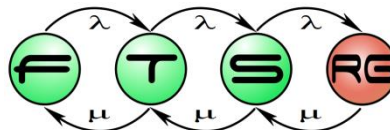


Development testing

Zoltan Micskei

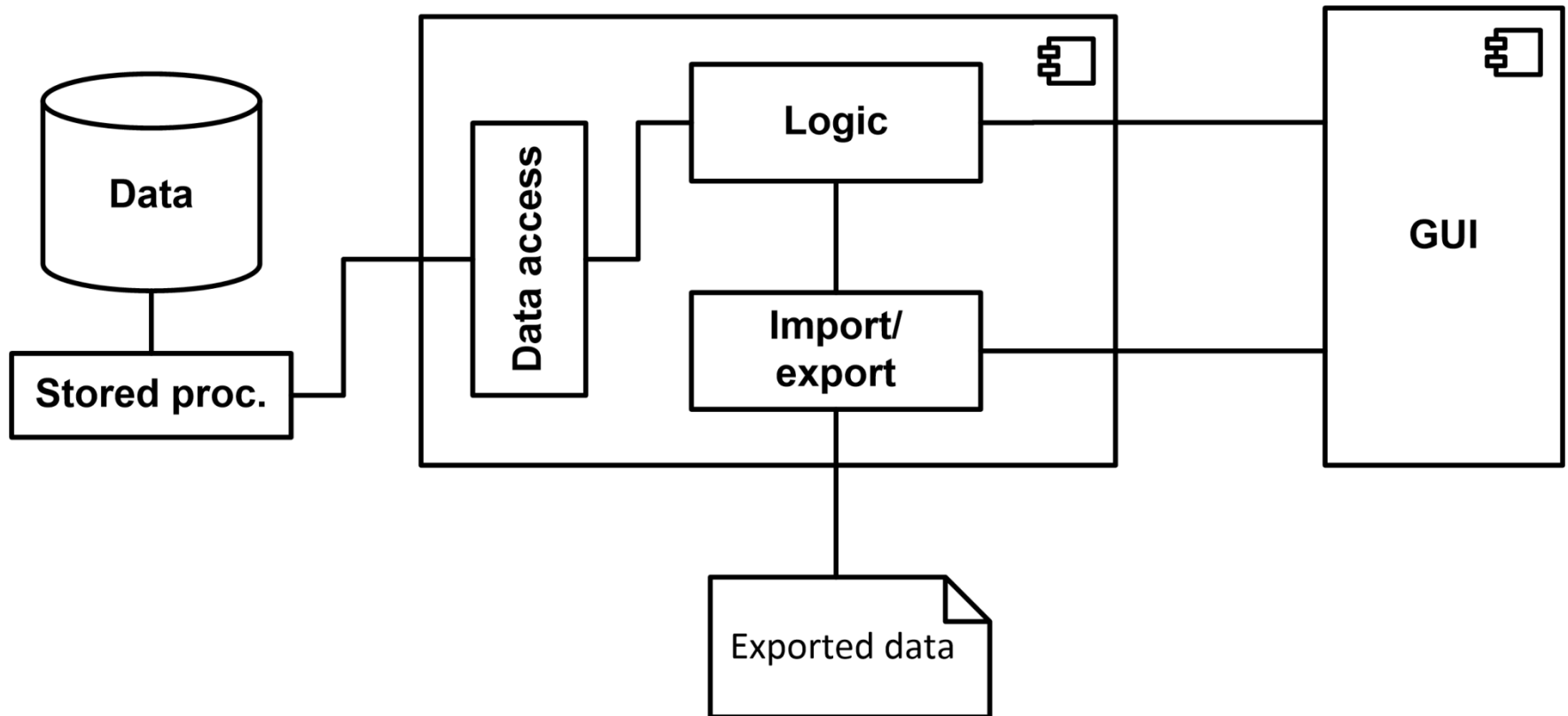
**Budapest University of Technology and Economics
Fault Tolerant Systems Research Group**



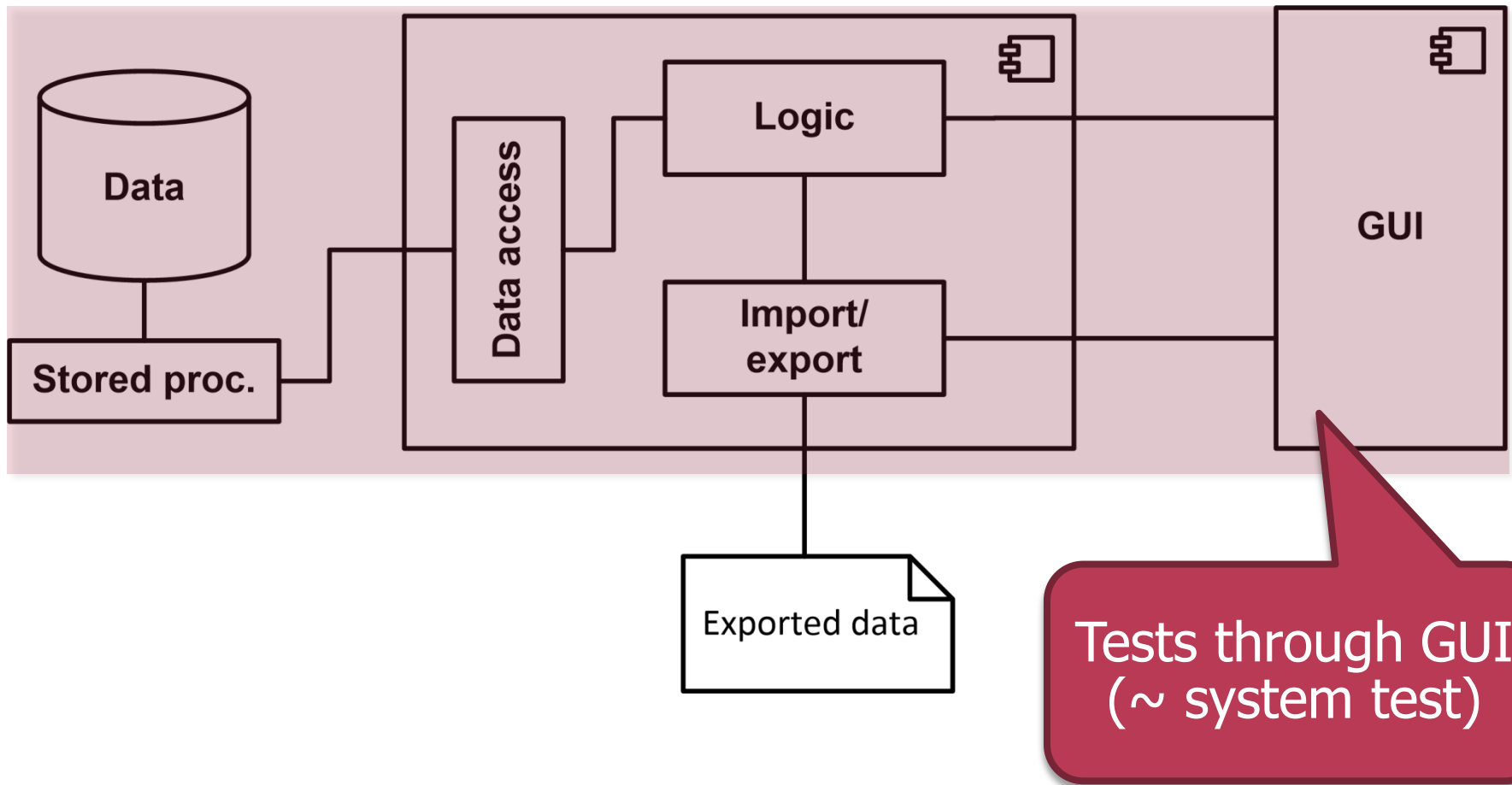
Main topics of the course

- Overview (1)
 - V&V techniques, Critical systems
- Static techniques (2)
 - Verifying specifications
 - Verifying source code
- **Dynamic techniques: Testing (7)**
 - **Developer testing**, Test design techniques
 - Testing process and levels, Test generation, Automation
- System-level verification (3)
 - Verifying architecture, Dependability analysis
 - Runtime verification

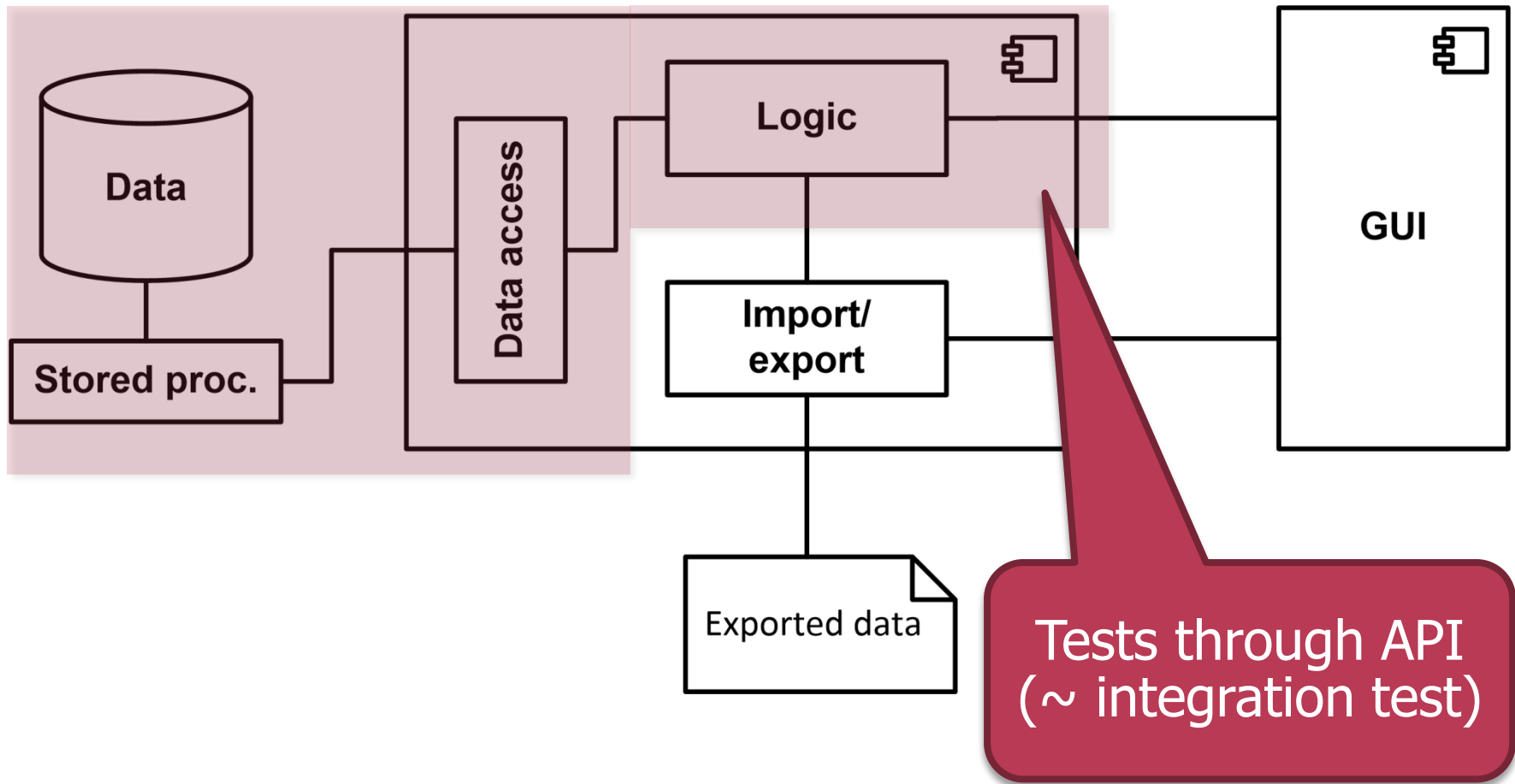
Example: what/how/where to test?



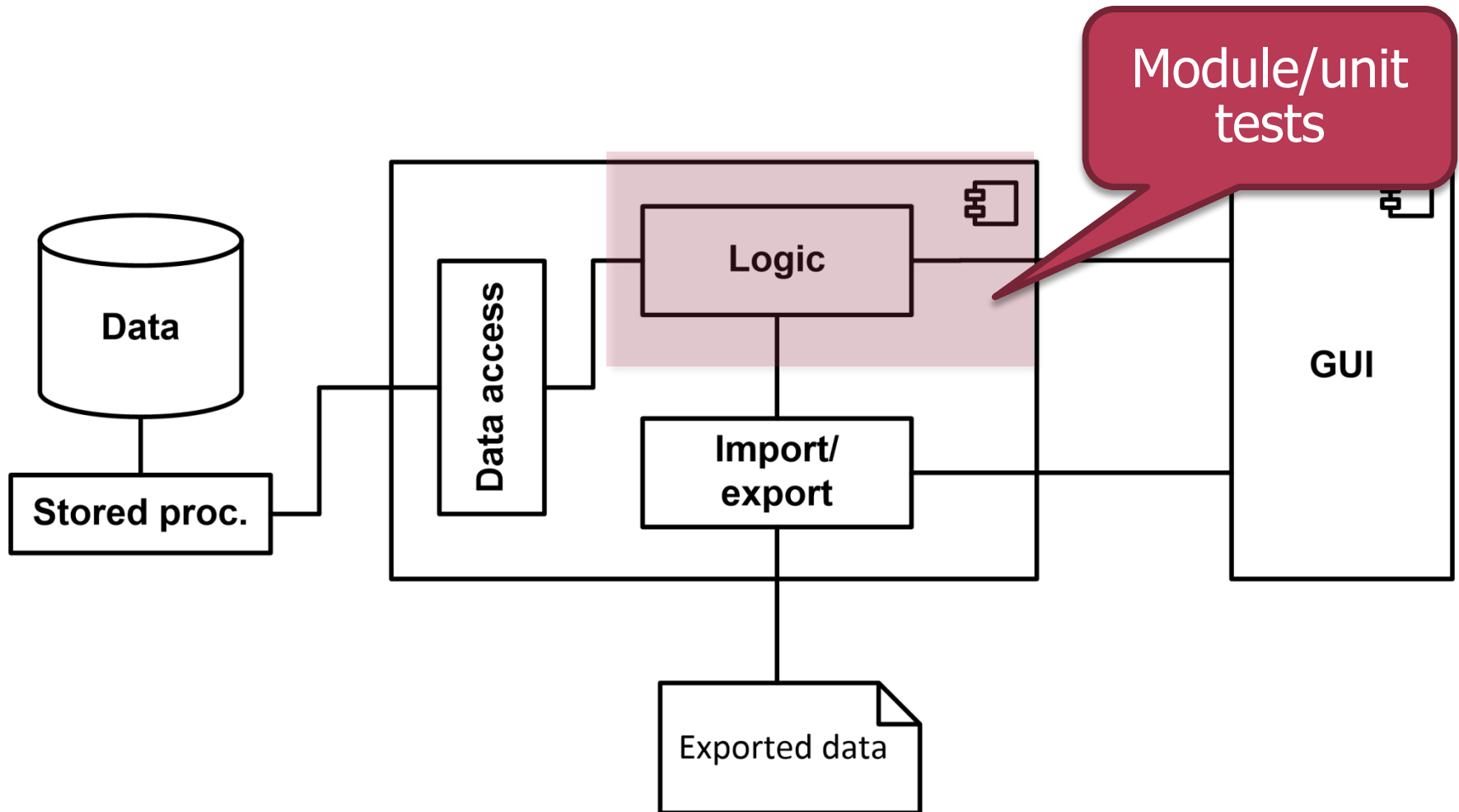
Example: what/how/where to test?



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Example: what/how/where to test?



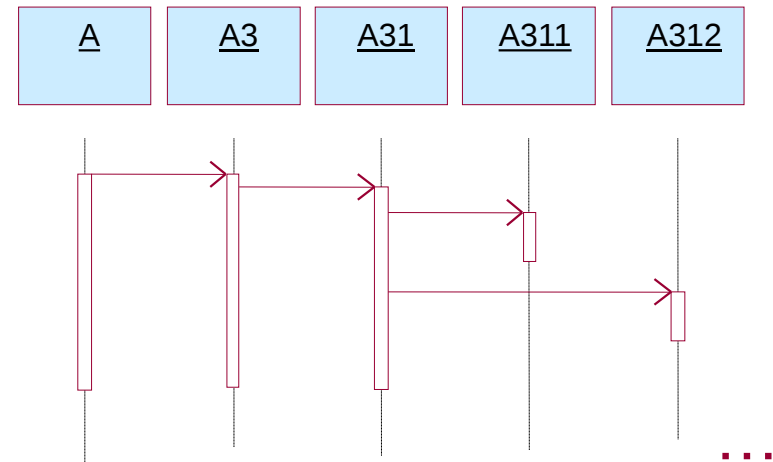
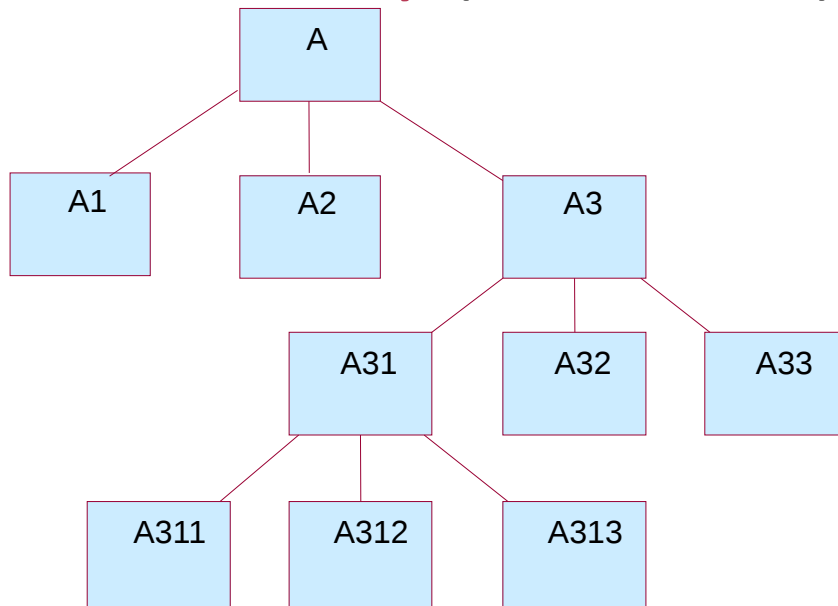
UNIT TESTING

Learning outcomes

- Explain characteristics of good unit tests (K2)
- Write unit tests using a unit testing framework (K3)

Module / unit testing

- **Module / unit:**
 - Logically separable part
 - Well-defined interface
 - Can be: method / class / package / component...
- **Call hierarchy** (ideal case):

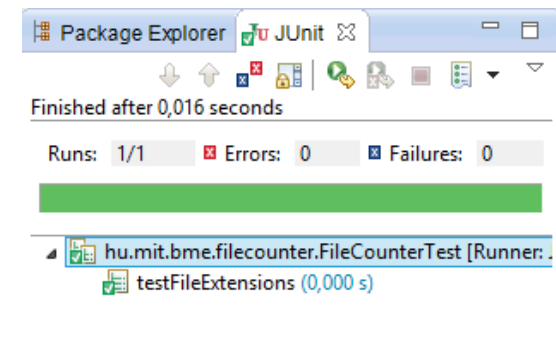


Why do we need unit testing?

- Goal: Detect and fix defects during development (lowest level)
 - Can integrated later tested modules
 - Developer of the unit can fix the defect fastest
- Units can be tested separately
 - Manage complexity
 - Locate defects more easily, fix is cheaper
 - Gives confidence for performing changes
- Characteristics of unit tests
 - Checks a well-defined functionality
 - Defines a “contract” for the unit
 - Can be used as an example
 - (Not necessarily automatic)

Unit test frameworks

- Run unit tests frequently
 - During development (e.g. refactoring)
→ Need to be fast
- Good tool support
 - Frameworks (JUnit, xUnit, TestNG, ...)
 - Support in IDE (Eclipse, VS, ...)
- Usually simple functionality
 - Define test sequences and checks
 - Run tests
 - Display results (red-green)



Example: simple JUnit test

```
public class ListTest{
```

```
    List list; // SUT
```

```
    @Before public void setUp(){
```

```
        list = new List();
```

```
    }
```

```
    @Test public void add_EmptyList_Success(){
```

```
        list.Add(1);
```

```
        assertEquals(1, list.getSize());
```

```
    }
```

```
}
```

Preparing test

Calling SUT

Checking

JUnit annotations (excerpt)

Annotation	Description
@Test	Defining a test method
@Before	Executed before each test, e.g. setting environment
@After	Executed after each test
@BeforeClass	Executed only once before all tests (caution, tests will be not independent!)
@AfterClass	Executed after all tests, e.g. global cleanup
@Ignore	Do not execute given test
@Test(expected=IllegalArgumentException.class)	Test passes if code throws this Exception
@Test(timeout=100)	Limits execution time of test

Others: creating Suite, Category, Parametrized...

Good unit tests (guidelines!)

- Simple, reliable
 - No complex logic (e.g. loops, try/catch)
- One test does one thing
 - (not necessarily one assert statement)
- This is also quality code
 - No duplicated code
 - Easy to understand and maintain
- Tests are independent
- Checks are not overspecified
- ...

Coding conventions

- Name of test class: **[Unit_neve]Test**
- Name of test method:
 - **Method_StateUnderTest_ExpectedBehavior**
 - **MethodName_DoesWhat_WhenTheseConditions**
 - **[feature being tested]**
- Structure of test:

// Arrange

// Given

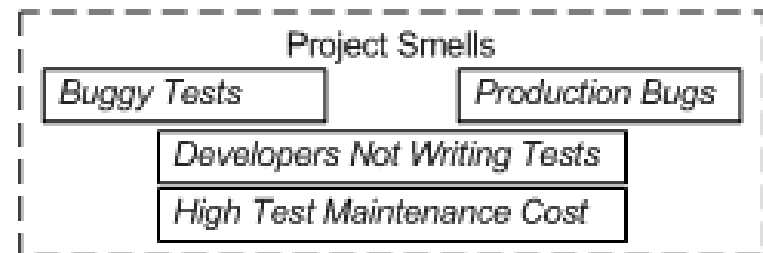
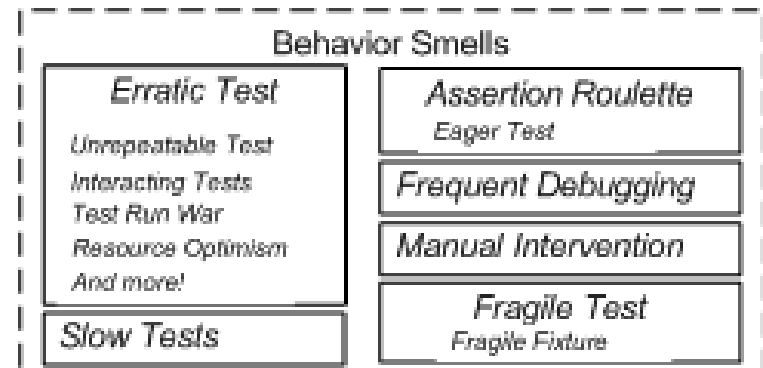
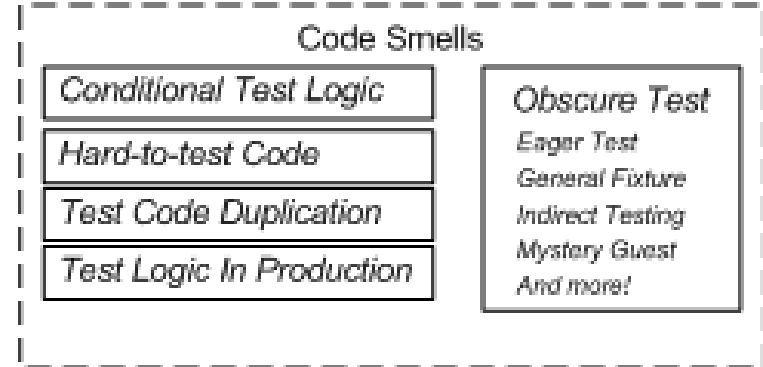
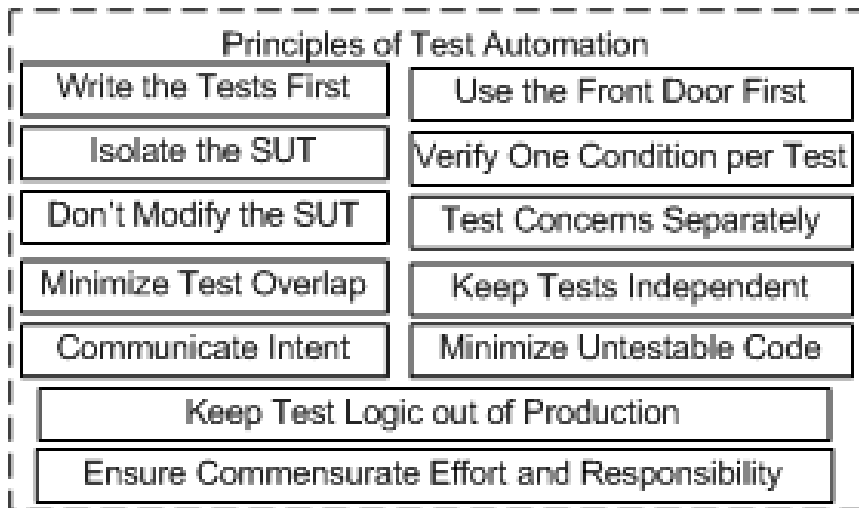
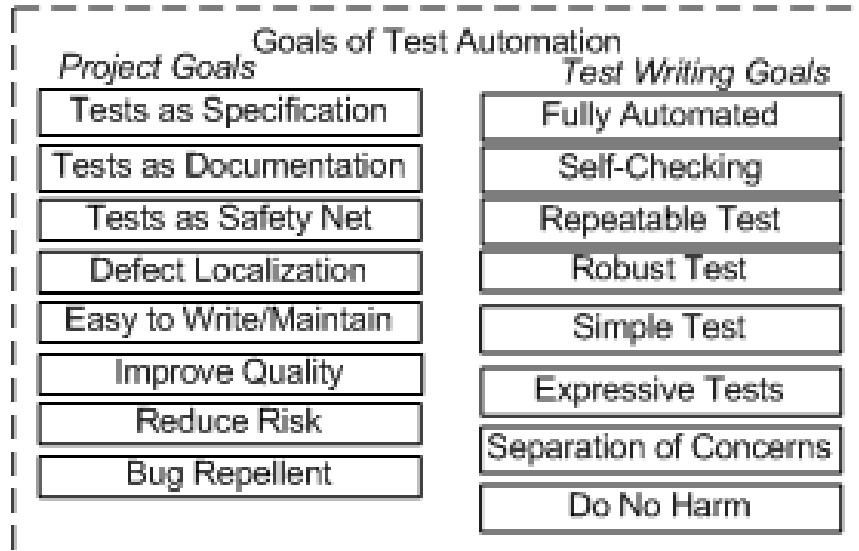
// Act

// When

// Assert

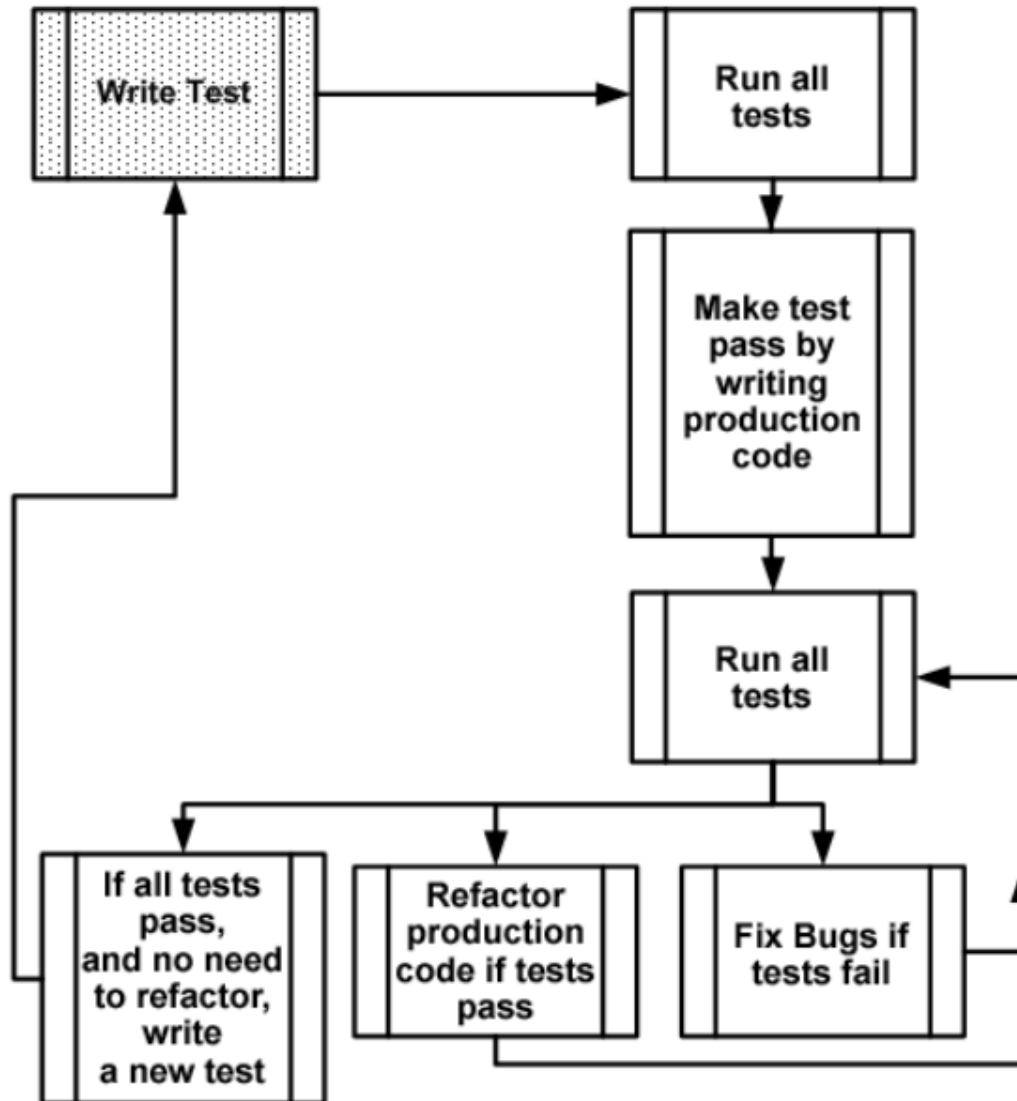
// Then

Guidelines from “xUnit Test Patterns”



Source: Gerard Meszaros, <http://xunitpatterns.com/>

Test-Driven Development (TDD)



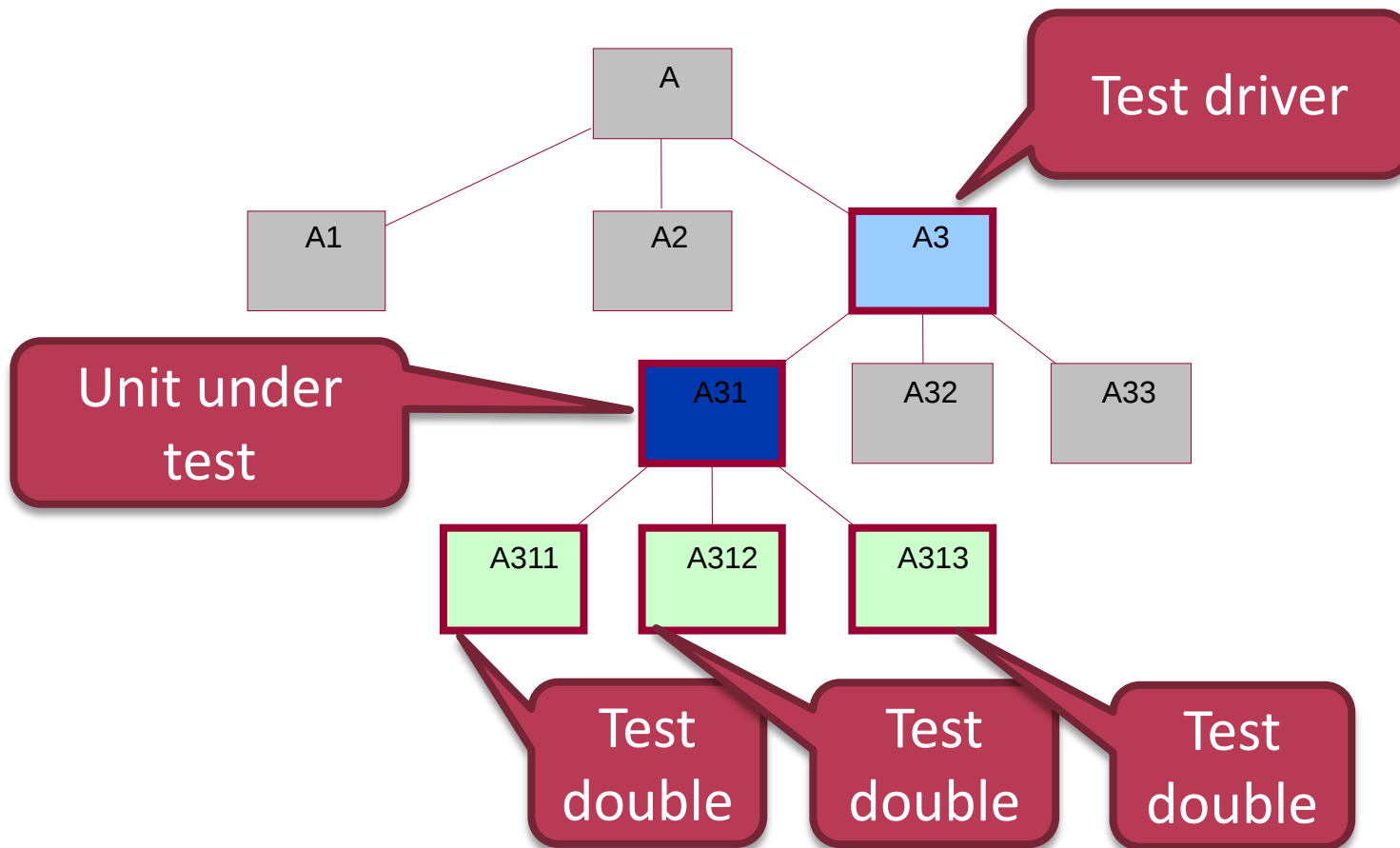
UNIT ISOLATION

Learning outcomes

- Explain why and when isolation of dependencies is recommended in unit tests (K2)
- Use an isolation framework to write isolated unit tests (K3)

Isolation in unit tests

- Tests unit separately in isolation
- Needed: test drivers and test doubles



Problem: Handling dependencies

■ What is a dependency?

Anything that

- is collaborating with the SUT,
- but does not belong to (could not control it)

■ Examples:

- Other modules
- File system, network call
- Using current date/time
- ...

Example: Hard to test code

```
public class PriceService{  
    private DataAccess da = new DataAccess();  
  
    public int getPrice(String product)  
        throws ProductNotFoundException {  
        Integer p = this.da.getProdPrice(product);  
        if (p == null)  
            throw new ProductNotFoundException();  
  
        return p;  
    }  
}
```

Hard to isolate,
how to specify a
test version?

Example: Making the SUT testable

```
public class PriceService{
    private IDataAccess da;

    public PriceService(IDataAccess da){
        this.da = da;
    }

    public int getPrice(String product)
        throws ProductNotFoundException {
        Integer p = this.da.getProdPrice(product);
        if (p == null)
            throw new ProductNotFoundException();
        return p;
    }
}
```

Passing
implementation
in constructor

Example: Unit tests for the SUT

```
public class PriceServiceTest{
    @Before public void init(){
        DataAccessStub das = new DataAccessStub();
        das.add("A100", 50);
        ps = new PriceService(das);
    }
```

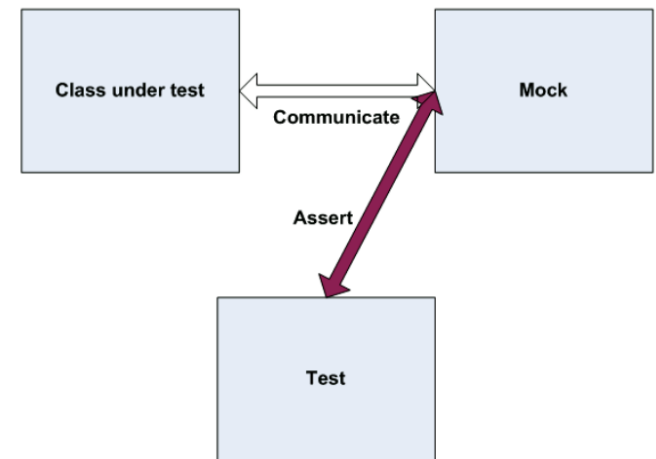
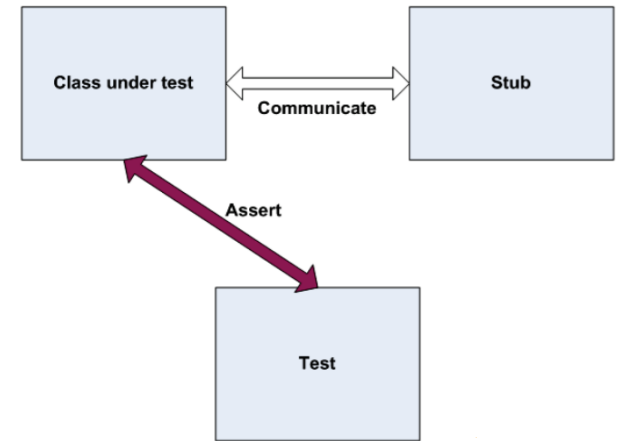
Using a stub in the test

```
@Test public void SuccessfulPriceQuery(){
    int p = ps.getPrice("A100");
    assertEquals(50, p);
}
```

```
@Test(expected = ProductNotFoundException.class)
public void NotExistingProduct(){
    ps.getPrice("notExists");
}
}
```

Stub, Mock, Dummy, Fake... objects

- Many techniques for substituting dependencies
 - Different names (see *xUnit Patterns*)
 - Common name: **Test double**
- Stub
 - Checks the **state** of the SUT
- Mock
 - Check the **interactions** of the SUT
- Dummy
 - Not used object (filler)
- Fake
 - Working, but not the real one



Isolation frameworks

- Tedious to create mocks and stubs
 - Lots of repeated, plumbing code
 - Time-consuming to maintain
- Framework functionality
 - Input: interface or class description
 - Output: generate stub/mock dynamically
- Example:
 - JMock, Mockito, Rhino Mocks, Typemock...

Example: Using mocks (Mockito)

```
public class PriceServiceTest{
    @Before public void init(){
        DataAccess mockDA = mock(DataAccess.class);
        ps = new PriceService(mockDA);
    }

    @Test public void SuccessfulPriceQuery(){
        // Arrange
        when(mockDA.getProdPrice("A100")).thenReturn(50);

        // Act
        int p = ps.getPrice("A100");

        // Assert
        verify(mockDA, times(1)).getProdPrice("A100")
    }
    ...
}
```

Create a compatible
test double

Specify rules

Check interactions

SUMMARY

Is it worth to create such unit tests?

Calculations on an example project:

Stage	Team without tests	Team with tests
Implementation (coding)	7 days	14 days
Integration	7 days	2 days
Testing and bug fixing	Testing, 3 days Fixing, 3 days Testing, 3 days Fixing, 2 days Testing, 1 day Total: 12 days	Testing, 3 days Fixing, 1 day Testing, 1 day Fixing, 1 day Testing, 1 day Total: 8 days
Overall release time	26 days	24 days
Bugs found in production	71	11

Source: Roy Osherove, The Art of Unit Testing, 2009.

Data on a safety-critical projects

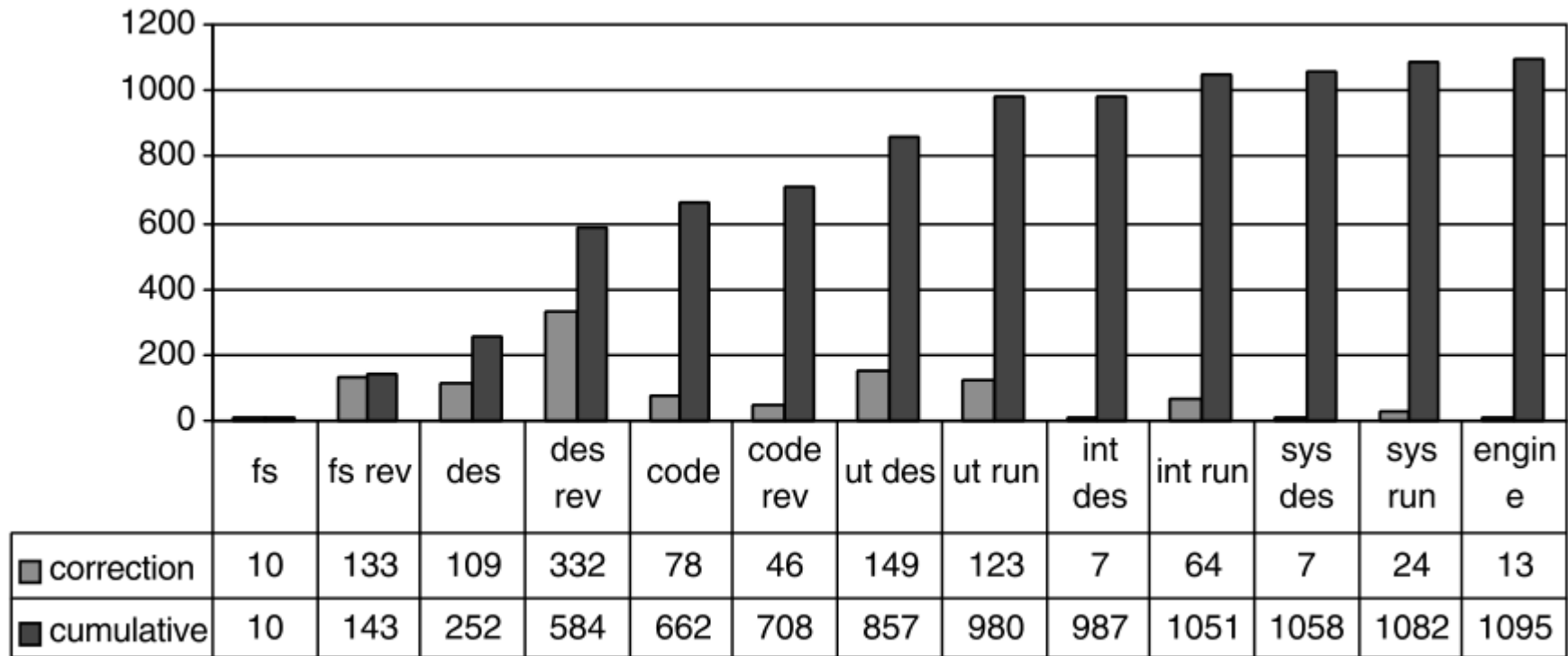


Fig. 2 Corrections found at each phase and cumulative totals

fs – functional specification

des – design

ut des – unit test design

int – integration test

fs rev – fs review

des rev – review

ut run – ut execution

sys – system test

Source: [The Economics of Unit Testing](#), ESE 11: 5–31, 2006

“Is TDD Dead?”

What is a unit?

Test-induced design damage.

Self-testing code

Is separate QA needed?

Costs and benefits of unit testing

if I screw up this line of code is a test going to fail?



See: <http://martinfowler.com/articles/is-tdd-dead/>

Further information

- Martin Fowler: Mocks Aren't Stubs, 2007
 - URL: <http://martinfowler.com/articles/mocksArentStubs.html>
- Martin Fowler: UnitTest, 2014
 - <http://martinfowler.com/bliki/UnitTest.html>
- Roy Oshero: The Art of Unit Testing: With Examples in .Net.
 - Manning Publications; 1st edition (June 3, 2009)
 - URL: <http://artofunittesting.com/>
- Brett L. Schuchert: Mockito.LoginServiceExample
 - URL: <http://schuchert.wikispaces.com/Mockito.LoginServiceExample>