Course Information

Course Topics

- Software process
- Requirement analysis
- Software design
  - Architecture styles
  - Design patterns
- Unified Modeling Language
- Software testing
- Software maintenance
- SE research topics

Grading Scale

Score	Grade
93-100	A
90-92.9	A-
87-89.9	B+
83-86.9	B
80-82.9	B-
77-79.9	C+
73-76.9	C
70-72.9	C-
60-69.9	D
<60	F

- I may choose to curve the grades at the end of the term

Group Project

- Work in teams (4 people)
- Create or extend an open-source project
  - Choose from a set of given topics
  - Come up with your own and get the instructor's approval
- Go through analysis, design, implementation, testing, and some maintenance
- Turn in the software artefacts
- Give a presentation
- Peer review inside/between groups

Introduction to Software Engineering

Overview

- Software in our lives
- Hardware vs. Software
- What is ***software engineering***?
- Software engineering - precis of a short history by [Barry Boehm, ICSE'06 Keynote]
- Software myths
- Learning objectives

Software is ubiquitous

- System software
  - OS, compilers, device drivers
- Business software
  - Payroll, accounting
- Engineering/scientific software
  - Computer-aided design, simulation
- Embedded software
  - GPS navigation, Flight control, Toaster

Software is ubiquitous

- Product-line software (PC-like based)
  - Spreadsheets, word processing, games
- Web-based software
  - Gmail, Facebook, Youtube
- Artificial intelligence software
  - Robotics, artificial neural networks, theorem proving

What is Software?

- Definition [Pressman]
  - The product that software professionals build and then support over the long term
- Software encompasses:
  - Executable programs
  - Data associated with these programs
  - Documents: user requirements, design documents, user/programmer guides

Hardware vs. Software

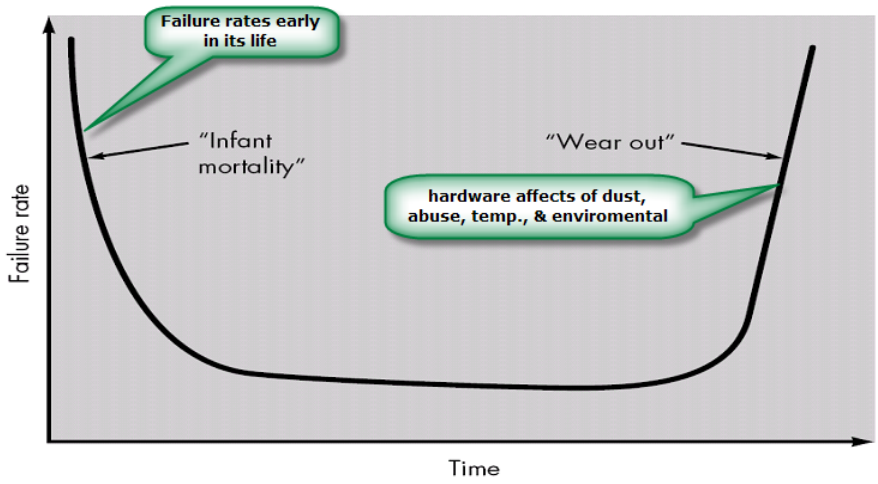
- Manufactured
- Wear out
- Built using components
- Relatively simple

- Developed/ engineered
- Deteriorate
- Custom built
- Complex

Manufacturing vs. Development

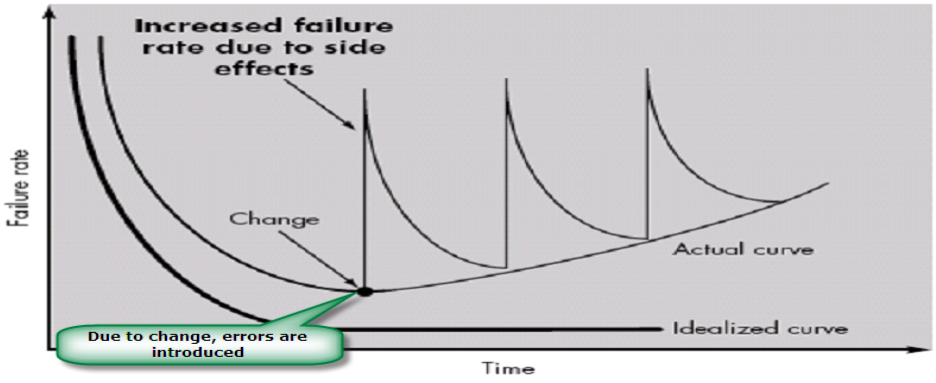
☐ Hardware is difficult or impossible to modify	☐ Software is routinely modified and upgraded
☐Hiring more people causes more work done	☐This is not always true
☐Costs are more concentrated on products	☐ Costs are more concentrated on design

Hardware does "wear out"



Failure curve of hardware—"bathtub curve"

Software does "deteriorate"



Failure curve of software

Component based vs. Custom built

- Hardware products employ many standardized design components.
- Most software is always custom built.
- The software industry does seem to be moving (slowly) toward component-based construction.

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?

Pressman's book

A discipline that encompasses

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

Process, Methods, 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

Importance of Historical Perspective

- Santayana half-truth:
  - "Those who cannot remember the past are condemned to repeat it"
- Don't remember failures?
  - Likely to repeat them
- Don't remember successes?
  - Unlikely to repeat them

Cf Barry Boehm, ICSE06 Keynote

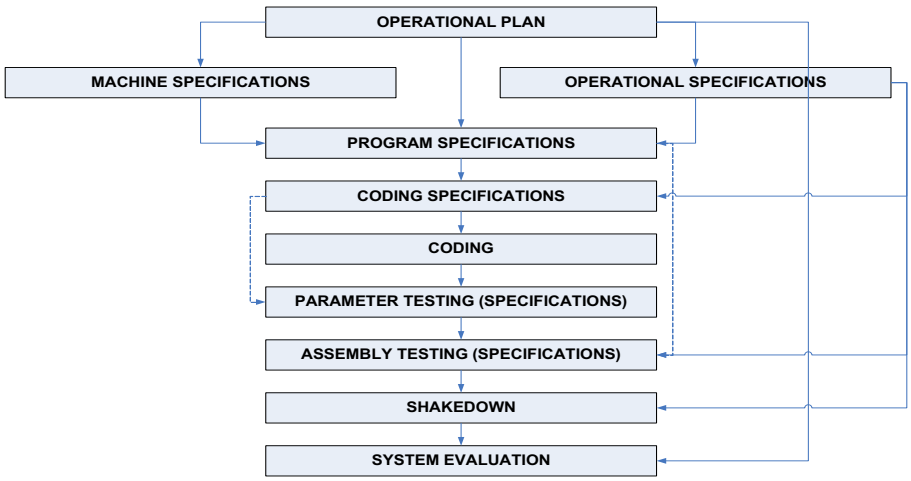
History of SW Development

1950's: engineer software like hardware

- Hardware-oriented software applications
  - Airplanes, circuits
- Economics: computer time more valuable than people time
  - Boehm supervisor, 1955: "We're paying $600/hour for that computer, and $2/hour for you, and I want you to act accordingly."

Cf Barry Boehm, ICSE06 Keynote

SAGE Software Development Process



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1960's: software is NOT LIKE hardware

- Properties
  - Invisible, complex, had to be executed by computers, hard to change, doesn't wear out, unconstrained by physical laws of nature
- Demand for programmers exceeded supply
  - Cowboy programmers as heroes
  - Computer Science Department formed

Cf Barry Boehm, ICSE06 Keynote

1960's: software is NOT LIKE hardware

- Code-and-fix process
- Better infrastructures
  - OS, compilers, utilities
- Some large successes
  - Apollo, ESS
- Failure of most large systems
  - Unmaintainable spaghetti code
  - Unreliable, undiagnosable systems
  - Code-and-fix process is too expensive

1970's Formal and Waterfall Approaches

- Structured programming, eliminate goto
- Formal methods
  - Specification, development, verification
  - Problems
    - Successful for small, critical programs
    - Proofs show presence of defects, not absence
    - Scalability of programmer community

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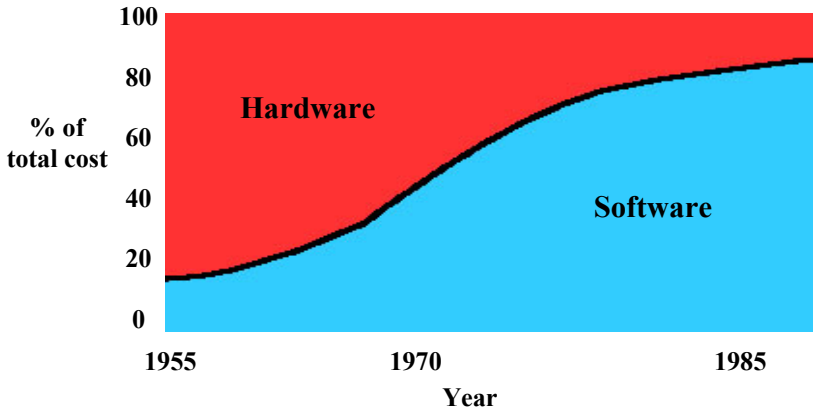
- Waterfall process model
  - Requirements, design, coding, testing, operations (maintenance)
  - Problems
    - Customers' changing requirements destroy distinctions between phases
    - Heavyweight documentation hard to review and maintain
    - Assumption for smooth transition from design and implementation

Large-Organization HW/SW Cost Trends (1973)



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1980's Synthesis: Productivity, Reuse, Objects

- Major SW productivity enhancers
  - Working faster: tools and environments
  - Working smarter: processes and methods
  - Work avoidance: reuse, simplicity, objects
  - Technology silver bullets: AI, Do what I mean, programming by example
- Reuse libraries
- Object orientation
  - Smalltalk, Eiffel, C++

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"No Silver Bullet", Fred Brooks

IEEE Computer, 1987

"There is no single development, in either technology or management technique, which by itself promises even one order-of-magnitude improvement within a decade in productivity, in reliability, in simplicity."

- "Essential" difficulties to build software
  - Complexity: no two parts are alike
  - Conformity: conform to existing interfaces
  - Changeability: subject to change
  - Invisibility: has no ready geometric representation
- Closest thing to silver bullet: great designers and communicators

1990's maturity models and agile methods

- Capacity Maturity Models (CMM)
  - Reliance on explicit documented knowledge
  - Heavyweight but verifiable, scalable
- Agile Methods
  - Reliance on interpersonal tacit knowledge
  - Lightweight, adaptable, not very scalable
- Other trends
  - reverse engineering, Open Source SW, Spiral process model

Cf Barry Boehm, ICSE06 Keynote

2000's Synthesis

- Model-driven development
- Risk-driven model
- Service-oriented architecture
- Hybrid agile/plan-driven product and process architectures

Existing SW Problems

- Software is too expensive
- Software takes too long to build
- Software quality is low
- Software is too complex to support and maintain
- Software does not age gracefully
- Not enough highly-qualified people to design and build software

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

Software Myths

Management Myths

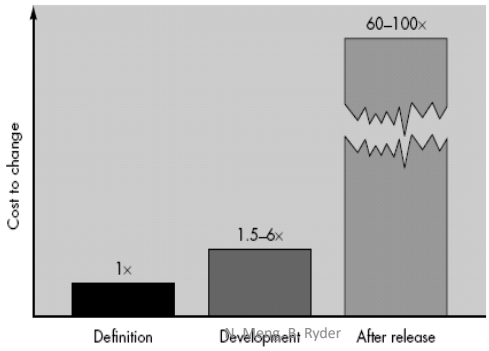
- "If we get behind schedule, we can just add more people and catch up"
- Fact: Adding people to a late project makes it even later
  - The people working now must spend time educating the newcomers

Customer Myths

- "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

Customer Myths

- "Changes in requirements are easy to deal with because software is flexible"
- Fact: Changes are hard and expensive



Practitioner's Myths

- "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

Practitioner's Myths

- "Until I get the program running, I cannot assess quality"
- Fact: Software reviews can be applied once code is written and are very effective; pair programming techniques as well

Practitioner's Myths

- "The only deliverable work product is the running program"
- Fact: Need the entire configuration
  - Documentation of system requirements, design, programming, and usage

Practitioner's Myths

- "SE will slow us down by requiring unnecessary documentation"
- Fact: SE is about creating quality
  - Better quality -> reduced rework -> faster delivery time
  - Brooks recommends time division of: 1/3 planning; 1/6 coding; 1/4 component test and early system test; 1/4 system test

Learning Objectives

- Knowledge of basic concepts in software engineering
- Ability to do Object-oriented requirement analysis
- Ability to do Object-oriented design
- Good command of UML and Patterns
- Understanding importance of teamwork

Software Engineering

- Software is complex, expensive, late, low-quality, hard to maintain
- Goal: approach these problems using software engineering
- Key message: the field is very young – The term "SE" was introduced in 1968