TESTING

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WHY DO WE TEST?

interaction!!

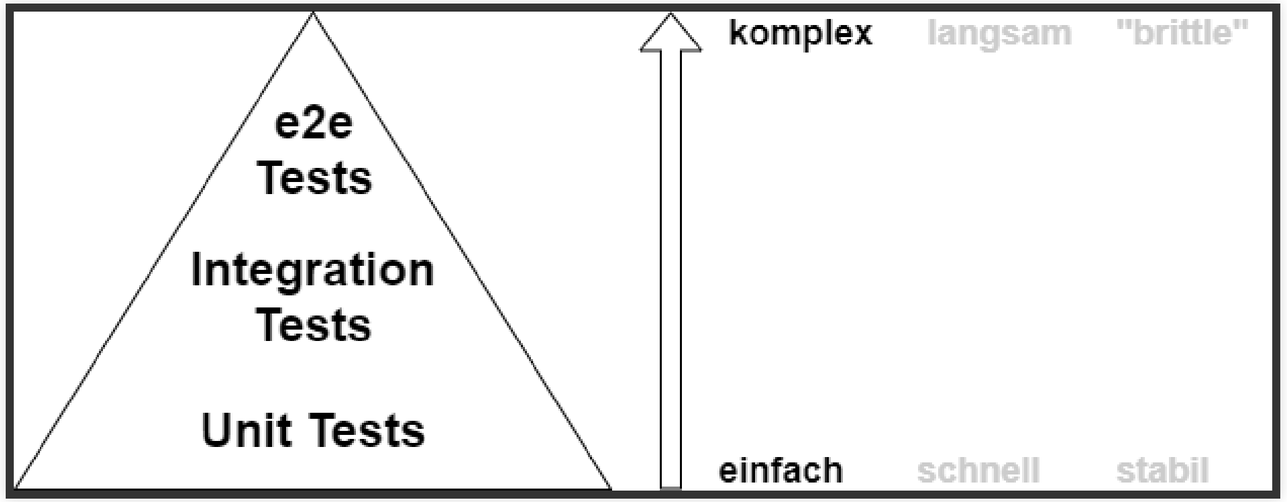
pen & paper -> write sticky notes

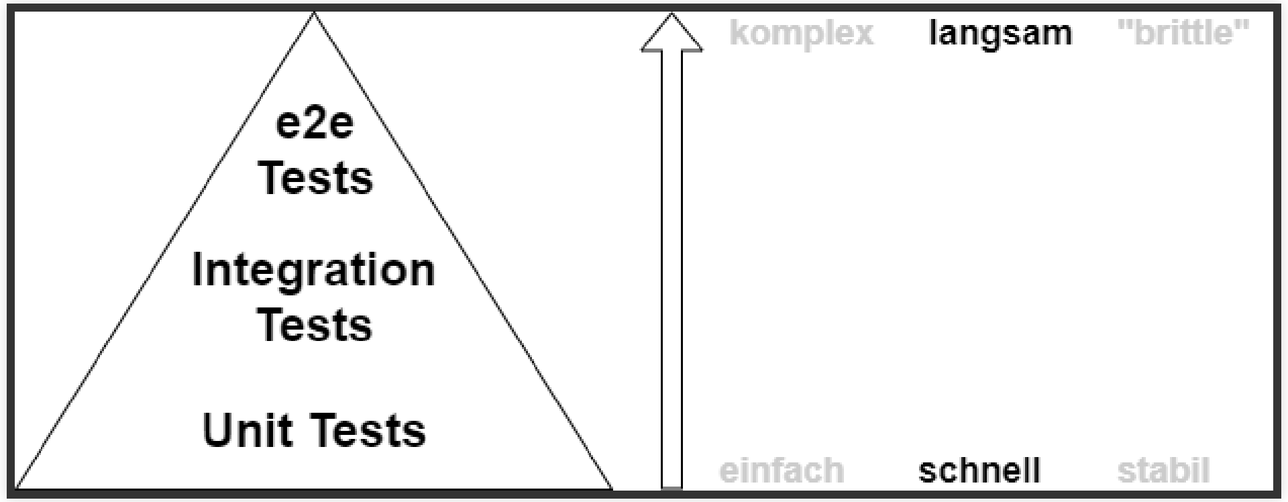
- prevent regression bugs
- improve quality / exposes edge cases
- find bugs early
- documentation
- simplifies debugging
- forces us to think about design (for example integration with other components)

DIFFERENT KINDS OF TESTS

- unit tests
- integration tests
- smoke tests
- end-to-end tests
- system tests
- acceptance tests
- ui tests
- ...

TEST PYRAMIDE


e2e
Tests
Integration
Tests
Unit Tests
komplex
langsam
"brittle"
einfach
schnell
stabil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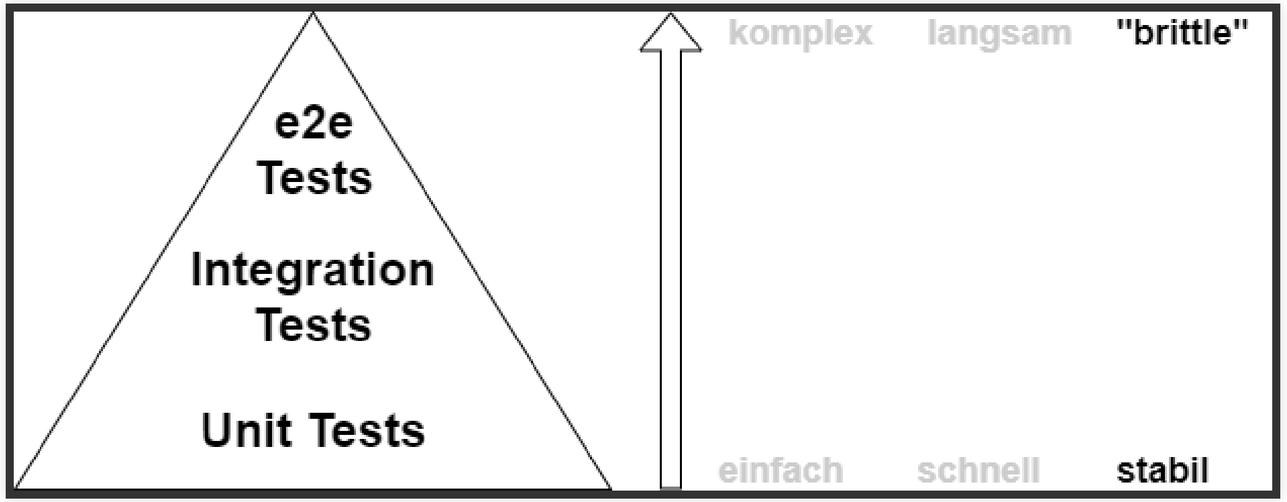
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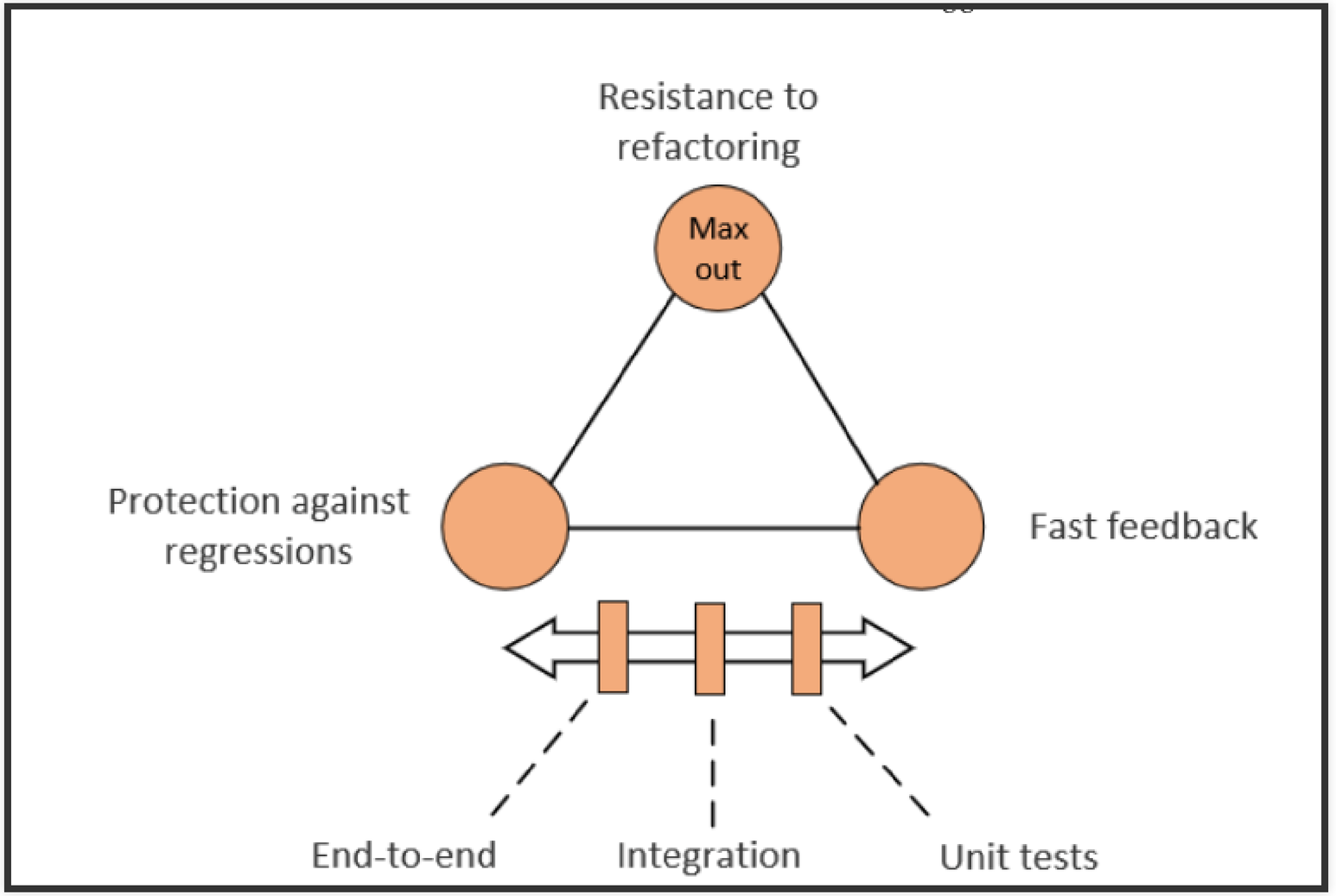
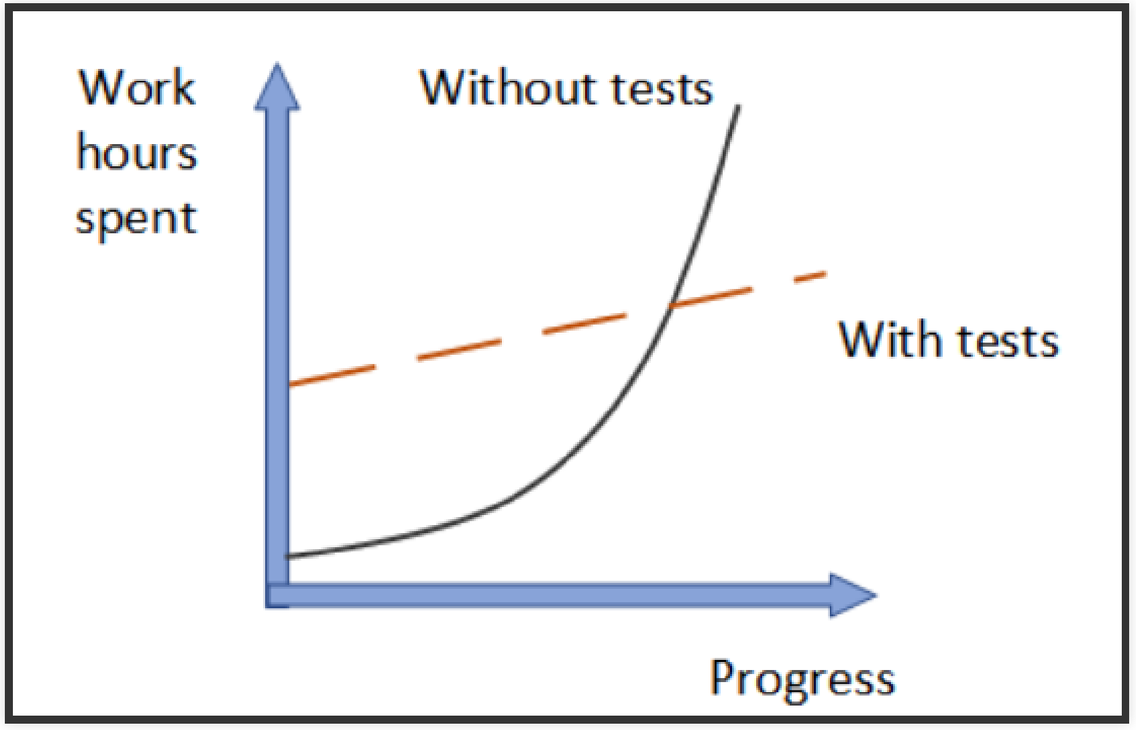
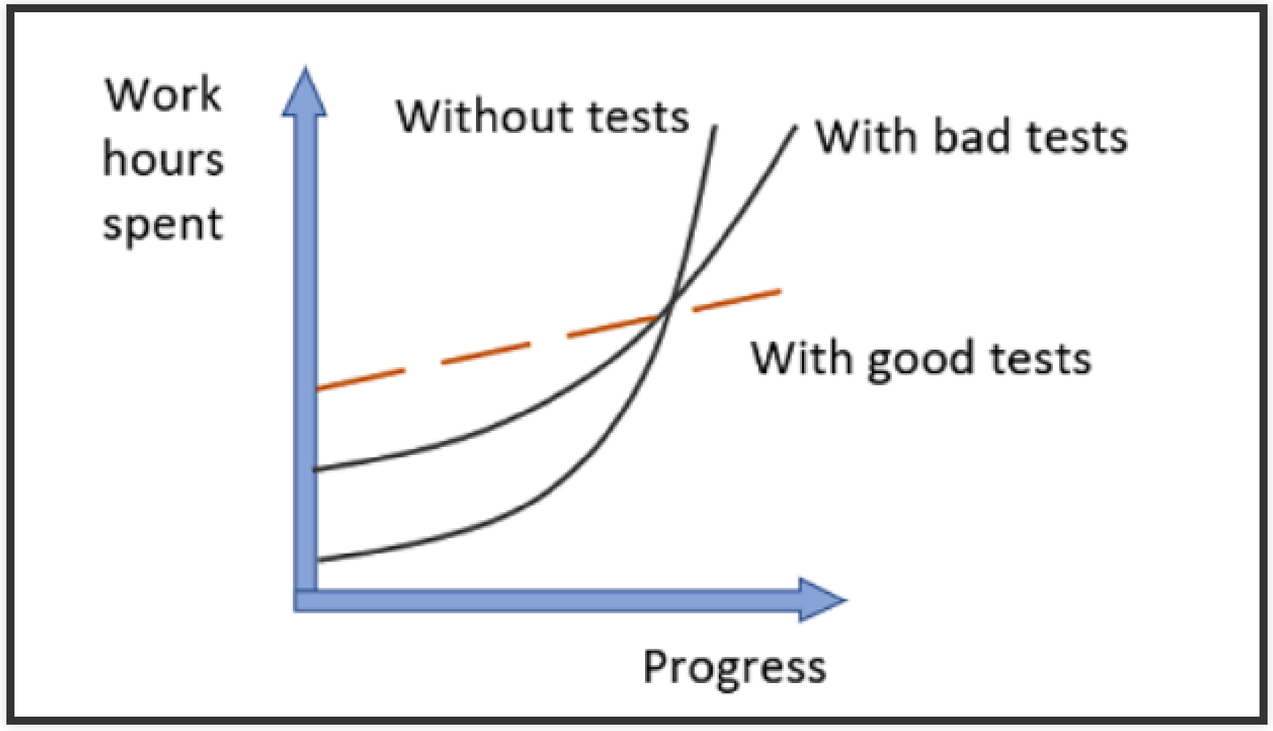

Resistance to refactoring
Max out
Protection against regressions
Fast feedback
End-to-end
Integration
Unit tests


Work
hours
spent
Without tests
With tests
Progress


Work
hours
spent
Without tests
With bad tests
With good tests
Progress

AGENDA

- purpose of testing
- testing frameworks basics
- assertion libraries
- **we code!**
- integration testing & mocking
- **we code!**
- introduction to TDD

HELLO WORLD UNIT TEST

```
// production code
public int Add(int a, int b) ⇒ a + b;

// test code
[Test]
public void Add_1_and_1_returns_2()
    ⇒ Assert.That(Add(1, 1), Is.EqualTo(2));
```

C# TESTING FRAMEWORKS

- MSTest
  - the "IE" of testing frameworks
- NUnit
  - port of JUnit
  - very stable & actively maintained
- xUnit
  - successor of NUnit
  - modern, stable & very modular
  - Microsoft uses xUnit

NUNIT BASICS

- `TestFixture` attribute on test class
- `Test` attribute on method

```
[TestFixture] // ←
public class CustomerRepositoryTests
{
    [Test]    // ←
    public void GetById_bla(){}
}
```

NUNIT ASSERTIONS

https://github.com/nunit/docs/wiki/Assertions

- Classic model (deprecated!): https://github.com/nunit/docs/wiki/Classic-Model
- Constraint model: https://github.com/nunit/docs/wiki/Constraint-Model

NUNIT CLASSIC ASSERTIONS

```
var result = "foo";

// (1)
Assert.IsTrue(result == "foox");

// (2)
Assert.AreEqual(result, "foox");
```

- Both assertions fail.

Error message from (1) is useless:

```
Expected: True
But was:  False
```

Error message from (2):

```
Expected string length 3 but was 4. Strings differ at index 3.
Expected: "foo"
But was:  "foox"
--------------^
```

PROBLEM WITH ALL ASSERTION EQUAL TESTS

```
Assert.AreEqual(result, "foox");
```

I can never remember the order of parameters, because each framework is different.

- some use `(actual, expected)`
- others use `(expected, actual)`

This makes reading the error message difficult.

NUNIT CONSTRAINT MODEL

- always uses the `Assert.That( ... )` syntax

Example:

```
var result = "foo";
Assert.That(result, Is.EqualTo("foox"));
```

- readability improvement
- sane error message

WHY ARE ERROR MESSAGE IMPORTANT?

- local machine: Quick feedback
  - continous testing
  - just read the error message and know what's wrong
- CI server
  - Fail email: why?
- Test naming & error message should tell a story

TEST NAMING CONVENTIONS

- always name test so that error message is clear
- readability tip: use snake case for tests

```
Adding_1_and_1_returns_2
Creating_customer_with_missing_name_throws
```

- use inner classes for methods needing multiple tests

```
CustomerProvider with method GetCustomerById
```

Example

```
[TestFixture]
public class CustomerProviderTests
{
    private class GetById
    {
        [Test]
        public void With_valid_id() {}

        [Test]
        public void With_invalid_id_returns_null() {}
    }
```

Error message:

```
CustomerProviderTests
    → GetById
        → With_valid_id
        → With_invalid_id_returns_null
```

ALTERNATIVE ASSERTION LIBRARIES

- FluentAssertions: https://fluentassertions.com/
- NFluent: http://www.n-fluent.net/

Goal: improve readability and error messages

```
// FluentAssertions
"foo".Should().Be("foox");
```

Bonus: **works with all test frameworks**

FLUENTASSERTIONS

https://fluentassertions.com/

ERROR MESSAGE: REASON

Most methods have an optional "reason" string

```
// wrong implementation
IEnumerable<int> GetEvenNumbers(IEnumerable<int> input)
    ⇒ input.Where(x ⇒ x % 2 ≠ 0).ToList();

[Test]
public void Parse_even_numbers()
{
    var input = new List<int>{0, 1, 2, 3, 4};
    var result = GetEvenNumbers(input);
    result.Should()
        .BeEquivalentTo(
            new List<int>{0, 2, 4},
            "odd numbers are wrong");
}
```

```
Expected result to be a collection with 3 item(s)
because odd numbers are wrong, but {1, 3}
contains 1 item(s) less than {0, 2, 4}.
```

COLLECTIONS

```
// FluentAssertionDemos
var list = new List<string>
{
    "foo",
    "bar",
    "baz"
};

list.Should()
    .HaveCount(3)
    .And.Contain("foo")
    .And.Contain("bar")
    .And.Contain("baz")
    .And.NotContain("42");
```

EXCEPTIONS

```
// FluentAssertionDemos
private static void Throws()
    => throw new Exception("Ups");

[Test]
public void Exceptions_tests()
{
    Action action = () => Throws();
    action.Should()
        .Throw<Exception>()
        .WithMessage("Ups");
}
```

EQUIVALENTTO

Shameless self plug:

http://draptik.github.io/blog/2016/05/09/testing-objects-have-same-properties/

TEST ANATOMY

- Arrange, Act, Assert (AAA)
- Given, When, Then

ANTIPATTERNS

- Avoid multiple AAA sections
  - keep test small
  - try to only test one thing
- Avoid if statements
- Avoid "Act" statement with more than 1 line
- Avoid high coupling in setup methods

```
// Arrange
var num1 = 1;
var num2 = 1;
var sut = new Calculator();
var expectedResult = 2;

// Act
var result = sut.AddNumbers(num1, num2);

// Assert
result.Should().Be(expectedResult);
```

- `Arrange` can be very long!
  - redesign?
- `Act` should only be 1 line!
- `Assert` can be very long!
  - write dedicated assertion?
  - use `AssertionScope`

- Test code should be treated with the same care as production code

ARRANGE: PARAMETERIZED TESTS (1/2)

```
// FluentAssertionDemos
[TestCase(-1, Bar.Undefined)]
[TestCase(0, Bar.All)]
[TestCase(1, Bar.Beer)]
[TestCase(2, Bar.Whiskey)]
[TestCase(3, Bar.Water)]
[TestCase(4, Bar.Undefined)]
[TestCase(99, Bar.Undefined)]
public void MapIntToBar(int input, Bar expected)
{
    MapIntToBar(input).Should().Be(expected);
}
```

ARRANGE: PARAMETERIZED TESTS (2/2)

- https://github.com/nunit/docs/wiki/TestCaseSource-Attribute

```
// FluentAssertionDemos
[TestCaseSource(typeof(CustomerTestData))]
public void CustomerIsValid(Customer customer, bool expected)
{
    customer.IsValid().Should().Be(expected);
}

private class CustomerTestData : IEnumerable
{
    public IEnumerator GetEnumerator()
    {
        yield return new object[] {
            new Customer {FirstName = null, LastName = null}, false};
        yield return new object[] {
            new Customer {FirstName = "a", LastName = "b"}, true};
    }
}
```

RUN CODE BEFORE / AFTER EACH TEST

- Useful when code repeats itself

RUN CODE BEFORE / AFTER EACH FIXTURE

- Useful for integration tests
  - example: DB setup/teardown

TEST SUITES AND OTHER ANNOTATIONS

- slow running tests
  - nightly build

ENCAPSULATION

- avoid testing private methods
  - maybe refactor?
- C# fallback:
  - make method `internal`
  - `InternalsVisibleTo` in assembly

AUTOMATION

- Automation is a critical part of testing!
- within IDE: continous test runner
  - NCrunch
  - R#
- CI (i.e. Jenkins)

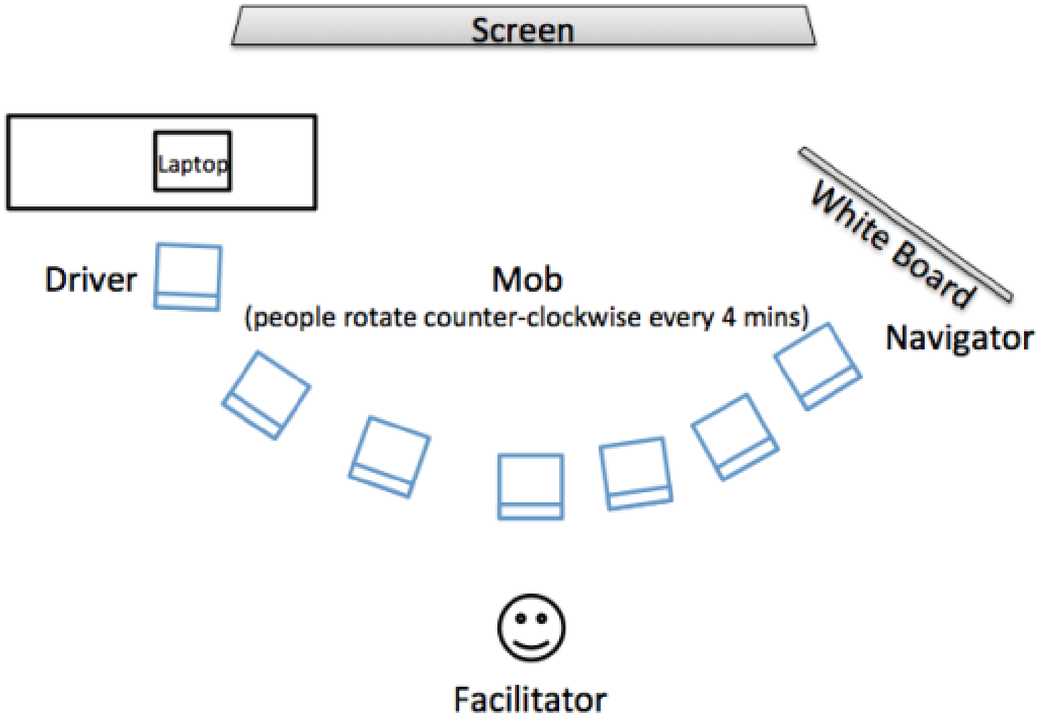
let's code

(One more thing... Mobbing)

MOB PROGRAMMING

- wir lernen gemeinsam
- Pair Programming in der Gruppe

Mob Programming Setup



- Driver: Sitzt an der Tastatur (darf nicht denken)
- Navigator: Sagt dem Driver, was zu tun ist
- Mob: Unterstützt den Navigator
- Regelmäßiger Wechsel (3-5min)

"ASSISTED" MOB PROGRAMMING

- Facilitator unterstützt den Navigator

let's code

Gilded Rose Kata

WHAT SHOULD WE TEST?

WHAT SHOULD WE TEST?

- **focus on user stories**, not on technical details
- **often evokes better design!**

Let's code!

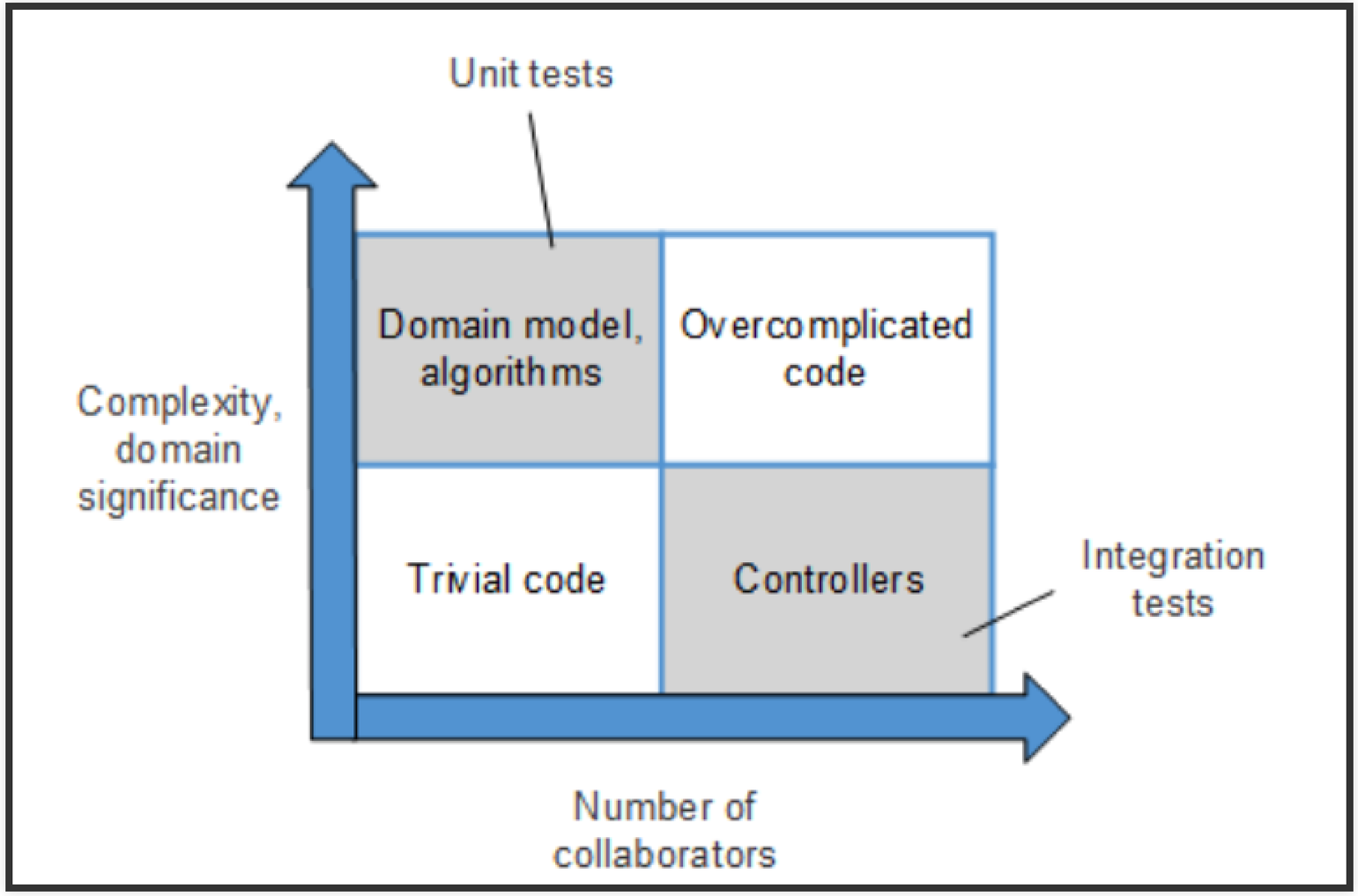
INTEGRATION TESTING

- testing how different components interact
- composing interactions

INTEGRATION TESTING

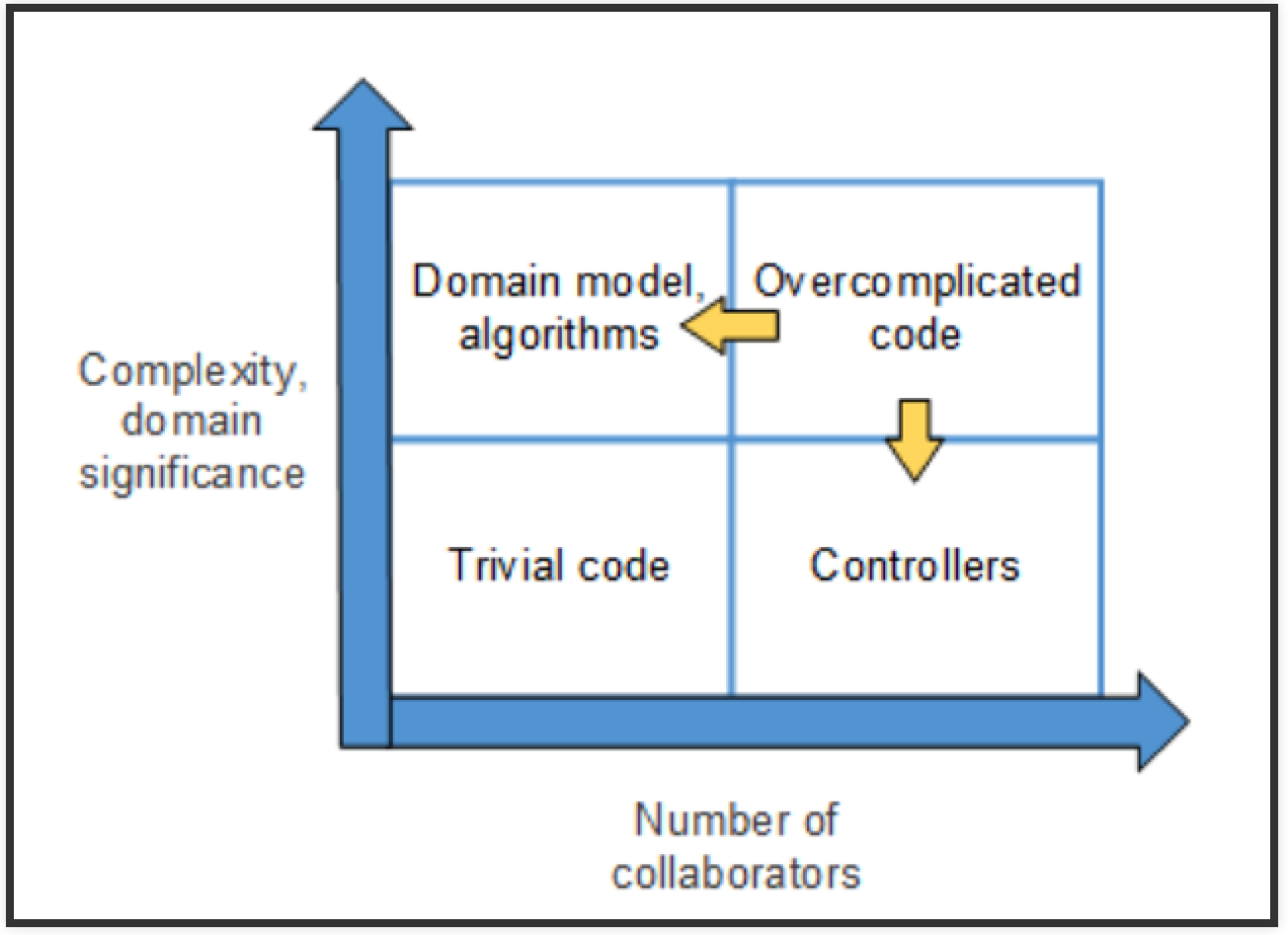
- Always a good indicator for
  - decoupling
  - correct layer of abstraction

TEST MATRIX


Unit tests
Domain model, algorithms
Overcomplicated code
Complexity, domain significance
Trivial code
Controllers
Integration tests
Number of collaborators

TEST MATRIX - CODE SMELL

- "overcomplicated code" quadrant
  - wrong layer of abstraction
  - missing encapsulation
- solution: move logic to domain object


Domain model, algorithms
Overcomplicated code
Trivial code
Controllers
Complexity, domain significance
Number of collaborators

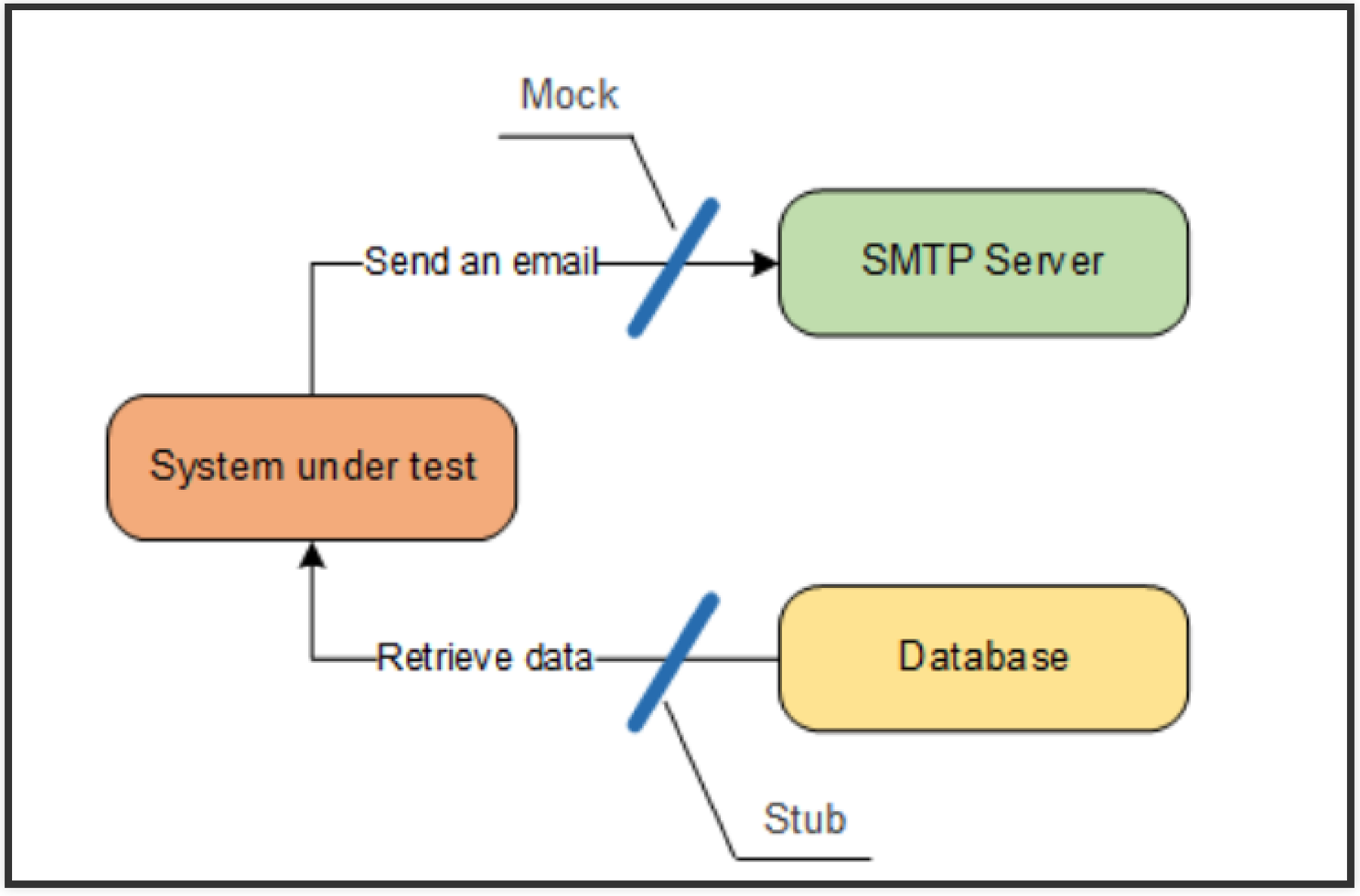
WHAT SHOULD WE TEST?

- **focus on user stories**, not on technical details
- **often evokes better design!**
- when testing technical details:
  - focus on happy path
  - bug report: write a test demonstrating the bug; then fix the bug
  - keep techn. tests maintainable!

TEST DOUBLES

- Mock (spy)
  - emulate **outcoming** interactions
- Stub (dummy, fake)
  - emulate **incoming** interactions

Many modern frameworks don't make this distinction.


Mock
Send an email
SMTP Server
System under test
Retrieve data
Database
Stub

MANUALLY CREATING MOCKS

- only useful for simple objects
- time consuming

MOCKING FRAMEWORKS

- often require interface or virtual methods (C#)
- focus on methods required in test
- setup pre conditions
- verify post conditions

C# MOCKING FRAMEWORKS

- Moq
  - can also mock classes without interfaces
- NSubstitute
  - nice API
- FakeItEasy
  - nice API

NSUBSTITUTE

```
// Arrange
var mailer = Substitute.For<IMailer>(); // ←

var validCustomer = new ValidCustomer();

// We inject an interface to the system-under-test!
// Mocking frameworks can control the behaviour of the injected object!
var sut = new RegistrationService(mailer);

// Act
sut.Register(validCustomer);

// Assert
mailer.Received().Send(); // ←
```

examples in code

GOLDEN MASTER

- use actual program behaviour as reference
- useful when working with legacy code you don't understand
- compares final ouptut with previously "recorded" output (record analogy)

now you know the **tooling**!

Let's use **testing** to **DRIVE** our **development**!

RECAP: TRADITIONAL APPROACH

- Design
- Implementation
- Test

DRAWBACKS WHEN WRITING TESTS AT END

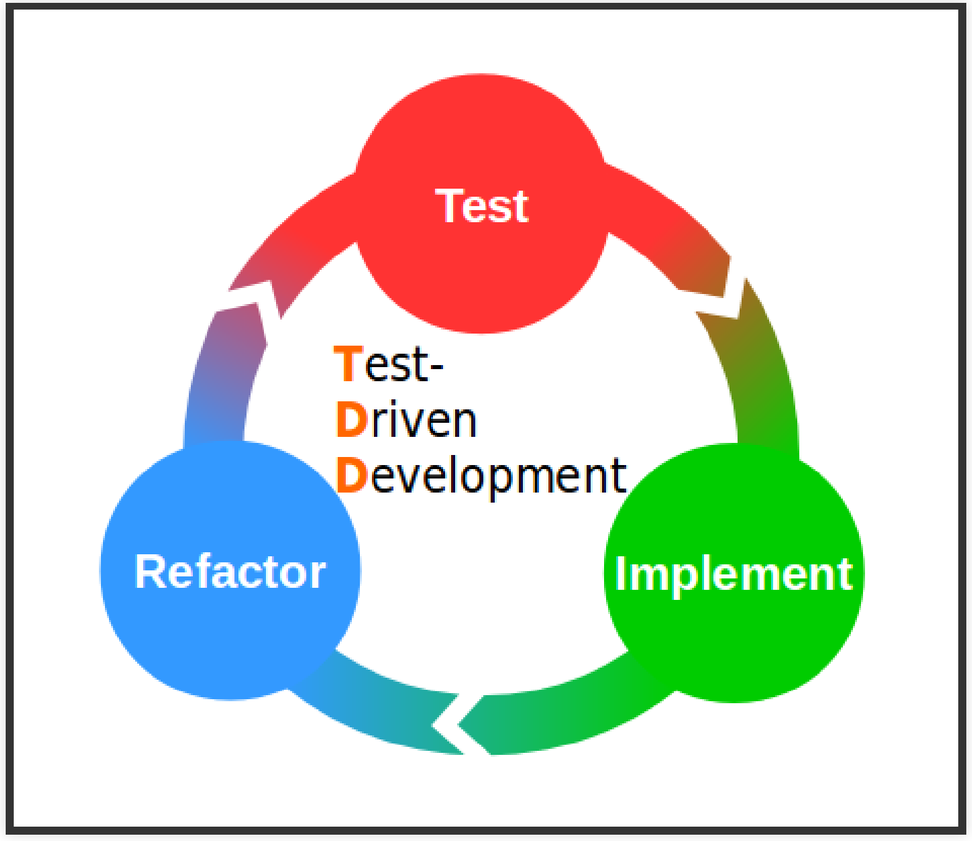
- low test coverage
- late testing: rethink problem
- knowledge of implementation: changes how tests are written
- not automated

TEST-DRIVEN DEVELOPMENT (TDD)

- Design
- Test
- Implementation

TDD WORKFLOW

- Red
- Green
- Refactor


Test
Test-
Driven
Development
Refactor
Implement

- no code without test
- untested code should not go live
- baby steps: only write code to make test pass

TDD PATTERNS

- isolated tests
- Test List (on paper, not in code -> small steps)
- Test first -> less "stress"
- Assert first
- use Test data (vs realistic data)

RED BAR PATTERNS

Patterns decribing

- when to write tests
- where to write tests
- when to stop writing test

RED BAR PATTERNS

- Starter test
- Explaining test
- Regression test
- One step test

STARTER TEST

- Output equals input
- input as small as possible

EXPLAINING TEST

- Test should explain what is happening

REGRESSION TEST

- small test reproducing error
- why wasn't the test there before?
- Redesign?

ONE STEP TEST

- Categorize tasks by difficulty
  - Obvious
  - no idea
  - WAT?
  - **this I can do**

GREEN BAR PATTERNS

Patterns describing how to go from red to green

- obvious implementation
- triangulation
- "fake it til you make it"

OBVIOUS IMPLEMENTATION

- simple enough -> just implement it (driving in 2nd gear)
- BUT: if you encounter surprising red bars -> take smaller steps ("be prepared to downshift")

TRIANGULATION

- Abstract only if you have 2 or more examples
- Use when you are really unsure about correct abstraction.
- Prefer "fake it til you make it" or "Obvious Implementation"

FAKE IT TIL YOU MAKE IT

TRANSFORMATION PRIORITY PREMISE

- ...gradually replace constants with variables...
- taken one step further
- Example using Transformation Priority Premise

ADVANTAGES OF TDD

- high test coverage
- increases modularity
- improves maintainability
- implicit documentation

let's code

Fizz-Buzz Kata

SCHOOLS OF TDD

- **Classical**
  - aka Detroit, Chicago, "inside-out", "fake it til you make it"
  - K. Beck: Test-Driven Development By Example
- **London**
  - aka moquist, "outside-in"
  - Freeman & Pryce: Growing Object Oriented Software Guided by Tests
- Munich: David Voelkl
- Hamburg: Ralph Westpfahl

RESSOURCEN

- Kent Beck: Test-Driven Development By Example
- Roy Osherove: The Art of Unit Testing
- Steve Freeman and Nat Pryce: Growing Object Oriented Software Guided by Tests
- Vladimir Khorikov: Unit testing. Principles, Practices and Patterns