Gestion de Projet et Génie Logiciel
Master 1, Lyon 1

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UCBL

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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 = Sept 30th 2018, 23:59 (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/104027466@N04/7165270428

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 couru 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

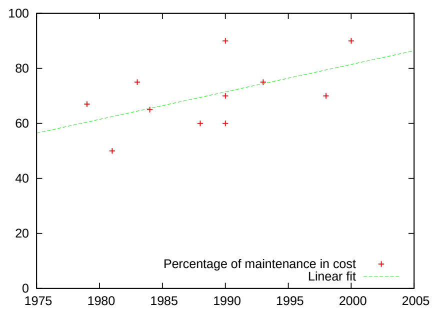
- Evolution and maintenance:
  - Corrective maintenance (Bug fixing)
  - Adaptive maintenance (Porting, ...)
  - Evolutionary maintenance (New features, ...)

“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:



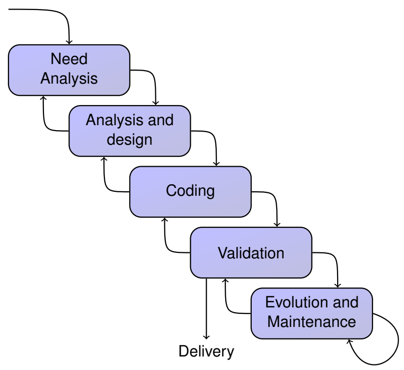
⇒ better optimize for maintainability than for initial development

Effort distribution in Initial Development

As a rule of thumb ...

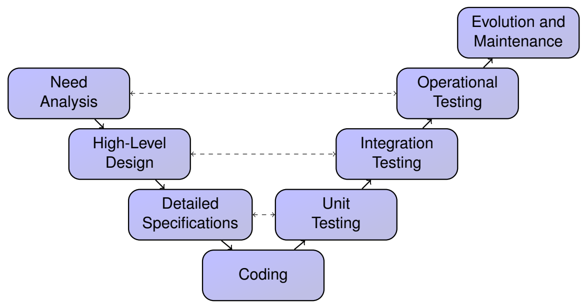
- Initial development:
  - Requirement analysis, architectural design: 40%
  - Coding, debugging: 20%
  - Validation: 40%

Waterfall Lifecycle



V Lifecycle

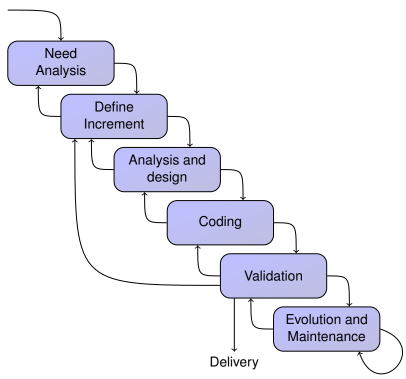
Variant of the Waterfall Lifecycle



Waterfall/V Lifecycle

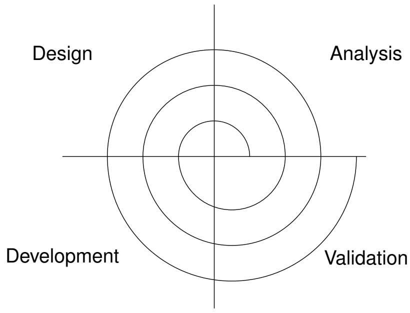
- Guiding principle: Interactions occur only between two successive states.
- Advantages:
  - Clean design (hopefully), no evolution within initial development.
  - Contractualization: specifications and effort estimates are known (hopefully) early
- Drawbacks:
  - Defect in first steps can have catastrophic 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 ...

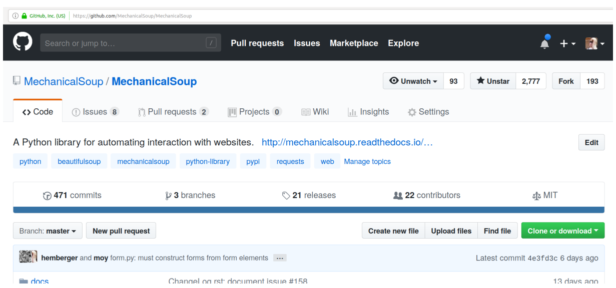
- Necessary for development (compiler, text editor)
- Catch mistakes early (tests, code analysis)
- Automate stuff (I’m lazy, too)

A Small Example: MechanicalSoup (Python library)

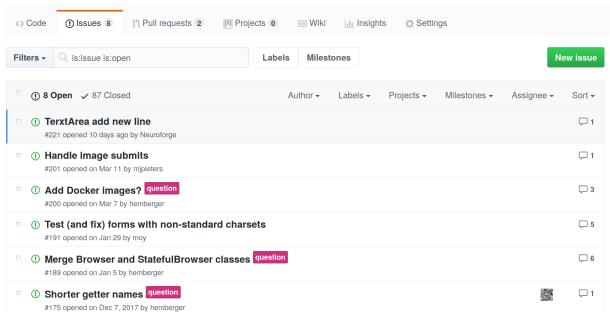
Disclaimer: I’m one of the authors

- Small library (400 LOC of Python + 1000 LOC of tests) for browsing websites
- Small, developed on free-time $\Rightarrow$ 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)

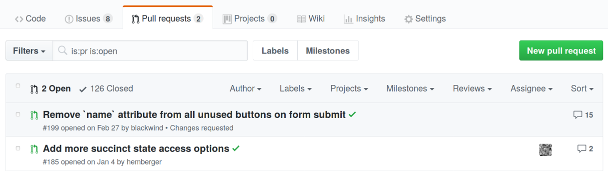
Hosting: Git, GitHub



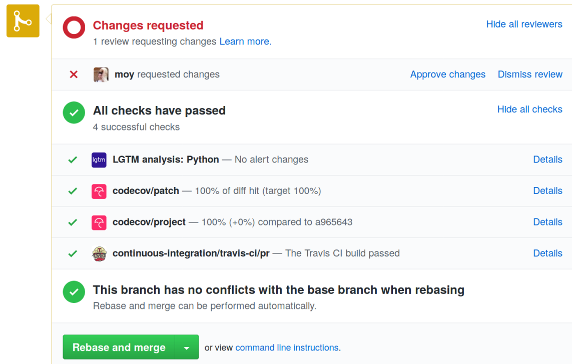
Report bugs, discuss future features: issue tracker



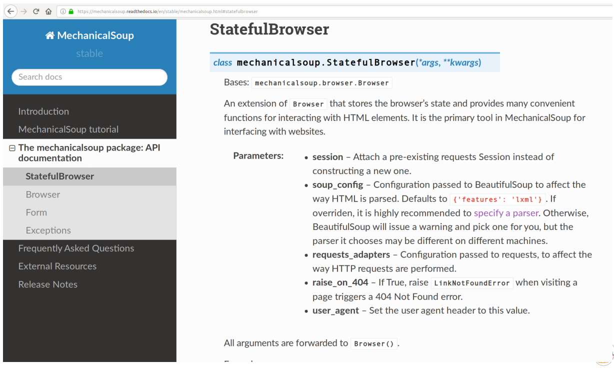
Submit code: pull-requests



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!