Introduction to Operating Systems

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How This Course Fits in the UW CSE Curriculum

- CSE 333: Systems Programming
  – Project experience in C/C++
  – How to use the operating system interface
- CSE 451: Operating Systems
  – How to make a single computer work reliably
  – How an operating system works internally
- CSE 452: Distributed Systems (spring 2013)
  – How to make a set of computers work reliably, despite failures of some nodes

Project: Pintos

- Build an operating system
  – That can boot on PC hardware
  – Run a web server (and other apps)
- We give you some basic building blocks
  – Four assignments, that build on each other
    - Threads, user programs, virtual memory, networking
  – Work in **groups of 2-3**
- First assignment due two weeks from Thursday

Problem Sets

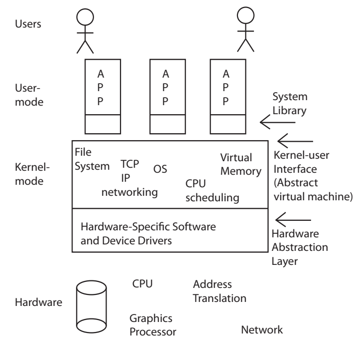
- Four assignments spread over quarter
  – Practice for exams
  – Done **individually**
- First assignment, due a week from Thursday
  – Build a shell, with pipes: ls | wc
  – Should be review from 333
  – See Chapter 3.1-3.4 for a review
  – Posted online

Main Points (for today)

- Operating system definition
  - Software to manage a computer's resources for its users and applications
- OS challenges
  - Reliability, security, responsiveness, portability, …
- OS history
  - How are OS X, Windows 7, and Linux related?

What is an operating system?

- Software to manage a computer's resources for its users and applications



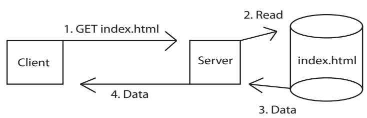
Operating System Roles

- Referee:
  - Resource allocation among users, applications
  - Isolation of different users, applications from each other
  - Communication between users, applications
- Illusionist
  - Each application appears to have the entire machine to itself
  - Infinite number of processors, (near) infinite amount of memory, reliable storage, reliable network transport
- Glue
  - Libraries, user interface widgets, …

Thought Question

- What do you need from hardware to be able to:
  - Isolate different applications from each other?
  - Isolate different users from accessing each others files?

Example: web service



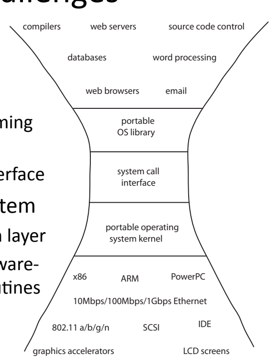
- How does the server manage many simultaneous client requests?
- How do we keep the client safe from spyware embedded in scripts on a web site?
- How do we keep updates to the web site consistent?

OS Challenges

- Reliability
  - Does the system do what it was designed to do?
  - Availability
    - What portion of the time is the system working?
    - Mean Time To Failure (MTTF), Mean Time to Repair
- Security
  - Can the system be compromised by an attacker?
  - Privacy
    - Data is accessible only to authorized users
- Both require very careful design and code

OS Challenges

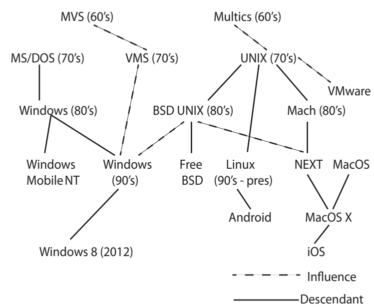
- Portability
  - For programs:
    - Application programming interface (API)
    - Abstract machine interface
  - For the operating system
    - Hardware abstraction layer
    - Pintos provides hardware-specific OS kernel routines



OS Challenges

- Performance
  - Latency/response time
    - How long does an operation take to complete?
  - Throughput
    - How many operations can be done per unit of time?
  - Overhead
    - How much extra work is done by the OS?
  - Fairness
    - How equal is the performance received by different users?
  - Predictability
    - How consistent is the performance over time?

OS History



Computer Performance Over Time

	1981	1996	2011	factor
MIPS	1	300	10000	10K
MIPS/$	$100K	$30	$0.50	200K
DRAM	128KB	128MB	10GB	100K
Disk	10MB	4GB	1TB	100K
Home Internet	9.6 Kbps	256 Kbps	5 Mbps	500
LAN network	3 Mbps (shared)	10 Mbps	1 Gbps	300
Users per machine	100	1	<< 1	100+

Early Operating Systems: Computers Very Expensive

- One application at a time
  - Had complete control of hardware
  - OS was runtime library
  - Users would stand in line to use the computer
- Batch systems
  - Keep CPU busy by having a queue of jobs
  - OS would load next job while current one runs
  - Users would submit jobs, and wait, and wait, and

Time-Sharing Operating Systems: Computers and People Expensive

- Multiple users on computer at same time
  - Multiprogramming: run multiple programs at same time
  - Interactive performance: try to complete everyone's tasks quickly
  - As computers became cheaper, more important to optimize for user time, not computer time

Today's Operating Systems: Computers Cheap

- Smartphones
- Embedded systems
- Web servers
- Laptops
- Tablets
- Virtual machines
- …

Tomorrow's Operating Systems

- Giant-scale data centers
- Increasing numbers of processors per computer
- Increasing numbers of computers per user
- Very large scale storage

Bonus Thought Question

- How should an operating system allocate processing time between competing uses?
  - Give the CPU to the first to arrive?
  - To the one that needs the least resources to complete? To the one that needs the most resources?
  - What if you need to allocate memory?
  - Disk?

Textbook

- Lazowska, Spring 2012: "The text is quite sophisticated. You won't get it all on the first pass. The right approach is to [read each chapter before class and] re-read each chapter once we've covered the corresponding material… more of it will make sense then. *Don't save this re-reading until right before the mid-term or final – keep up."*