CSE 333

Lecture 22 -- wrapup

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Administrivia

HW4 due last night, 11pm

- (ok to use usual late days ***if*** you have them)

Final exam Wednesday, Dec. 13, 2:30 pm, here

- Topic list and old exams on the web
  - Anything all quarter is possible, but biased toward 2nd half
- Last-minute review Q&A Tuesday, Dec. 12, 4:30, EEB 045

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

?

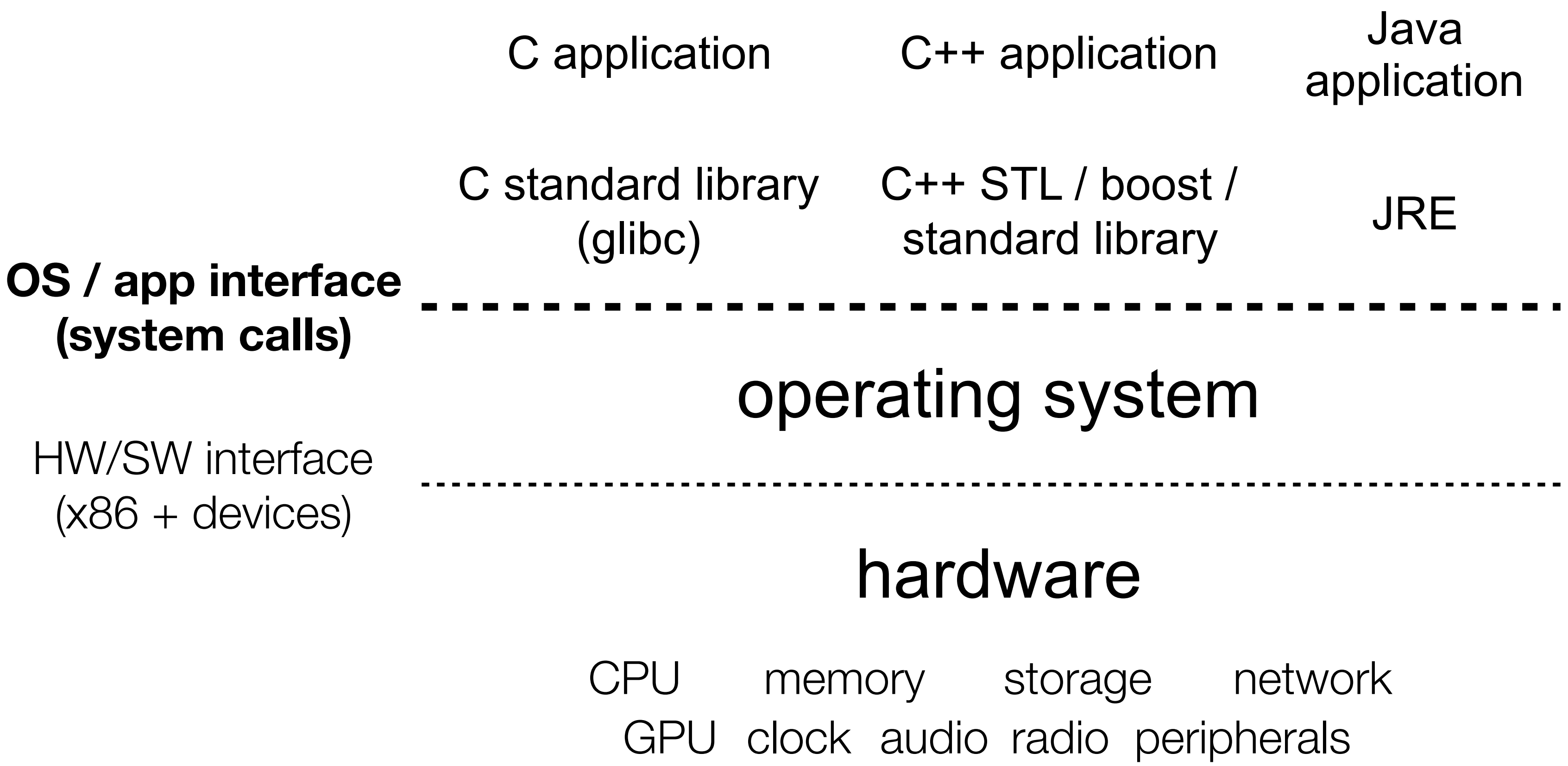
Course goals

Explore the gap between

Intro: the computer is a magic appliance that runs programs

CSE 351: the computer is a stupid appliance that executes really, really simple instructions (really, 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

Goals

Skills

- Programming closer to the hardware: C/C++
- Disciplined design, testing, debugging

Knowledge

- OS interface and semantics, languages, some networking
- A deep(er) understanding of “the layer below”
  - *quiz: when is the data safely on disk after a write? Actually received over the network? How many copies are made along the way?*

Main topics

C Programming, tools, and workflow

Memory management

System interfaces and services (files, etc.)

C++ : the 800-lb gorilla of programming languages

"better C" + classes + STL + smart pointers + ...

Networking basics: TCP/IP, sockets, ...

Drilling deeper…

The C/C++ Ecosystem

System layers: C/C++, libraries, operating system

Building programs

- cpp: #include, #ifndef, and all that
- compiler (cc1): source → .o
- loader (ld): .o + libraries → executable

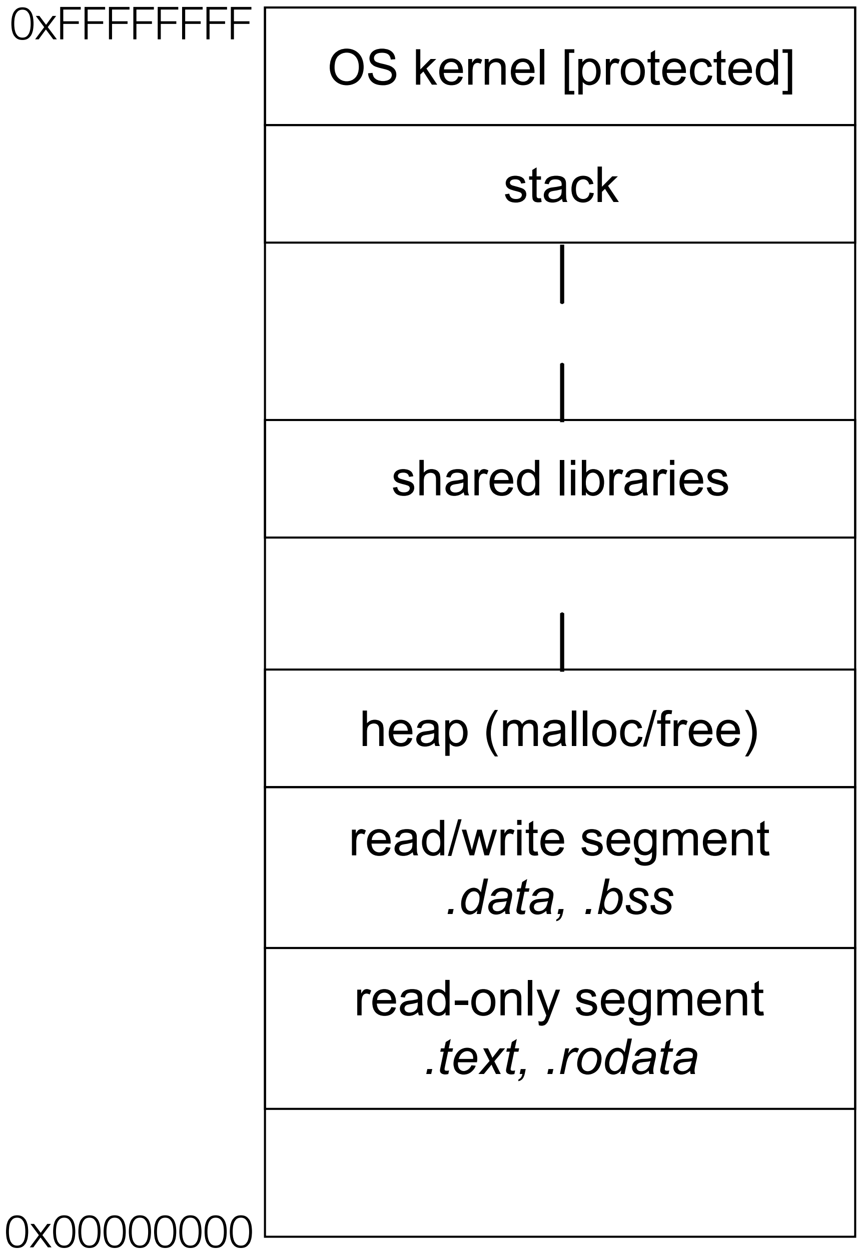
Make and related tools to automate the process

- dependency graphs

Program execution

What's a process?

- Address space
- Thread(s) of execution
- Environment (arguments, open files, ...)



C language

Structure of C programs

- Header files and implementations; declaration vs definition
- Internal vs external linkage
- Standard types and operators (scalars, including things like uint64_t, structs, arrays, typedef, etc.)
- Functions: defining, using, execution model
- Standard libraries and data structures (strings, streams, ...)
  - C standard library, system calls, and how they are connected
- Handling errors in a language without exception handling
  - return codes, errno, and friends

Memory

Object *scope* and *lifetime* (static, automatic, dynamic)

Pointers and associated operators (&, *, ->, [ ])

- Using pointers for call-by-reference as well as linked data

Dynamic memory allocation (malloc/free; new/delete)

- Who is responsible for dynamic memory & what happens if not done right (dangling pointers, memory leaks, ...)

Tools: debuggers (gdb), monitors (valgrind), ...

- Most important tool: thinking(!)

C++ (and C++11)

A “better C”

- Type-safe streams and memory mgmt (new, delete, delete[ ]), etc.

References and const

C with classes (and objects)

- Constructors, copy constructor, destructor, assignment

Subclasses and inheritance

- Dynamic vs static dispatch & why it matters, virtual functions, vtables
- Pure virtual functions and abstract classes

C++ casts - what are they and why so many (compared to C)?

Templates, STL, and smart ptrs

Templates: parameterized classes and functions

- How the idea is similar to Java generics and what's different
- How C++ implements templates (expansion)

STL: basics = vector, list & map containers and iterators

- Copy semantics

Smart pointers: unique, shared, and weak

- Reference counting, resource management

Using class heirarchies with STL

- Pointer vs value semantics, assignment slicing

Networking

Layered protocol model, particularly TCP and IP

- What they do, how they are related, how they differ

Network addresing and protocols: IP addresses, DNS, IPv4, IPv6, ports

Application protocols: where HTTP fits in the scheme

Network Programming

Client side

1. get IP address / port
2. create socket
3. **connect** socket to server
4. **read** / **write** data
5. **close** socket

Server side

1. get IP address / port
2. create socket
3. **bind** socket to address / port
4. indicate that socket is a **listener**
5. **accept** connection from client
6. **read** / **write** data
7. **close** socket

Concurrency

Why?

- Better resource utilization
- Better throughput

Processes

- Heavyweight, isolated, created by cloning: fork( )

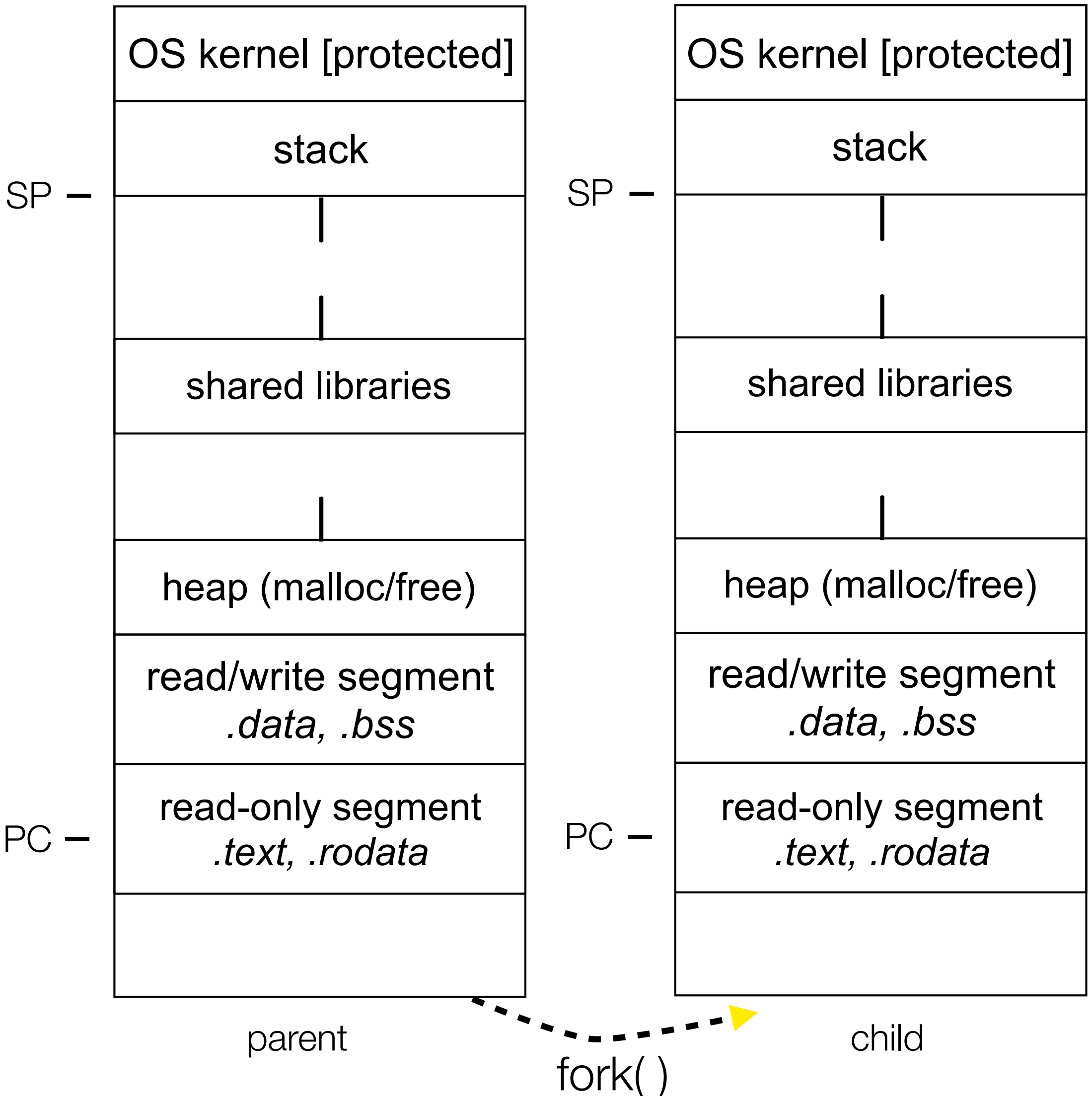
Threads

- Lightweight, share address space, pthreads

Synchronization (particularly threads)

- What are the main issues?

Processes vs threads on one slide



OS kernel [protected]

stack

shared libraries

heap (malloc/free)

read/write segment
.data, .bss

read-only segment
.text, .rodata

SP

PC

parent

OS kernel [protected]

stack

shared libraries

heap (malloc/free)

read/write segment
.data, .bss

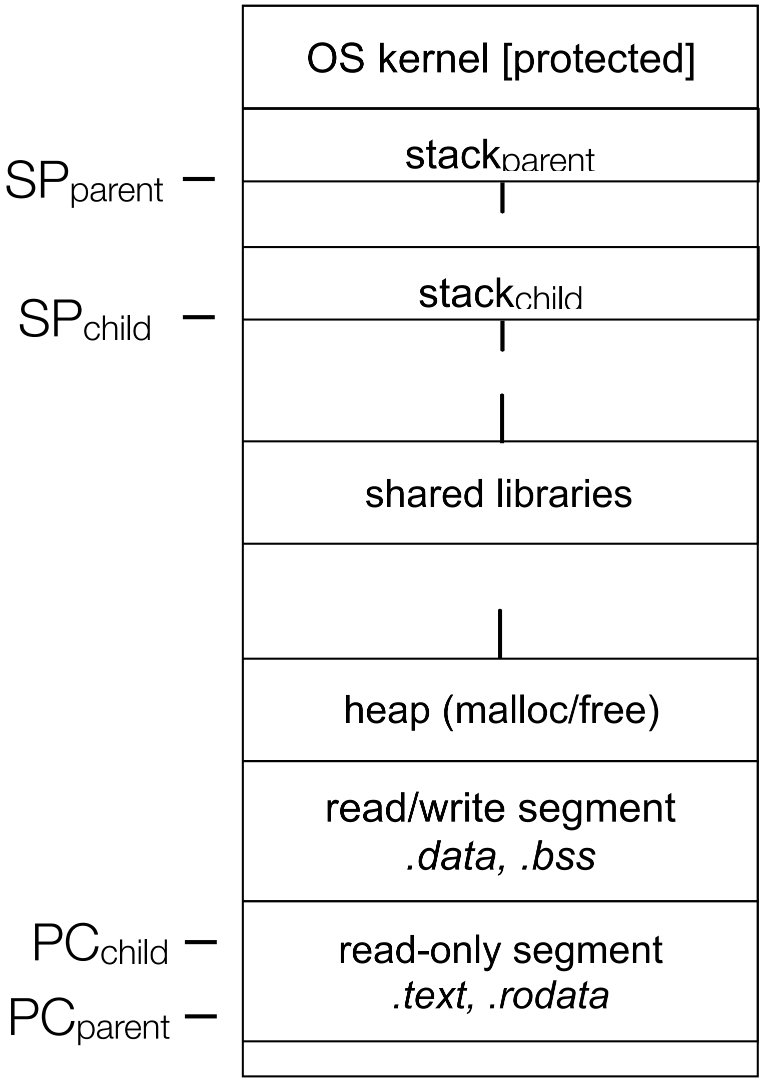
read-only segment
.text, .rodata

SP

PC

child

fork( )



OS kernel [protected]

$\text{stack}_{\text{parent}}$

$\text{stack}_{\text{child}}$

shared libraries

heap (malloc/free)

read/write segment
.data, .bss

read-only segment
.text, .rodata

$\text{SP}_{\text{parent}}$

SP_{child}

PC_{child}

$\text{PC}_{\text{parent}}$

Phew! That's it!!

But that's a lot!!!

Studying for the exam

- Review lecture slides, assignments, exercises
- Try some of the end-of-lecture problems for practice
- Look at old exams and topic list on the web
  - Try the old exam questions first, before looking at answers
- Study groups! Ask questions / trade ideas on the discussion board! Ask course staff questions!
- The goal is learning and mastery

That’s it (almost)

But first, ...

This doesn’t happen without great help! Thanks!!

Course staff:

Meghan Cowan

Renshu Gu

Steven Lyubomirsky

Josh Rios

Nathan Wong

Jack Xu

One more thing...

Course evals

- Constructive feedback (positive we hope, but negative when called for) is what helps us get better
- Please fill out online before it closes (i.e., today or tomorrow - take a couple of minutes after class - thx)

Congratulations and good luck on the exam!!

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

See you Wednesday!