Course Wrap-Up

CSE 333 Autumn 2018

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Administrivia

- hw4 due last night
  - (late days – max 2 – expire Saturday; if you have them)

- Please finish course evals while they are still available

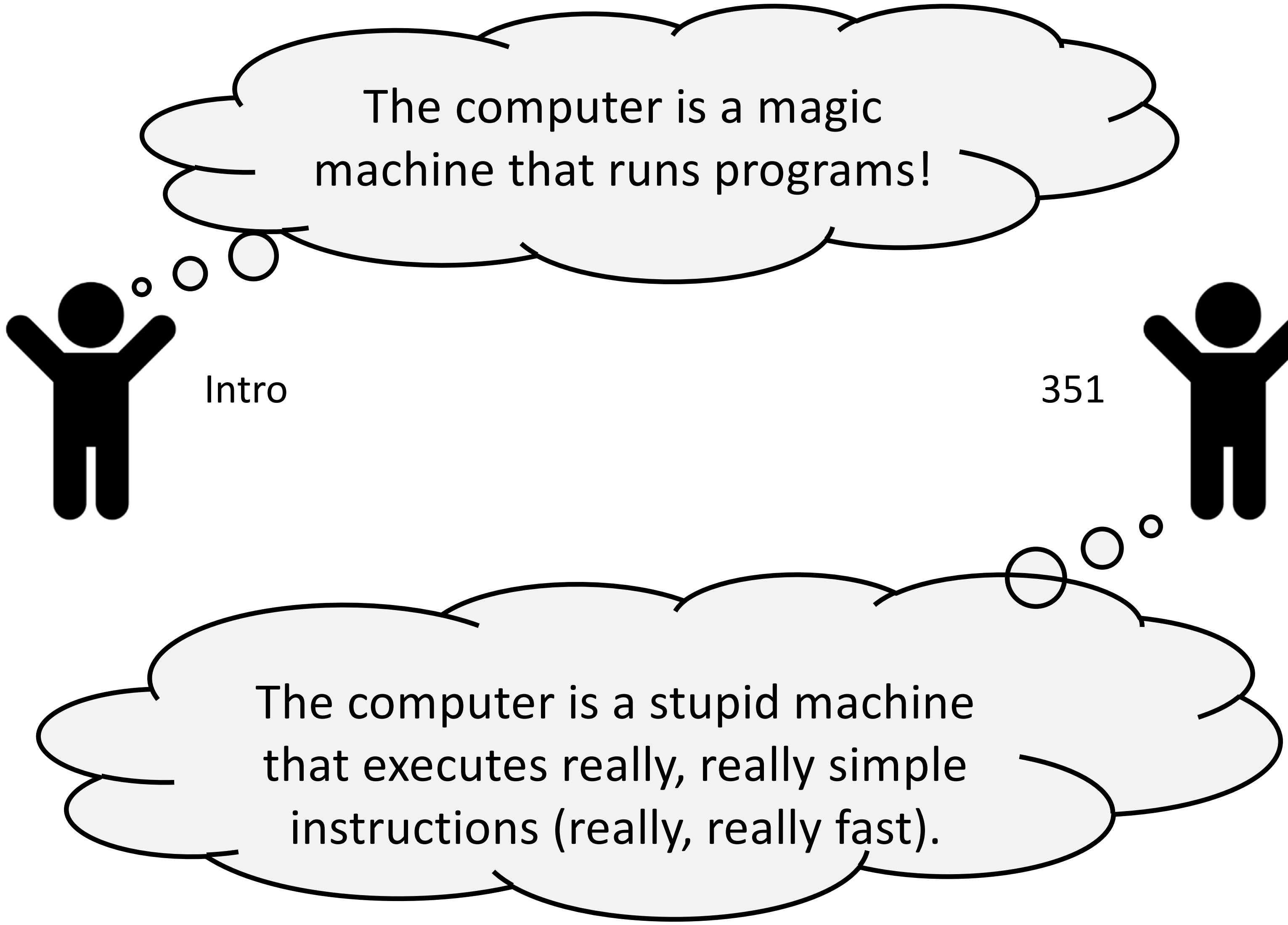
- Final exam Wed. 12/12, 2:30-4:20
  - Review Q&A Tue. 12/11, 4:30, SIG 134 – bring questions!
  - Topic list and old finals on Exams page
    - Summer final exams are 1 hour; regular quarters are usual 2 hours

So what have we been doing for the last 10 weeks?

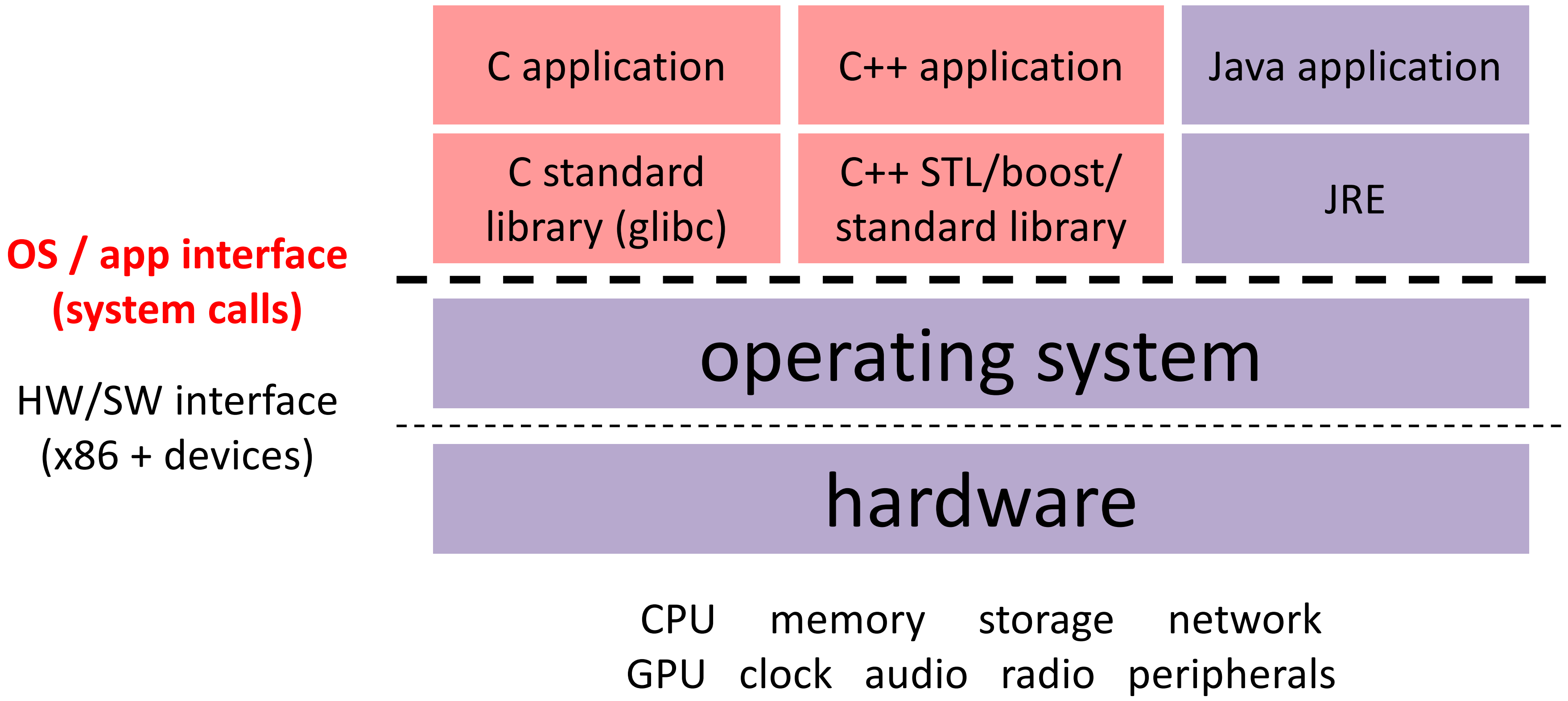
?

Course Goals

- Explore the gap between:


The computer is a magic machine that runs programs!
Intro
351
The computer is a stupid machine that executes really, really simple instructions (really, really fast).

Course Map: 100,000 foot view


C application
C++ application
Java application
C standard library (glibc)
C++ STL/boost/ standard library
JRE
OS / app interface (system calls)
operating system
HW/SW interface (x86 + devices)
hardware
CPU memory storage network
GPU clock audio radio peripherals

Systems Programming

- The programming skills, engineering discipline, and knowledge you need to build a system
  - **Programming:** C / C++
  - **Discipline:** design, testing, debugging, performance analysis
  - **Knowledge:** long list of interesting topics
    - Concurrency, OS interfaces and semantics, techniques for consistent data management, distributed systems algorithms, …
    - Most important: a deep understanding of the "layer below"

Main Topics

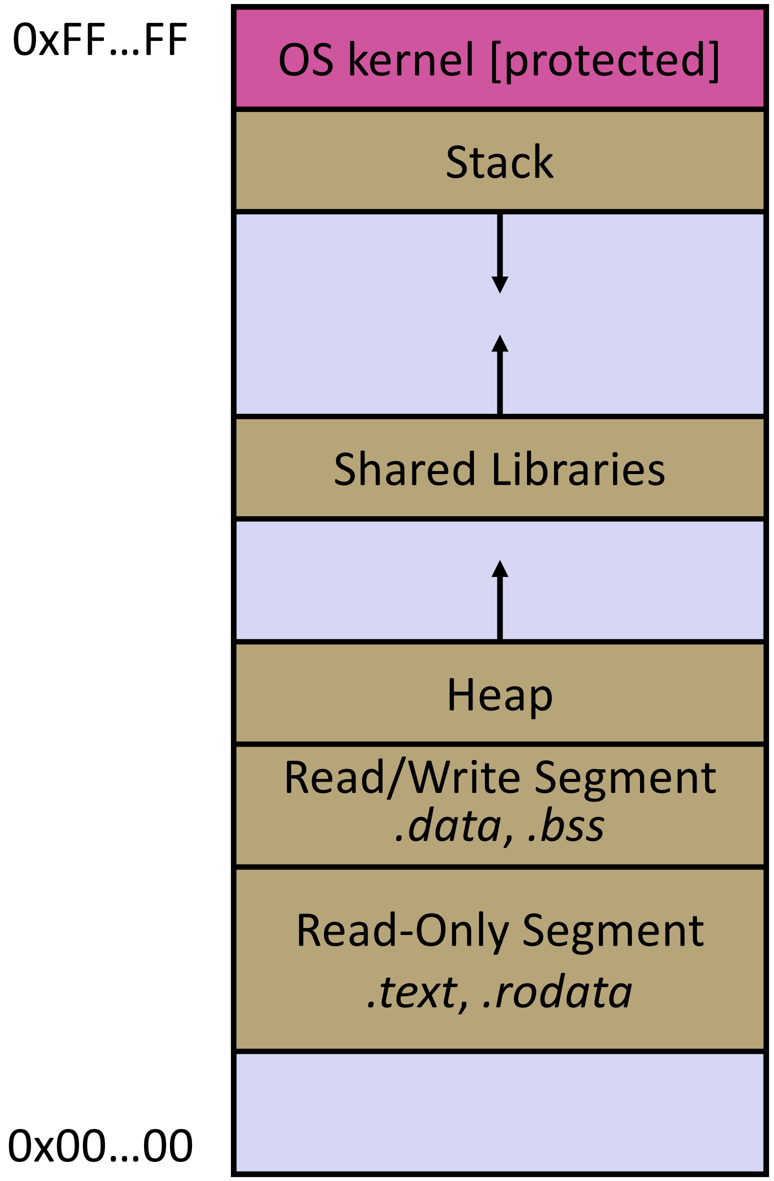
- C
  - Low-level programming language
- C++
  - The 800-lb gorilla of programming languages
  - “better C” + classes + STL + smart pointers + …
- Memory management
- System interfaces and services
- Networking basics – TCP/IP, sockets, …
- Concurrency basics – POSIX threads, synchronization

The C/C++ Ecosystem

- System layers:
  - C/C++
  - Libraries
  - Operating system
- Building Programs:
  - Pre-processor (`cpp`, `#include`, `#ifndef`, …)
  - Compiler: source code → object file (`.o`)
  - Linker: object files + libraries → executable
- Build tools:
  - `make` and related tools
  - Dependency graphs

Program Execution

- What's in a process?
  - Address space
  - Current state
    - SP, PC, register values, etc.
  - Thread(s) of execution
  - Environment
    - Arguments, open files, etc.



Structure of C Programs

- Standard types and operators
  - Primitives, extended types, structs, arrays, typedef, etc.
- Functions
  - Defining, invoking, execution model
- Standard libraries and data structures
  - Strings, streams, etc.
  - C standard library and system calls, how they are related
- Modularization
  - Declaration vs. definition
  - Header files and implementations
  - Internal vs. external linkage
- Handling errors without exception handling
  - `errno` and return codes

C++ (and C++11)

- A "better C"
  - More type safety, stream objects, memory management, etc.
- References and const
- Classes and objects!
  - So much (too much?) control: constructor, copy constructor, assignment, destructor, operator overloading
  - Inheritance and subclassing
    - Dynamic vs. static dispatch, virtual functions, vtables and vptrs
    - Pure virtual functions and abstract classes
    - Subobjects and slicing on assignment
- Copy semantics vs. move semantics

C++ (and C++11)

- C++ Casting
  - What are they and why do we distinguish between them?
  - Implicit conversion/construction and `explicit`
- Templates – parameterized classes and functions
  - Similarities and differences from Java generics
  - Template implementations via expansion
- STL – containers, iterators, and algorithms
  - `vector`, `list`, `map`, `set`, etc.
  - Copying and types
- Smart Pointers
  - `unique_ptr`, `shared_ptr`, `weak_ptr`
  - Reference counting and resource management

Memory

- Object scope and lifetime
  - *Static*, *automatic*, and *dynamic* allocation / lifetime
- Pointers and associated operators (`&`, `*`, `->`, `[]`)
  - Can be used to link data or fake “call-by-reference”
- Dynamic memory allocation
  - **`malloc`**/**`free`** (C), **`new`**/**`delete`** (C++)
  - Who is responsible? Who owns the data? What happens when (not if) you mess this up? (dangling pointers, memory leaks, …)
- Tools
  - Debuggers (`gdb`), monitors (`valgrind`)
  - Most important tool: thinking!

Networking

- Conceptual abstraction layers
  - Physical, data link, network, transport, session, presentation, application
  - Layered *protocol* model
    - We focused on IP (network), TCP (transport), and HTTP (application)
- Network addressing
  - MAC addresses, IP addresses (IPv4/IPv6), DNS (name servers)
- Routing
  - Layered packet payloads, security, and reliability

Network Programming

Client side

1) Get remote host IP address/port
2) Create socket
3) Connect socket to remote host
4) Read and write data
5) Close socket

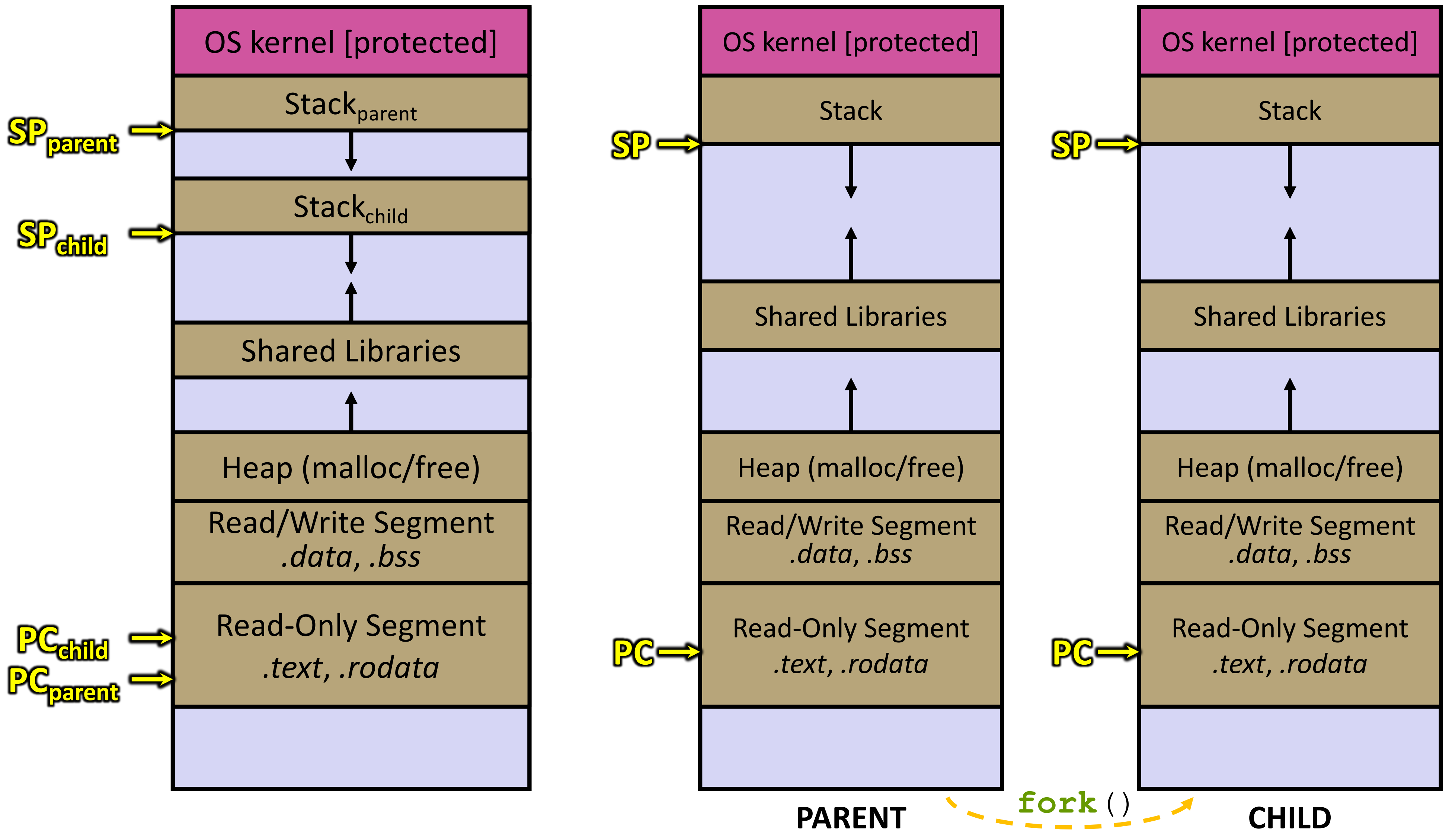
Server side

1) Get local host IP address/port
2) Create socket
3) Bind socket to local host
4) Listen on socket
5) Accept connection from client
6) Read and write data
7) Close socket

Concurrency

- Why or why not?
  - Better throughput, resource utilization (CPU, I/O controllers)
  - Tricky to get right – harder to code and debug
- Threads – “lightweight”
  - Address space sharing; separate stacks for each thread
  - Standard C/C++ library: pthreads
- Processes – “heavyweight”
  - Isolated address spaces
  - Forking functionality provided by OS
- Synchronization
  - Data races, locks/mutexes, how much to lock…

Processes vs Threads on One Slide



Phew! That's it!

- But that's a lot!!
- Studying for the exam: (your mileage may vary)
  - Review *first*, make notes
    - Review lecture slides, exercises, sections, end-of-lecture problems
    - Look at topic list on website to check your coverage and help organize
    - Brainstorm and trade ideas with other students
  - "Simulate" an old exam
    - Do it in one timed sitting
    - Working problems is far more important than reading old answers!
  - "Grade" yourself, then go back and review problems
    - If still unsure why, ask the staff or your fellow students
    - Rinse and repeat!

Courses: What's Next?

- **CSE401:** Compilers (pre-reqs: 332, 351)
  - *Finally* understand why a compiler does what it does
- **CSE451:** Operating Systems (pre-reqs: 332, 333)
  - How do you manage all of the computer's resources?
- **CSE452:** Distributed Systems (pre-reqs: 332, 333)
  - How do you get large collections of computers to collaborate (correctly!)?
- **CSE461:** Networks (pre-reqs: 332, 333)
  - The networking nitty-gritty: encoding, transmission, routing, security
- **CSE455:** Computer Vision
- **CSE457:** Computer Graphics

This doesn't happen without lots of help…

- Thanks to a great staff – it can't work without them!!

  Tarkan Al-Kazily Renshu Gu Travis McGaha

  Harshita Neti Thai Pham Forrest Timour

  Soumya Vasisht Yifan Xu

- And thanks to the folks who put the course together:
  - Steve Gribble, John Zahorjan, me
  - Justin Hsia for the great new set of slides!

Congratulations! Good luck on the exam!

You’ve learned a *lot* – go out and build great things!

Come by and say hello in the future – I’d love to know what you’ve been up to after 333!

See you on Wednesday!

That's all Folks!