Inf2C: Software Engineering

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About this course

This course has two main jobs:

- give you an overview of what software engineering is
- take you beyond programming to engineering software

This is a tall order for one 10pt course!

Why do this course?

Because software engineering is fascinating :-)

– blend of human and technical challenges; fast-moving; important

Job relevance!

Learning outcomes

- Explain how to apply commonly agreed ethical principles to a software engineering situation.
- Motivate and describe the activities in the software engineering process.
- Construct use cases for an application scenario.
- Explain and construct UML class diagrams and sequence diagrams.
- Explain how a software system and its construction may be assessed using testing and other relevant techniques.
- Evaluate aspects of human usability of an application program or web site.
- Compare different approaches to software licensing.
- Use a modern IDE (Integrated Development Environment) to build a large Java system, making appropriate use of configuration management, testing and other appropriate tools.

Teaching style

Lectures as guidance and overview (not self-contained notes).

Self-study (web, Java)

Required and suggested readings (take notes!)

Practical coursework: a single exercise, in two parts

Exam: short answers, written on the question paper

Support: Bulletin board. Tutorials. Email only if your query is personal or confidential.

Books

No book is essential.

The following are worth considering:

Somerville, *Software Engineering*
- Large, classic. Comprehensive on SE, but limited on UML and Java.

Stevens with Pooley, *Using UML*
- Covers basic SE, does UML thoroughly, no Java.

Why is software engineering still hard?

Easy (or at least routine) projects

small systems (up to c. 100k LOC),

- without hard timescales or budgets,
- without requirement for very high reliability,
- without complex interfaces or legacy requirements [...]

Hard projects

everything else. Projects with *all* the above challenges, and more.

Statistics

The Standish Chaos reports on medium-larg organisations classify software development projects:

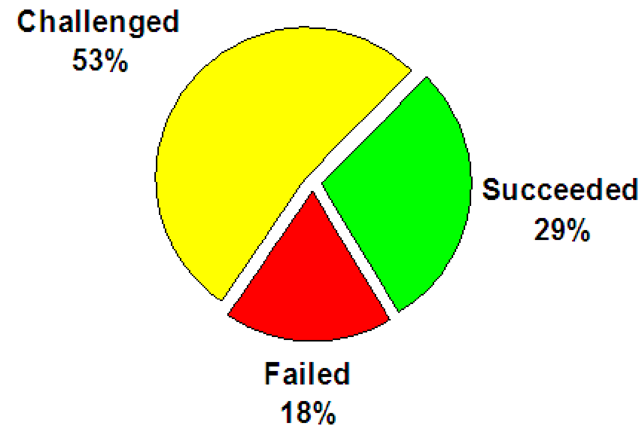
- Succeeded
  1994: 16% ... 2004: 29% ...2009: 32%)
- Challenged (i.e., delivered something but maybe reduced scope, late, over budget)
  no real trend, around 50%
- Failed (i.e., cancelled without delivering anything)
  1994: 31% ... 2004: 18% ...2009: 24%)

Methodology not perfect, but statistics are indicative.

CHAOS 2004

SURVEY RESULTS

Resolution of Projects



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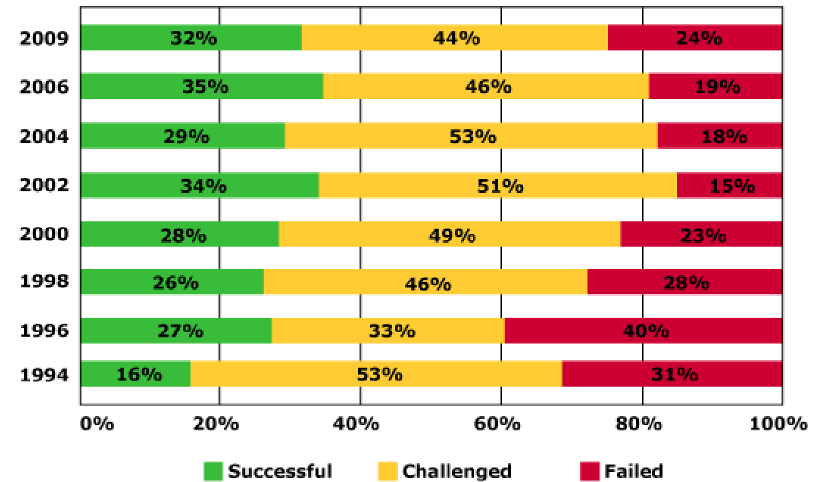
Standish Chaos trends to 2009



The fundamental tension

control ↔ flexibility

Historically a natural tendency to tackle problems with ever greater control, e.g.

- uncertain requirements
- overruns of time or budget

Greater control: more planning, more documentation, tighter management...

More *ceremony*.

1990's/2000's backlash: agile methods, e.g. Extreme Programming, with slogans like "Embrace Change".

Deliberately *low ceremony*.

In this course we try to give you a flavour of both approaches.

Software engineering activities

Syllabus list:

- *requirements capture*
- *design*
- *construction*
- *testing, debugging and maintenance*
- *software process management*

software development process: How these activities are ordered and related

Requirements capture

Identifying what the software *must do* (not *how*). Recorded using a mixture of *structured text* and *use case diagrams*.

Interesting issues:

- Multiple stakeholders often with different requirements – how to resolve conflicts?
- Prioritisation. Which requirements should be met in which release?
- Maintenance: managing evolving requirements.

Techniques: use e.g., case analysis, viewpoint analysis, rapid prototyping.

Design

Requirements: what the software must do.

Design: how should it do that?

Higher level than code. Often recorded using a modelling language e.g. UML (*Unified Modeling Language*).

Multiple levels of design:

- architectural design
- high-level design
- detailed design

Interesting issues: understandability ("elegance"); robustness to requirement change; security; efficiency; division of responsibility ("buildability").

Techniques: e.g., introspection, reviews of various kinds, design patterns, Class-Responsibility-Collaboration (CRC) cards...

Construction/implementation

More general than "coding", includes:

- detailed design (the level that doesn't get written down)
- coding
- unit testing
- "hygiene" tasks like configuration management
- developer-targeted documentation

Interesting issues: scale: managing large amounts of detail, esp. code. Need systems that work when it's not possible for one person to know everything.

Techniques: Lots of software tools...

Testing and debugging

Testing happens at multiple levels, from unit tests written before coding by developer, to customer acceptance testing.

Debugging covers everything from "which line of code causes that crash?" to "why can't users work out how to do that?".

Interesting issues: containing cost – how to test and debug efficiently; software tools to support testing and debuggin

Techniques: software tools e.g. JUnit, Selenium, IDE debugger.

Maintenance

Any post-(major)-release change.

1. corrective maintenance (bugfixing!)
2. perfective maintenance (enhancing existing functionality)
3. adaptive maintenance (coping with a changing world)
4. preventative maintenance (improving maintainability)

Traditionally an after-thought - mistakenly! In the "total cost of ownership" (TCO) of software system, maintenance costs often dwarf development costs.

Interesting issues: retaining flexibility; when to refactor/rearchitect/retire/replace system

Techniques: e.g., refactoring

Software process management

Meta-level activity. How can a group of people carry out all these activities so as to produce software that customers are happy to pay for?

How should the activities be structured? E.g. all requirements analysis first, or just enough to do the first bit of design?

Interesting issues: balancing flexibility against controllability, producing just enough paper; enabling continual improvement of process.

Techniques: e.g., reviews, various kinds of certification, Capability Maturity Model.

Software engineering discipline

What is a software engineer, as distinct from a programmer?

E.g. someone who isn't going to be surprised when the customer turns round and wants something else. Someone who's thought about/been educated in the wider software engineering issues such as ethics.

Software engineering is a (relatively) young discipline. Is it "engineering"?

What does a software engineer need to know? What must they be able to do? IEEE SWEBOK; SE2004 curriculum; etc.

Should software engineers be chartered? Should they be legally required to be?

Ethics

As software has come to be more depended on, the dangers of unethical – immoral – behaviour of software engineers have become more apparent. This is a major argument for chartering software engineers.

The ACM and IEEE have written a Software Engineering Code of Ethics and Professional Practice:

`http://www.acm.org/about/se-code`

It all seems simple — until you spot the conflicts. E.g.:

Your company depends on a major contract from Client X. Client X insists you use Software Y to develop a product (3.08) on which people's lives depend. You are not satisfied with Y's correctness, and think using it might introduce a risk of life-threatening failure of the product (1.03). What do you do?

Reading

Aim: deepen your understanding of what software engineering is and why the term was invented and is still used, and why problems still exist.

Compulsory: Read the ACM/IEEE Ethics code `http://www.acm.org/about/se-code` and think about cases where the principles might conflict.

Compulsory: Read the coursework (on web page)

Suggested: browse the proceedings of the NATO conferences on Software Engineering (see web page).

Suggested: Somerville Chapter 1 and/or Stevens Chapter 1.

Suggested: google Chaos Standish reports, find e.g. `http://www.infoq.com/articles/Interview-Johnson-Standish-CHAOS`

Suggested: google software engineering ethics.