cs2220: Engineering Software

Class 1:
Engineering Software?

Fall 2010
University of Virginia
David Evans

Menu

Can we **engineer** software?

About this Course

Managing **Complexity**

Can we **engineer** software?

What is ***engineering***?

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Webster's Definitions

en·gi·neer·ing (n j -nîr ng) *n.*

1a. The application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

b. The profession of or the work performed by an engineer.

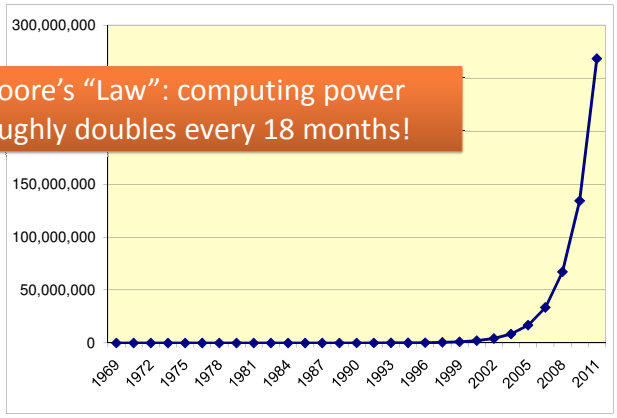
2. Skillful maneuvering or direction: *geopolitical engineering; social engineering.*

Design Under Constraint

"Engineering is **design under constraint**… Engineering is synthetic - it strives to create what can be, but it is **constrained by nature**, **by cost**, **by concerns of safety**, **reliability**, **environmental impact**, **manufacturability**, **maintainability** and many other such 'ilities.' …"

William Wulf and George Fisher

Computing Power 1969-2010



Constraints Software Engineers Face

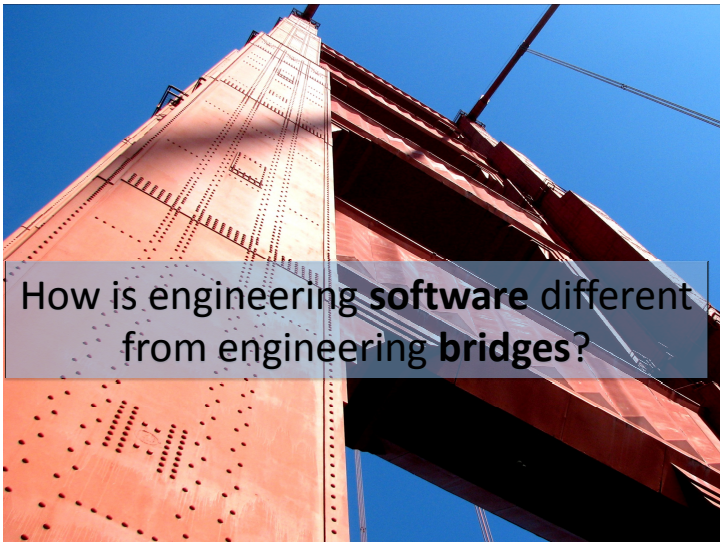
Not like those for "real" engineers:

- Weight, physics, etc.

Complexity of what we can understand

- Most important constraints:
  - Limits of **human memory**
  - **Cost** of human effort

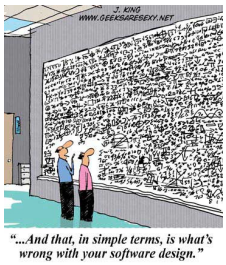
This class is about **managing complexity** to efficiently produce reliable complex software systems.



Bridges	**Software**
Physical stuff	virtual stuff
important to get it right first time	
Testability? "easy" to test continuous	hard to test discrete

Bridges	**Software**
Continuous Calculus Testing/analysis is "easy" if the bridge holds for 1M kg, it also probably holds 0.99M kg	**Discrete** Logic, Discrete Mathematics Testing/analysis is difficult
Made of **physical** stuff Most costs are obvious Changes after construction are hard	Made of **virtual** stuff All costs are non-obvious Changes should be easy (but they're not)

Bridges	**Software**
Requirements are (usually) obvious and easy to describe	Requirements are mysterious and hard to describe
A good design is apparent to everyone immediately	A good design is only apparent to "experts" but has impact later on



Bridges

Obvious when it fails

- Bridge makers get sued
- Architects need licenses
- Sibley & Walker (~30 years between failures)

Software

Falls down quietly (usually)

- Software vendors blame user, charge for upgrades
- Anyone can make software, no one gets sued

Software Failures

Ariane 5 (1996)

Spanair flight 5022 (2008)

Course Overview

Introductions Thursday

where cs1120 ends…

Computer Science

I think that it's extraordinarily important that we in computer science keep fun in computing. When it started out, it was an awful lot of fun. Of course, the paying customer got shafted every now and then, and after a while we began to take their complaints seriously. We began to feel as if we really were responsible for the successful, error-free perfect use of these machines. I don't think we are. I think we're responsible for str… ping fun… los… pe, is … you were first led up to it, that you can make it more.

Software Engineering: taking "customer" complaints seriously!

but, it should still be fun and stretching what one can do with computers!

Alan Perlis, preface to Abelson & Sussman,
Structure and Interpretation of Computer Programs

Small, Fun Programs ("cs1120")
vs.
Big, Important Programs
(*simulated* in "cs2220")

Small, Fun Programs	Important Programs
Fast enough to finish	fast enough to satisfy requirements
friendly inputs	unfriendly inputs
keep in memory	too big

Small, Fun Programs

If it doesn't work on some input, no big deal

Happy if it works once

flickr cc:foolswisdom

Important Programs

If it doesn't work on **just one input** people may die, $$$$ lost

Must work on all inputs

flickr cc: scottvanderchijs

Small, Fun Programs

Manage complexity mostly by memory

Written by a few people over a short period of time

Important Programs

Written by many people over many years

Need to **design and document well to manage complexity**

How Big are Big Programs?

Largest program in cs1120: ~1000 lines of code

F-22 Steath Fighter Avionics Software: 1.5M loc

Linux: 10M lines of code

Windows (XP): ~50M lines of code

Amazon.com: ~100M lines of code

Modern automobile: ~100M lines of code

Typical estimate: **$18** per **line of code**

Typical estimate: **1** bug per **1000 lines of** (production) **code**

Goal of cs2220

Develop the concepts and skills necessary to successfully build important software.

Grading

A+: I would be willing to fly in a plane running software you designed and wrote

A: I would be willing to shop in an ecommerce store you built

B: I would trust you to *manage* programmers working on important software

(See syllabus for grading details.)

Course Summary

Main ideas:

Abstraction
Using and designing data abstractions

Specification
Understanding and writing declarative specifications

Analysis
Static: reasoning about behavior
Dynamic: developing and executing testing strategies

Learn by doing:

5 smallish software projects (problem sets 1-5)
individually, in small teams, 1-2.5 weeks each
1 larger team project: (almost) anything you want

Expected Background

Prerequisite: cs1120/cs150

You should be able to:

- Write and understand **short programs**
- Write and understand **recursive definitions**
- Use **procedures** as parameters and results
- Analyze the **asymptotic running-time** of a procedure
- Understand replacement (BNF) **grammars**

If you don't have this background, you may still be able to take the class (talk to me).

Course History

2002: First offered (cs201j)

Developed with support from National Science Foundation

Spring 2006: BACS Degree launched

Fall 2006: cs205

Fall 2007, 2008, 2009: cs205 (taught by Paul Reynolds)

Fall 2010: cs2220

Course Pledge

Not the **classroom pledge**!

The whole point of being at a University is so you can:

- Learn from your classmates
- Learn better by teaching your classmates

READ, sign and return the cs2220 Pledge next class (Thursday)

If you disagree with anything, this is your chance to object

There may be questions about the pledge on a quiz!

Help Available

Me: David Evans
Office hours: Mondays, 1:15-2:30pm
Thursdays, 11am-noon
Blog comments: http://www.cs.virginia.edu/cs2220
Please use this for things that would be useful for everyone
Email: evans@cs.virginia.edu (anytime)

Don't be afraid to ask for help!

Assistant Teacher:
Web site: http://www.cs.virginia.edu/cs2220
Almost Everything goes on the web

Charge

This class is about:

Managing complexity: modularity, abstraction, specification

Engineering dependability: analysis, redundancy, design

By **5pm Tomorrow**: submit registration survey

Thursday: Print, read, and return **cs2220 pledge**

Beginning of class Tuesday: **Problem Set 1 Due**

If you do not satisfy the prereq for this course but want to stay in it, please talk to me now (or Thursday 11-noon, or arrange another time.