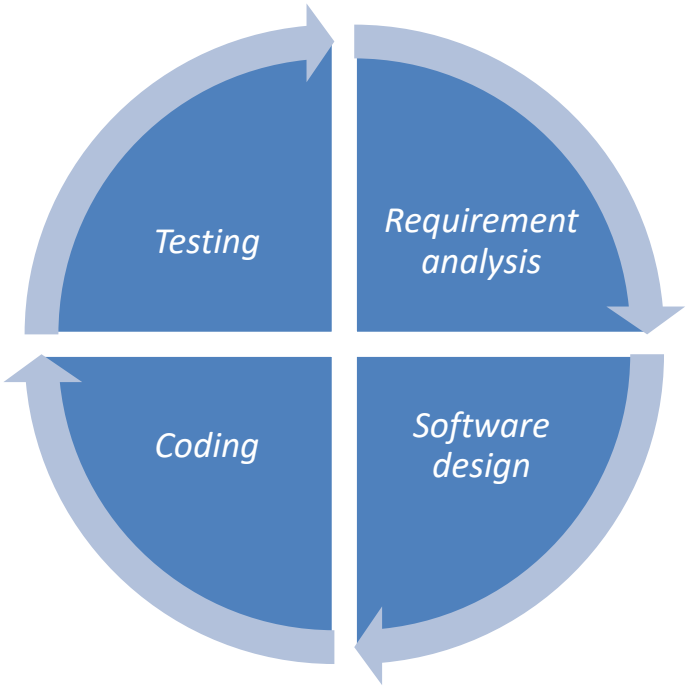
UNIVERSITAT DE BARCELONA

Software Integrated Project (2019-2020)

Software testing

Karim Lekadir, PhD
Universitat de Barcelona
Dpt. Matemàtiques & Informàtica

Development Lifecycle



Motivation

- Software development can be carried out without a proper requirement analysis, but not without testing
- Good software companies have testing teams / experts
- It is important to plan ahead the software testing procedures, well before software development begins
- Timing is key: Sufficient time needs to be allocated to testing before software release

Real Examples

Search International edition
The Guardian

Amazon sellers hit by nightmare before Christmas as glitch cuts prices to 1p

Small businesses count cost of error in RepricerExpress software that resulted in thousands of items going for a song

▲ Boxes of goods at an Amazon warehouse. Photograph: Graeme Robertson for the Guardian

There were Christmas shopping bargains galore on Amazon's website over the weekend ... for about an hour. Because of a technical glitch, the prices of thousands of items crashed to 1p - giving eagle-eyed customers a pre-Christmas treat while leaving scores of small family-owned businesses nursing heavy losses, with some warning they could enter the new year facing closure.

Real Examples

Bad Software Causes Million-Vehicle Nissan Airbag Recall

Posted on 26 March 2014 by Kenneth Zino

Nissan North America is conducting a recall on almost one million Nissan and Infiniti 2013 and 2014 models because defective software can prevent the passenger-side airbag from working during an accident. Affected are some of the company's most popular vehicles including the Altima, Pathfinder, Sentra as well as Infiniti Q50 and QX60 vehicles, which were built in Japan, Mexico and the U.S.

Engine vibration can apparently fool the software into thinking the seat is empty.

The safety defect is caused by software that thinks the passenger seat is empty when it is occupied. Failure of the airbag to deploy during a crash of sufficient intensity could increase the risk of injury to the passenger. It is the latest example of how computer programming of electronics is a growing problem in not only safety matters but also hurting customer satisfaction ratings.

Real Examples

REUTERS

Business Markets World Politics TV More

BUSINESS NEWS FEBRUARY 6, 2020 / 4:43 PM / 3 MONTHS AGO

New 737 MAX software flaw found during tests, Boeing sticks to return timeline

Alistair Smout, David Shepardson

4 MIN READ

LONDON/WASHINGTON (Reuters) - Flight testers discovered another flaw in the software of Boeing Co's grounded 737 MAX, the plane that suffered two fatal crashes, though the company and the top U.S. aviation regulator said on Thursday the issue most likely could be fixed without extending the target date for the plane's return to service.

Types of Software Testing

- More than 100 types, for example:

✓ Acceptance, Accessibility, Agile, Ad-hoc, Alpha, API, Automated, Beta, Benchmark, Black box, Code-driven, Compatibility, Comparison, Component, Configuration, Compliance, Error-Handling, End-to-end, Endurance, Functional, Gray Box, Integration, Install/uninstall, Localization, Non-functional, Negative, Operational, Performance, Regression, Recovery, Requirements, Security, Scenario, Scalability, Stability, Storage, Stress, System, Upgrade, Unit, User Interface, Volume, White box, Workflow

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Types of Software Testing

- White-box testing: Inside of the software, i.e. structure, design and code:
  - ✓ Unit testing
  - ✓ Integration testing
- Black-box testing: End-user perspective, i.e. expected results.

- Functional testing: Functions of the software, i.e. usability.
- Non-functional testing: Non-functional aspects such as interoperability, scalability, load/volume, etc.

Unit Testing

- Test each function, class and component of the code separately and specifically
- When: During development/coding
- Typical error: Doing minimal unit testing to save time. This leads to more defects and higher system testing
- Best approach: Write code for automated unit testing, e.g. by verifying the code for a range of cases (e.g. values including extreme values), then flag failed test cases.
- Re-run the test functions every time you modify the unit's implementation.

Unit Testing

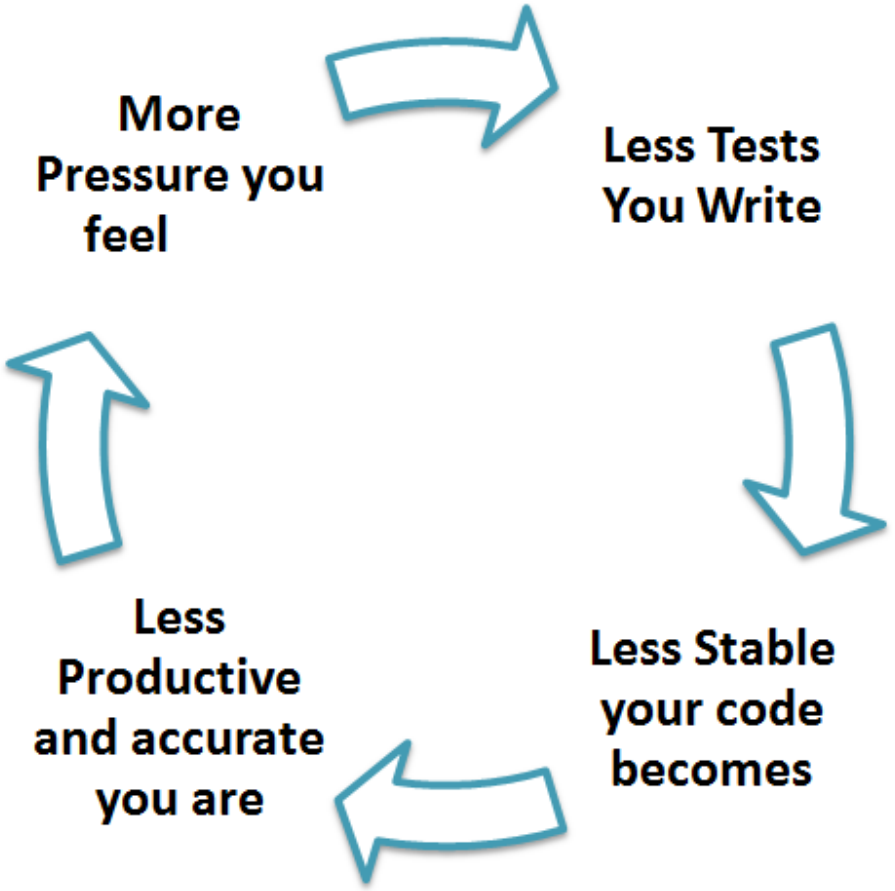
- Example 1: HeartApp
- Write code to test the function that reads blood pressure from a device
- Test cases:
  - ✓ Range of values for blood pressure
  - ✓ Test zero, negative and very high/low values
  - ✓ Test empty values (users did not use properly the device)
  - ✓ Test EU vs. American devices (ask manufacturers for potential errors to verify)

Unit Testing

- Example 2: HeartApp
- Write code to test the function that estimates risk
- Test cases:
  - ✓ Range of values for blood pressure, weight, heart rate, etc
  - ✓ Test zero, negative and very high/low values
  - ✓ Test missing values
  - ✓ Test errors in the input (e.g. age = 162 instead of 62)
  - ✓ Test extreme output values (very high or zero probability)

Unit Testing

- Avoid vicious cycles during testing



Integration Testing

- Important as different units are developed and tested by different team members
- Tests (1) the joint functioning of the units and (2) communication / interfaces between modules
- Method 1: Big bang approach, i.e. all modules at once
- Method 2: Incremental, i.e. test two modules together, than three, than four, etc.
- The incremental approach facilitates detection of errors, but does not allow for early prototyping

Integration Testing

- Example: HeartApp
- Write code to test the function that estimates risk, while reading data from medical devices
- Test cases:
  - ✓ Multiple devices and metric systems
  - ✓ Retrospective data (e.g. 100 cases from hospital)
  - ✓ Retrospective data + noise + outliers
  - ✓ Simulated data and groups (normal / abnormal)
  - ✓ Different combination of extreme values, exceptions, etc.
  - ✓ Verify outputs (e.g. high values)

Performance Testing

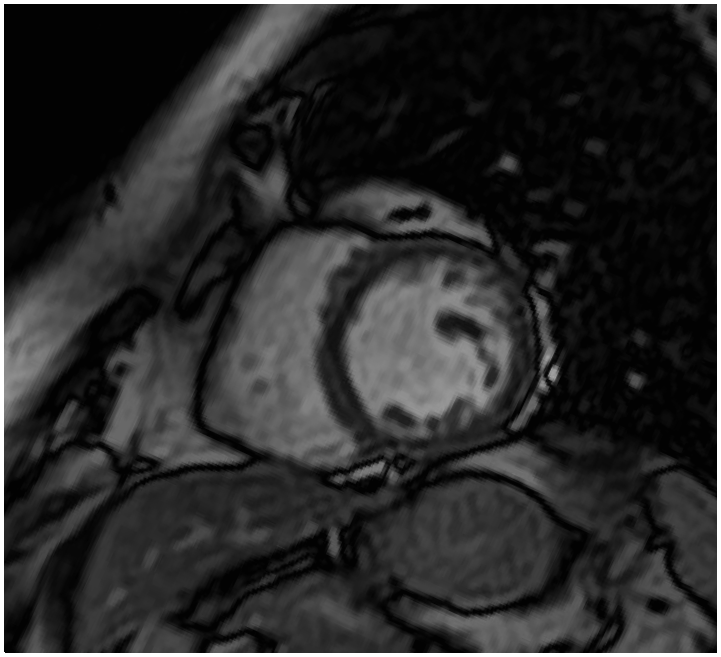
- Test whether (or to which extent) the software achieves the expected results (depending on the goal of the software)
- This often requires a dedicated test study with retrospective (existing) and prospective (new) data
- The process includes the definition of procedures, including the data, users and testers
- Performance testing will require metrics, indicators or criteria

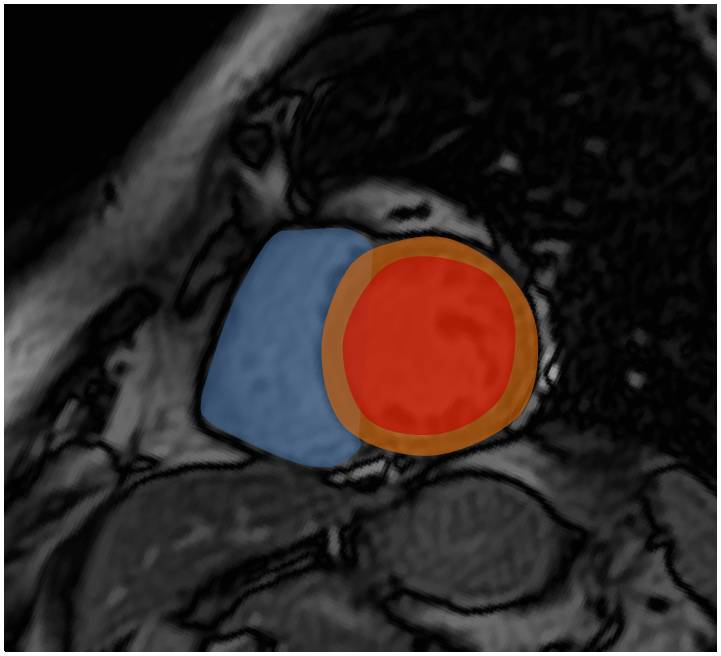
Performance Testing

- Example: Heart App
- Data retrospective: 200 cases from Vall d'Hebron Hospital (100 with heart attack, 100 without)
- Data prospective: 100 new individuals
- Metrics: Accuracy of risk prediction (number of correct predictions / total number of cases)
- Acceptance criteria: Prediction accuracy > 80 %

Performance Testing

- Example 2: Software to delineate medical images





Performance Testing

- Example 2: Software to delineate medical images
- Study:
  - ✓ 10 cardiologists
  - ✓ Record time to delineate manually
  - ✓ Record time to delineate using automatic method (e.g. deep learning)
  - ✓ Criteria: Reduces time by 50% at least

Performance Testing

- Example 3: Software to compress files
- Study:
  - ✓ Different types of files (text, images, videos, etc)
  - ✓ Metric 1: Reduction in disk space
  - ✓ Metric 2: Time taken to compress the file
  - ✓ Metric 3: Time taken to decompress the file

Usability / Acceptance Testing

- Even if the software is performant, it is important to test usability and acceptance by the end-users:

✓ Do they like the aesthetics and design?

✓ User-friendliness: Is the software easy to use? Intuitive? Do the users understand it?

✓ If they like it, will they use it, how often and when?

Usability / Acceptance Testing

- Methods: (1) using observers, (2) by using surveys, (3) by recording user reactions (voice recording, face expression, screen activity, etc).
- Select the appropriate users for the tests
- Select the appropriate testing environment (e.g. home or hospital)
- Identify usability indicators

Usability / Acceptance Testing

- Example: HeartApp - 10 patients or cardiologists in 2 hospitals (Vall d'Hebron + Hospital Clinic)
- Usability indicators:

✓ Average time to obtain risk prediction

✓ Ergonomics (e.g. total number of clicks, number of steps per task, system speed);

✓ Percentage of messages dismissed by the patient;

✓ Number of times user consults help services;

✓ Time to learn to use the system;

Usability / Acceptance Testing

- Example: HeartApp - 10 patients or cardiologists in 2 hospitals (Vall d'Hebron + Hospital Clinic)
- Usability questionnaires:

✓ Level of understanding of software by users (from 0 to 10);

✓ Satisfaction with the visual interfaces (from 0 to 10);

✓ Usefulness of error messages/alerts (from 0 to 10);

✓ Impact on clinician's productivity (low to high);

✓ Level of intention-to-use of the system (e.g. only when needed vs. full use).

Non-Functional Testing

- The software has a great performance, the users like it, BUT:
- Is it compatible with different IT systems, devices, etc?
- Is it portable to other systems?
- Is it interoperable with American/Japanes devices?
- Can it be installed in all hospitals?
- Is it safe and secure (can people hack it)?
- Is it scalable to other domains, markets, areas, users, etc?

Scalability Testing

- Example: HeartApp

✓ Is it possible to add new predictors (e.g. voice, face expression)?

✓ How easy it is to add a new device, for example to estimate blood coagulation?

✓ How much time it takes to train HeartApp to predict stroke, instead of heart attacks?

✓ How easy it is to scale the software so it can be used by GPs?

Submission

- Three slides to include in the project presentation:

1. Performance testing method and plan
2. Usability testing method and plan
3. Non-functional testing method and plan

Calendar

Week	Date	Topic	Delivery
1	12 Feb	Introduction	Group compositions
2	19 Feb	Project proposals	Mock-up
3	26 Feb	Project proposals: Example 1	
4	04 Mar	Project proposals: More examples	Team proposals
5	11 Mar	Requirements	
6	18 Mar	Requirements	
7	25 Mar	Testing	
8	01 Apr	Partial exams	
9	08 Apr	Semana santa	
10	15 Apr	Presentations / discussions	Software design
11	22 Apr	Presentations / discussions	
12	29 Apr	Fira d'empresses	Demo
13	06 May	Metafest - Infofest	
14	13 May	Company visit	Inter-group feedback
15	20 May	Presentations / discussions	
16	27 May	Presentations / discussions	Final project

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12	29 Apr	Testing	
13	06 May	Testing 2	
14	13 May	Summary	
15	20 May	Presentations / discussions	Group
16	27 May	Presentations / discussions	Group

Continuous Assessment

Task	Percentage
Individual proposals	10 %
Team proposals	10 %
User interface	10 %
Software design	10 %
Demo (beta)	10 %
Teamwork	10 %
Exam* (minimum 5 to pass)	10 %
Final project	30 %

*Exam: 0.5 hours written example (Multiple choice)

Continuous Assessment

Task	Percentage
Individual proposals	10 %
Team proposals	10 %
User interface	10 %
Software design	10 %
Demo (beta)	10 %
Teamwork	10 %
Exam* (minimum 3.5 to pass)	10 %
Final project	30 %

*Exam: 0.5 hours written example (Multiple choice)

Unique Assessment

Task	Percentage
Proposal	10 %
User interface	10 %
Software design	10 %
Final project	30 %
Exam	40 %

Exam:

- ✓ 0.5 hours written example (Multiple choice)
- ✓ 2.5 hours coding