Gestion de Projet et Génie Logiciel
Master 1, Lyon 1

Matthieu Moy

UCBL

2018-2019

Objectives

- Software engineering (Génie Logiciel): the art of making “good” software, at reasonable price
- Project management: what’s left, other than development? (need analysis & specification, team management, ...)
- Approach:
  - Good practices: tests, design patterns, ...
  - Tooling: continuous integration, version control, unit testing, ...
  - Organization: project lifecycle, agile methods
  - Speakers from several external companies
- Many notions usable directly ⇒ apply in your school project, your company (apprentices), ...

Practical Aspects

- Course material: `https://forge.univ-lyon1.fr/matthieu.moy/m1if01`
  - In your web browser
  - `git clone https://forge.univ-lyon1.fr/matthieu.moy/m1if01` once, `git pull` periodically.
  - Slides, exercises, labs, examples of code
- Evaluation:
  - Final exam
  - Mini-project: deadline = Oct 6th 2018, 20:00 (TOMUSS)
- Schedule: see ADE

Assumed to be Previously Learnt

- Object-Oriented Programming basics: `http://tabard.fr/courses/2015/mif17/2015/MIF17_Rappel_objet.pdf`
- UML Modeling basics:
  - Class diagrams (classes, object, package, etc.): `http://tabard.fr/courses/2015/mif17/2015/UML-Statique.pdf`
  - Dynamic diagrams (sequence, state-machine): `http://tabard.fr/courses/2015/mif17/2015/UML-Dynamique.pdf`

Outline

- Generalities (today, tomorrow)
- Tools for code management
- Use-cases
- Agile methods
- Design-patterns
- Tests
- Ethics
- Project management

Distribution

- 8×2h Lecture (CM)
- 2×2h Tutorial (TD)
- 5×2h Labs (TP)

Quality Criteria for Software

- Some criteria for the user
  - **Reliable** Gives the expected result,
  - **Robust** Doesn’t crash, behaves reasonably in unexpected conditions,
  - **Efficient** Gives the result quickly,
  - **User-friendly** Easy to use,
  - **Secure** Ability to resist to malicious uses.

Quality Criteria for Software

- Criteria for the developer
  - **Readable** Easy to read, to understand. Well documented,
  - **Maintainable** Easy to modify, to fix,
  - **Portable** Runs on various systems,
  - **Extensible** Easy to improve,
  - **Reusable** Can be adapted to other applications.

Software Crisis

Cost of software is always important and higher than expected.

- Success of projects (Standish group, CHAOS Summary 2014):

	Number of projects
Abandonned, never used	31%
Late, over budget, incomplete	52%
On time and on budget	16%

- Usage of features (Waste In Software Projects, http://thecriticalpath.info/2011/07/07/waste-in-software-projects/):

Use of features	Number of features
Never used	45%
Rarely used	19%
Sometimes	16%
Often	13%
Always	7%

Why is it so hard?

Software development is easy:

https://www.flickr.com/photos/jacobavanzato/16152519186

Why is it so hard?

A first prototype is easy to get ...

https://www.flickr.com/photos/78044378@N00/364003706

Why is it so hard?

... but how do we extend it? How do we scale?

https://www.flickr.com/photos/104027460N04/7165270428

Scale? How big?

- Typical lab work = 100 LOC
- Typical school project = 1000 LOC
- 100 developers, 100 LOC/day[1], 10 years = 20 MLOC
- Linux Kernel 4.13: 20 MLOC
- Facebook: 60 MLOC
- Windows: 3 million *files*
- Google's full codebase: 2 *Billion* LOC

Nice visualization:
https://informationisbeautiful.net/visualizations/million-lines-of-code/

⇝ Not all programs are that big, but most programs are orders of magnitude bigger than what you've experienced so far.

[1] Optimistic estimate, e.g. COCOMO model estimates to 10-20 LOC/day ⇒ > 10 $/LOC ...

How buggy is it?

"Industry Average: about 15 – 50 errors per 1000 lines of delivered code."

"Microsoft Applications: about 10 – 20 defects per 1000 lines of code during in-house testing, and 0.5 defect per KLOC in production."

(Source: Steve McConnell book, "Code Complete")

A few Famous Bugs

- Therac-25: radiotherapy machine killed at least 6 persons
  http://cr4.globalspec.com/blogentry/19025/Failure-of-the-Therac-25-Medical-Linear-Accelerator
- Ariane 5 crash: arithmetic overflow ⇒ self-destruction of the shuttle ⇒ most expensive firework ever (≈ 500 M$). Ironically: well-tested software (re-used from Ariane 4), hardware redundancy (both computers crashed).
  http://www-users.math.umn.edu/~arnold/disasters/ariane.html
- Mont Saint-Odile's crash: "the pilots inadvertently left the autopilot set in Vertical Speed mode (instead of Flight Path Angle mode) then entered "33" for "3.3^o descent angle", which for the autopilot meant a descent rate of 3,300 feet (1,000 m) per minute." ⇒ a UI bug that costed 87 lives.
  https://en.wikipedia.org/wiki/Air_Inter_Flight_148
- Mars Climate Orbiter: "software which produced output in non-SI units of pound-force seconds (lbf·s) instead of the SI units of newton-seconds (N·s) specified in the contract between NASA and Lockheed" ⇒ Incorrect interpretation of specification = ≈ 300$M$$ crash
  https://en.wikipedia.org/wiki/Mars_Climate_Orbiter

OK, these were critical systems. I just write ERPs/Accounting software

Well, you're in the game too!

Louvois: paiment system for french militaries

- "Pendant près de 7 ans, de nombreux soldats français ont vécu l'enfer. Non pas sur le terrain mais à cause de leur fiche de paie"
- Started in 2011, affected 120,000 employees.
- Over and under-payments.
- More complex than it seems: 174 different kinds of bonus
- "C'était courru d'avance", "De 150 points de vérification, on est passé à 15 pour tenir les délais"
- ⇒ complete rewrite decided. No fix available/possible.
- "Un logiciel nouveau comme ça, il faut au moins trois ans pour l'installer", "Il y aura donc bien un an de retard, et peut-être plus si l'on en croit d'autres sources.", "On prévoit le lancement au 1er janvier 2019"

⇝ Not just "one unfortunate bug": a 7-years failure due to initial bad management choices.

https://www.franceinter.fr/emissions/secrets-d-info/secrets-d-info-27-janvier-2018

Failure of "Agile" Contract at Macif

Alors qu'elle était plaignante, la Macif vient d'être condamnée à payer à un éditeur de logiciel 1.45 millions d'euros" (et 4 ans de développement).

https://www.linkedin.com/pulse/saffranchir-du-cycle-en-v-agile-canada-dry-ou-comment-maxime-blanc

Keep in Mind ...

1. Computer systems are complex and require good methods
2. Methods must combine rigor and adaptation to unknown and to change

UML Modeling?

- Modeling:
  - Helps informal discussions between developers (e.g. quick and dirty diagrams on white board)
  - Helps rigorous specifications
  - Helps deriving implementation (manually or automatic)
- Modeling is not sufficient:
  - Need for design and programming techniques
  - Write readable and reusable code

Software Lifecycle

- Requirement analysis and definition
- Analysis and design
- Coding/Debugging
- Validation
- Evolution and Maintenance

Software Lifecycle

- Requirement analysis and definition
  - specifications
  - feasibility study (may involve a prototype)

Software Lifecycle

- Analysis and design
  - Specification
  - Architecture (= hard-to-change decisions)
  - Detailed design (algorithms, data-structures)

Software Lifecycle

- Coding

Software Lifecycle

- Validation: make sure the program “works”
  - Static analysis and proof
  - Code review (very efficient)
  - Tests (essential)

Software Lifecycle

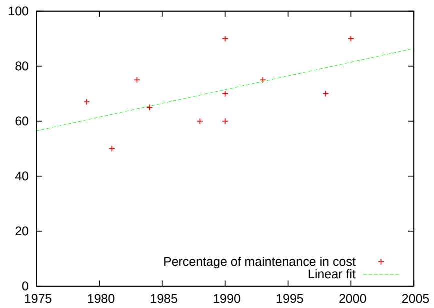
- Evolution and maintenance:
  - Corrective maintenance (Bug fixing)
  - Adaptive maintenance (Porting, ...)
  - Evolutionary maintenance (New features, ...)

“Always code as if the guy who ends up maintaining your code will be a violent psychopath who knows where you live.”

Effort distribution

http://users.jyu.fi/~koskinen/smcosts.htm

- Part of Maintenance in Total Cost:



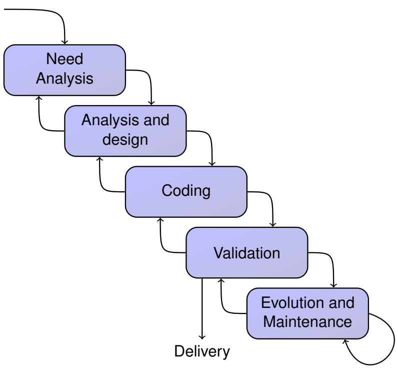
⇒ better optimize for maintainability than for initial development

Effort distribution in Initial Development

As a rule of thumb ...

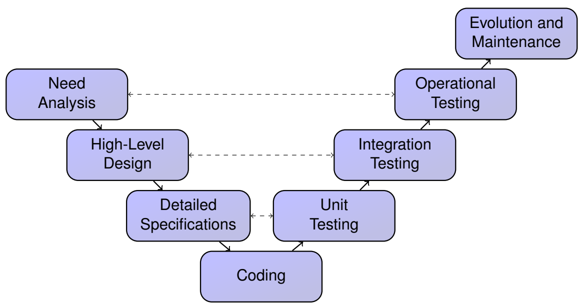
- Initial development:
  - Requirement analysis, architectural design: 40%
  - Coding, debugging: 20%
  - Validation: 40%

Waterfall Lifecycle



V Lifecycle

Variant of the Waterfall Lifecycle

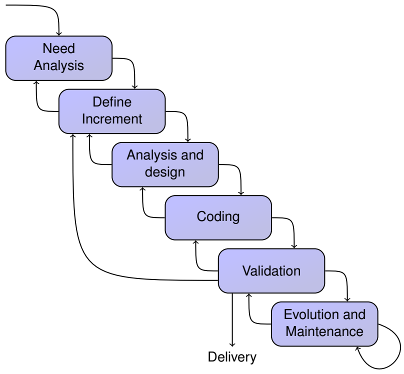


Waterfall/V Lifecycle

- Guiding principle: Interactions occur only between two successive states.
- Advantages:
  - Clean design (hopefully), no evolution within initial development.
  - Contractualization: specifications and effort estimates are known (hopefully) early
- Drawbacks:
  - Defect in first steps can have catastrophic consequences
  - Validation of specification late in the design
  - Integration late in the cycle ⇒ most risks eliminated late
  - Hardly parallelizable
  - Perfect in theory, but not adapted to humans?
- Variant: de-risk with “W”-lifecycle

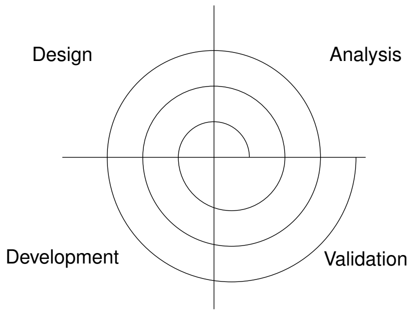
  “The management question, therefore, is not whether to build a pilot system and throw it away. You *will* do that. [...] Hence *plan to throw one away; you will, anyhow.*” (The Mythical Man-Month, 1975, Brooks)

Incremental Lifecycle



Spiral Lifecycle

Another view of the Incremental Lifecycle



Incremental Lifecycle

- Guiding principle: divide the program in small amounts of analyzed, coded, and tested features.
- Advantages:
  - Early discovery of problems,
  - Early availability of prototypes (essential to get feedback from the client),
  - Helps continuous validation,
  - Allows time-based releases, as opposed to feature-based releases.

Specifying the increment

- Informally
- With a subset of the specification (if it exists)
- With a use-case (or "user story")
- With a set of tests

  $\Rightarrow$ Test Driven Development

  while true loop
    write tests
    make sure they don't pass
    implement feature
    debug until test pass
    commit and push
  end loop

Planning and Architecture with Iterative Development

Example with a typical web application: each feature may need entries in the database, modification to an internal REST API, JavaScript for the client-side logic and HTML&CSS for rendering.

	DB	API	JS	HTML & CSS
Feature A				
Feature B				
Feature C				
Feature D				

Unit/integration tests

Layer-by-layer $\rightsquigarrow$ First usable prototype after $\approx$ 90% work is done
Feature-by-feature $\rightsquigarrow$ Prototypes/releases available all along development

Organize the Work

- Principles: general guideline. Examples:
  - "Our highest priority is to satisfy the customer[...]" (Agile Manifesto)
  - "every module or class should have responsibility over a single part of the functionality provided by the software" (Single Responsibility Principle)
  - "The process of developing software consists of a number of phases." (Software Development Life Cycle common principles)
- Practices: concrete things one can do. Examples:
  - Pair Programming
  - Test Driven Development
  - Code Review
  - Refactoring
  - DevOps
- Methods/methodologies: set of practices and how they are organized. Examples:
  - Waterfall
  - Merise ($\approx$ ancestor of UML)
  - Scrum

Principles? Practices? Methods?

How to (not) Get the Best of it

- You may agree with principles and dislike the associated method
- Good practices of one method may apply to other methods
- Applying a method without understanding its principles is doomed[2]
- No silver bullet: a method that works in a context may fail in another
- A successful method needs/attracts consultants to train people on this method $\Rightarrow$ creates business $\Rightarrow$ creates marketing.

[2] Remember the Macif example above?

Methods in Software Engineering

- Main classes of methods:
  - Strategic management methods
  - Development methods
  - Project management methods
  - Quality assurance and control methods
- Development methods to:
  - Build operational systems
  - Organize the work
  - Manage the project's lifecycle
  - Manage costs
  - Manage risks
  - Get repeatable results

Evolution of methods

4 successive trends:

- Modeling by functions
- Modeling by data
- Object-oriented modeling
- Agile methods

1st generation: function-based modeling

- Decompose a problem into sub-problems: functions, sub-functions, ...
- Each function defines inputs and outputs
- Examples: IDEF0, SADT
- When one function changes, everything may change

2nd generation: data-based modeling

- "Systemic" approaches
- Information system = structure + behavior
- Model the data, how they are organized (e.g. UML entity-relationship diagrams, MERISE).
- Data-modeling important with (R)DBMS.
- Behavior modeled separately
- Strengths:
  - Data consistency, abstraction levels well-defined
- Weaknesses:
  - Lack of consistency between data and behavior
  - Pushes towards long lifecycles (V)

3rd generation: object-oriented modeling

- "Systemic" approaches with data/processing consistency
- Set of objects that collaborate, considered statically (what the system is: data) and dynamically (what the system does: functions).
- Functional evolution possible without changing the data
- Modularity through abstraction and encapsulation

Current trend: agile/adaptive ($\neq$ predictive) methods

- Short iterations (e.g. demonstrate new features to the client every week)
- Strong and continuous interaction with client
- Value responding to change over following a plan
- Self-organized teams
- Adaptive: retrospective and adaptation periodically

Tools ...

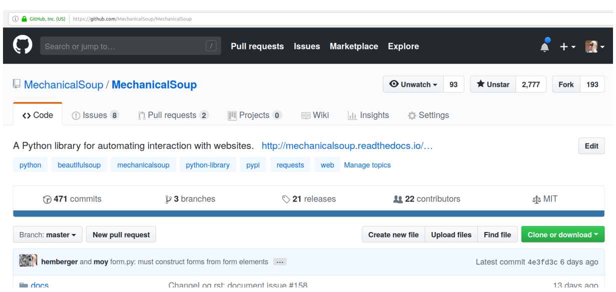
- Necessary for development (compiler, text editor)
- Catch mistakes early (tests, code analysis)
- Automate stuff (I'm lazy, too)

A Small Example: MechanicalSoup (Python library)

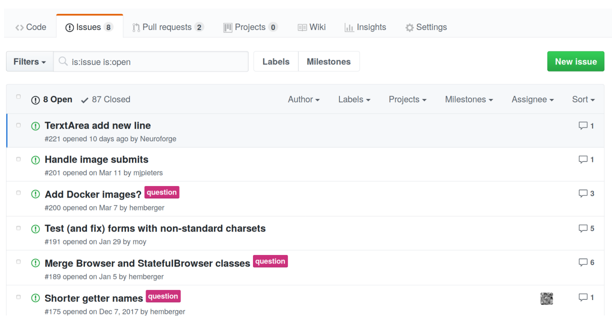
Disclaimer: I'm one of the authors

- Small library (400 LOC of Python + 1000 LOC of tests) for browsing websites
- Small, developed on free-time ⇒ no planning, no real methodology
- Tries to follow best practices and uses many fun tools
- Let's go trough a few of them... (you can do similar things with Lyon1's GitLab)

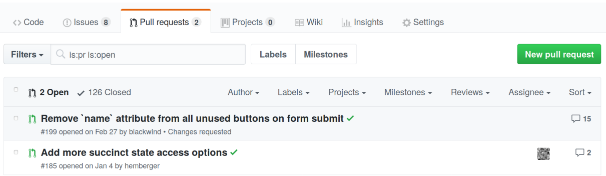
Hosting: Git, GitHub



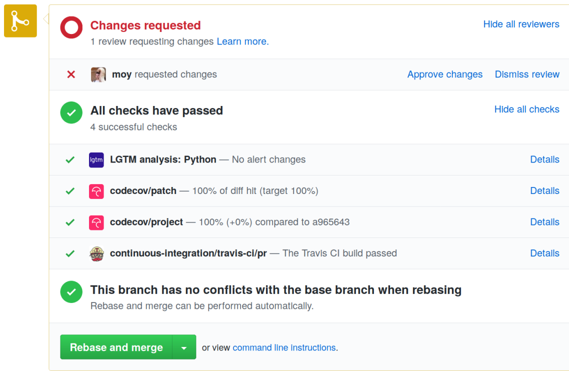
Report bugs, discuss future features: issue tracker



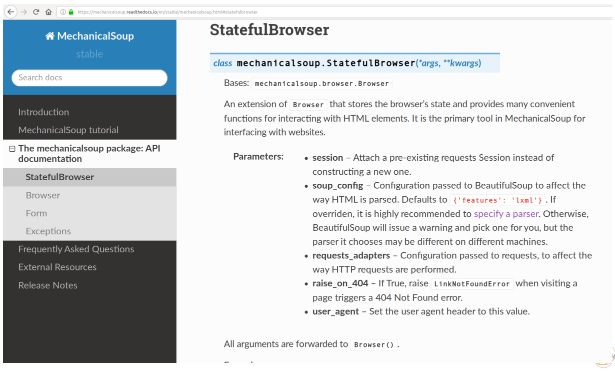
Submit code: pull-requests



Automated checks on pull-requests



Documentation automatically generated at each push



About pull-requests and checks ...

- Anyone can submit a pull-request
- Pull-requests trigger build + testsuite + coverage check + style check + static analysis
  - Test failing ⇒ fail
  - Incompatibility with one supported version of Python ⇒ fail
  - Incorrect style (lines >80 characters, mis-placed space, ...) ⇒ fail
  - Line of code not covered by a test ⇒ fail
  - Bad pattern detected by code analysis ⇒ fail
- How we did all that? Mainly "use tools/services" and 30-lines long .travis.yml file.

Automated testing

(Because life it too short to spend time on manual testing)

- Code that tests code:

```
def test_no_404(httpbin):
    browser = mechanicalsoup.StatefulBrowser()
    resp = browser.open(httpbin + "/nosuchpage")
    assert resp.status_code == 404
```

- General form of automated tests:

```
def name_of_test_function():
    # given
    some_object = ...
    # when
    some_object.some_action(...)
    # then
    assert ...
```


Next Course: More on Tooling

- Build a complex Java project with gazillions of dependencies without pain
- Discover the awesomeness of GitLab
- Apply in your lab works!