Course Objective

- Bridge the gap between hardware and software

- Establish a foundation for building higher-level programs
  - How to optimize programs
  - How to debug large systems
  - How to deal with complexity
What is an Operating System?

An operating system (OS) provides a virtual execution environment on top of hardware that is more convenient than the raw hardware interface:

- “All of the code you did not write”
- Simpler
- More reliable
- More secure
- More portable
- More efficient
What do OSes do?

- Manage physical resources
- Provide virtual resources
- Implement mechanisms and enforce policies for the control and use of resources
- Mediate the interaction of mutually distrusting applications
What Physical Resources Do OSes Control?

- CPU
- Memory
- Storage Devices
- Networks
- Input Devices (keyboard, mice, cameras)
- Output Devices (printers, displays, speakers)
- And many virtual resources
Issues In OS Design

Structure: how is an OS organized?
Concurrency: how are parallel activities created and controlled?
Sharing: how are resources shared?
Naming: how are resources named by users?
Protection: how are distrusting parties protected from each other?
Security: how to authenticate, authorize and ensure privacy?
Performance: why is it so slow?
More Issues

- Reliability: how do we deal with failures?
- Extensibility: how do we add new features?
- Communication: how do we exchange information?
- Scale: what happens as demands increase?
- Persistence: how do we make information outlast the processes that created it?
- Accounting: who pays the bills and how do we control resource usage?
Why Learn Operating Systems?

- Provides an understanding from the bottom up
- Even if few people build OSes, understanding how OSes work is crucial for building working systems
- This course will go far beyond OS design to cover all aspects of computer organization, including concurrency, synchronization, input/output, filesystems, networking, routing, distributed systems and so forth
- Engineering pride alone requires full understanding
Fact

- There has never been as exciting a time to work on systems hardware and software as now!!

- The world is increasingly dependent on computer systems
  - Connected, networked, interlinked

- People just do not know how to build robust systems
### BSOD

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#### Unhandled Kernel Exception

**Exception Code:** c0000047 from fa8418b4 (8025ea21, fd6829e8)

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#### Address Dword Dump

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**Kernel Debugger Using: COM\**

(Host 0x2fe, Hand Rate 19200)

Restart and set the recovery options in the system control panel or the \CRASHTEST\ system start option. If this message reappears, contact your system administrator or technical support group.
BSOD
BSOD
Therac-25

- A safety-critical system with software interlocks
- Beam controlled entirely through a custom OS
Therac-25

- Old system used a hardware interlock
  - A lever that could either be in the “zap” or “x-ray” position

- New system was computer controlled

- A synchronization failure was triggered when competent nurses used the back arrow to change the data on the screen “too quickly”
Therac-25 Outcome

- Beam killed one person directly, burned others, and may have given inadequate treatment to cancer patients.

- Problem was very difficult to diagnose; initial fix involved removal of the back arrow key from the keyboard.

- People died because a programmer could not write correct code for a concurrent system.
Denver airport

- The most modern, most expensive airport in recent history
  - Cost overrun in excess of $2B

- Highly automated luggage handling system was supposed to deliver your luggage to you at arrival

- Lack of persistence caused luggage carts to “forget” their contents, sprinkling the luggage on the runway
USS Yorktown

- Modern guided missile cruiser off of Norfolk, VA in 1998
- Crew member entered 0 for a data value
- Cascade of failures led to a failure of the propulsion system
- Yorktown was dead in the water for a couple of hours
Other Systems

- FAA air traffic control system
- IRS data management system
- IBM “Microkernel”
- Pentagon data security
- Many others, too numerous to list
Summary

We do not have the necessary technologies and know-how to build robust computer systems.

There is huge demand for people who deeply understand and can build robust systems.
Logistics

Lectures

- Tuesday, Thursday 2:55-4:10pm, Hollister B14

Instructor

- Prof. Sirer, egs at systems.cs.cornell.edu
- Office Hours
  - T/Th 4:10-5:10pm
  - Or by prior appointment

TAs

- Deniz Altinbuken, Robert Escriva, Jason Wu
- Dinesh Bhat, Jian Chear
Communication

Course Web Page
- Office hours, assignments, lectures, and other supplemental materials will be on the web site

Email
- cs4410staff at systems.cs.cornell.edu
- The email alias goes to me and the TAs, not to the whole class
Administrative

Course has three components

- Lectures and Readings
- Exams
- Projects and MiniProjects

Textbook

- Silberschatz, Galvin & Gagne
- Operating System Concepts, 8th ed.

You are expected to keep up with all three
Grading

CS4410 Breakdown
- ~40% MiniProjects
- ~12% Prelim 1
- ~18% Prelim 2
- ~25% Final
- ~5% Flexgrade (participation, attitude, effort)

CS4411 Breakdown
- ~90% Projects
- ~10% Flexgrade

Grading will not be done on a curve

- It is my goal to be able to give everyone an A+
- Help me achieve this
Projects in CS4411

Projects will be done in two-person teams
- You may indicate a desired partner
- If they also indicate you, we will pair you up
- If you don’t have a preferred partner, we’ll pair you up with someone suitable

Working in groups
- Start early, time management is key
- Manage the team effort
- Part of what you are supposed to learn is how to manage to get work done in a small team
MiniProjects in 4410

- There will be approximately 4-6 mini-projects
- MiniProjects will be done individually
- Working individually
  - Start early, time management is key
Academic Integrity and Honor Code

- All submitted work must be your own
  - All homeworks must be your own independent work
  - OK to study together
  - Cannot share solutions, ever

- Project groups submit joint work
  - All group assignments must represent solely the work of the two people in that group
  - Cannot be in possession of someone else’s solution

- Violations will be prosecuted to the fullest extent

- Closed-book exams, no calculators
Draft Syllabus

- Introduction
- Architectural Support for Operating Systems
- Processes and Threads
- Scheduling
- Synchronization, Mutual Exclusion, Spin Locks, Semaphores, Condition Variables
- Deadlocks, Detection and Avoidance
- Memory Management
- Networking, LANs, WANs, Ethernet, ARP, IP, UDP, TCP
- Disks and RAID
- Filesystems, UFS, LFS
- Security
Draft Project Plan for CS4411

- Threads and Concurrency
- Scheduling
- Basic Datagram Networking
- Reliable Streaming Protocols
- Routing
- Filesystems
Questions?

And demographics…