Lecture 1: Overview and Introduction

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  • Execute user programs and make solving user problems easier
  • Make the computer system convenient to use
  • Use the computer hardware in an efficient manner
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- Rest of this lecture:
  - Background
  - Overview of topics we’ll cover in this half of the course
Why study operating systems?

· Maturing field
  · Most people only use one OS

· But, lots of new technology
  · High performance computing
  · Distributed computing
  · Cloud computing
  · Fault-tolerant computing

· OS issues faced in many places
  · Security, protection, resource management

· New devices need OSes
  · iPhones, iPads, (Galaxy Tabs)
Outline

- OS Definition

- OS interface with subsystems
  - I/O systems
  - Storage systems

- Basic functionality
  - Protecting resources
  - Managing resources
    - Processes
    - Memory
    - Storage
What do Operating Systems do?
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• Depends on the point of view
• Users want convenience, **ease of use**
  • Don’t care about **resource utilization**
• But shared computer such as **mainframe** or **minicomputer** must keep all users happy
• Users of dedicated systems such as **workstations** have dedicated resources but frequently use shared resources from **servers**
• Handheld computers are resource poor, optimized for usability and battery life
• Some computers have little or no user interface, such as embedded computers in devices and automobiles
Operating System Definition

• OS is a **resource allocator**
  • Manages all resources
  • Decides between conflicting requests for efficient and fair resource use

• OS is a **control program**
  • Controls execution of programs to prevent errors and improper use of the computer
Operating System Definition (Cont.)

• But, no universally accepted definition

• “Everything a vendor ships when you order an operating system” is good approximation
  • But varies wildly (IE, anyone?)

• “The one program running at all times on the computer” is the **kernel**. Everything else is either a system program (ships with the operating system) or an application program.
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- Basic functionality
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  - Managing resources
    - Processes
    - Memory
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Computer Startup

- **bootstrap program** is loaded at power-up or reboot
  - Typically stored in ROM or EPROM, generally known as **firmware**
  - Initializes all aspects of system
  - Loads operating system kernel and starts execution

- Will not focus on bootstrapping in this course (take CS5600)
Computer System Organization

- Computer-system operation
  - One or more CPUs, device controllers connect through common bus providing access to shared memory
  - Concurrent execution of CPUs and devices competing for memory cycles
How do the devices communicate?

- I/O devices and the CPU can execute concurrently
- Each device controller is in charge of a particular device type
- Each device controller has a local buffer
- CPU moves data from/to main memory to/from local buffers
- I/O is from the device to local buffer of controller
- Device controller informs CPU that it has finished its operation by causing an interrupt
Common Functions of Interrupts

• Interrupt transfers control to the interrupt service routine generally, through the **interrupt vector**, which contains the addresses of all the service routines

• Interrupt architecture must save the address of the interrupted instruction

• Incoming interrupts are *disabled* while another interrupt is being processed to prevent a *lost interrupt*

• A *trap* is a software-generated interrupt caused either by an error or a user request

• An operating system is **interrupt driven**
Interrupt Handling

- The operating system preserves the state of the CPU by storing registers and the program counter

- Determines which type of interrupt has occurred:

- Separate segments of code determine what action should be taken for each type of interrupt
Interrupt Timeline

CPU
- user process executing

I/O device
- idle
- transferring

I/O request
- transfer done
- I/O request
- transfer done
I/O Structure: Two options
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• After I/O starts, control returns to user program only upon I/O completion
  • Wait instruction idles the CPU until the next interrupt
  • Wait loop (contention for memory access)
  • At most one I/O request is outstanding at a time, no simultaneous I/O processing
I/O Structure: Two options

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• After I/O starts, control returns to user program without waiting for I/O completion
  • **System call** – request to the operating system to allow user to wait for I/O completion
  • **Device-status table** contains entry for each I/O device indicating its type, address, and state
  • Operating system indexes into I/O device table to determine device status and to modify table entry to include interrupt
Storage Structure: Many levels

- Main memory – only large storage media that the CPU can access directly
  - Random access
  - Typically volatile
- Secondary storage – extension of main memory that provides large nonvolatile storage capacity
- Magnetic disks – rigid metal or glass platters covered with magnetic recording material
  - Disk surface is logically divided into tracks, which are subdivided into sectors
- SSDs – solid-state memory disks with no moving parts
Storage Hierarchy

- Storage systems organized in hierarchy
  - Speed
  - Cost
  - Volatility

- **Caching** – copying information into faster storage system; main memory can be viewed as a *cache* for secondary storage
Caching

• Important principle, performed at many levels in a computer (in hardware, operating system, software)

• Information in use copied from slower to faster storage temporarily

• Faster storage (cache) checked first to determine if information is there
  • If it is, information used directly from the cache (fast)
  • If not, data copied to cache and used there

• Cache smaller than storage being cached
  • Cache management important design problem
  • Cache size and replacement policy
How do we protect resources?

- Interrupt driven by hardware
- Software error or request creates exception or trap
  - Division by zero, request for operating system service
- Other process problems include infinite loop, processes modifying each other or the operating system
- Dual-mode operation allows OS to protect itself and other system components
  - User mode and kernel mode
- Mode bit provided by hardware
  - Provides ability to distinguish when system is running user code or kernel code
  - Some instructions designated as privileged, only executable in kernel mode
  - System call changes mode to kernel, return from call resets it to user
How to prevent processes hogging CPU?

- Timer to prevent infinite loop / process hogging resources
  - Set interrupt after specific period
  - Operating system decrements counter
  - When counter zero generate an interrupt
  - Set up before scheduling process to regain control or terminate program that exceeds allotted time
How do we protect a process’s memory?

- Rogue processes could access any part of memory
  - Even parts that are not their’s

- Kernel memory, other processes’ memory, etc

- Many OSes has little protection against such processes
  - Mac OS 9, e.g.

- How to protect against this?
  - Need to only allow processes to mess with their own memory

- Requires user/kernel privilege separation
  - Why?
Processes

• Definition: A process is a program in execution. It is a unit of work within the system. Program is a *passive entity*, process is an *active entity*.

• Process needs resources to accomplish its task
  - CPU, memory, I/O, files
  - Initialization data

• Process termination requires reclaim of any reusable resources

• Single-threaded process has one *program counter* specifying location of next instruction to execute
  - Process executes instructions sequentially, one at a time, until completion

• Multi-threaded process has one program counter per thread

• Typically system has many processes, some user, some operating system running concurrently on one or more CPUs
  - Concurrency by multiplexing the CPUs among the processes / threads