Software Engineering I (02161)

Week 3

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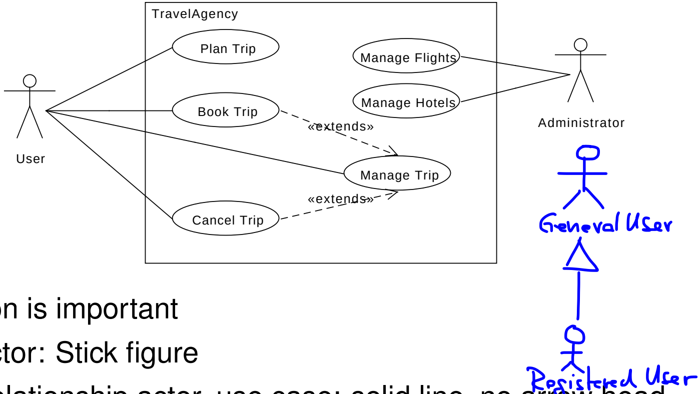
Recap

- Requirements Engineering
  - functional / non-functional requirements
  - Elicitation, Documentation, Validation
- Glossary
- Use Cases
  - use case diagrams
  - detailed use cases descriptions
- User Stories

Use Case Diagram



Notation is important

- Actor: Stick figure
- Relationship actor, use case: solid line, no arrow head
- Relationship use case, user case: broken line with arrow and <<extends>> or <<*includes*>>
- Relationship actor, actor: Generalization: solid line with closed arrow head
- System boundary: Box

Contents

Software Testing

Acceptance tests

JUnit

Test Driven Development

How calendars and dates work in Java

Mock objects

Purpose of tests

- Goal: finding bugs

Edsger Dijkstra

”Tests can show the presence of bugs, but not their absence.”

- Types of bugs: requirement-, design-, implementation errors
- Types of testing:
  - validation testing
    - Does the software conform to the requirements?
    - **Have we built the right system?**
  - defect testing
    - Does the software has any unexpected behaviour (e.g. crashes)?
    - **Have we built the system right?**

Validation testing vs defect testing

Validation Test

- Start city is Copenhagen, destination city is Paris. The date is 1.3.2012. Check that the list of availabe flight contains SAS 1234 and AF 4245

Defect Test

- Start city is Copenhagen, the name of the destination city contains the Crtl-L character.

Types of tests

1. Developer tests (basically validation testing)
   - a) Unit tests (single classes and methods)
   - b) Component tests (single components = cooperating classes)
   - c) System tests / Integration tests (cooperating components)
2. Release tests (validation and defect testing)
   - a) Scenario based testing
   - b) Performance testing
3. User tests
   - a) Acceptance tests

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Acceptance Tests

- Tests defined by / with the help of the user
  - based on the requirements
- Traditionally
  - manual tests
  - by the customer
  - *after* the software is delivered
  - based on use cases / user stories
- Agile software development
  - automatic tests: JUnit, Fit, ...
  - created *before* the user story is implemented

Example of acceptance tests

- Use case

  name: Login Admin
  actor: Admin
  precondition: Admin is not logged in
  main scenario

  1. Admin enters password
  2. System responds true

  alternative scenarios:

  1a. Admin enters wrong password
  1b. The system reports that the password is wrong and the use case starts from the beginning

  postcondition: Admin is logged in

Manual tests

Successful login

Prerequisit: the password for the administrator is “adminadmin”

Input	Step	Expected Output	Fail	OK
	Startup system	“0) Exit” “1) Login as administrator”		✓
“1”	Enter choice	“password?”		✓
“adminadmin”	Enter string	“logged in”		✓

Failed login

Prerequisit: the password for the administrator is “adminadmin”

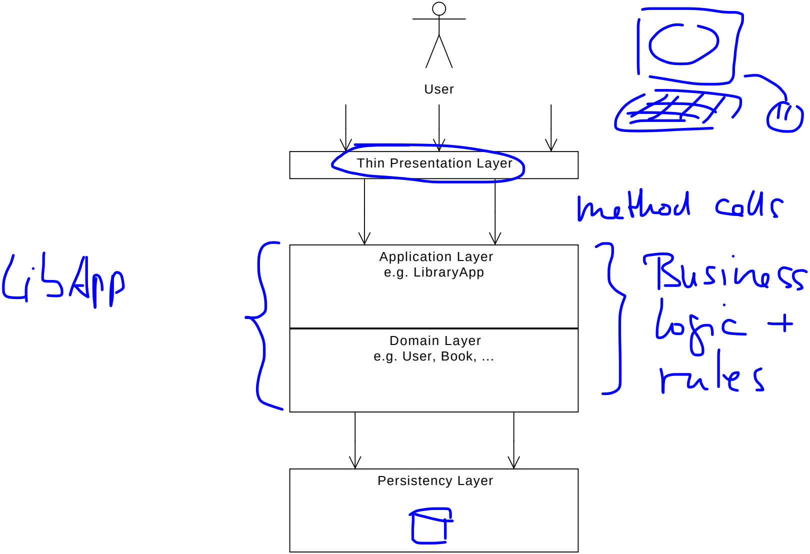
Input	Step	Expected Output	Fail	OK
	Startup system	“0) Exit” “1) Login as administrator”		
“1”	Enter choice	“password”		
“admin”	Enter string	“Password incorrect” “0) Exit” “1) Login as administrator”		

- Automatic test for the main scenario

Manual vs. automated tests

- Manual tests should be avoided
  - They are expensive (time and personal) to execute: Can't be run often
- Automated tests
  - Are cheap (time and personal) to execute: Can be run as soon something is changed in the system
    - → immediate feedback if a code change introduced a bug
    - → Regression tests
  - More difficult (but not impossible) when they include the UI
  - → Solution: Test under the UI
- Robert Martin (Uncle Bob) in
  → `http://www.youtube.com/watch?v=hG4LH6P8Syk`
  - manual tests are immoral from 36:35
  - how to test applications having a UI from 40:00

Testing under the UI



User

Thin Presentation Layer

Application Layer
e.g. LibraryApp

Domain Layer
e.g. User, Book, ...

Persistency Layer

Automatic tests

Successful login

```
@Test
public void testLoginAdmin() {
   LibraryApp libApp = new LibraryApp();

   assertFalse(libApp.adminLoggedIn());

   boolean login = libApp.adminLogin("adminadmin");

   assertTrue(login);
   assertTrue(libApp.adminLoggedIn());
}
```

Failed login

```
@Test
public void testWrongPassword() {
   LibraryApp libApp = new LibraryApp();

   assertFalse(libApp.adminLoggedIn());

   boolean login = libApp.adminLogin("admin");

   assertFalse(login);
   assertFalse(libApp.adminLoggedIn());
}
```

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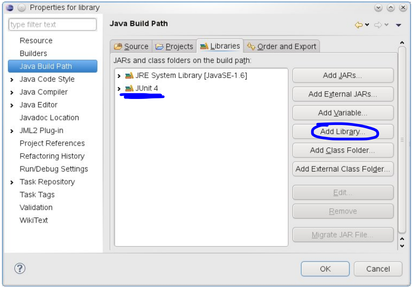
JUnit

- Framework for automated tests in Java
- Developed by Kent Beck and Erich Gamma
- Unit-, component-, and *acceptance* tests
- `http://www.junit.org`
- *x*Unit

JUnit and Eclipse

- JUnit 4.x libraries



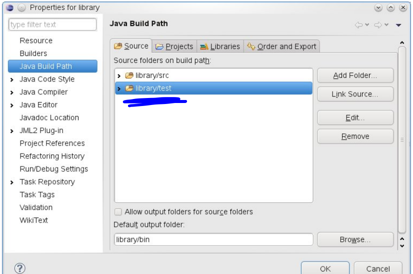
Properties for library

Java Build Path

JARs and class folders on the build path:

- JRE System Library [JavaSE-1.6]
- JUnit 4

- New source directory for tests



Properties for library

Java Build Path

Source folders on build path:

- library/src
- library/test

□ Allow output folders for source folders

Default output folder: library/bin

JUnit *4.x* structure

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

public class C {
   @Test
   public void m1() {..}
   @Test
   public void m2() throws Exception {..}
   ...
}
```

- *Independent* tests
- No try-catch blocks (exception: checking for exceptions)

JUnit *4.x* structure (Before and After)

```
...
public class C {
   @After
   public void n2() {...}
   @Before
   public void n1() {...}
   @Test
   public void m1() {..}
   @Test
   public void m2() {..}
   ...
}
```

n1; m1; n2; n1; m2; n2

Struture of test cases

- Test class = one use case
- Test method = one scenario
- Use inheritance to share sample data between use cases

```
public class SampleDataSetup {
   @Before()
   public void setUp() { .. }
   @After()
   public void tearDown { .. }
   ... }

public class TestBorrowBook extends SampleDataSetup {..}
```

JUnit assertions

General assertion

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

assertTrue(bexp)
assertTrue(msg,bexp)
```

Specialised assertions for readability

```
1. assertFalse(bexp)          assertTrue(!bexp)

2. fail()             assertTrue(false)

3. assertEquals(exp,act)

4. assertNull(obj)            assertTrue(obj == null)

5. assertNotNull(obj)         assertTrue(obj != null)
...
```

JUnit: testing for exceptions

- Test that method m() throws an exception MyException

```
@Test
public void testMThrowsException() {
   ...
   try {
      m();
      fail(); // If we reach here, then the test fails because
              // no exception was thrown
   } catch(MyException e) {
      // Do something to test that e has the correct values
   }
}
```

- Alternative

```
@Test(expected=MyException.class)
public void testMThrowsException() {..}
```

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Test Driven Development
- Test Driven Development
- Example of Test-Driven Development
- Refactoring

How calendars and dates work in Java

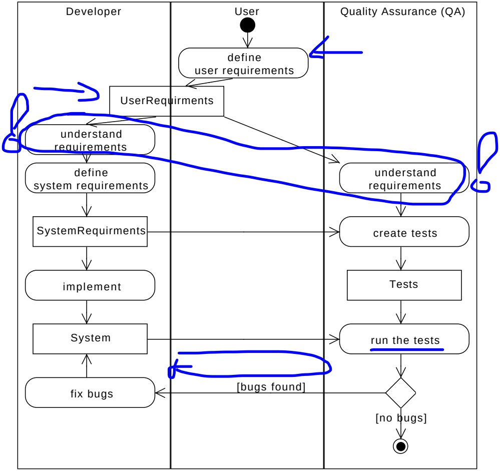
Mock objects

Test-Driven Development

- Test *before* the implementation
- Tests = expectations on software
- All kind of tests: unit-, component-, system tests

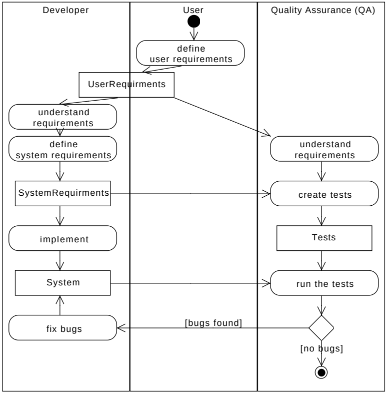
Test-Driven Development

Traditional testing

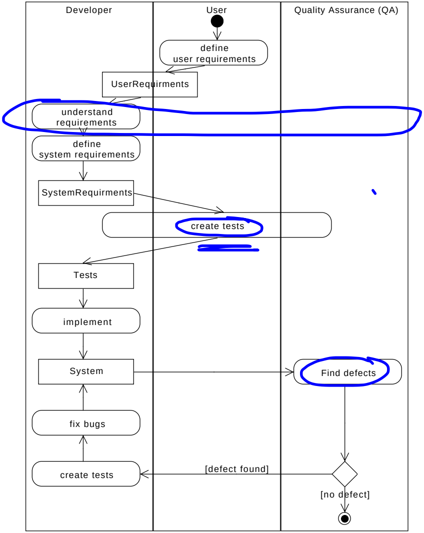


Test-Driven Development

Traditional

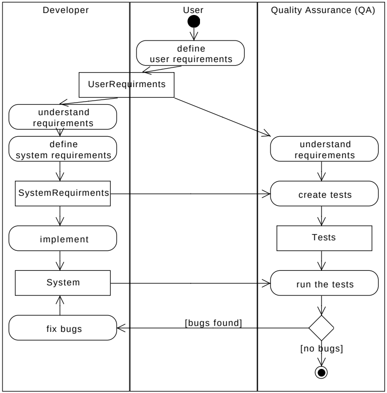


Moving to TDD

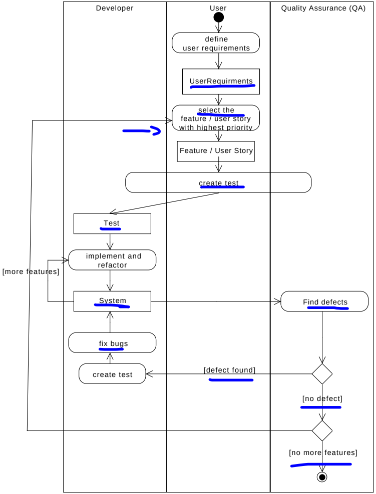


Test-Driven Development

Traditional



Real TDD



TDD cycle

- Repeat for functionality, bug, . . .

  red: Create a *failing* test
  green: Make the test pass
  refactor: clean up your code

- Until: no more ideas for tests
- Important:
  - One test at a time
  - Implement only as much code so that the test does not fail.
    - If the method looks incomplete,

    → add more failing tests that force you to implement more code

Ideas for tests

1. Use case scenarios (missing functions): Acceptance tests
2. Possibility for defects (missing code): Defect tests
3. You want to write *more* code than is necessary to pass the test
4. Complex behaviour of classes: Unit tests
5. Code experiments: ”How does the system behave, if ...”

→ Make a list of new test ideas

TDD example: Borrow Book

- Use case

  name: borrow book
  description: the user borrows a book
  actor: user
  main scenario:

  1. the user borrows a book

  alternative scenario

  1. the user wants to borrow a book, but has already 10 books borrowed
  2. the system presents an error message

Create a test for the main scenario

- test data:
  - a user with CPR ”1234651234” and book with signature ”Som001”
- Test case
  - Retrieve the user with CPR number ”1234651234”
  - Retrieve the book by the signature ”Som001”
  - The user borrows the book
  - The book is in the list of books borrowed by that user

Create a test for the main scenario

```
@Test
public void testBorrowBook() throws Exception {
   String cprNumber = "1234651234";
   User user = libApp.userByCprNumber(cprNumber);
   assertEquals(cprNumber,user.getCprNumber());

   String signature = "Som001";
   Book book = libApp.bookBySignature(signature);
   assertEquals(signature,book.getSignature());

   List<Book> borrowedBooks = user.getBorrowedBooks();
   assertFalse(borrowedBooks.contains(book));

   user.borrowBook(book);

   borrowedBooks = user.getBorrowedBooks();
   assertEquals(1,borrowedBooks.size());
   assertTrue(borrowedBooks.contains(book));
}
```

Implement the main scenario

```
public void borrowBook(Book book) {
  borrowedBooks.add(book);
}
```

Create a test for the alternative scenario

- test data:
  - a user with CPR ”1234651234”, book with signature ”Som001”, and 10 books with signatures ”book1”, . . . , ”book10”
- Test case
  - Retrieve the user with CPR number ”1234651234”
  - Retrieve and borrow the books with signature ”book1”, . . . , ”book10”
  - Retrieve and borrow the book by the signature ”Som001”
  - Check that a TooManyBooksException is thrown

Implementation of the alternative scenario

```
public void borrowBook(Book book) throws TooManyBooksException
  if (borrowedBooks.size() >= 10) {
    throw new TooManyBooksException();
  }
  borrowedBooks.add(book);
}
```

More test cases

- What happens if book == null in borrowBook?
- Test Case:
  - Retrieve the user with CPR number ”1234651234”
  - Call the borrowBook operation with the null value
  - Check that the number of borrowed books has not changed

Final implementation so far

```
public void borrowBook(Book book) throws TooManyBooksException
  if (book == null) return;
  if (borrowedBooks.size() >= 10) {
    throw new TooManyBooksException();
  }
  borrowedBooks.add(book);
}
```

Another example

- Creating a program to generate the n-th Fibonacci number

→ Codemanship's Test-driven Development in Java by Jason Gorman

  `http://youtu.be/nt2KKUSSJsY`

- Note: The video uses JUnitMax to run JUnit tests automatically whenever the test files change (`junitmax.com`)
- A tool with similar functionality but free is Infinitest (`https://infinitest.github.io`)

Refactoring and TDD

- Third step in TDD
- *restructure* the system without *changing* its functionality
- Goal: *improve* the design of the system, e.g. remove code duplication (DRY principle)
- Necessary step
- Requires good test suite

→ later in the course more about refactoring mechanics

TDD: Advantages

- Test benefits
  - Good code coverage: Only write production code to make a failing test pass
- Design benefits
  - Helps design the system: defines usage of the system before the system is implemented

  → Testable system

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How to use Date and calendar (I)

- Date class deprecated
- Calendar and GregorianCalendar classes
- An instance of Calendar is created by

  ```
  new GregorianCalendar() // current date and time
  new GregorianCalendar(2011, Calendar.JANUARY,10)
  ```
- Note that the month is 0 based (and not 1 based). Thus 1 = February.
- Best is to use the constants offered by Calendar, i.e. Calendar.JANUARY

How to use Date and calendar (I)

- One can assign a new calendar with the date of another by

  ```
  newCal.setTime(oldCal.getTime())
  ```

- One can add years, months, days to a Calendar by using add: e.g.

  ```
  cal.add(Calendar.DAY_OF_YEAR,28)
  ```

- Note that the system roles over to the new year if the date is, e.g. 24.12.2010
- One can compare two dates represented as calendars using before and after, e.g.

  ```
  currentDate.after(dueDate)
  ```

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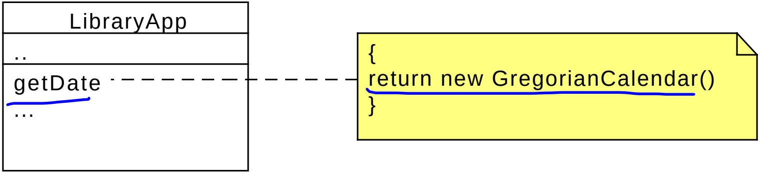
Problems

- How to test that a book is overdue?
  - Borrow the book today
  - Jump to the data in the future when the book is overdue
  - Check that the book is overdue



LibraryApp

..

getDate

...

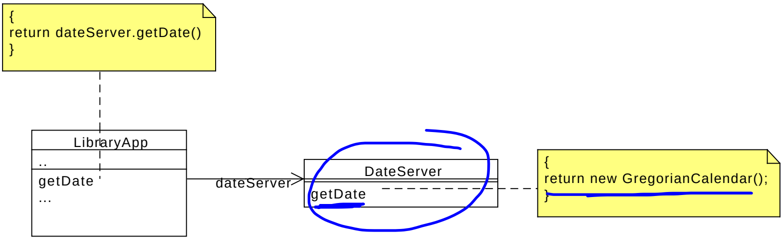
```
{
return new GregorianCalendar()
}
```

- How do we jump into the future?

→ Replace the GregorianCalendar class by a *mock* object that returns fixed dates

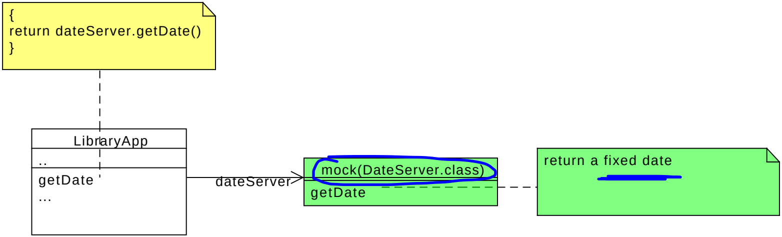
- Problem: Can't replace GregorianCalendar class

Creating a DateServer class



Creating a DateServer class

- The DateServer can be mocked



How to use

- Import helper methods

```
import static org.mockito.Mockito.*;
```

- Create a mock object on a certain class

```
SomeClass mockObj = mock(SomeClass.class)
```

- return a predefined value for `m1(args)`

```
when(mockObj.m1(args)).thenReturn(someObj);
```

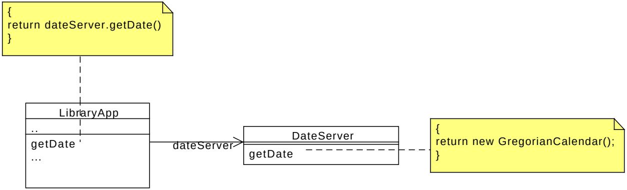
- verify that message `m2(args)` has been sent

```
verify(mockObj).m2(args);
```

Mock Example 1: Overdue book

```
@Test
public void testOverdueBook() throws Exception {
   DateServer dateServer = mock(DateServer.class);
   libApp.setDateServer(dateServer);
   Calendar cal = new GregorianCalendar(2011,Calendar.JANUARY,10);
   when(dateServer.getDate()).thenReturn(cal);
   ...
   user.borrowBook(book);
   newCal = new GregorianCalendar();
   newCal.setTime(cal.getTime());
   newCal.add(Calendar.DAY_OF_YEAR, MAX_DAYS_FOR_LOAN + 1);
   when(dateServer.getDate()).thenReturn(newCal);
   assertTrue(book.isOverdue());
}
```

LibraryApp Code



```
{
return dateServer.getDate()
}
```

LibraryApp

..

getDate
...

dateServer

DateServer

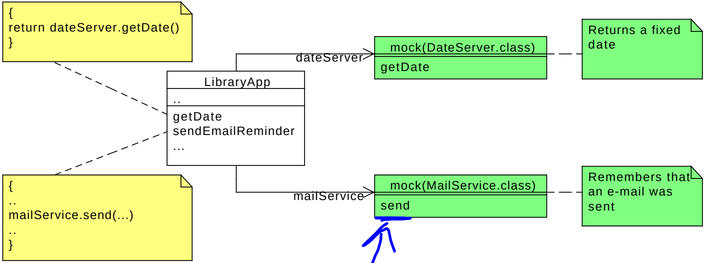
getDate

```
{
return new GregorianCalendar();
}
```

```
public class LibraryApp {
   private DateServer ds = new DateServer();
   public setDateServer(DateServer ds) { this.ds = ds;}
   ...
}

public class DateServer {
   public Calendar getDate() {
      return new GreogorianCalendar();
   }
}
```

Testing for e-mails



{
return dateServer.getDate()
}

LibraryApp

..

getDate
sendEmailReminder
...

dateServer

mock(DateServer.class)

getDate

Returns a fixed date

{
..
mailService.send(...)
..
}

mailService

mock(MailService.class)

send

Remembers that an e-mail was sent

```
@Test
public void testEmailReminder() throws Exception {
   DateServer dateServer = mock(DateServer.class);
   libApp.setDateServer(dateServer);

   MailService mailService = mock(MailService.class);
   libApp.setMailService(mailService);
   ...
   libApp.sendEmailReminder();
   verify(mailService).send("..","..","..");
}
```

Verify

Check that no messages have been sent

```
verify(ms,never()).send(anyString(), anyString(), anyString());
```

Mockito documentation: `http://docs.mockito.googlecode.com/hg/org/mockito/Mockito.html`

Exercises and Next Week

- Exercises
  - Programming exercise number 3
  - Exercise 3: Acceptance Tests and TDD
- Systematic tests and code coverage