[CS3704] Intermediate Software Design and Engineering

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Announcements

HW0 due Monday at 11:59pm!

- Slack introductions
- Syllabus/Course review questions

Software Crisis

"*The major cause of the software crisis is that the machines have become several orders of magnitude more powerful! To put it quite bluntly: as long as there were no machines, programming was no problem at all; when we had a few weak computers, programming became a mild problem, and now we have gigantic computers, programming has become an equally gigantic problem.*" [Dijkstra]

Software Crisis

- Projects running over-budget
- Projects running over-time
- Software was very inefficient
- Software was of low quality
- Software often did not meet requirements
- Projects were unmanageable and code is difficult to maintain
- Software was never delivered

What is software engineering?

A discipline that encompasses:

- the ***process*** of software development;
- ***methods*** for software analysis, design, construction, testing, and maintenance; and
- ***tools*** that support the processes and the methods.

[Pressman]

Software Engineering

"... a new subdiscipline, software engineering, has arisen. ***The development of a large piece of software is perceived as an engineering task, to be approached with the same care as the construction of a skyscraper****, for example, and* ***with the same attention to cost, reliability, and maintainability of the final product****... Even with such an engineering discipline in place, the software-development process is expensive and time-consuming."*

[Encyclopaedia Britannica]

Software Engineering?

“ ‘It’s Engineering... but not as we know it’… Software Engineering - solution to the software crisis, or part of the problem? ”

[Bryant]

Processes, Methods, and Tools

- Various tasks required to build and maintain software
  - e.g. design, testing, etc.
- *SE process:* the organization and management of these tasks
  - various process models
- *SE methods:* ways to perform the tasks
- *SE tools:* assist in perform the tasks
  - UML tools, IDEs, issue tracking tools

Warm-Up

Discuss: What are some of your favorite software applications? Why?

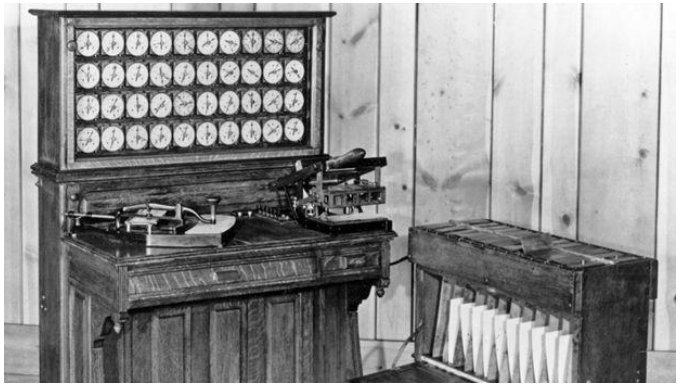
SE History

- Why study software engineering history?
  - To learn what has been done before and how we got here.
  - CS/SE is not that old, compared to other disciplines.
- Don't remember failures? Likely to repeat them
- Don't remember successes? Unlikely to repeat them

"Those who cannot remember the past are condemned to repeat it."
– Santayana [https://liberalarts.vt.edu/magazine/2017/history-repeating.html]

History of Computer Programming

- **1843:** Sequence of steps from Ada Lovelace to Charles Babbage considered first computer program
- **1889:** Hollerith tabulating machine



- **1940s:** First electronic computers
- **1956:** First programming language - FORTRAN

History of Software Engineering

1950s: Engineer software like hardware

- First programming languages
  - **1956:** FORTRAN (Formula Translation);
  - **1958:** LISP (List Processor);
  - **1959:** COBOL (Common Business Oriented Language);
- Punch cards

History of SE (cont.)

1960s: Software is NOT like hardware

- Different properties:
  - invisible, complex, difficult to change, unconstrained by physical laws of nature,…
- Demand for programmers exceeded supply
- First college Computer Science departments formed 🎓
  - **1962:** Purdue University
- First use of the term *“**software engineering**”*!

"Software Engineering"

1963/1964: "While developing the guidance and navigations systems for the Apollo missions, computer scientist and systems engineer Margaret Hamilton coins the term '*software engineering*'. Hamilton felt that software developers earned the right to be called engineers." [Juhasz]

History of SE (cont.)

1960s (cont.): Software is NOT like hardware

- Still disorganized, but with better infrastructure
  - Operating systems, compilers, utilities, etc.
- Some successes:
  - Apollo
  - Electronic switching systems (ESS)
- Problems:
  - Unmaintainable spaghetti code
  - Unreliable, undiagnosable systems
  - Software development is too expensive

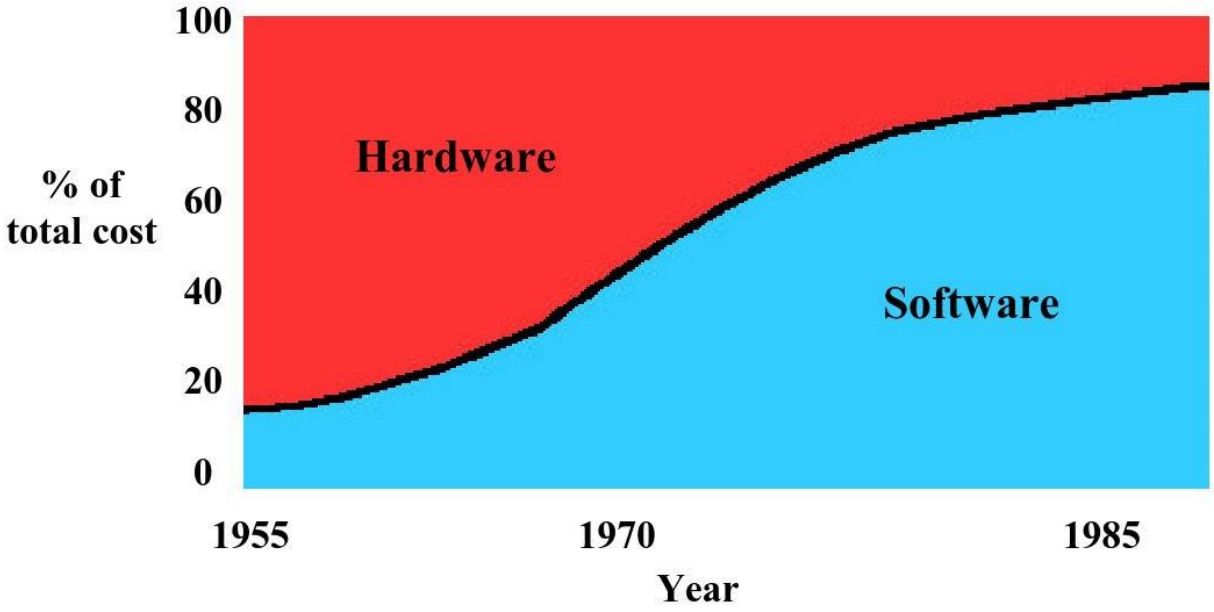
History of SE (cont.)

1970s: Formal Approaches and Waterfall

- Structural programming processes
- Formal methods begin to form
  - Specification
  - Development
  - Verification
- Punch cards starting to become obsolete…
- **Plan-Driven process models**

History of SE (cont.)

1970s: Software costs surpass hardware



1973!

History of SE (cont.)

1980s: More Productivity, Less Plan-Driven

- Major productivity enhancements
  - Working faster: tools and environments
  - Working smarter: processes and methods
  - Work avoidance: code reuse, simplicity, objects
- **Iterative process models**
- Other trends: Iterations, Code reuse libraries, codes of ethics, licenses, Object oriented…
  - Smalltalk, Eiffel, Ada, C++

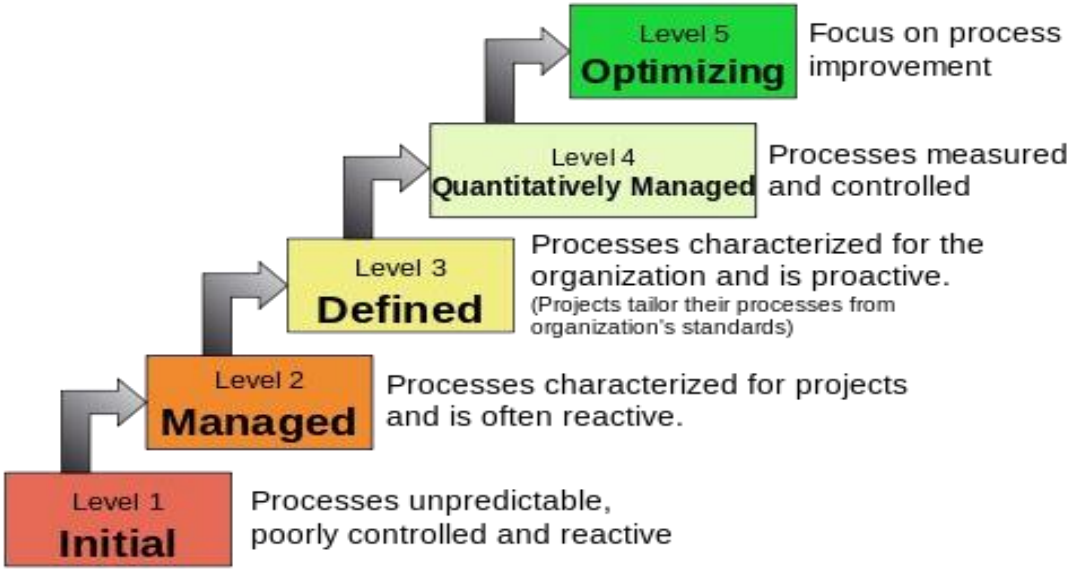
History of SE (cont.)

1990s: CMM and Iterative Models

- Capacity Maturity Models (CMM)
- Growing divide between ***plan-driven*** and ***iterative*** models (Standish Group)
- Other trends: Open source software, reverse engineering, computer viruses, etc.
- Modern programming languages
  - Java, Python, JavaScript, Ruby, etc.
  - End-user programming: HTML, CSS, R, etc.

Capacity Maturity Model

- **Model to evaluate/improve SE processes**
  - *NOT a software development process model!*



Data by the Standish Group (1995)

- $81B on canceled software projects
- $59B for budget overruns
- Only 1/6 projects were completed on time and within budget
- Nearly 1/3 projects were canceled
- Over half projects were considered “challenged”
- Among canceled and challenged projects
  - Budget overrun: 189% of original estimate
  - Time overrun: 222% of original estimate
  - Only 61% of the originally specified features

The CHAOS Report 1995

“In the United States, we spend more than $250 billion each year on IT application development…A great many of these projects will fail. Software development projects are in chaos, and we can no longer imitate the three monkeys -- hear no failures, see no failures, speak no failures. The Standish Group research shows a staggering 31.1% of projects will be canceled before they ever get completed. Further results indicate 52.7% of projects will cost 189% of their original estimates. The cost of these failures and overruns are just the tip of the proverbial iceberg.”

[Standish Group]

History of SE (cont.)

2000s-*present*: Process Synthesis

- **2001:** Agile manifesto
- **2004:** Software Engineering Body of Knowledge (SWEBOK)
- Model, feature, and test-driven development
- Service-oriented software
- Hybrid agile/plan-driven processes
- **Discuss with a partner: Anything else???**

[Review] What is SE?

A discipline that encompasses:

- the *process* of software development
- *methods* for software analysis, design, construction, testing, and maintenance
- *tools* that support the process and the methods

[Pressman]

What is a SE process?

– a framework for the tasks that are required to build high-quality software to provide stability, control and organization to an otherwise chaotic activity [Pressman]

– a software development process defines ***who*** does ***what***, ***when***, in order to build a piece of software. [Wilson]

SE Myths

Management

- "If we get behind schedule, we can just add more people and catch up"
- **Fact:** Adding more people to a late project will make it later
  - The people working now must spend time educating the newcomers

SE Myths (cont.)

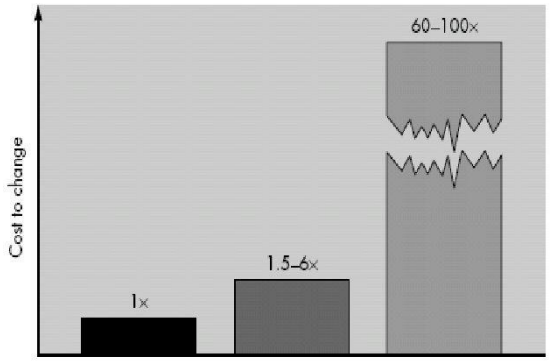
Customers/Clients

- "A general statement of objectives is enough to start programming"
- **Fact:** An ambiguous statement of objectives leads to project failures
  - Unambiguous requirements need effective and continuous communication between customer and developer

SE Myths (cont.)

Customers/Clients

- "Changes in requirements are easy to deal with because software is flexible"
- **Fact:** Changes are harder and more expensive over a project



SE Myths (cont.)

Practitioners

- "Once we get the program running, we are done"
- **Fact:** 60-80% effort comes after the software is delivered for the first time
  – Bug fixes, feature enhancements, software reengineering, migration

SE Myths (cont.)

Practitioners

- "Until I get the program running, I cannot assess quality"
- **Fact:** Software assessment methods can be applied once code is written and are very effective

SE Myths (cont.)

Practitioners

• “The only deliverable work product is the running program”

• **Fact:** Need the entire configuration

– Documentation of system requirements, design, programming, and usage

SE Myths (cont.)

Practitioners

- "SE will slow us down by requiring unnecessary documentation"
- **Fact:** SE is about creating quality

Better quality □ reduced rework □ faster delivery time

SE Myths (cont.)

Practitioners

- "I need to be an exceptional coder to be in software engineering.
- **Fact:** There are a variety of roles and skills needed to successfully develop and maintain software applications.

– Managers, QA/testers, scrum masters, UI/UX designers, business analysts, IT, customer support, data analysts, database administrators (DBA), architects, security specialists, deployment engineers,...

Software Development Life Cycle

1. Requirements
2. Design
3. Implementation
4. Testing
5. Deployment/Maintenance

➔ *As defined in this class. Specific terms to describe phases will vary based on company, team, process, etc., but basic ideas will apply.*

Requirements

Goal: Understand customer requirements for the software system

- The *what* of the project

- Very difficult to "get right" the first time and evolve over the course of development
  - Remember 2 of the Top 3 reasons for project failure: **(2)** Incomplete and **(3)** Changing Requirements
- *Software Artifacts:* requirements documents, use cases, user stories,...

Design

Goal: decide the software structure and enable programmers to implement requirements by designating projected parts of the implementation

  - The *how* of the project

- design: a representation or model of the software to be built
- How individual classes and software components work together (Programs can have 1000s+ of classes/methods)
- *Software Artifacts:* design documents, class diagrams,...

Implementation

Goal: translating design into a concrete system (i.e. code)

- Can use any language, but some languages are better suited to certain types of programs than others
- *Software Artifacts*: source code, documentation, configuration files, media, executables, bug database, source code repository, issue trackers…

Testing

Goal: Execute software with intent of finding errors

- While you can't test until there is code to run, you can start planning testing when you're analyzing the requirements
- Includes Unit (Ut) and System (St) tests to verify code and functionality
- *Software Artifacts*: test code, bug database, test database, test inputs and outputs, documentation,...

Deployment/Maintenance

Goal: release, upgrade, and fix the software

- deployment: delivery of software to users
  - When software is completed, it must be ***deployed*** to customers for usage.
- *Just because you deliver your software doesn't mean you're done with it*: Software must be ***maintained*** such that user problems are addressed after operation (next version, debugging, increased testing, refactoring, updates to requirements, etc.)
- *Software Artifacts:* All!

The First Law

“No matter where you are in the system life cycle, ***the system will change****, and* ***the desire to change it will persist throughout the life cycle.****”*

[Bersoff, 1980]

Next Class

- **Software Process**

- **HW0 due Monday at 11:59pm**

References

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