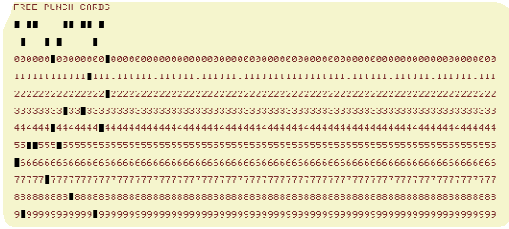
Introduction to Operating Systems (Part 1)

Computer

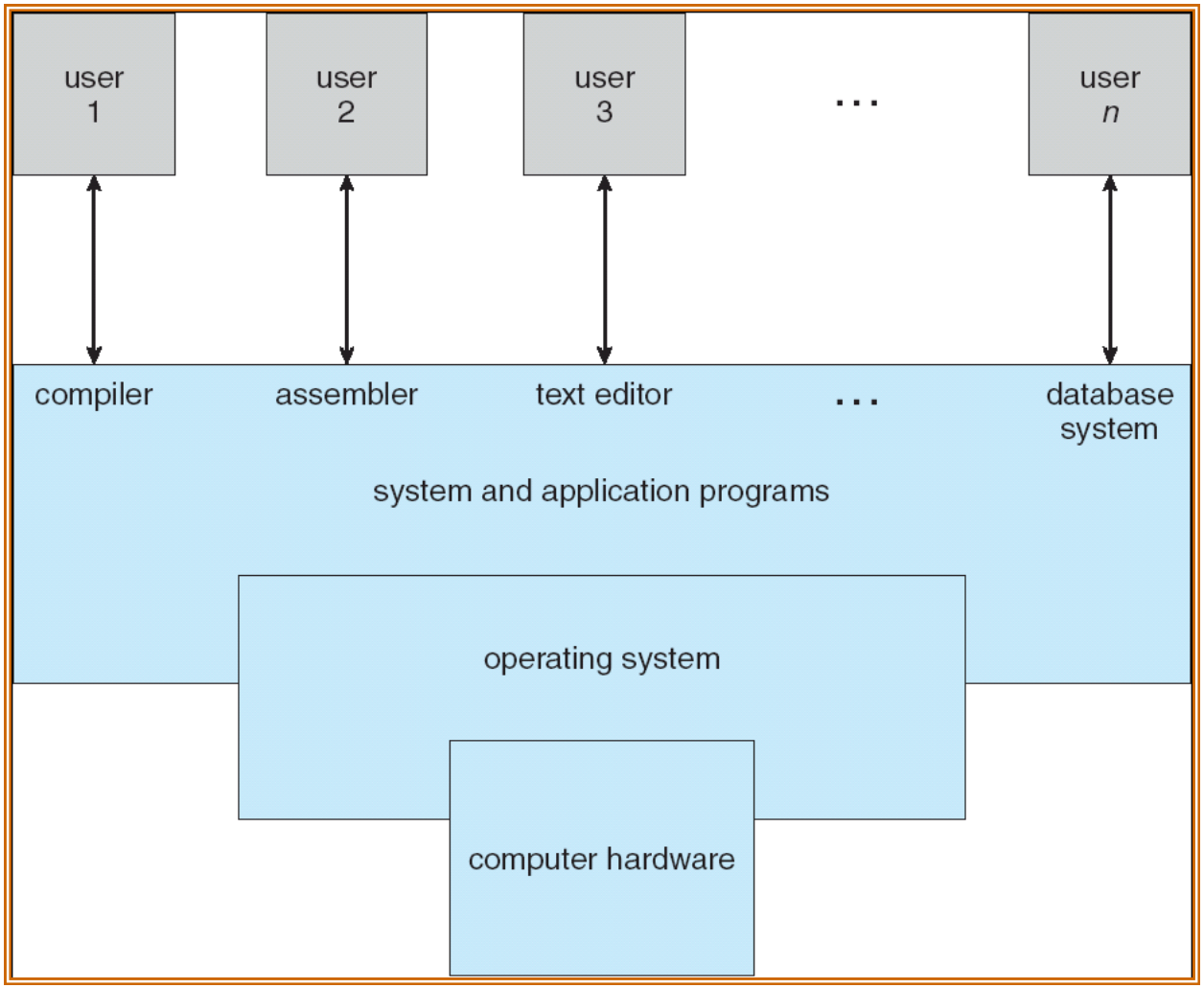
- A computer is an electronic device that manipulates information or data. It has the ability to store, retrieve, and process data.
- Generations of Computer:
  - First generation (1946-1959) – Vacuum tubes
  - Second generation (1959-1965) - Transistors
  - Third generation (1965-1971) – ICs
  - Fourth generation (1972- 1980) - Microprocessors
  - Fifth generation (1980-till) – ULSI, AI



Computer System Structure

- Computer system can be divided into four components
  - Hardware – provides basic computing resources
    - CPU, memory, I/O devices
  - Operating system
    - Controls and coordinates use of hardware among various applications and users
  - Application programs – define the ways in which the system resources are used to solve the computing problems of the users
    - Word processors, compilers, web browsers, database systems, video games
  - Users
    - People, machines, other computers

Four Components of a Computer System



Software

- Application software
- System software

Operating System Definition

- User view
  - OS is designed for ease of use
  - OS is designed to maximize resource utilization

- System view
  - 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

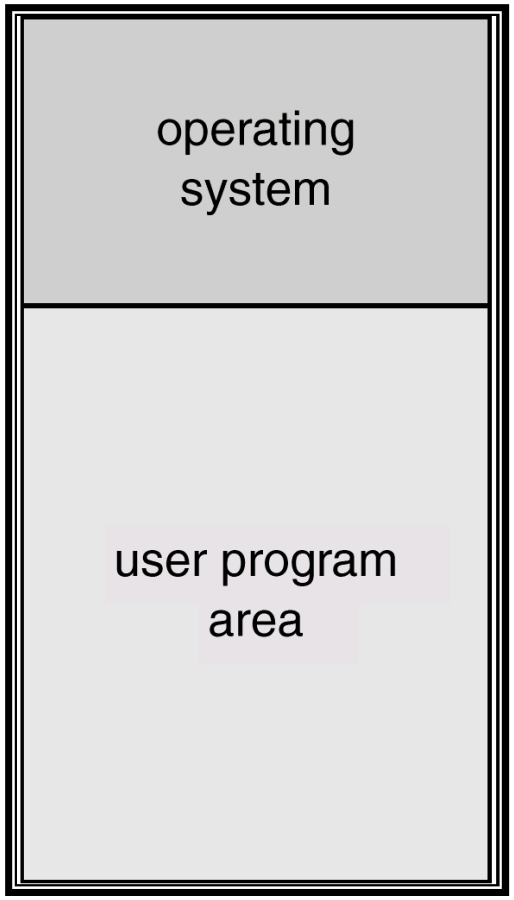
Operating System Definition (Cont.)

- No universally accepted definition
- "Everything a vendor ships when you order an operating system" is good approximation
  - But varies wildly
- "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

Mainframe Systems

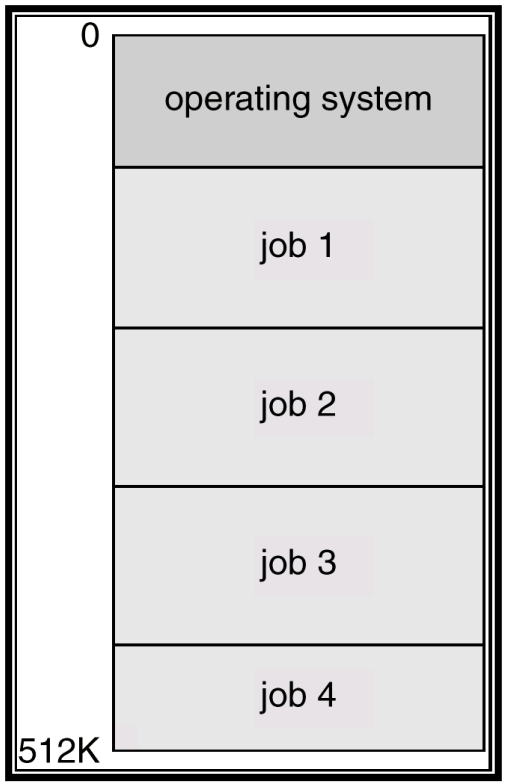
- Reduce setup time by batching similar jobs
- Automatic job sequencing – automatically transfers control from one job to another. First rudimentary operating system.
- Resident monitor
  - initial control in monitor
  - control transfers to job
  - when job completes control transfers pack to monitor

Batch Systems



Multiprogrammed Batch Systems

- Several jobs are kept in main memory at the same time, and the
- CPU is multiplexed among them.



OS Features Needed for Multiprogramming

- I/O routine supplied by the system.
- Memory management – the system must allocate the memory to several jobs.
- CPU scheduling – the system must choose among several jobs ready to run.
- Allocation of devices.

Time-Sharing Systems–Interactive Computing

- The CPU is multiplexed among several jobs that are kept in memory and on disk (the CPU is allocated to a job only if the job is in memory).
- A job swapped in and out of memory to the disk.
- On-line communication between the user and the system is provided; when the operating system finishes the execution of one command, it seeks the next “control statement” from the user’s keyboard.
- On-line system must be available for users to access data and code.

Desktop Systems

- *Personal computers* – computer system dedicated to a single user.
- I/O devices – keyboards, mice, display screens, small printers.
- User convenience and responsiveness.
- Can adopt technology developed for larger operating system' often individuals have sole use of computer and do not need advanced CPU utilization of protection features.
- May run several different types of operating systems (Windows, MacOS, UNIX, Linux)

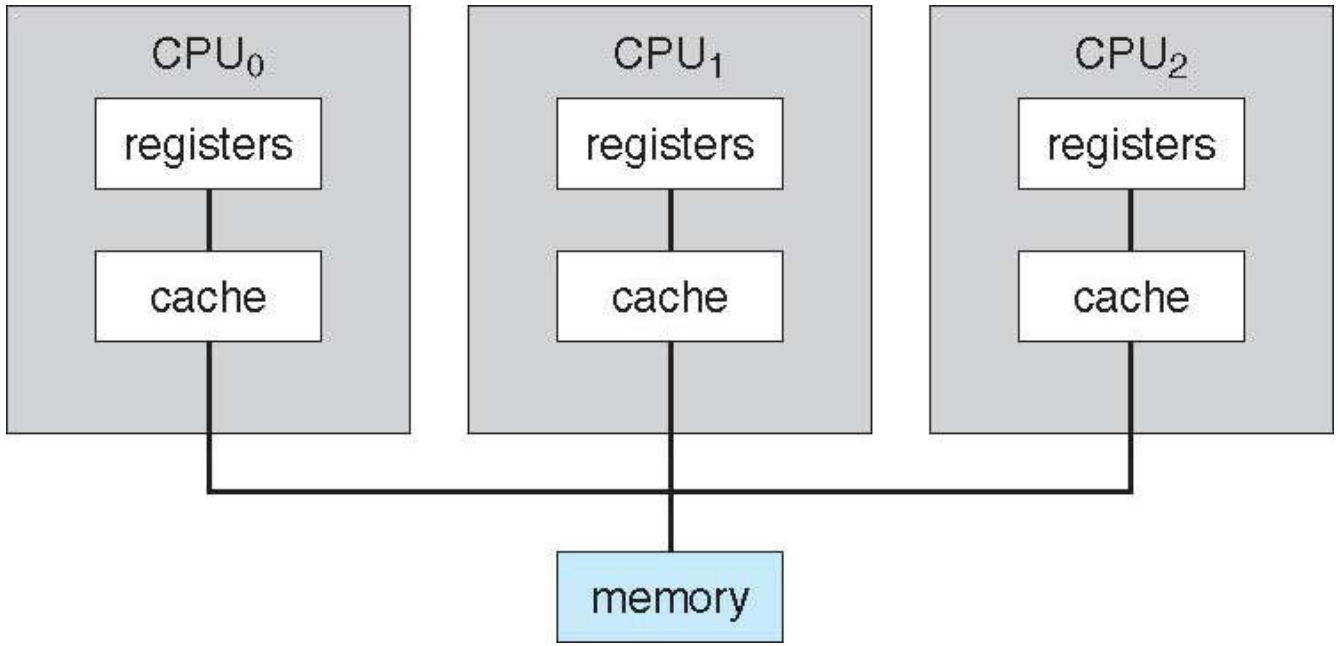
Parallel Systems

- Multiprocessor systems with more than on CPU in close communication.
- *Tightly coupled system* – processors share memory and a clock; communication usually takes place through the shared memory.
- Advantages of parallel system:
  - Increased *throughput*
  - Economical
  - Increased reliability
    - graceful degradation
    - fail-soft systems

Parallel Systems (Cont.)

- *Symmetric multiprocessing (SMP)*
  - Each processor runs and identical copy of the operating system.
  - Many processes can run at once without performance deterioration.
  - Most modern operating systems support SMP
- *Asymmetric multiprocessing*
  - Each processor is assigned a specific task; master processor schedules and allocated work to slave processors.
  - More common in extremely large systems

Symmetric Multiprocessing Architecture



Distributed Systems

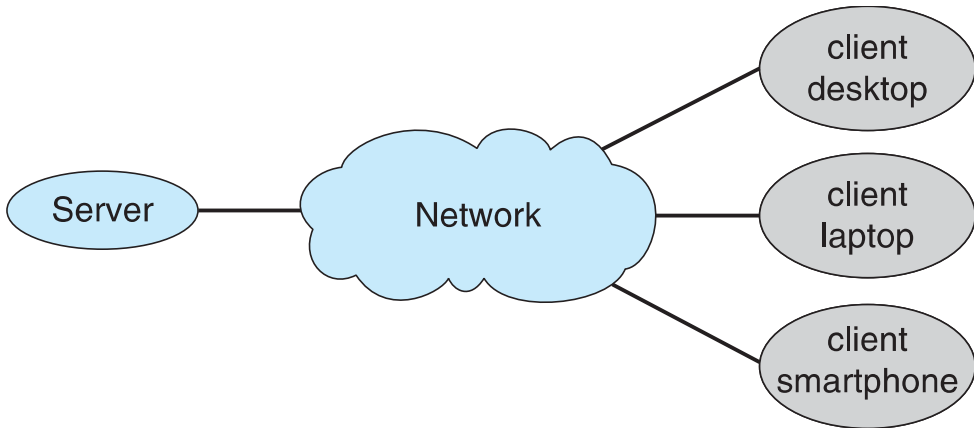
- Distribute the computation among several physical processors.
- *Loosely coupled system* – each processor has its own local memory; processors communicate with one another through various communications lines, such as high-speed buses or telephone lines.
- Advantages of distributed systems.
  - Resources Sharing
  - Computation speed up – load sharing
  - Reliability
  - Communications

Distributed Systems (cont.)

- Collection of separate, possibly heterogeneous, systems networked together
  - Network is a communications path, TCP/IP most common
    - Local Area Network (LAN)
    - Wide Area Network (WAN)
    - Metropolitan Area Network (MAN)
    - Personal Area Network (PAN)
- Network Operating System provides features between systems across network
  - Communication scheme allows systems to exchange messages
  - Illusion of a single system

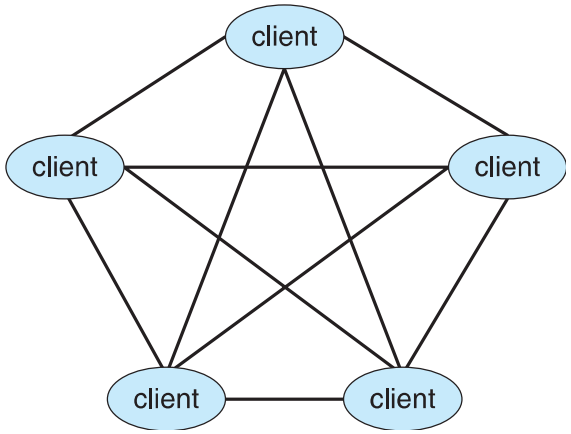
Distributed Systems (cont.)

- 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 (i.e., database)
    - File-server system provides interface for clients to store and retrieve files



Distributed Systems (cont.)

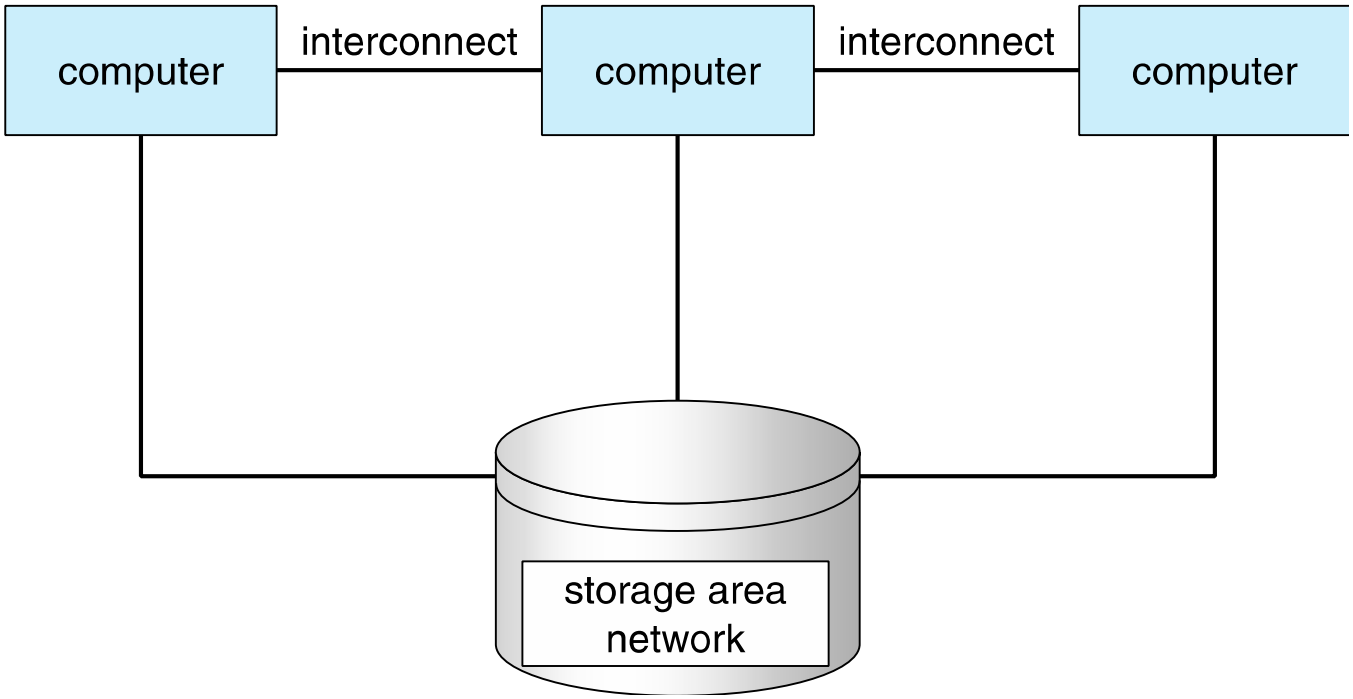
- Peer-to-Peer Systems: another model of distributed system
- P2P does not distinguish clients and servers
  - Instead all nodes are considered peers
  - May each act as client, server or both
  - Node must join P2P network
    - Registers its service with central lookup service on network, or
    - Broadcast request for service and respond to requests for service via discovery protocol
  - Examples include Napster and Gnutella, Voice over IP (VoIP) such as Skype



Clustered Systems

- Clustering allows two or more systems to share storage.
- Provides high reliability.
- *Asymmetric clustering*: one server runs the application while other servers standby.
- *Symmetric clustering*: all N hosts are running the application.

Clustered Systems (cont.)



Real-Time Systems

- Often used as a control device in a dedicated application such as controlling scientific experiments, medical imaging systems, industrial control systems, and some display systems.
- Well-defined fixed-time constraints.
- Real-Time systems may be either *hard* or *soft* real-time.

Real-Time Systems (Cont.)

- Hard real-time:
  - Secondary storage limited or absent, data stored in short term memory, or read-only memory (ROM)
  - Conflicts with time-sharing systems, not supported by general-purpose operating systems.
- Soft real-time
  - Limited utility in industrial control of robotics
  - Useful in applications (multimedia, virtual reality) requiring advanced operating-system features.

Mobile Computing Systems

- Personal Digital Assistants (PDAs)
- Cellular telephones
- Tablets
- Issues:
  - Limited memory
  - Slow processors
  - Small display screens.

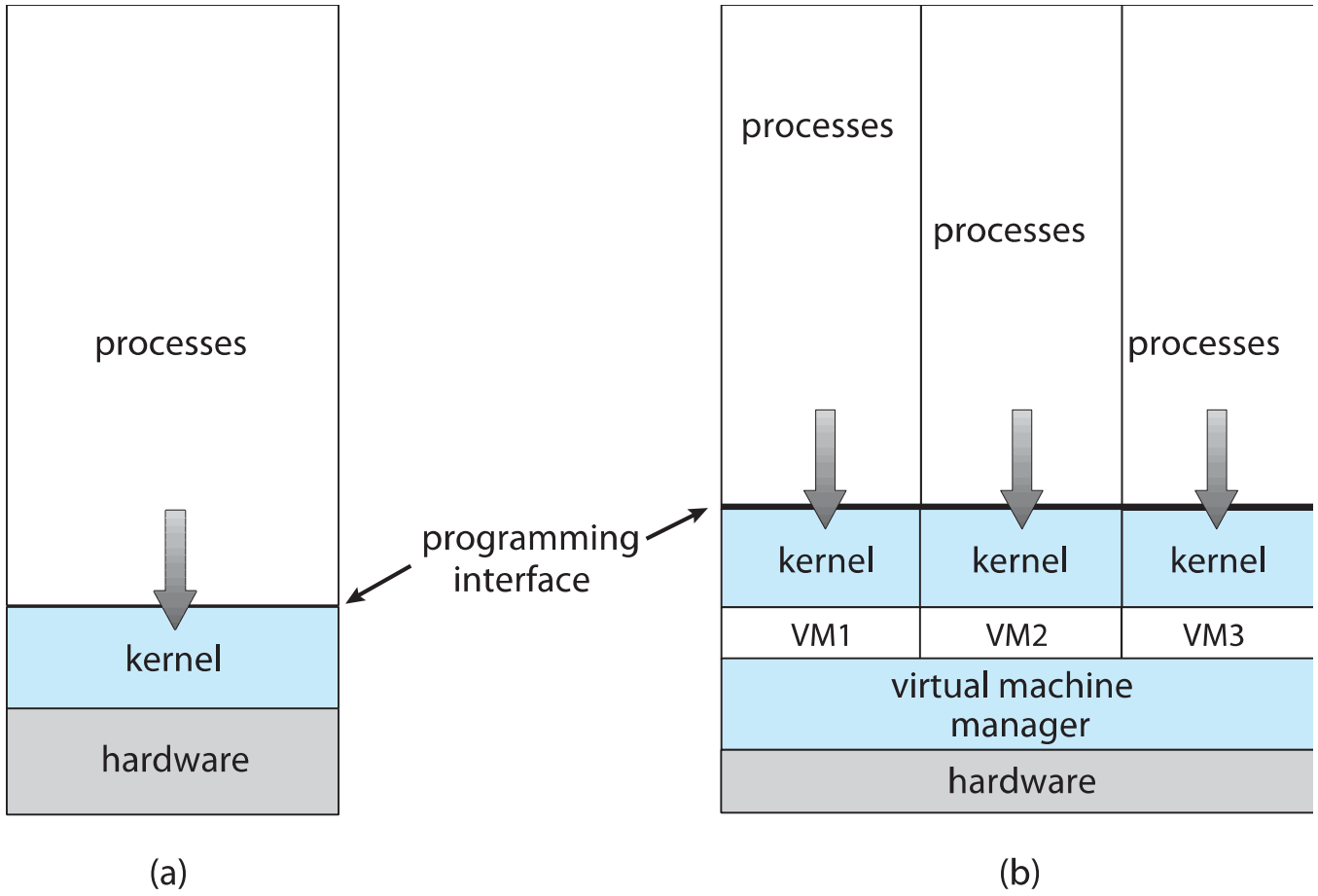
Virtualization

- Allows operating systems to run applications within other OS
  - Vast and growing industry
- Emulation used when source CPU type different from target type (i.e. PowerPC to Intel x86)
  - Generally slowest method
  - When computer language not compiled to native code – Interpretation
- Virtualization – OS natively compiled for CPU, running guest OS also natively compiled
  - Consider VMware running WinXP guests, each running applications, all on native WinXP host OS
  - VMM (virtual machine Manager) provides virtualization services

Virtualization

- Use cases involve laptops and desktops running multiple OS for exploration or compatibility
  - Apple laptop running Mac OS X host, Windows as a guest
  - Developing apps for multiple OS without having multiple systems
  - QA testing applications without having multiple systems
  - Executing and managing compute environments within data centers
- VMM can run natively, in which case they are also the host
  - There is no general purpose host then (VMware ESX and Citrix XenServer)

Virtualization



Cloud Computing

- Cloud computing is computing over the Internet, where resources like application software, storage, processing units, CPU cycles, etc. are virtually shared to fulfill the demands of users on a pay-per-use basis.

- Logical extension of virtualization because it uses virtualization as the base for it functionality.
  - Amazon **EC2** has thousands of servers, millions of virtual machines, petabytes of storage available across the Internet, pay based on usage

- Cloud Computing five essential characteristics:
  - On-demand service
  - Broad network access
  - Resource pooling
  - Rapid elasticity
  - Measured value

Cloud Computing

- **Service models**
  - Software as a Service (**SaaS**) – accessing application resources through a thin client or via the Internet (i.e., word processor)
  - Platform as a Service (**PaaS**) – accessing platform resources like the support of operating systems, framework for software development, etc. via the Internet (i.e., a database server)
  - Infrastructure as a Service (**IaaS**) – accessing resources like storage units, processing units, and network resources, etc. over Internet (i.e., storage available for backup use)

- **Deployment models**
  - Private cloud – run by a company for the company's own use
  - Community cloud – used by some specific communities having common interests
  - Public cloud – available via Internet to anyone willing to pay
  - Hybrid cloud – includes both public and private cloud components

Cloud Computing

- Cloud computing environments composed of traditional OS, plus VMMs, plus cloud management tools
  - Internet connectivity requires security like firewalls
  - Load balancers spread traffic across multiple applications