ECE450S Lecture Notes

ECE450H - Software Engineering

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Marking	Mid term test	15%
	Final Exam	35%
	Course Project	50%
Text	Hans van Vliet	
	Software Engineering - Principles and Practice, 2nd ed.	
Web Page	`www.cs.toronto.edu/~yijun/ece450h/`	

Course Project

- Reengineering a large software system
- Work in teams
- Three Phase Project
  - A. Study a large legacy software and specify new requirements
  - B. Partial implementation
  - C. Swap software and complete implementation
- Select any other teams software at swaps
- Project specification announced soon

Immediate Project Issues

- Team Selection

  Work in teams of 5, self-selection of teams

  Form teams *ASAP* for start of project

  Instructor/tutor deal with orphans/disputes

- Programming Language for Project

  Discuss/decide in class after project is announced

  Possible choices   Java, C++, XML

- **Selecting a hard-working, compatible team is important for success in the course project**

Major Themes

- What is Software Engineering

  van Vliet Chapter 1

- The Software Process

  van Vliet Chapter 3

- Software Project Management

  van Vliet Chapters 2,5,6,7,8

- Software Construction

  van Vliet Chapters 4, 17, 19

- Software Testing and Validation

  van Vliet Chapters 13,15

- Software Product Delivery, Software Maintenance

  van Vliet Chapter 14

- Requirements and Specifications

van Vliet Chapter 9

- Software Architecture and Software Design

  van Vliet Chapters 10, 11, 12

Reading Assignment

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van Vliet, Chapter 1

           Sections  3.5,  3.7

           Sections 11.1.1 .. 11.1.3

Usenet news group    comp.risks

READ comp.risks on a regular basis
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Alternative Major Themes

- How to survive in a large software project
- Getting software right the first time
- Minimizing software production costs
- Maximizing software quality
- Being organized and systematic is infinitely better than not being so
- An engineering approach should be used for the development of software
- Design for Maintainability is really important.

Software Engineering Information Sources

- IEEE Transactions on Software Engineering
- ACM Transactions on Software Engineering and Methodology
- International Conference on Software Engineering (yearly)
- IEEE Software
- ACM SigSoft - Software Engineering Notes (monthly)
- Software - Practice & Experience
- International Conference on Software Maintenance
- Usenet news group - comp.risks, comp.soft-eng
  comp.risks archive: http://catless.ncl.ac.uk/Risks/
- Libraries: CS & Engineering, Gerstein, Metro Reference

What is Software Engineering

- The science and art of building *LARGE* Software Systems

  On time

  On budget

  With Acceptable Performance

  With Correct Operation

- *LARGE* means:

  Many people, team not individual effort

  Many $s spent on design and implementation

  Over 75,000 lines of source code

  Lifetime measured in years

  Continuing modification and maintenance

- Software costs dominate hardware costs

Calibration on LARGE

- 1,000,000 lines of source code
- 13,333 pages at 75 lines/page (laser print)
- A 4’ 5” (1.46m) high stack of paper at 500 pages/2”
- 41,667 screens at 24 lines/screen, or
  20,833 screens at 48 lines/screen
- 22.2 hours to print at 10 pages/minute
- 16.7 hours to compile at 1000 lines/minute (wildly optimistic)

Many real software systems are 3,000,000 to 6,000,000 lines of source code.

Many existing systems are in the 10,000,000 to 20,000,000 range.

Windows 98 is alleged to be more than 50,000,000 lines.

Why is Software Engineering Important

- Cost of getting software *wrong* is often horrendous

  Bankruptcy of software producer

  Injury or loss of human life **Broken software can KILL people**

- Software producer profitability depends on producing software efficiently and minimizing maintenance effort. Software reuse is an economic necessity

- Immense body of old software (legacy code or dusty decks) that must be rebuilt or redesigned to be usable on modern computer systems

- Software maintenance increases the entropy (disorder) in a software system. Without proper care the software can become unmanageable and unusable

- Very, very few contemporary systems work correctly when first installed. We need to do much better

- Over $600,000,000,000 spent each year on producing software

Software Horror Stories[a]

- Bank of America spent \$23,000,000 on a 5-year project to develop a new accounting system. Spent over \$60,000,000 trying to make new system work, finally abandoned it. Loss of business estimated in excess of \$1,000,000,000
- Starting in 1982, Allstate Insurance spent \$8,000,000 on an effort to automate its business. The supposed 5-year project continued until 1993 at a cost approaching \$100,000,000
- The B1 Bomber required an additional \$1,000,000,000 to improve its air defense software, but the software still isn't working to specification
- A U.S. Air Force air defense system was \$1,000,000,000 over budget, 4 years behind schedule and only marginally usable
- A regional Blue Cross service lost \$60,000,000 in incorrect over payments due to errors in a \$200,000,000 computer processing system that wasn't adequately tested before being put into service.

[a]P.Neuman, System Development Woes, CACM, Oct 1993

- Ariane 5, Flight 501

  The loss of a $500,000,000 spacecraft was ultimately attributed to errors in requirements, specifications and inadequate software reuse practices.

- Therac-25

  Hospital patients died or were seriously injured due to errors in programming the user interface of this machine.

- London Ambulance Service

  Major software problems rendered this ambulance dispatching system unusable. Poor project management and poorly developed requirements contributed to the problems. People died and/or received less than optimal medical care due to the problems with this system.

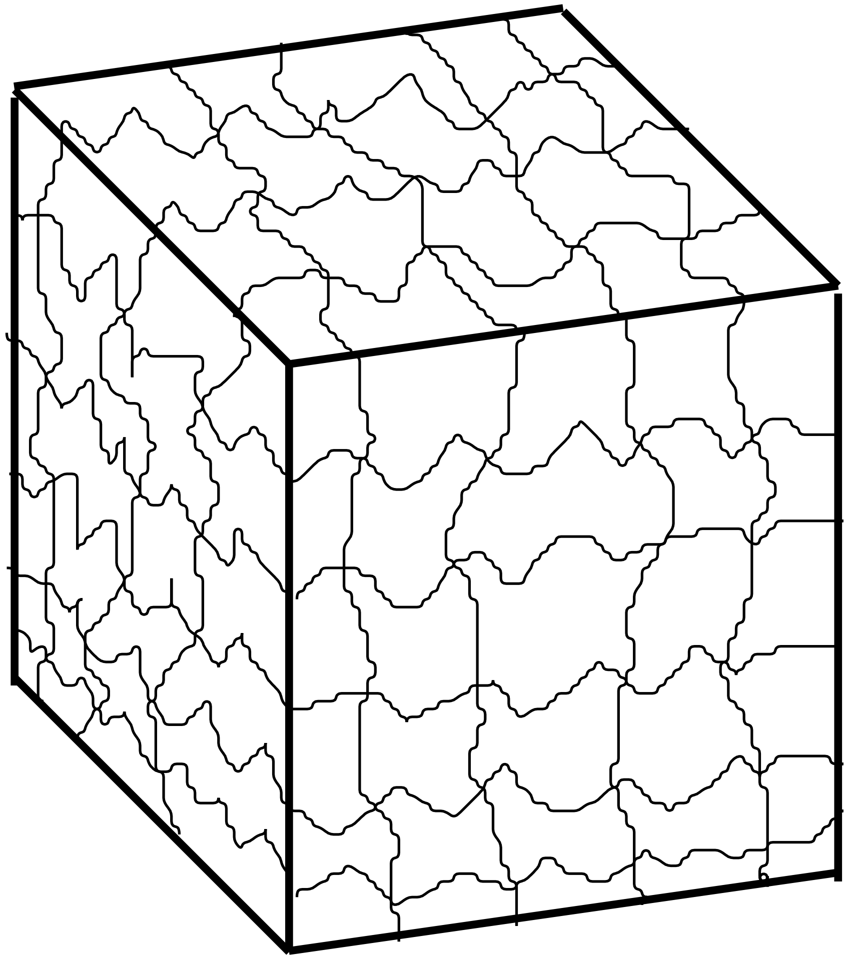
What is Software ?

- Requirements and specification documents
- Design documents
- Source Code
- Test suites and test plans
- Interface to hardware and software operating environment
- Documentation, internal and external

What Makes Large Software Different ?

Scale	Precludes total comprehension
Complexity	Number of functions, modules, paths
Team Effort	Continuingly changing body of programmers
Communication	Distribution of specifications and documentation
Continuing Change	During design & implementation
	During lifetime
Lifetime	Measured in years or decades
Imprecise goals	Conflicting or ambiguous, changing

Real Programs Resemble Large Puzzles



- The dimensionality of the puzzle (connections between pieces) is much higher that can be shown on a 2-dimensional slide.
- Each piece may be written by different (group of) programmers.
- Each piece has a *rigorously specified* **interface** that describes how it interconnects with other pieces.
- For a program to be correct, all of the pieces must fit exactly.
- The shape of the pieces and the interconnections between them change over time as the program is modified and maintained.

Issues in Software Engineering

- Major concern is the construction of *large* programs.
- Central theme is *mastering complexity*.
- Software evolves over its lifetime.
- The efficiency of *software development* is of crucial importance
- Regular cooperation between people is an essential and unavoidable part of large software development.
- Software has to support its users effectively.
- Software Engineering is a field in which members of one culture (designers, programmers) create artifacts on behalf of members of another culture (end users).

The Ideal Goals of Software Engineering

- To produce software that is absolutely correct.
- To produce software with a minimum of effort.
- To produce software at the lowest possible cost.
- To produce software in the least possible time.
- To maximize the profitability of the software production effort.
- To produce software that can be maintained with a minimum of effort.

In practice, none of these ideal goals is ever completely achievable.
The challenge of Software Engineering is to see how close we can get to achieving these goals.

The *art* of software engineering is achieving the best balance among these goals for a particular project.

What is Good Software?

- **Correct, Correct, Correct**
- Maintainable and easy to modify
- Well modularized with well-designed interfaces
- Reliable and robust
- Has a good user interface
- Well Documented

  internal documentation for maintenance and modification

  external documentation for end users
- Efficient

  Not wasteful of system resources, cpu & memory

  Optimized data structures and algorithms

Goodness Goals Conflict

- All goodness attributes cost $s to achieve
- Interaction between attributes

  High efficiency may degrade maintainability, reliability

  More complex User Interface may degrade efficiency, maintainability,
  and reliability

  Better documentation may divert effort from efficiency and reliability

- Software Engineering management has to trade-off satisfying goodness goals
- Software Development is (usually) done with a relatively inelastic upper bound on resources expended.

TANSTAAFL **T**here **A**in’t **N**o **S**uch **T**hing **A**s **A** **F**ree **L**unch

Need Different Approaches for Developing Large Software

- Need formal management of software production process
- Formal & detailed statement of requirements, specification and design
- Much more attention to modularity and interfaces

  Must be separable into manageable pieces
- Need configuration management and version control
- More emphasis of rigorous and thorough testing
- Need to plan for long term maintenance and modification
- Need much more documentation, internal and external

  ”A typical commercial software project involves creating more than 20 kinds of paper documents on such items as requirements and functional, logic, and data specifications. For civilian projects, at least 100 English words are produced for every source code statement in the software. For military software, about 400 words are produced for every source code statement. Many new software professionals are surprised when they spend more time producing words than code.”[a]

[a]Capers Jones, Gaps in programming education,IEEE Computer, April 1995 v.28 n.4, pg. 71

Why is Software Development Hard?

- Changing requirements and specifications
- Inability to develop complete and correct requirements
- Programmer variability and unpredictability
- Communication and Coordination
- Imprecise and incomplete Requirements and Specifications
- Inadequate Software Development Tools
- Inability to accurately estimate effort or time required
- Overwhelming complexity of large systems, more than linear growth in complexity with size of the system
- Poor software development processes
- Lack of attention to issues of Software Architecture