Introduction

CS 351: Systems Programming
Michael Saelee <lee@iit.edu>
Michael (Sae) Lee

- lee@iit.edu
- http://moss.cs.iit.edu
- Office: SB 226C
Agenda

- Syllabus & Administrivia
- Course overview ("Systems Programming")
§ Syllabus
Prerequisites

- “substantial” programming experience
- data structures: concepts & implementation
- basic run-time analysis (big O)
- knowledge of (any) assembly language
- computer organization essentials
- computer organization essentials:
  - data representation (binary, two’s comp, f.p. inaccuracy, etc.)
  - von Neumann model
    - CPU, memory, I/O
  - stack usage / conventions
Online resources

1. Course website
   moss.cs.iit.edu/cs351
   - static information
   - lecture calendar, assignment writeups, slides, screencasts, links, etc.
Online resources

2. Blackboard
   - only for grade reporting!
Online resources

3. Vimeo channel: screencasts
   - vimeo.com/channels/cs351
   - walkthroughs & tutorials
     (check before starting labs!)
Online resources

4. Piazza: discussion forum
   - all class-related questions
   - monitored by TAs
   - scales *way* better than e-mail
   - announcements, links to additional readings & resources
Textbooks
Grading

- 50% Labs
- 25% Midterm exam
- 25% Final exam
  - exam scores normalized to 70%
  - need $\geq 50\%$ on both exams to pass
Grade Scale

```cpp
char letter_grade(float score) {
    if (score >= 90.0) return 'A';
    else if (score >= 80.0) return 'B';
    else if (score >= 70.0) return 'C';
    else if (score >= 60.0) return 'D';
    else return 'E';
}
```
Labs

- fairly substantial machine problems
  - 100-1000 LOC
- real-world application of concepts covered in lecture & textbook
- 1-3 weeks allotted for each
§Course Overview
“Systems Programming”

system  |ˈsɪstəm|

noun

1 a set of connected things or parts forming a complex whole

(New Oxford American Dictionary)
“Systems Programming”

- Programming the *operating system*

- What does *that* mean?
OS vs. OS kernel

- OS kernel $\approx$ smallest subset of OS code needed to bootstrap system and provide basic services to user programs

- “smallest” is debatable
How to “program” it?

- Require some API
  - Application Programming Interface
    - A collection of (documented) functions
      - e.g., get/put/del for a hashtable
OS API

- a.k.a. “system call” interface

- OS as a very low-level library

- common purpose: provide services to user level programs

- def: program in execution = \textit{process}
The Process

- A program in execution
- Code + Data \{ global, local, dynamic \}
  + OS kernel data
- OS hides complexity of machine from processes by creating *abstractions*
AN x64 PROCESSOR IS SCREAMING ALONG AT BILLIONS OF CYCLES PER SECOND TO RUN THE XNU KERNEL, WHICH IS FRANTICALLY WORKING THROUGH ALL THE POSIX-SPECIFIED ABSTRACTION TO CREATE THE DARWIN SYSTEM UNDERLYING OS X, WHICH IN TURN IS STRAINING ITSELF TO RUN FIREFOX AND ITS GECKO RENDERER, WHICH CREATES A FLASH OBJECT WHICH RENDERS DOZENS OF VIDEO FRAMES EVERY SECOND BECAUSE I WANTED TO SEE A CAT JUMP INTO A BOX AND FALL OVER.

I AM A GOD.

“Abstraction”

http://xkcd.com/
Primary Abstractions

- Logical control flow
- Exceptional (extra-process) control flow
- Logical address space
- Uniform I/O
- Interprocess Communication
In the old days …

- … every program had to include its own implementation of all the above!
- Now, OS simplifies life for all of us.
  - Only need to know how to use them, not how they’re implemented.
But!

- In this class we dig a bit deeper
- What facilities are encapsulated by syscalls?
- What limitations/restrictions do they have?
- Why are they designed the way they are?
- How do they work behind the scenes?
But why should I care?
- **efficiency**: know how to use tools optimally; reuse existing features and design/layer new ones appropriately

- **robustness**: avoid bugs/failures & know how to diagnose and fix them
the real reason: it’s fun to take things apart!
goal: turn you into a **hacker**
(or: make you a better hacker)
hacker |ˈhɑːkər|
noun
1 A person who enjoys exploring the details of programmable systems and how to stretch their capabilities, as opposed to most users, who prefer to learn only the minimum necessary.
Our tools (& approach)

- C & Linux
  - C: low-level language
  - GNU Linux: open source kernel & tools
    - GNU gdb & gcc; debugger & compiler