The software design process

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"Weeks of coding can save you hours of planning." - Unknown

Why do we do this?

For the present

- Enable collaborative development (collaborative tools)
- In > months of dev, the team might change! (documentation, both internal and external)
- Automate testing and releasing

Ultimately, every team member should focus on few tasks, the ones that fit him/her better!

For the future

- Make the mantainance process easier
- Enable future extensions/development

The Apollo 13

“We need find a way to put this, in the hole for this, using these”

› https://www.youtube.com/watch?v=ry55--J4_VQ

Software engineering

The discipline of building big, complex systems

- Applies methodologies from the engineering world, to software development process
- The only way of dealing with complex software systems and teams
- A systhematic approach to design, development, testing, deploy and maintenance (IEEE 1990)

...don't worry... ☺

- This won't make of you an engineer
- It will help you engineering software

Think today, for tomorrow

Engineering:

- Have a strong focus on the process
- Treat everything as “a resource”, either physical (a brick for a wall, a chip for a server farm) or non-physical (software artifacts, licenses, etc)
- In years, they (..we… ☺) developed an common methodology for multiple application areas

Software, on the contrary, is (correctly) treated as a non-physical entity, “a product of the mind”

- During the development, you care less of physical assets (mostly, computers, desks…)
- *“Sul mio computer funziona”*
- When you design SW, you care more of people and their skills

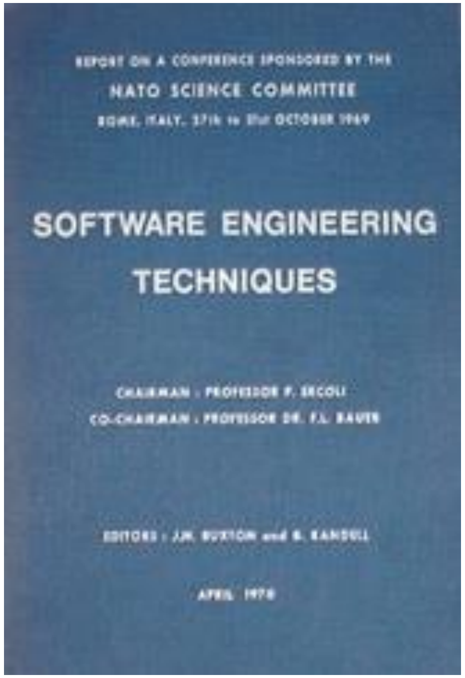
This is no longer acceptable!

- Future systems will be distributed CPSs, made with different computers (high-performance, energy efficient, ect..) with tight(est) interaction with the world
- Will be large-scale 24/7 distributed systems, updated over-the-air
- Designed today, thought for tomorrow (e.g., Software-Defined Vehicles)

A bit of history…

SW engineering was born in 1968, at the NATO conference, focusing on

- software crisis
- software reuse
- software engineering



REPORT ON A CONFERENCE SPONSORED BY THE
NATO SCIENCE COMMITTEE
ROME, ITALY, 27th to 31st OCTOBER 1969

SOFTWARE ENGINEERING
TECHNIQUES

CHAIRMAN : PROFESSOR P. ERCOLI
CO-CHAIRMAN : PROFESSOR DR. F.L. BAUER

EDITORS : J.N. BUXTON and B. RANDELL

APRIL 1970

SOFTWARE ENGINEERING

[illegible]

In the nineties...

- ....the era of object oriented programming
- Design tools (UML), and patterns

In the last decade(s)

Internet-of-Things

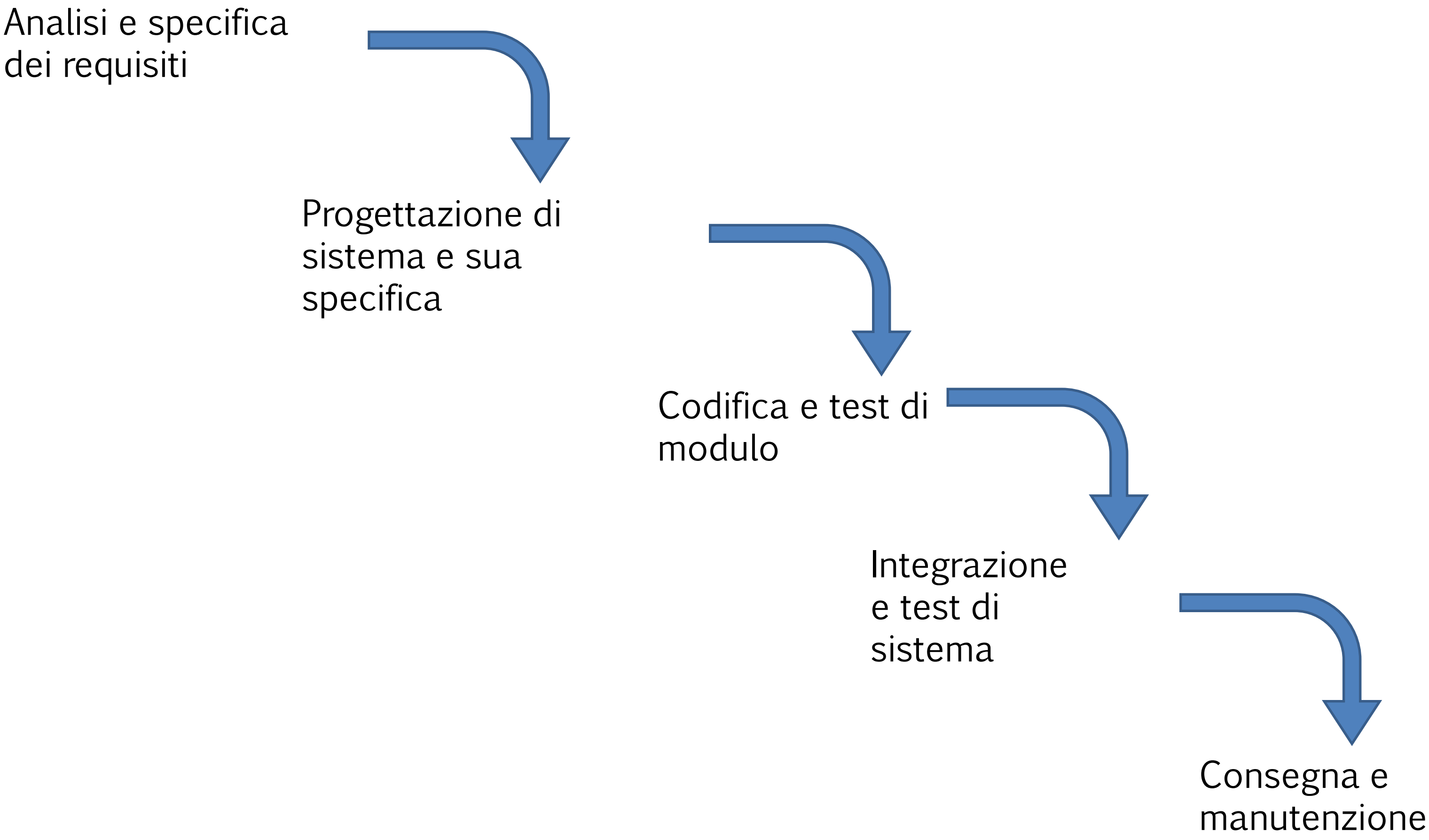
- Large scale cloud projects
- Ubiquity, pervasiveness, CPSs
- Massively parallel computers (GPGPUs)

The era of machine learning

- How can you structure a probabilistic-based SW component?
- Design of the training process
- Data engineering!

In the last decade(s) – cont'd

The Waterfall model



Analisi e specifica dei requisiti

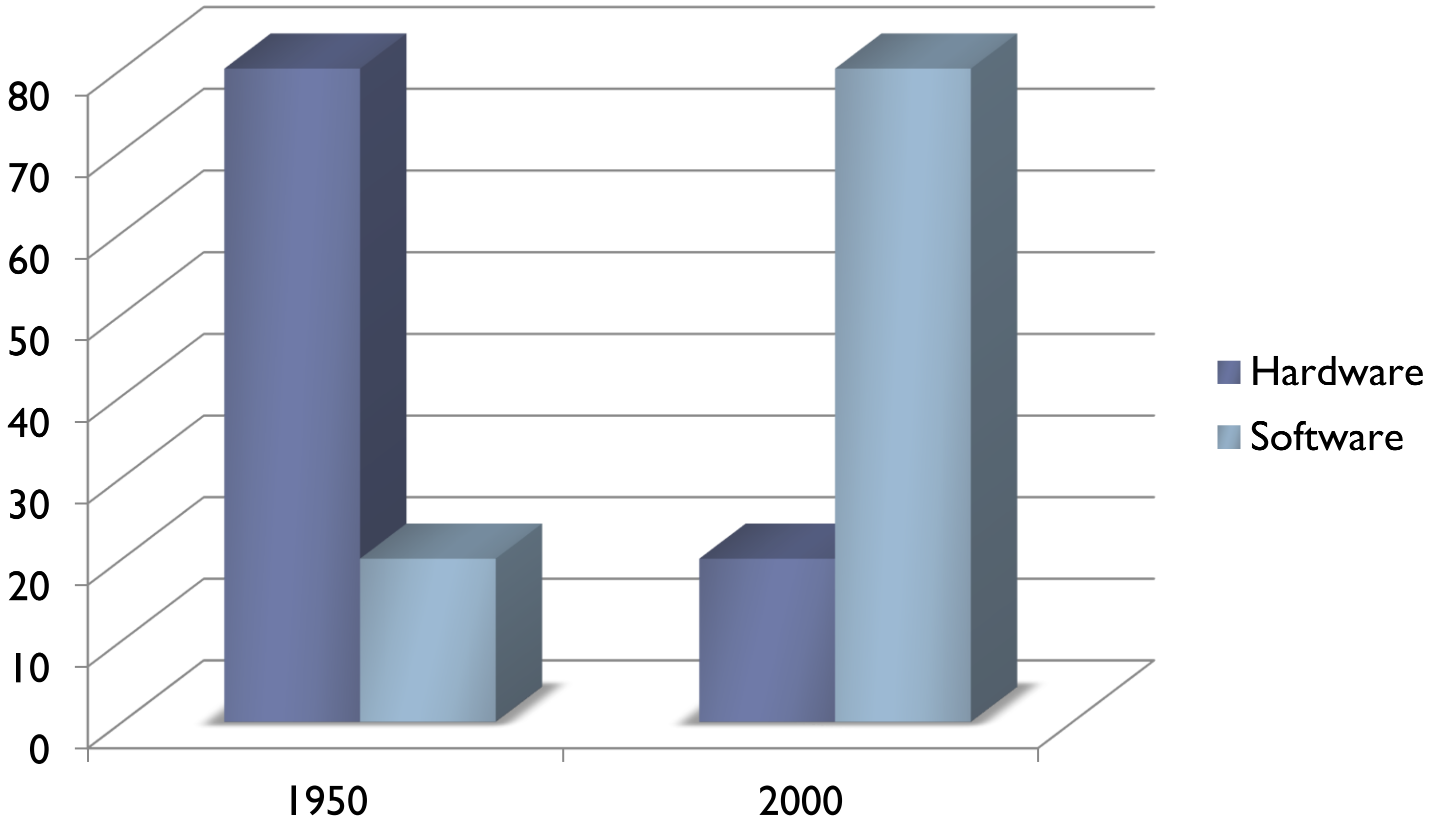
Progettazione di sistema e sua specifica

Codifica e test di modulo

Integrazione e test di sistema

Consegna e manutenzione

Costs: HW vs SW



Who is our customer?

For whom it is developed?

- (This includes also open source, and free software)
- We will generically speak of ***customer***, without loss of generality

Custom solutions, tailored for specific customer, or customer segment

- Time-to-market agreed with the customer
- Internal R&D projects (e.g., iotty)
- Market-wide products (E.g., MS Windows)

General-purpose software, released for the masses

- For research (e.g., Thundershot stack)
- Business models based on open-source (Home Assistant, GNU/Linux, Erika..)

Quality of software, and process

Product / extrinsics / external

- Refers to functionality, it's the main quality against which software is assessed!
- By the customer / segment / community
- Has directly reflect on pricing
- Assessed by functional requirements

Process / intrinsics / internal

- Refer to how the software is developed
- Relates mainly to the company/team (hence, even more important!)
- Hard to map onto product pricing
- Reflects into non-functional requirements

Assessing the quality

Correctness

- *Does my software do what I want it to do?"*
- The easy part: captured by functional requirements, which are directly negotiated with the customer

Ease-of-use

- Involves UX, documentation...

Performance/efficiency

- *"Is it fast?"*
- What do "fast" mean? FPS? E2E latency? On which computer?
- How many resources does it need (e..g, power, physical space)?

Dependability

- *"Can I rely on it?"*
- Definition applies to specific fields...

On dependability

“a measure of a system’s availability, reliability, maintainability, and in some cases, other characteristics such as durability, safety and security. In real-time computing, dependability is the ability to provide services that can be trusted within a time-period.[2] The service guarantees must hold even when the system is subject to attacks or natural failures.”

Specific of application domains (can overlap!!!)

- Real-Time systems
- Embedded systems
- Exascale systems
- ...

The IFIP working group identified three main elements

- **Attributes**, i.e., Key Performance Indicators (KPIs) to assess the dependability
- **Threats** to dependability
- **Means** to increase dependability

Non-functional properties

A system is

- **Verifyable** if we can assess its characteristics (what about ML?)
- **Mantainable**, if we can easily modofy it (docs are in order??)
- **Reusable**, if it's well packed for deployment (docker?)
- **Portable**, if we get the same functionality on different HW/OS/.... (and also performance!!!! – see GPGPus)
- **Interoperable**, if it's open for interaction with other systems...
- ...

Basic design principles ~~of software engineering~~

Our friends

- Strictness, formalism
- Separation of concern
- Modularity
- Right level of abstraction
- Resiliency / robustness
- ...

Strictness, formalism

Still, we are artists! Software is a piece of art!

- GPL licenses apply also to books, paintings...

But...we need to systhematize the process

- Typically, we borrow from mathematics / logics / engineering ☺

Separation of concern

Divide-et-impera

- Split the problem onto subproblems

..but, which problem?

- Lifecycle (Waterfall vs. Agile/Scrum)
- System architecture (e.g., Microservices)
- Internal system architecture MVC - MVVM

Modularity

Comes directly from the separation of concern principle

Two main approaches

Top-down

- Where we have a complete view of the project, and we split it into components
- When we typically start from scratch

Bottom-up

- where we first develop the components, and then integrate them
  - A typical scenario is when we need to re-use existing modules

Abstraction

Example: how shall we model a user?

- In a gym club: name, age, weight, height, gender, email
- In the City Servers: name, age, address, CF, phone nr
- In a smart city roundabout: Lat, Long, velocity, class (car, bike, pedestrian)

What about costs?

Software costs outperform all other “structural” costs

- Licensing for libraries
- Fees for platforms (who has in-house servers anymore??)
- Electricity/heating/cooling

Maintenance is the main component

- A bad design is costly on the long term (see Apple’s)

Personnel costs

- Developers (80%)
- Support/aftermarket

Other costs

- HR, generic costs (chairs, laptops..)

Maintenance

The need for modifying the system after it has been deployed

- Bugfixing (typically for free in 12-24 months) – Functional testing with customer is really important to mitigate this – 20%
- Performance improvement – 60%
- Changes in the operational domain (e.g., new version of libraries, OS, hardware) – 20%

But most of all..

- ...l'appetito vien mangiando ☺ - customer might ask modifications, even paying them in advance!

Often, more than 50% of the overall costs!

- 75% (Hewlett-Packard)
- 70% (US Defense)

Main issues with SW, today

Aka: “the generational debt”

- Old, legacy systems, developed with obsolete technologies, which cannot be replaced due to bad engineering practices
- The Comune di XXX example

Systems are increasingly complex and heterogeneous

- The rise of micro-services architectural pattern

Time-to-Market

Professionality, and ethics

Sw developers shall always keep an ethic and professional conduct of work

- What does “ethic” mean?
- E.g., Hipert srl does, and never will, produce weapons

Confidentiality

- Often, you need to sign an NDA – Non disclosure agreement, before working
- After resigning a contract, some pros might not be hired by other competitor companies for 1-2 years!!!
- Example: Maserati SpA

Intellectual Property and licensing

- How much do you know about licenses/patents?

Structuring ethics

- Personal ethics
- Company rules (see Hipert)
- Professional
  - see “Ordine degli ingegneri”
  - Association for Computer Machinery (ACM) ed Institute of Electrical and Electronics Engineers (IEEE) - http://www.acm.org/about/se-code

References

Course website

- http://hipert.unimore.it/people/paolob/pub/ProgSW/index.html

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