COMP 321:
Introduction to Computer Systems

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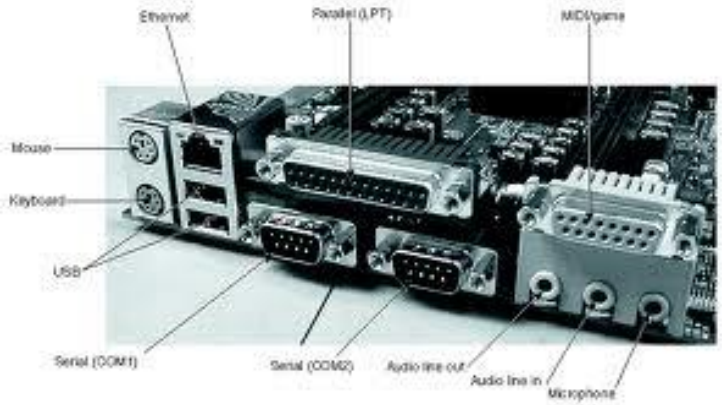
Goals

Understand programming better

- Linking
- Exceptions
- Memory
- I/O
- Networking



Prepare for systems classes

- Computer architecture
- Compilers
- Operating systems
- Networking

Computer Organization

Hardware/software interface (ELEC 220)

- Basic hardware organization of computer systems
- Assembly language
- How low-level software manipulates hardware state

System/application interface (COMP 321)

- Abstract hardware organization
- C language (one step above assembly language)
- How to use operating system services to access system resources

Who are we?

Who are you?

Why use C?

Interfacing with run-time and operating systems is more suited to low-level programming

Much of the software that you use is written in C

Understanding C and assembly is key to understanding how programs execute

- **Behavior of programs in presence of bugs**
  - **High-level language model breaks down**
- **Tuning program performance**
  - **Understanding sources of program inefficiency**
- **Implementing system software**
  - **Compiler has machine code as target**
  - **Operating systems must manage process state**

Problems in Low-Level Programming

It's easy to make mistakes

When you do, you're out of luck

Imperative programming

Few abstractions

- **No objects, abstract functions, …**

No safety net

- **Direct access to system resources**
- **Manual memory management**

Programming Survival Skills

Planning

Good style & documentation

Defensive programming

Debugging

What this course is *not*

This is not a course about the art of programming

- Other courses have/will cover programming principles (e.g., COMP 215, 310, …)

This is not a course about the C language

- You will gain a familiarity with C
- There are a lot of C concepts that we will not cover
- We will not focus on large-scale design in C

C is simply a useful vehicle for learning system-level concepts

Course Perspective

Upper-level systems courses teach how systems work so you can *build* them

- **Computer architecture**
  - How does a microprocessor work?
- **Compilers**
  - How does a compiler work?
- **Operating systems**
  - How does an operating system work?
- **Networking**
  - How do network protocols work?

Course Perspective

This course teaches how to *use* systems

- Purpose is to show how by knowing more about the underlying system, one can be more effective as a programmer
- Enable you to
  - Write programs that are more reliable and efficient
  - Incorporate features that require hooks into OS
    - E.g., concurrency, signal handlers

This course covers some material that you won't see elsewhere

Syllabus Overview

Machine-level representation of programs

- Assembly to C

Linking and Virtual Memory

- How does a program actually get loaded and run?

Exceptions

- Critical events can happen outside your program

I/O, Networking, and Concurrency

- Programs must communicate to be useful

Linking

Libraries

- What are they?
- How are they used by your program?

Incremental compilation

- How can you minimize recompilation?
- How are 1000s of files combined into one program?

Errors

- Why does your program compile but not run?
- Why does Windows tell you that “<blah>.dll is out of date”?

Virtual Memory

Address spaces

- What does a program's address space look like?
- How are programs loaded into memory?
- How are programs isolated and protected from each other?
- How do programs share memory?

Allocating memory

- Where is your program's data stored?
- What if you need more memory?
- How is this allocation managed?

Exceptions

Running programs

- How does the shell work?
- What is a process, and how is it created?

Communicating with a program

- What happens when you type Ctrl-C, Ctrl-Z, etc.?
- How does your program find out about external events?

System calls

- What happens to your program when you invoke the operating system?

I/O, networking, and concurrency

I/O interface

- How are files read, written, shared, etc.?
- Which I/O functions should you use and why?

Network access

- Who manages the network?
- How can your program access the network?

Concurrency

- What are some of the problems with concurrency?
- How are concurrent programs written?

Exposure to Real Programs

Over the course of the semester you will be exposed to several "real" programs

Shell

- **You will write pieces of a functioning Unix shell**

Dynamic memory allocator

- **You will write a functioning memory allocator**

And more…

Logistics

Lectures: T and Th 2:30-3:45 Keck Hall 100

Labs: M 4:00-5:30, T 4:00-5:30, or
W 3:00-4:30 Symonds II Lab

Lecturers: Alan L. Cox
(Scott Rixner and Dave Johnson)

TAs: See Webpage

Webpage: http://www.clear.rice.edu/comp321/

Announcements: On Piazza

Textbook: *Computer Systems: A Programmer's Perspective*, 3rd Ed. by Bryant and O'Hallaron

Weekly Labs

Emphasis

- C programming, debugging
- In-depth hands-on exercises
- General programming tips
- Other cool topics in computer systems as time permits

Requires access to CLEAR servers

- Go to http://apply.rice.edu/ for an account

Labs

Everyone should attend

- You should treat labs like lectures
- Many key concepts needed by assignments will be covered in labs
- Especially crucial for those who have never programmed in C
- And for those who have not programmed in a Unix environment

Opportunity to ask questions

- Instructor and TAs will be available
- You might learn some unexpected neat tricks!

Assignments/Projects

Assignments all involve programming

- 6 assignments throughout the semester
- First 2 are to get you familiar with C programming
- Last 4 are to teach the course concepts and assume you are comfortable with C
- An introductory book on C may be helpful, e.g., *Head First C*

Comprehensive take-home exam during finals period

- No quizzes or exams during the semester

Assignment Policies

Carefully read the assignments web page

- **Honor code policy**
- **Slip day policy**

All assignments will be posted on the web page

Assignments are due at 11:55PM on the due date, unless otherwise specified

Assignments must be done on CLEAR servers

- **Other systems may behave differently!**

Next Time

Begin introduction to C

- Lab this week will show some basic C programs
- Start with simple data types
- First programming assignment to get everyone familiar with C