CS 134:
Operating Systems

Definitions, Abstractions, Taxonomies, Early History

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Overview

What Is an OS?

History

Hardware

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What *is* an Operating System Anyway?

Class Exercise: Devise three separate definitions. Discuss.

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Several slides follow that aren't on handout.

It’s A Programmer’s Toolkit

Provide useful functionality to programs:

- Prevent duplicated work
- Promote reuse

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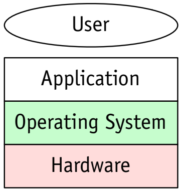
It’s an Abstraction Layer

Make the machine “nicer”, easier to program, higher level. . .

- Hide some of the idiosyncrasies of the machine
- Provide functionality the underlying machine doesn’t have



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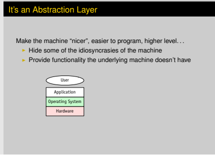

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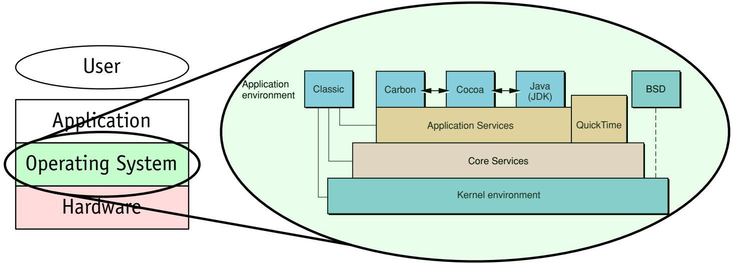

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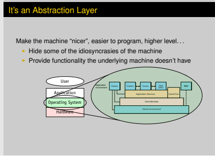

It's a Virtual Machine

OS provides an *environment*
This environment can be seen as a "new machine"...

Hardware	—Physical machine
+ Core OS	—Virtual machine
+ OS Libraries	—Virtual machine
+ OS Utilities	—Virtual machine
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It's a Policy Enforcer

OS provides the mechanisms to enforce various policies

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Class Exercise: Examples?

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Class Exercise: Examples?

It’s a Resource Manager

The operating system manages physical resources:

- Processor
- Memory
- Storage devices
- Network devices

  etc. . .

It’s a Resource Manager
The operating system manages physical resources:
Processor
Memory
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etc. . .

It’s a Resource Manager (cont’d.)

The operating system manages virtual resources:

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- Files
- Users
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- Windows

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It’s a Product

Many operating systems are sold by commercial companies

- Market vs. technical considerations
- The operating system is what comes in the box marked “operating system”

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Fundamental Abstractions

What are the (user-level) abstractions we'd expect to find in a modern OS?

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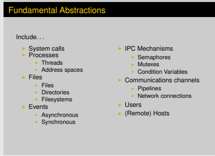
Fundamental Abstractions

Include...

- System calls
- Processes
  - Threads
  - Address spaces
- Files
  - Files
  - Directories
  - Filesystems
- Events
  - Asynchronous
  - Synchronous
- IPC Mechanisms
  - Semaphores
  - Mutexes
  - Condition Variables
- Communications channels
  - Pipelines
  - Network connections
- Users
- (Remote) Hosts



It’s a Resource Manager

What are the “resources” that an operating system manages?

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Taxonomy of Computer Systems

Different computer systems ask different things from their OS

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Partial Taxonomy of Computer Systems

Different computer systems ask different things from their OS:

Special-purpose	↔	*General-purpose*
Single-user	↔	*Multi-user*
Non–Resource-sharing	↔	*Resource sharing*
Single processor	↔	*Multiprocessor*
Stand alone	↔	*Networked*
Centralized	↔	*Distributed*
Batch	↔	*Interactive*
Deadline-free	↔	*Real-time*
Insecure	↔	*Secure*
Symmetric	↔	*Asymmetric*
Simple	↔	*Complex*
Small	↔	*Large*
Inexpensive	↔	*Expensive*
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Early Computers

1950s—large complex machines

- Operated directly from a console
- Used interactively by a single user
- Ran one program at a time (uniprogramming)
- Read data from paper tape, punched cards, or toggle switches

OS? Maybe a library containing code to work the I/O devices was useful.

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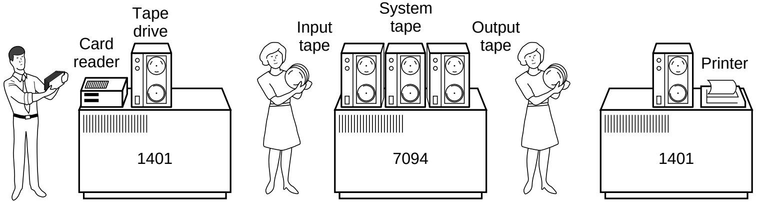
Simple Batch Systems

Provide better use of resources:

- Users access computer indirectly
- Programs and input *(jobs)* taken from a *batch queue*
- Computer has a human operator to feed it jobs



Need to:

- Manage the jobs:
- Protect the next program from the previous program

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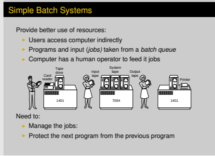
└History
└Simple Batch Systems



SPOOLing Batch Systems

Provide better use of resources—buffer input and output

- Read-ahead input from disk/tape
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Class Exercise: Why does buffering improve performance?
Does buffering *always* improve performance?
(What assumptions are we making?)

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Multiprogrammed Batch Systems

Provide better use of resources—multiplex the processor:

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- Switch to another program when running program waits for I/O

More work for OS. More complex management of

- I/O
- Memory
- Processor

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Time-Sharing Systems

Provide better environment for users—multiplex the processor between users:

- Run multiple independent programs at once
- Switch between users rapidly
  - Illusion of having the machine's full attention

Yet more complexity for OS:

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History Repeats Itself

As new, “smaller” hardware appears, it tends to repeat this evolution

- Mini computers
- Personal computers
- PDAs
- Embedded systems
  - Cell phones
  - MP3 Players
  - Cameras, etc.

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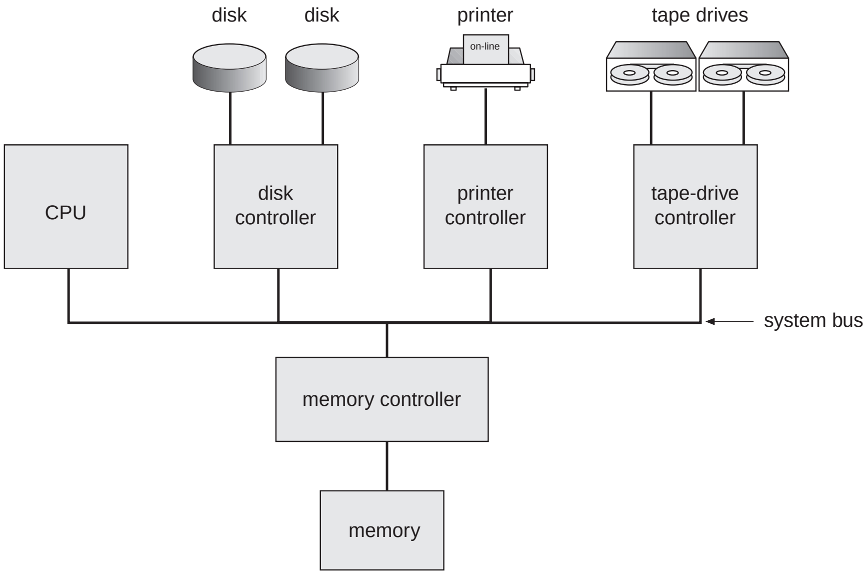
Computer Hardware



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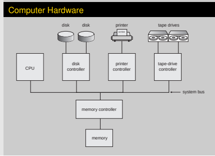
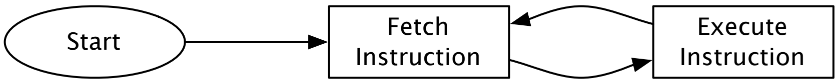
Hardware
Computer Hardware



Computer Hardware—CPU & Memory

Need to perform computation!



- Memory contains program instructions and program data
- Processor registers maintain processor state. Registers include:
  - General purpose (address & data) registers
  - Instruction pointer (aka program counter)
  - Stack pointer(s)
  - Control and status registers

Computer Hardware—CPU & Memory
Need to perform computation!
Start
Fetch Instruction
Execute Instruction
Memory contains program instructions and program data
Processor registers maintain processor state. Registers include:
General purpose (address & data) registers
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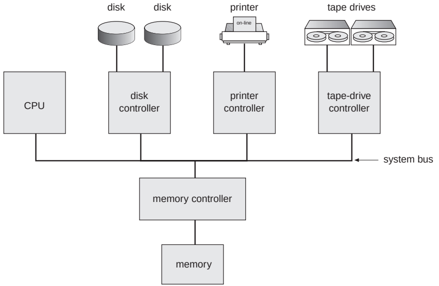
Stack pointer(s)
Control and status registers

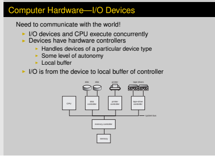
Computer Hardware—I/O Devices

Need to communicate with the world!

- I/O devices and CPU execute concurrently
- Devices have hardware controllers
  - Handles devices of a particular device type
  - Some level of autonomy
  - Local buffer
- I/O is from the device to local buffer of controller



Computer Hardware—I/O Devices



Programmed I/O

After I/O starts, control returns to user program only on I/O completion

- CPU waits until I/O completes.
- At most one I/O request is outstanding at a time
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Polled I/O

Polling == Querying the I/O device
Separate I/O into two parts:

- Initiation
- Polling

Advantages?

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Interrupt-Driven I/O

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I/O in User-Level Code

User-level code almost always uses "programmed I/O"
(e.g. `read` and `write` on a file)

Why?

I/O in User-Level Code

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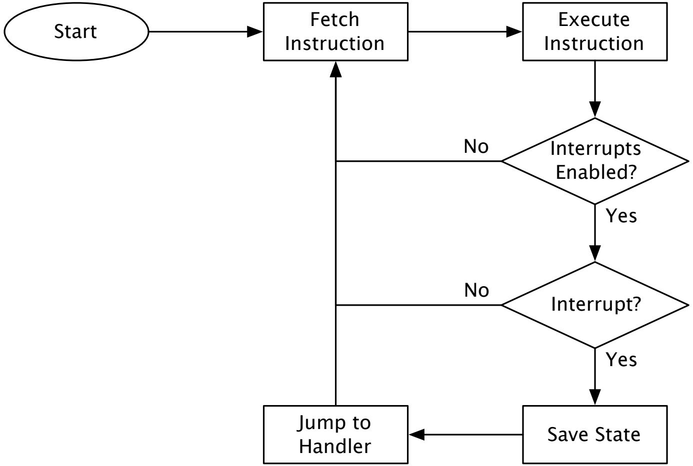
Why?

Computer Hardware—CPU with Interrupts

CPU needs another feature. . .



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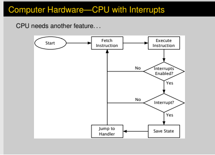
└Hardware

└Computer Hardware—CPU with Interrupts



Handling an Interrupt

What needs to happen:

- Save state
  - All registers
  - Switch stacks?
- Find out what interrupt was...
  - Polling
  - Vectored interrupts

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Types of Interrupts

Various types

- Software exception (also called a trap)
- Timer
- I/O
- Hardware failure

A modern operating system is *interrupt driven*

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Other Hardware Features

We've covered interrupts, but hardware has other cool features, including:

- Caches
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We'll come back to hardware as we address these topics.

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