Today's Plan

Upcoming:

- Quiz #1
- Assignment 1

Last time:

- Understanding the internals of computer systems

Today's topics:

- From last time: Operating System Structure
- Process Management
- Main Memory Management
- File/Secondary Storage Management
- I/O System Management
- Protection and Security
- Computing Environments

System Components – Process Management

- A **process** is a program in execution. It is a unit of work within the system. A program is a *passive entity*, a process is an *active entity*
- A process needs resources to accomplish its task
  - E.g. CPU, memory, I/O devices, files
- Process termination requires reclaiming of any reusable resources
- A *single-threaded process* has one program counter specifying location of next instruction to execute
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- A *multi-threaded process* has one program counter per thread
- Typically a system has many processes, some user, some operating system running concurrently on one or more CPUs

System Components – Process Management

- The operating system is responsible for the following activities in connection with process management
  - Process creation and deletion
  - process suspension and resumption
  - Provision of mechanisms for:
    -
    -
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System Components – Main Memory Management

- Memory is a large array of words or bytes, each with its own address
- Main memory is a *volatile* storage device
- The operating system is responsible for the following activities in connection with memory management:
  - Keep track of which parts of memory are currently being used and by whom
  - Decide which processes to load when memory space becomes available
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System Components – File Management

- A file is a collection of related information defined by its creator.
- The operating system is responsible for the following activities in connection with file management:
  - File/directory creation and deletion
  - Support of primitives for manipulating files and directories
  - Access control available on most systems
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System Components – Secondary Storage Management

- Since main memory (*primary storage*) is volatile and too small to accommodate all data and programs permanently, the computer system must provide *secondary storage* to back up main memory.
- Most modern computer systems use disks as the principle storage medium, for both programs and data.
- The operating system is responsible for the following activities in connection with disk management:
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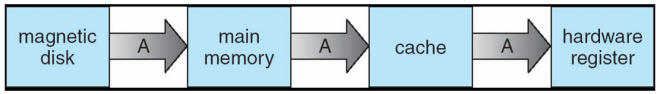
Performance of Various Levels of Storage

- Movement between levels of storage hierarchy can be explicit or implicit

Level	1	2	3	4	5
Name	registers	cache	main memory	solid-state disk	magnetic disk
Typical size	< 1 KB	< 16MB	< 64GB	< 1 TB	< 10 TB
Implementation technology	custom memory with multiple ports CMOS	on-chip or off-chip CMOS SRAM	CMOS SRAM	flash memory	magnetic disk
Access time (ns)	0.25-0.5	0.5-25	80-250	25,000-50,000	5,000,000
Bandwidth (MB/sec)	20,000-100,000	5,000-10,000	1,000-5,000	500	20-150
Managed by	compiler	hardware	operating system	operating system	operating system
Backed by	cache	main memory	disk	disk	disk or tape

Migration of Integer A from Disk to Register

- Multitasking environments must be careful to use most recent value, no matter where it is stored in the storage hierarchy



- Multiprocessor environment must provide cache coherency in hardware such that all CPUs have the most recent value in their cache
- Distributed environment situation even more complex
  - Several copies of a datum can exist

System Components – I/O System Management

- One purpose of OS is to hide peculiarities of hardware devices from the user

The I/O system consists of:

- A buffer-caching system
- A general device-driver interface
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- Drivers for specific hardware devices

Protection and Security

- **Protection** – any mechanism for controlling access of processes or users to resources defined by the OS
- **Security** – defense of the system against internal and external attacks
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Protection and Security

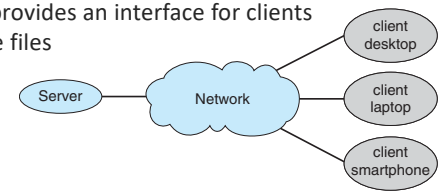
- Systems generally first distinguish among users, to determine who can do what
  - User identities (**user IDs**, security IDs) include name and associated number, one per user
  - User ID then associated with all files, processes of that user to determine access control
  - Group identifier (**group ID**) allows set of users to be defined and controls managed, then also associated with each process, file
  - **Privilege escalation** allows user to change to effective ID with more rights

Computing Environments – Traditional & Mobile

- Traditional
  - Stand-alone general-purpose computers
  - Range from network computers (thin clients) to powerful laptops/desktops
- Mobile
  - Handheld smartphones, tablets, etc.
  - OS must support many features enabled by sensors (GPS, gyroscope, cameras)
  - Allows for new types of apps like augmented reality

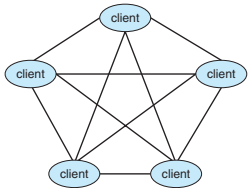
Computing Environments – Client Server

- Client-Server Computing
  - Dumb terminals supplanted by smart PCs
  - Many systems now **servers**, responding to requests generated by **clients**
    - **Compute-server system** provides an interface to client to request services (e.g. database)
    - **File-server system** provides an interface for clients to store and retrieve files



Peer-to-Peer Computing

- Another model for a distributed system
- P2P does not distinguish clients and servers
  - All nodes are considered peers
  - May each act as client, server, or both
  - Node must join P2P network
    - Registers its service with central lookup service on network, or
    - Broadcast request for service and respond to requests for service via **discovery protocol**
- Examples include *Napster, Gnutella*, and VOIP services



Computing Environments – Cloud Computing

- Delivers computing, storage, and apps as a service across a network
  - E.g. Amazon EC2 has thousands of servers, millions of virtual machines, petabytes of storage available via the internet – pay based on usage
  - **Public** and **private** clouds
  - **Software as a service** (SaaS) for applications
  - **Platform as a service** (PaaS) for entire software stack (e.g. database server)
  - **Infrastructure as a service** (IaaS) for servers or storage
  - **Load balancers** spread traffic across many servers

Open-Source Operating Systems

- Operating systems made available in source-code format rather than just binary closed-source
- Counter to the copy protection and Digital Rights Management (DRM) movement
- Started by Free Software Foundation (FSF), which has "copyleft" **GNU Public License** (GPL)
- Examples include *GNU/Linux* and *BSD UNIX* (including core of Mac OS X)