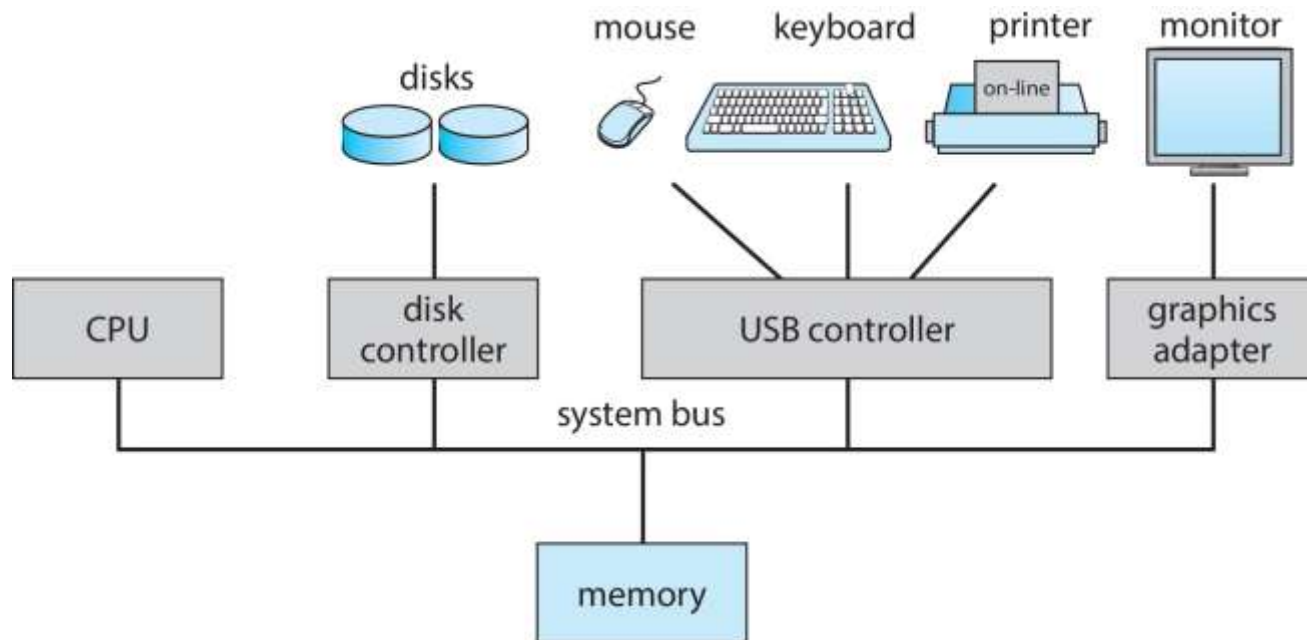# Computer System Organization

- 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

Computer-System Architecture

- Most systems use a single general-purpose processor

  - Most systems have special-purpose processors as well

- **Multiprocessors** systems growing in use and importance

  - Also known as **parallel systems**, **tightly-coupled systems**

  - Advantages include:

    1. **Increased throughput**

    2. **Economy of scale**

    3. **Increased reliability** – graceful degradation or fault tolerance

  - Two types:

    1. **Asymmetric Multiprocessing** – each processor is assigned a specie task.

    2. **Symmetric Multiprocessing** – each processor performs all tasks
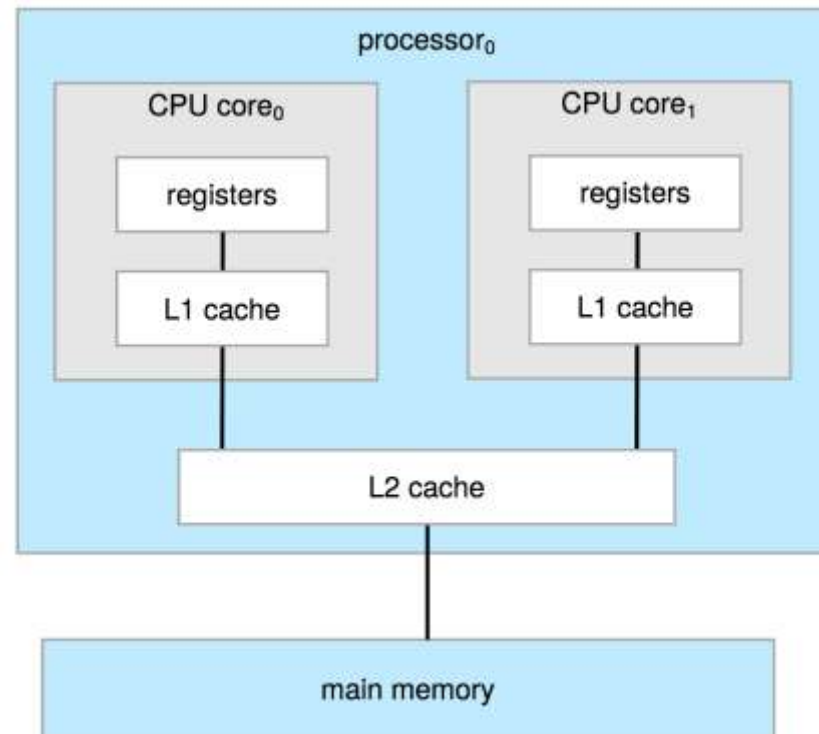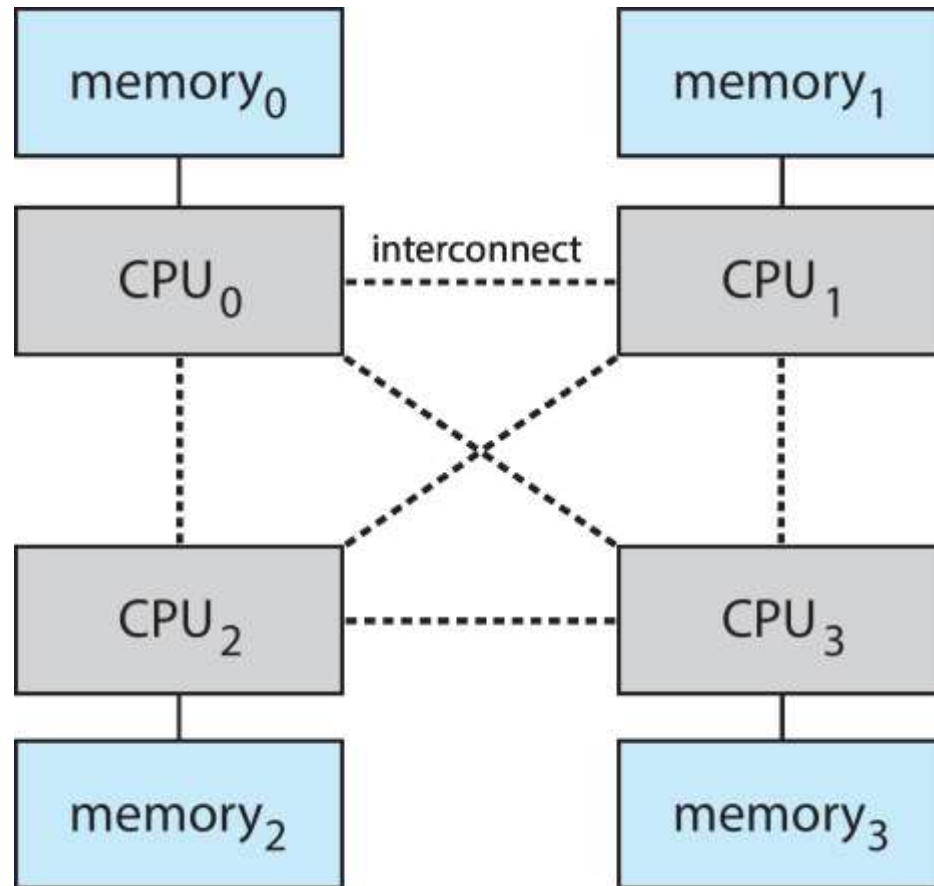
Symmetric Multiprocessing Architecture
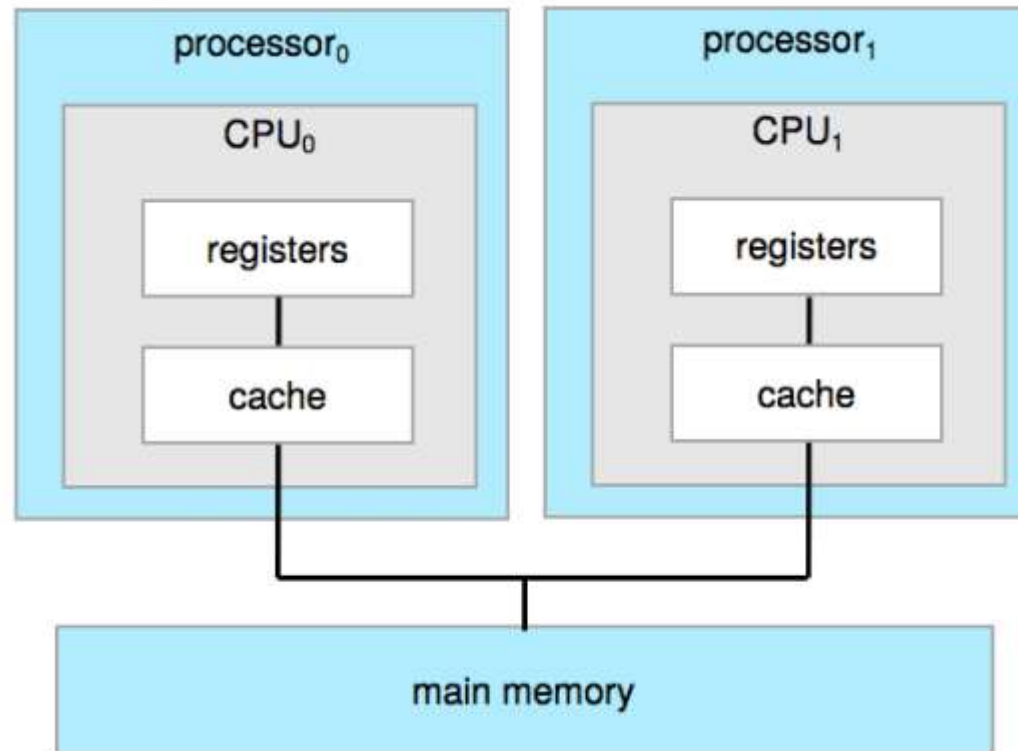
Dual-Core Design

- Multi-chip and **multicore**
- Systems containing all chips
  - Chassis containing multiple separate systems

Non-Uniform Memory Access System

Clustered Systems

- Like multiprocessor systems, but multiple systems working together
  - Usually sharing storage via a **storage-area network** (**SAN**)
  - Provides a **high-availability** service which survives failures
    - **Asymmetric clustering** has one machine in hot-standby mode
    - **Symmetric clustering** has multiple nodes running applications, monitoring each other
  - Some clusters are for **high-performance computing** (**HPC**)
    - Applications must be written to use **parallelization**
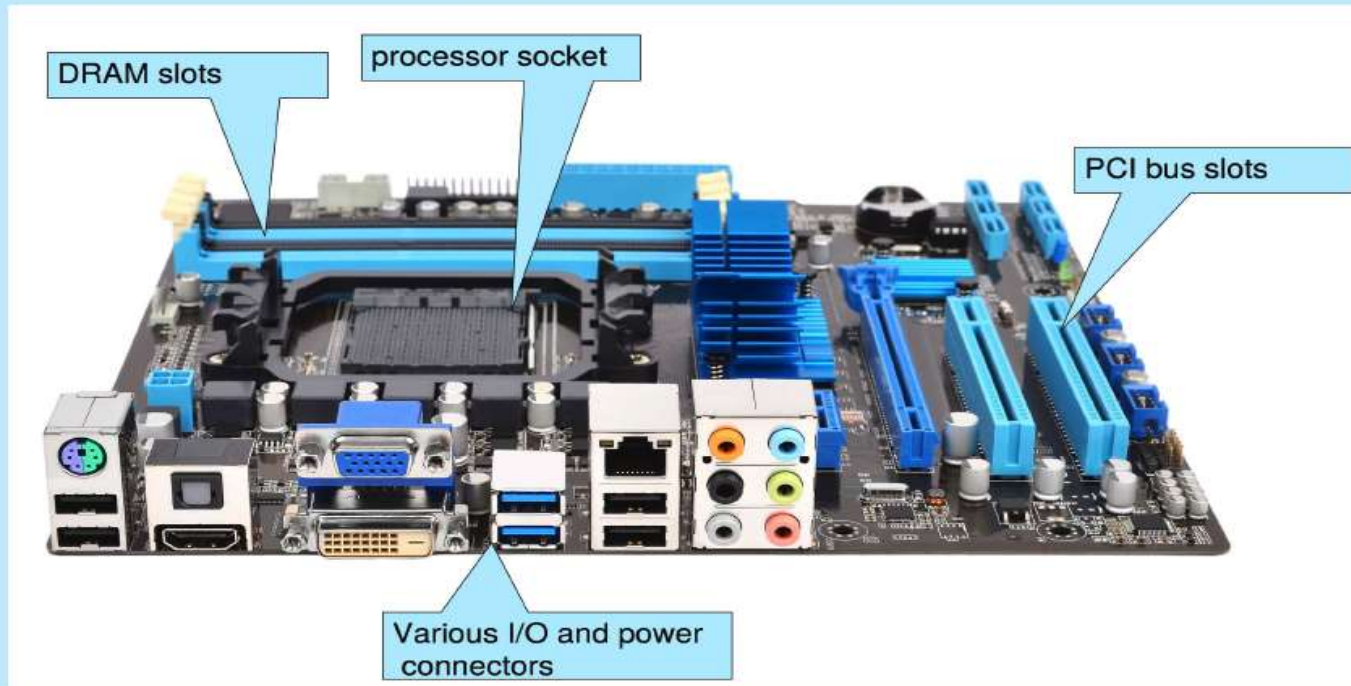 - Some have **distributed lock manager** (**DLM**) to avoid conflicting operations

Clustered Systems
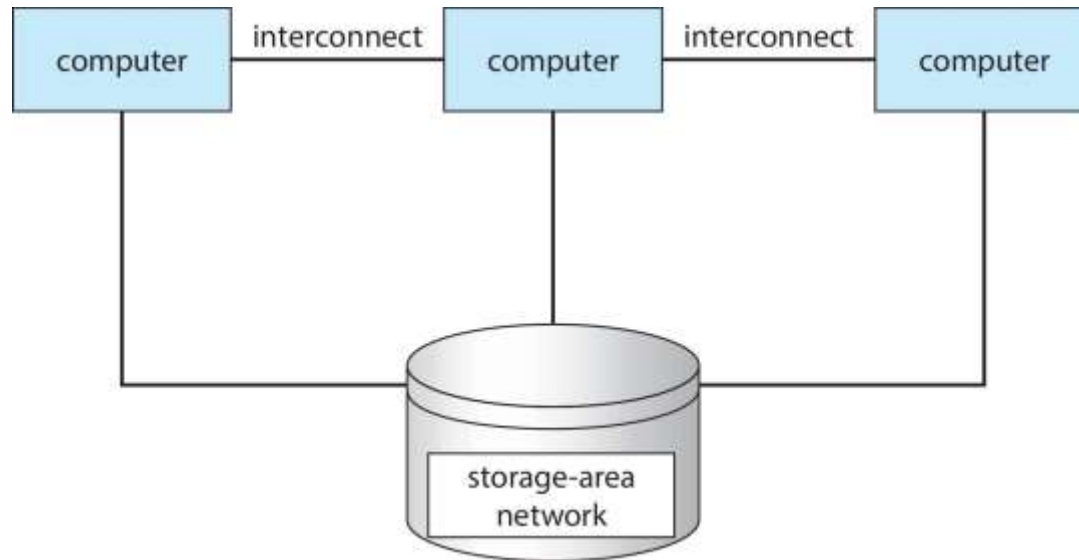
PC Motherboard

Consider the desktop PC motherboard with a processor socket shown below:

DRAM slots

processor socket

PCI bus slots

Various I/O and power connectors

This board is a fully-functioning computer, once its slots are populated. It consists of a processor socket containing a CPU, DRAM sockets, PCIe bus slots, and I/O connectors of various types. Even the lowest-cost general-purpose CPU contains multiple cores. Some motherboards contain multiple processor sockets. More advanced computers allow more than one system board, creating NUMA systems.

Computer System Environments

Computing Environments

- Traditional

- Mobile

- Client Server

- Pear-to-Pear

- Cloud computing

- Real-time Embedded

Traditional

- Stand-alone general-purpose machines

- But blurred as most systems interconnect with others (i.e., the Internet)

- **Portals** provide web access to internal systems

- **Network computers** (**thin clients**) are like Web terminals

- Mobile computers interconnect via **wireless networks**

- Networking becoming ubiquitous – even home systems use **firewalls** to protect home computers from Internet attacks

Mobile

- Handheld smartphones, tablets, etc.

- What is the functional difference between them and a "traditional" laptop?

- Extra feature – more OS features (GPS, gyroscope)

- Allows new types of apps like *augmented reality*

- Use IEEE 802.11 wireless, or cellular data networks for connectivity

- Leaders are **Apple iOS** and **Google Android**

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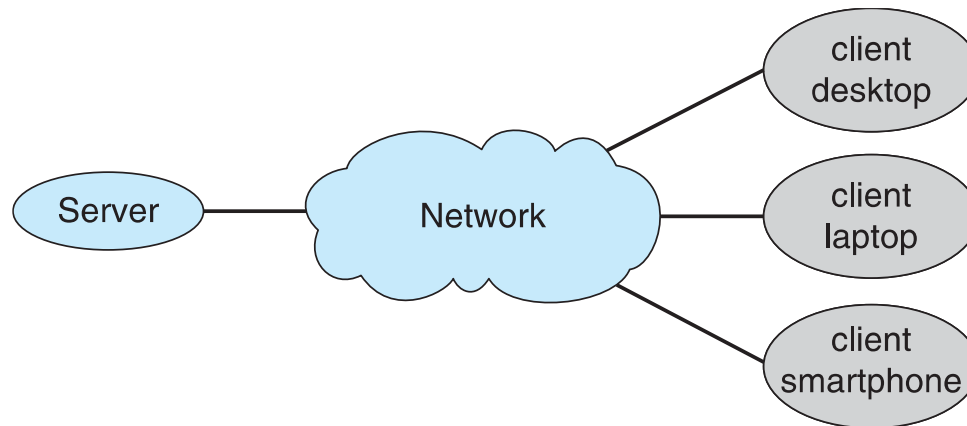
Peer-to-Peer

- 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
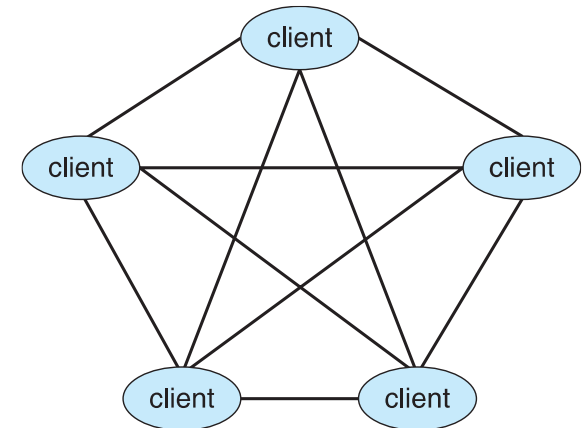
Cloud Computing

- Delivers computing, storage, even apps as a service across a network

- 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 (Cont.)

- Many types

  - **Public cloud** – available via Internet to anyone willing to pay

  - **Private cloud** – run by a company for the company's own use

  - **Hybrid cloud** – includes both public and private cloud components

  - Software as a Service (**SaaS**) – one or more applications available via the Internet (i.e., word processor)

  - Platform as a Service (**PaaS**) – software stack ready for application use via the Internet (i.e., a database server)

  - Infrastructure as a Service (**IaaS**) – servers or storage available over Internet (i.e., storage available for backup use)

Cloud Computing (cont.)

- Cloud computing environments composed of traditional OSes, plus VMMs, plus cloud management tools

    - Internet connectivity requires security like firewalls

    - Load balancers spread traffic across multiple applications
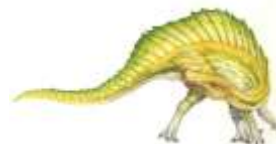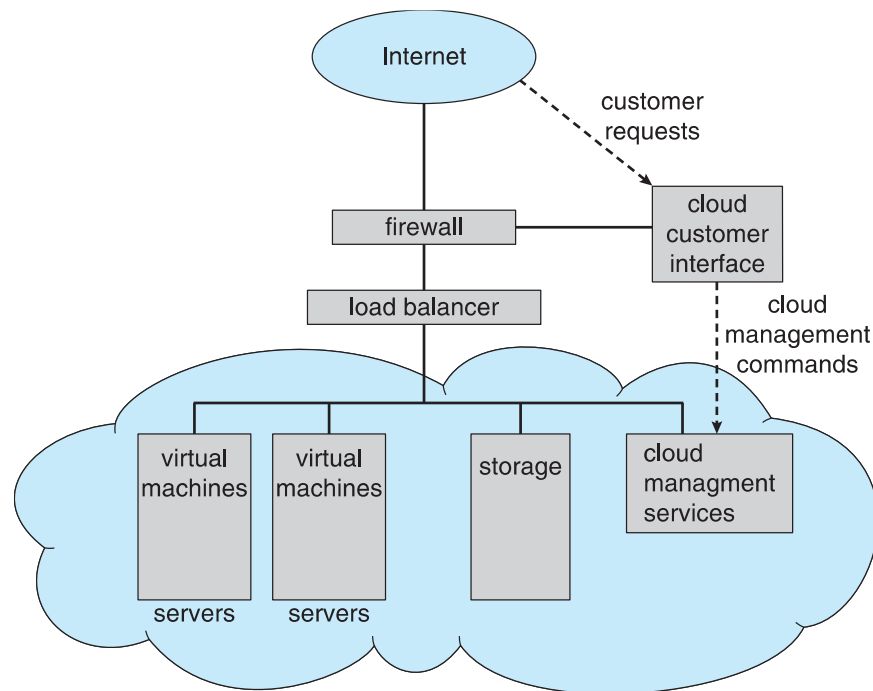
Real-Time Embedded Systems

- Real-time embedded systems most prevalent form of computers
  - Vary considerable, special purpose, limited purpose OS, **real-time OS**
  - Use expanding
- Many other special computing environments as well
  - Some have OSes, some perform tasks without an OS
- Real-time OS has well-defined fixed time constraints
  - Processing **must** be done within constraint
  - Correct operation only if constraints met

Free and Open-Source Operating Systems

- Operating systems made available in source-code format rather than just binary **closed-source** and **proprietary**

- Counter to the **copy protection** and **Digital Rights Management** (**DRM**) movement

- Started by **Free Software Foundation** (**FSF**), which has "copyleft" **GNU Public License** (**GPL**)
  - Free software and open-source software are two different ideas championed by different groups of people
    - http://gnu.org/philosophy/open-source-misses-the-point.html/

- Examples include **GNU/Linux** and **BSD UNIX** (including core of **Mac OS X**), and many more

- Can use VMM like VMware Player (Free on Windows), Virtualbox (open source and free on many platforms - http://www.virtualbox.com)
  - Use to run guest operating systems for exploration