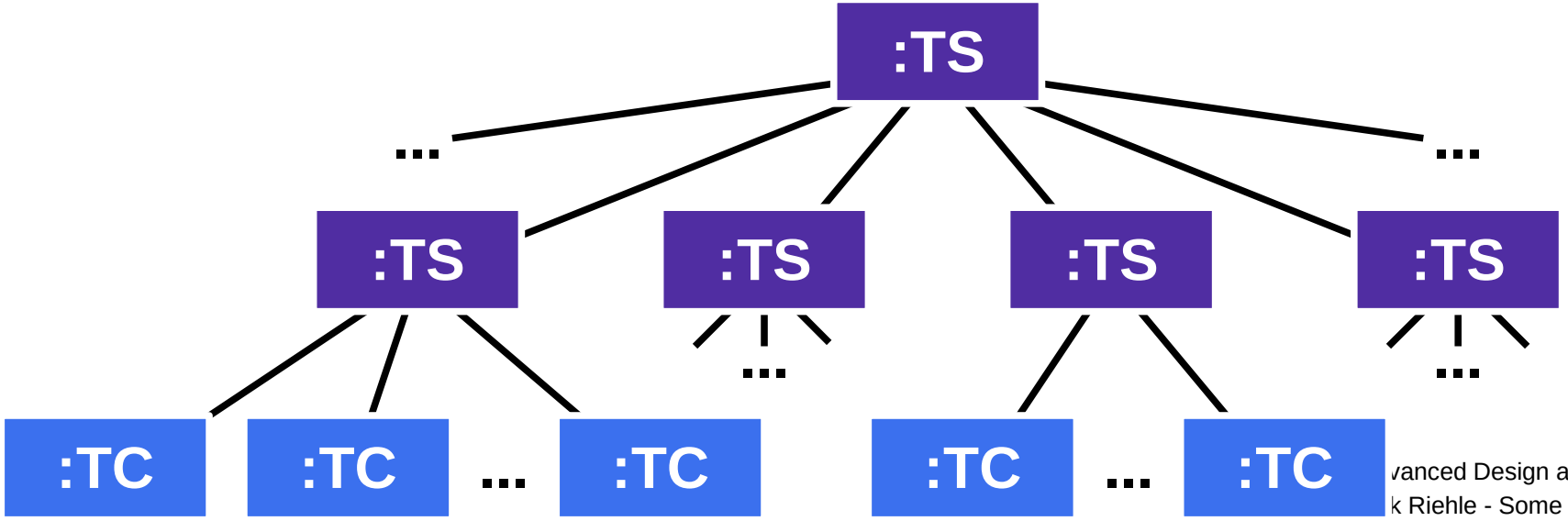
1. Arrange

2. Act

3. Assert

Test Suite

- A test suite groups related tests into one group (object)
- This allows the group to share the same set-up, if desired
- Test suites are applied recursively to build full test hierarchy
- Tests can be run starting with any test suite in the hierarchy
- The test suites typically mirror the Java package structure



Test Suites in JUnit

- JUnit realization of Test Suites
  - JUnit 4 or later
    - Have become mostly invisible
    - Can still be used to collect test cases across classes
  - JUnit 3.8 or before
    - Create new TestSuite instance using “new TestSuite()”
    - Collect test suites using “addTestSuite(Test.class)”

Example of (By-Hand) Test Suite

```
import org.junit.*;
import static org.junit.Assert.*;

public class QuantityUnitTest {
    @Test
    public void testAddWithCompatibleValues() {...}
    @Test(expected = IllegalArgumentException.class)
    public void testAddWithIncompatibleValues() {...}
    ...
}
```

```
import org.junit.runner.*;
import org.junit.runners.*;

@RunWith(Suite.class)
@Suite.SuiteClasses({
    org.jvalue.si.QuantityUnitTest.class,
    org.jvalue.si.QuantityUnitTypeTest.class,
    ...
})

public class AllTests { /** do nothing **/ }
```

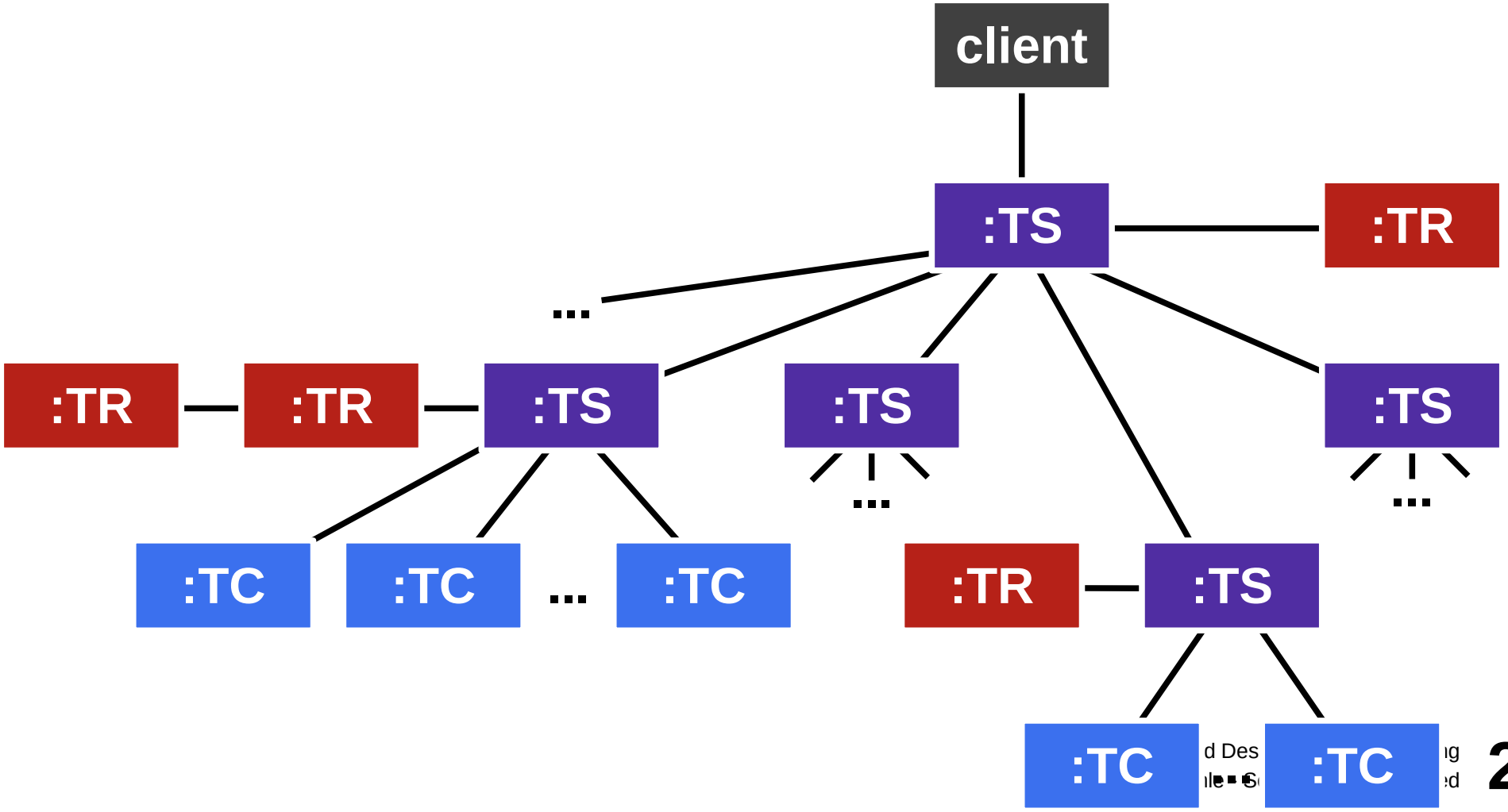
Static By-Test-Suite Test Set-ups

- Annotation @BeforeClass implements (static) set-up method
  - Is executed once before any test case in the class is run
  - Used to be TestSetup subclass (decorator)
- Annotation @AfterClass implements (static) tear-down method
  - Is executed once after all the test cases in the class have run
  - Used to be TestSetup subclass (decorator)
- Applies to (heavy-weight) required resources

Dynamic By-Test-Suite Test Set-ups

- TestRule supports dynamic set-up and tear-down
  - Test rules are attached to test suites in the test hierarchy
- Rule chain supports composition of test rules
  - Rule chain lines up test rules in sequence
  - Fluid programming style chains methods
- Supports method and class-level execution
  - Use @Rule and @ClassRule analogous to @Before and @BeforeClass

Rule-based Test Set-ups



Wahlzeit on GAE RuleChain for JUnit

```
@ClassRule
public static RuleChain ruleChain = RuleChain.
   outerRule(new LocalDatastoreServiceTestConfigProvider()).
   around(new RegisteredOfyEnvironmentProvider()).
   around(new SysConfigProvider()).
   around(new UserServiceProvider()).
   around(new UserSessionProvider());
```

- This RuleChain instance initializes most of what you'll need
- It may be an overkill for most situations but gets you going
- Example to be found in org.wahlzeit.services.LogBuilderTest

System-Specific Set-up and Tear-down

- More complex set-ups to be run once or only a few times
- Should be implemented in their own class, to be reused
- Applies, for example, to heavyweight database set-up
- In JUnit 4 or later to be implemented as ExternalResource

Location and Scope of Test Set-ups

- Test case
  - With test method (directly by calling set-up method)
  - Within test class, using @Before annotation
- Test suite
  - Within test class, using @BeforeClass annotation
  - With rules and rule chain, using separate classes
- System
  - As external resources called from outer test suite

Test Source Code Organization

- Three scopes of organizing tests
  - Within the same class
  - Within the same package
  - Within the same package hierarchy
- File locations depend on build tool
  - In Gradle, test directory captures all tests, branches of src
    - $project/src/main/java
    - $project/src/test/java
- Test package hierarchy should mirror the main hierarchy

Quiz: Simple Test Set-up

1. Your tests for the Money class all need a few example values to work with. Where should you create them?
   - In each test case method
   - In the test class' setup method
   - In a separate test setup class
2. You are programming tests for a Money.divideBy() method. Should you also test for any possible ArithmethicException?
   - Never
   - Always
   - Depends

Advanced Testing Concepts

- Handling complex system set-ups
  - Mocking, stubbing, nulling
  - Dependency injection
- Testing specific system aspects
  - Concurrency
  - Legacy code
- Test structure and practicality
  - Extent of tests run, run-time

Review / Summary of Session

- General testing
  - What are tests? What is testing?
  - What types of tests are there?
- Testing and JUnit
  - What is JUnit and how can it help you write tests?
  - What are the most basic annotations you'll need?
- Pragmatics of testing with JUnit
  - How are they aggregated into test suites?
  - How do you create test set-ups?

Thank you! Questions?

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