UNIVERSITY of WISCONSIN-MADISON
Computer Sciences Department

CS 537
Introduction to Operating Systems

Andrea C. Arpaci-Dusseau
Remzi H. Arpaci-Dusseau

Introduction and Overview

Questions answered in this lecture:

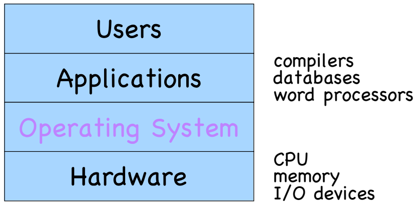
What is an operating system?

How have operating systems evolved?

Why study operating systems?

What is an Operating System?

Not easy to define precisely…



OS:

Everything in system that isn't an application or hardware

OS:

Software that converts hardware into a useful form for applications

What is the role of the OS?

Role #1: Provide standard Library (I.e., abstract resources)

What is a resource?

- Anything valuable (e.g., CPU, memory, disk)

Advantages of standard library

- Allow applications to reuse common facilities
- Make different devices look the same
- Provide higher-level abstractions

Challenges

- What are the correct abstractions?
- How much of hardware should be exposed?

What is the role of the OS?

Role #2: Resource coordinator (I.e., manager)

Advantages of resource coordinator

- Virtualize resources so multiple users or applications can share
- Protect applications from one another
- Provide efficient and fair access to resources

Challenges

- What are the correct mechanisms?
- What are the correct policies?

What Functionality belongs in OS?

No single right answer

- Desired functionality depends on outside factors
- OS must adapt to both user expectations and technology changes
  - Change abstractions provided to users
  - Change algorithms to implement those abstractions
  - Change low-level implementation to deal with hardware

Current operating systems driven by evolution

History of the OS

Two distinct phases of history

- Phase 1: Computers are expensive
  - Goal: Use computer's time efficiently
  - Maximize throughput (I.e., jobs per second)
  - Maximize utilization (I.e., percentage busy)
- Phase 2: Computers are inexpensive
  - Goal: Use people's time efficiently
  - Minimize response time

First commercial systems

1950s Hardware

- Enormous, expensive, and slow
- Input/Output: Punch cards and line printers

Goal of OS

- Get the hardware working
- Single operator/programmer/user runs and debugs interactively

OS Functionality

- Standard library only (no sharing or coordination of resources)
- Monitor that is always resident; transfer control to programs

Advantages

- Worked and allowed interactive debugging

Problems

- Inefficient use of hardware (throughput and utilization)

Batch Processing

Goal of OS: Better throughput and utilization

Batch: Group of jobs submitted together

- Operator collects jobs; orders efficiently; runs one at a time

Advantages

- Amortize setup costs over many jobs
- Operator more skilled at loading tapes
- Keep machine busy while programmer thinks
- Improves throughput and utilization

Problems

- User must wait until batch is done for results
- Machine idle when job is reading from cards and writing to printers

Spooling

Hardware

- Mechanical I/O devices much slower than CPU
- Read 17 cards/sec vs. execute 1000s instructions/sec

Goal of OS

- Improve performance by overlapping I/O with CPU execution

Spooling: Simultaneous Peripheral Operations On-Line

1. Read card punches to disk
2. Compute (while reading and writing to disk)
3. Write output from disk to printer

OS Functionality

- Buffering and interrupt handling

Problem

- Machine idle when job waits for I/O to/from disk

Multiprogrammed Batch Systems

Observation: Spooling provides pool of ready jobs

Goal of OS

- Improve performance by always running a job
- Keep multiple jobs resident in memory
- When job waits for disk I/O, OS switches to another job

OS Functionality

- Job scheduling policies
- Memory management and protection

Advantage: Improves throughput and utilization

Disadvantage: Machine not interactive

Inexpensive Peripherals

1960s Hardware

- Expensive mainframes, but inexpensive keyboards and monitors
- Enables text editors and interactive debuggers

Goal of OS

- Improve user's response time

OS Functionality

- Time-sharing: switch between jobs to give appearance of dedicated machine
- More complex job scheduling
- Concurrency control and synchronization

Advantage

- Users easily submit jobs and get immediate feedback

Inexpensive Personal Computers

1980s Hardware

- Entire machine is inexpensive
- One dedicated machine per user

Goal of OS

- Give user control over machine

OS Functionality

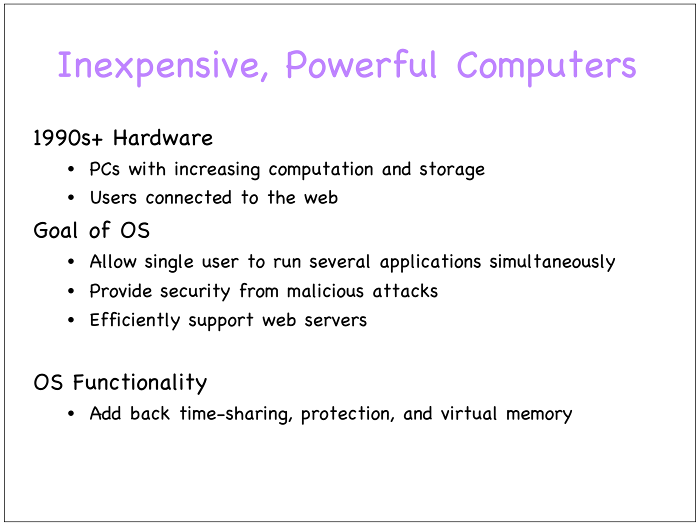
- Remove time-sharing of jobs, protection, and virtual memory

Advantages

- Simplicity
- Works with little main memory
- Machine is all your own (performance is predictable)

Disadvantages

- No time-sharing or protection between jobs



Inexpensive, Powerful Computers

1990s+ Hardware

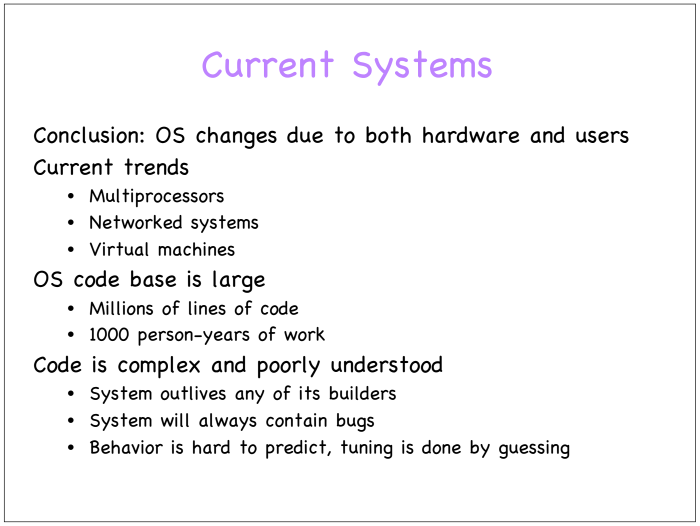
- PCs with increasing computation and storage
- Users connected to the web

Goal of OS

- Allow single user to run several applications simultaneously
- Provide security from malicious attacks
- Efficiently support web servers

OS Functionality

- Add back time-sharing, protection, and virtual memory



Current Systems

Conclusion: OS changes due to both hardware and users

Current trends

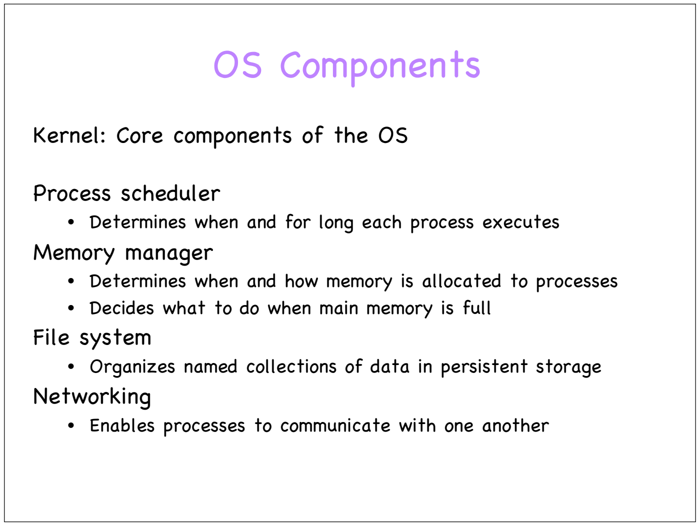
- Multiprocessors
- Networked systems
- Virtual machines

OS code base is large

- Millions of lines of code
- 1000 person-years of work

Code is complex and poorly understood

- System outlives any of its builders
- System will always contain bugs
- Behavior is hard to predict, tuning is done by guessing



OS Components

Kernel: Core components of the OS

Process scheduler

- Determines when and for long each process executes

Memory manager

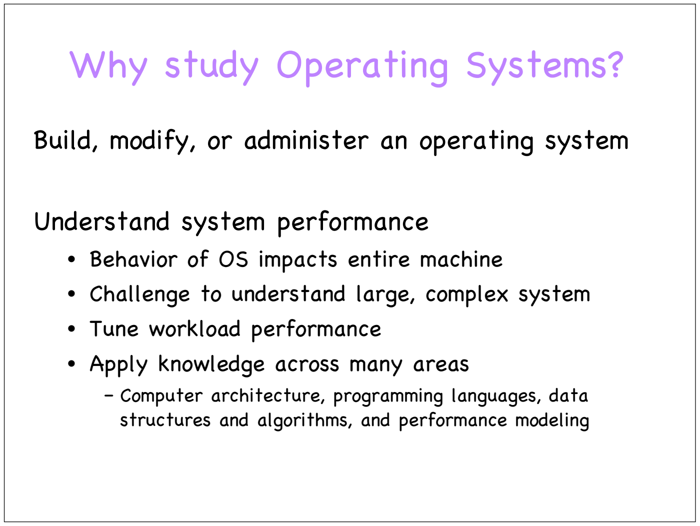
- Determines when and how memory is allocated to processes
- Decides what to do when main memory is full

File system

- Organizes named collections of data in persistent storage

Networking

- Enables processes to communicate with one another



Why study Operating Systems?

Build, modify, or administer an operating system

Understand system performance

- Behavior of OS impacts entire machine
- Challenge to understand large, complex system
- Tune workload performance
- Apply knowledge across many areas
  - Computer architecture, programming languages, data structures and algorithms, and performance modeling