CS 3204
Operating Systems

Lecture 2

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Announcements

- Prerequisite Forms
- My office hours: M/W 3-5pm
- Vijay: T/Th 2-4pm

Outline for today

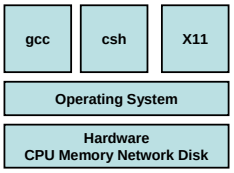
- Motivation for teaching OS
- Brief history
- A survey of core issues OS address
- What you should get out of this class

Why are OS interesting?

- OS are "magic"
  - Most people don't understand them – including sysadmins and computer scientists!
- OS are incredibly complex systems
  - "Hello, World" – program really 1 million lines of code
- Studying OS is learning how to deal with complexity
  - Abstractions (+interfaces)
  - Modularity (+structure)
  - Iteration (+learning from experience)

What does an OS do?

- Software layer that sits between applications and hardware
- Performs services
  - Abstracts hardware
  - Provides protection
  - Manages resources



OS vs Kernel

- Can take a wider view or a narrower definition what an OS is
- Wide view: Windows, Linux, Mac OSX are operating systems
  - Includes system programs, system libraries, servers, shells, GUI etc.
- Narrow definition:
  - OS often equated with the *kernel*.
  - The Linux kernel; the Windows executive – the special piece of software that runs with special privileges and actually controls the machine.
- In this class, usually mean the narrow definition.
- In real life, always take the wider view. (Why?)

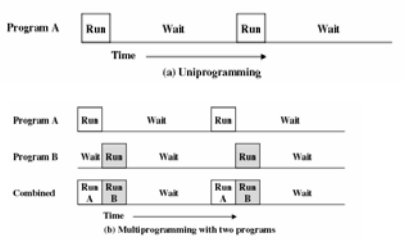
Evolution of OS

- OSs as a library
  - Abstracts away hardware, provide neat interfaces
    - Makes software portable; allows software evolution
  - Single user, single program computers
    - No need for protection: no malicious users, no interactions between programs
  - Disadvantages of uniprogramming model
    - Expensive
    - Poor utilization

Evolution of OS (II)

- Invent multiprogramming
  - First multi-programmed batch systems, then time-sharing systems
- Idea:
  - Load multiple programs in memory
  - Do something else while one program is waiting, don't sit idle (see next slide)
- Complexity increases:
  - What if programs interfer with each other (wild writes)
  - What if programs don't relinguish control (infinite loop)

Single Program vs Multiprogramming



Protection

- Multiprogramming requires isolation
- OS must protect/isolate applications from each other, and OS from applications
- This requirement is absolute
  - In Pintos also: if one application crashes, kernel should not! Bulletproof.
- Three techniques
  - Preemption
  - Interposition
  - Privilege

Protection #1: Preemption

- Resource can be given to program and access can be revoked
  - Example: CPU, Memory, Printer, "abstract" resources: files, sockets
- CPU Preemption using *interrupts*
  - Hardware timer interrupt invokes OS, OS checks if current program should be preempted, done every 1ms in Linux
  - Solves infinite loop problem!
- Q.: Does it work with all resources equally?

Protection #2: Interposition

- OS hides the hardware
- Application have to go through OS to access resources
- OS can interpose checks:
  - Validity (Address Translation)
  - Permission (Security Policy)
  - Resource Constraints (Quotas)

Protection #3: Privilege

- Two fundamental modes:
  - "kernel mode" – privileged
    - aka system, supervisor or monitor mode
    - Intel calls its PL0, Privilege Level 0 on x86
  - "user mode" – non-privileged
    - PL3 on x86
- Bit in CPU – controls operation of CPU
  - Protection operations can only be performed in kernel mode. Example: hlt
  - Carefully control transitions between user & kernel mode

OS as a Resource Manager

- OS provides illusions, examples:
  - every program is run on its own CPU
  - every program has all the memory of the machine (and more)
  - every program has its own I/O terminal
- "Stretches" resources
  - Possible because resource usage is bursty, typically
- Increases utilization

Resource Management (2)

- Multiplexing increases complexity
- Car Analogy (by Rosenblum):
  - Dedicated road per car would be incredibly inefficient, so cars share freeway. Must manage this.
  - (abstraction) different lanes per direction
  - (synchronization) traffic lights
  - (increase capacity) build more roads
- More utilization creates contention
  - (decrease demand) slow down
  - (backoff/retry) use highway during off-peak hours
  - (refuse service, quotas) force people into public transportation
  - (system collapse) traffic jams

Resource Management (3)

- OS must decide who gets to use what resource
- Approach 1: have admin (boss) tell it
- Approach 2: have user tell it
  - What if user lies? What if user doesn't know?
- Approach 3: figure it out through feedback
  - Problem: how to tell power users from resource hogs?

Goals for Resource Management

- Fairness
  - Assign resources equitably
- Differential Responsiveness
  - Cater to individual applications' needs
- Efficiency
  - Maximize throughput, minimize response time, support as many apps as you can
- These goals are often conflicting.
  - All about trade-offs