Introduction to Operating Systems and Practicum in Operating Systems

COS 414/415
Spring 2001
Prof. Emin Gün Sirer

Administrative

- Instructors:
  - Prof. Emin Gün Sirer, egs@cs, 4119A Upson, MF 2:30-3:30
- Communication
  - cs414@cs.cornell.edu
- TAs:
  - Ben Atkin, batkin@cs
  - Indranil Gupta, gupta@cs
  - Ranjita Jain, rjain@cs
  - Shrinivas Samat, samant@cs
- All official information is on the web site
  - http://www.cs.cornell.edu/courses/cs414/2001SP/

Administrative

- 414: Intro to Operating Systems
  - Fundamentals of OS design
- Textbook
  - Silberschatz & Galvin, Operating System Concepts, 5th Edition,
- Reading, weekly homeworks
- 415: Practicum in Operating Systems
  - Major programming assignment
  - This year, we'll use PDAs for the project
  - May work in pairs, may change project

Grading

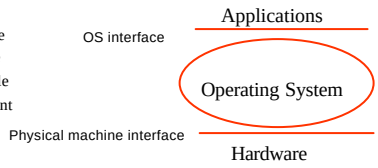
- Course prerequisite: Mastery of the material in CS 314, computer architecture
- 414: Intro to Operating Systems
  - Reading Assignments (~20%)
  - Midterm (~30%)
  - Final (~50%)
- 415: Practicum in Operating Systems
  - Three projects (100%)
- This is a rough guide

Course Outline

- History, architectural support, structure
- Concurrency, processes, threads
- Synchronization, monitors, semaphores
- Memory Management, virtual memory
- Storage Management, I/O, filesystems
- Networking, distributed systems
- Security

What is an Operating System?

- Definition: An Operating System (OS) provides a virtual machine on top of the 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
  - …



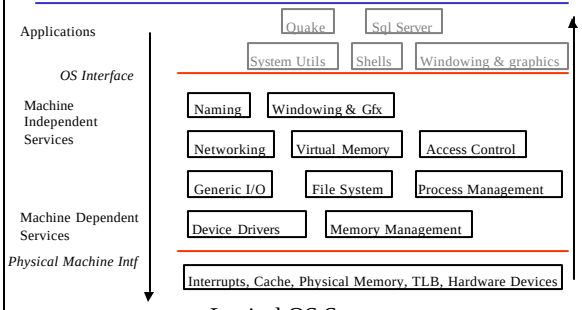
What do Operating Systems Do ?

- Manage physical and virtual resources
- Provide users with a well-behaved environment
- Define a set of logical resources (objects) and a set of well-defined operations on those resources (i.e. an interface to those objects)
- Provide *mechanisms* and *policies* for the control of resources
- Control how different users and programs interact

What Resources Need to Be Managed?

- The CPU(s)
- Memory
- Storage devices (disks, tapes, etc)
- Networks
- Input devices (keyboard, mouse, cameras, etc.)
- Output devices (printers, displays, speakers, etc.)

What's in an OS?



Logical OS Structure

Major Issues in Operating Systems

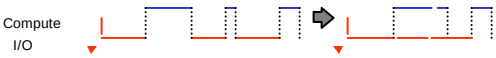
- **Structure** -- how is an operating system organized ?
- **Sharing** -- how are resources shared among users ?
- **Naming** -- how are resources named by users or programs ?
- **Protection** -- how is one user/program protected from another ?
- **Security** -- how to authenticate, control access, and secure privacy ?
- **Performance** -- why is it so slow ?
- **Reliability and fault tolerance** – how do we deal with failures ?
- **Extensibility** -- how do we add new features ?
- **Communication** -- how can we exchange information ?

Major Issues in OS (2)

- **Concurrency** -- how are parallel activities created and controlled ?
- **Scale and growth** -- what happens as demands or resources increase ?
- **Persistence** -- how to make data outlast the processes that created them
- **Compatibility** -- can we ever do anything new ?
- **Distribution** -- accessing the world of information
- **Accounting** -- who pays the bills, and how do we control resource usage?

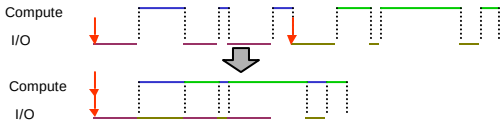
A Brief History of Operating Systems

- Initially, the OS was just a run-time library
  - You linked your application with the OS, loaded the whole program into memory, and ran it
  - How do you get it into the computer ? Through the control panel!
- Simple batch systems
  - Permanently resident OS in primary memory
  - It loaded a single job from card reader, ran it, and loaded the next job...
  - *Control cards* in the input file told the OS what to do
  - *Spooling* allowed jobs to be read ahead of time onto tape/disk or into memory

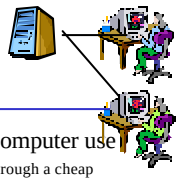


Multiprogrammed Batch Systems

- *Multiprogramming* systems provided increased utilization
  - Keeps multiple runnable jobs loaded in memory
  - Overlaps I/O processing of a job with computation of another
  - Benefits from I/O devices that can operate asynchronously
  - Requires the use of interrupts and DMA
  - Optimizes for *throughput* at the cost of *response time*



Timesharing



- *Timesharing* supported interactive computer use
  - Each user connects to a central machine through a cheap terminal, feels as if she has the entire machine
  - Based on time-slicing -- dividing CPU equally among the users
  - Permitted active viewing, editing, debugging, participation of users in the execution process
  - Security mechanisms required to isolate users from each other
  - Requires memory protection hardware for isolation
  - Optimizes for *response time* at the cost of *throughput*

Distributed Operating Systems

- Distributed systems facilitate use of geographically distributed resources
  - Machines connected by wires, no shared memory or clock
- Supports communication between parts of a job or different jobs
  - Interprocess communication
- Sharing of distributed resources, hardware and software
  - Resource utilization and access
- Permits some parallelism, but speedup is not the issue

Parallel Operating Systems

- Support parallel applications wishing to get speedup of computationally complex tasks
- Needs basic primitives for dividing one task into multiple parallel activities
- Supports efficient communication between those activities
- Supports synchronization of activities to coordinate sharing of information
- It's common now to use networks of high-performance PCs/workstations as a parallel computer

Real-time Operating Systems

- Goal: To cope with rigid time constraints
- Hard real-time
  - OS guarantees that applications will meet their deadlines
  - Examples: TCAS, health monitors, factory control, etc.
- Soft real-time
  - OS provides prioritization, on a best-effort basis
  - No deadline guarantees, but bounded delays
  - Examples: most electronic appliances
- Real-time means "predictable"
  - NOT fast

Personal Computing

- Computers are cheap, so give everyone a dedicated computer
- Initially, the OS became a library again due to hardware constraints
- Multiprogramming, memory protection, and other advances were added back
  - For entirely different reasons

Ubiquitous Computing

- The decreased cost of processing makes it possible to embed computers everywhere. Each "embedded" application needs its own control software:
  - PDAs, cell phones, intelligent appliances, etc.
- In the near future, you will have 100s of these devices
  - If not already
- Poses lots of problems for current systems
  - Structure, naming, scaling, security, etc.
- We will tackle some of them in this class

Lessons from History

- The point is not that batch systems were ridiculous
  - They were exactly right for the tradeoffs at the time
- The tradeoffs change

	1981	2001	Factor
MIPS	1	1000	1000
$/MIPS	$100000	$5000	20000
DRAM	128KB	256MB	2000
Disk	10MB	80GB	8000
Net Bandwidth	9600 b/s	100 Mb/s	10000
# Users	>> 10	<= 1	0.1

- Need to understand the fundamentals
  - So you can design better systems for tomorrow's tradeoffs

COS 414/415

- In this class we will learn:
  - What the parts of an OS are
  - How the OS and each sub-part is structured
  - What the important mechanisms are
  - What the important policies are
  - What algorithms are typically used
- We will do this through reading, lectures, and a project
  - Project will involve some aspect of ubiquitous computing using Palmax @migo 600's equipped with Aeronet cards
  - Reading: Chapters 1 & 2.
  - Reading Assignment: Due Friday, described on the web.
- You will need to keep up with all three of these