CHAPTER 11: Modern Computer Systems

The Architecture of Computer Hardware, Systems Software & Networking:
An Information Technology Approach

4th Edition, Irv Englander

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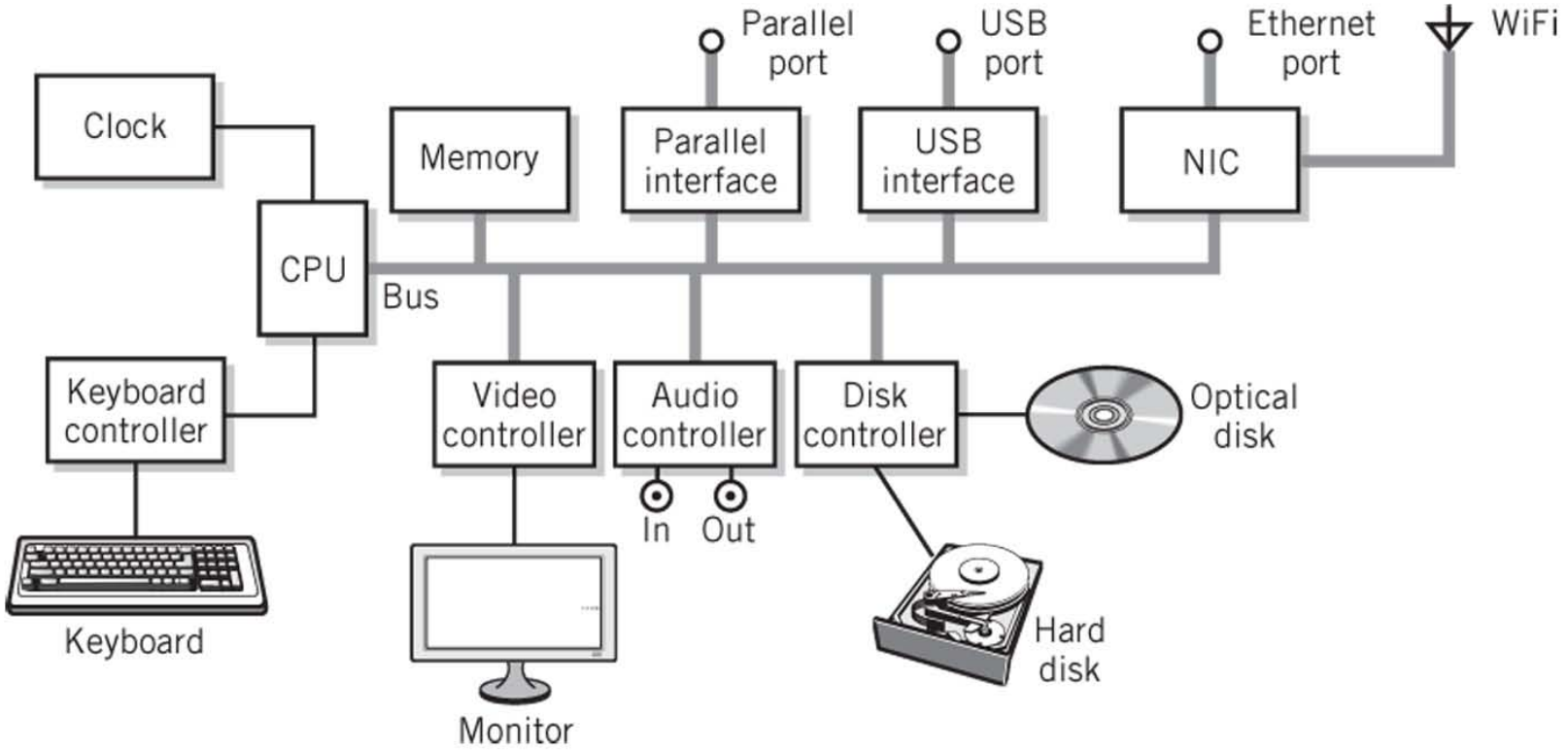
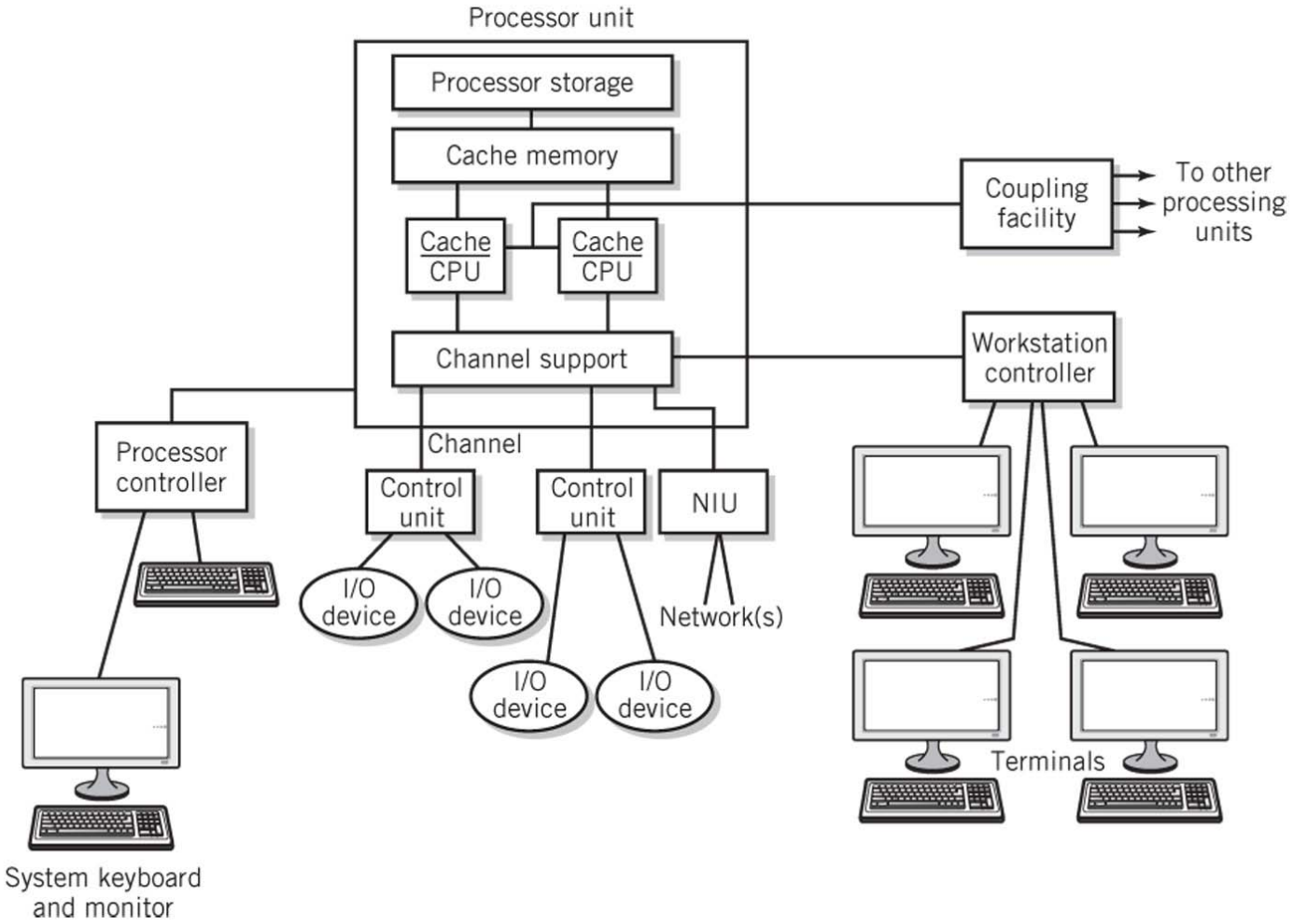
Objectives

- Links all pieces covered in chapters 6-10 together
  - CPUs, Memory (Main and Cache), Buses, I/O Modules, I/O Devices (Peripherals)
  - Machine cycle, Pipelining, DMA data transfer, Programmed I/O, Interrupts
- How all these pieces fit together to achieve synergy?

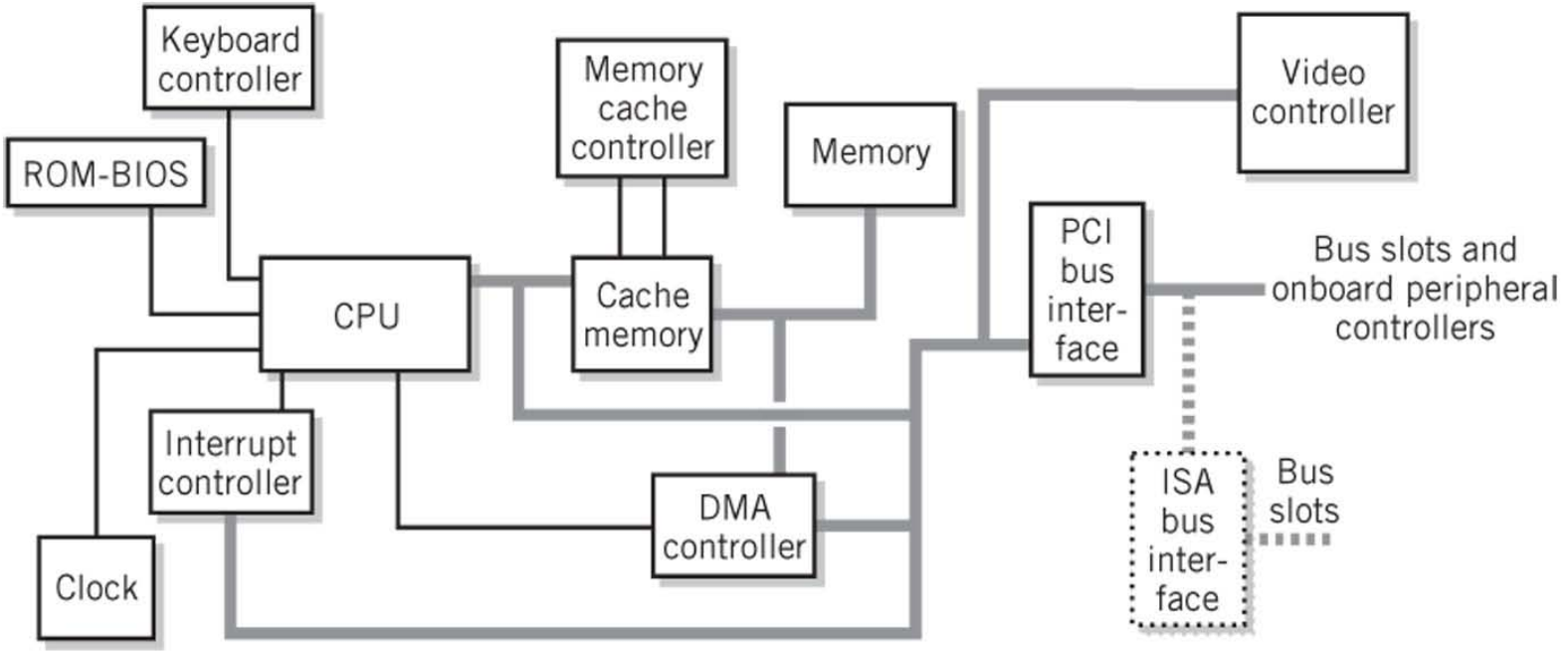
Basic Personal Computer System



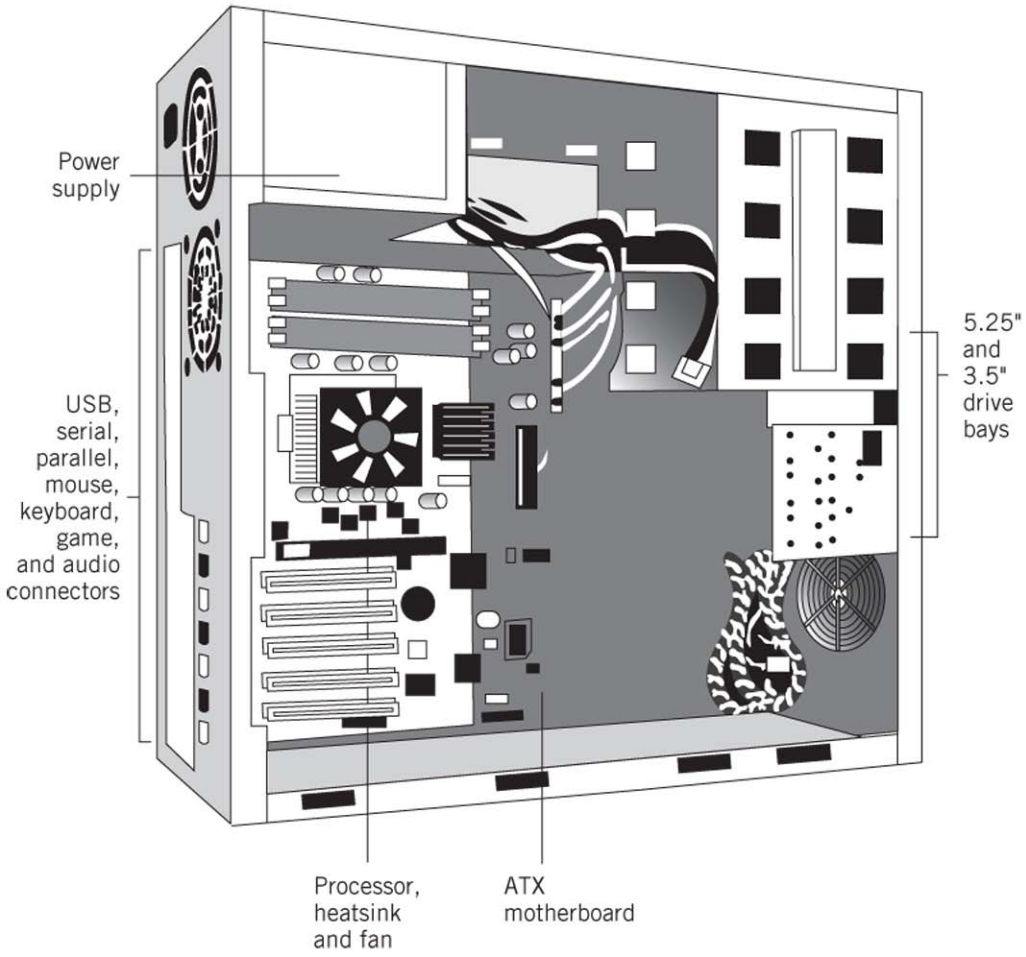
Mainframe Computer System



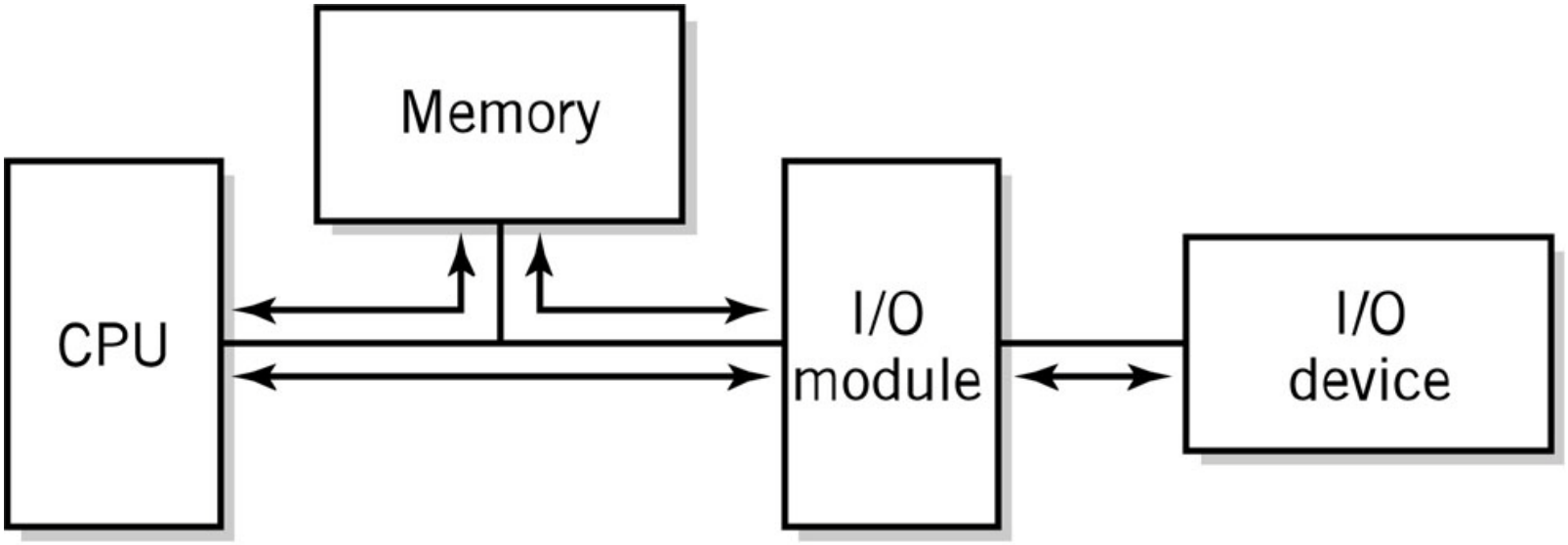
Major PC System Components



Typical Desktop PC



Basic CPU-Memory-I/O Pathway*



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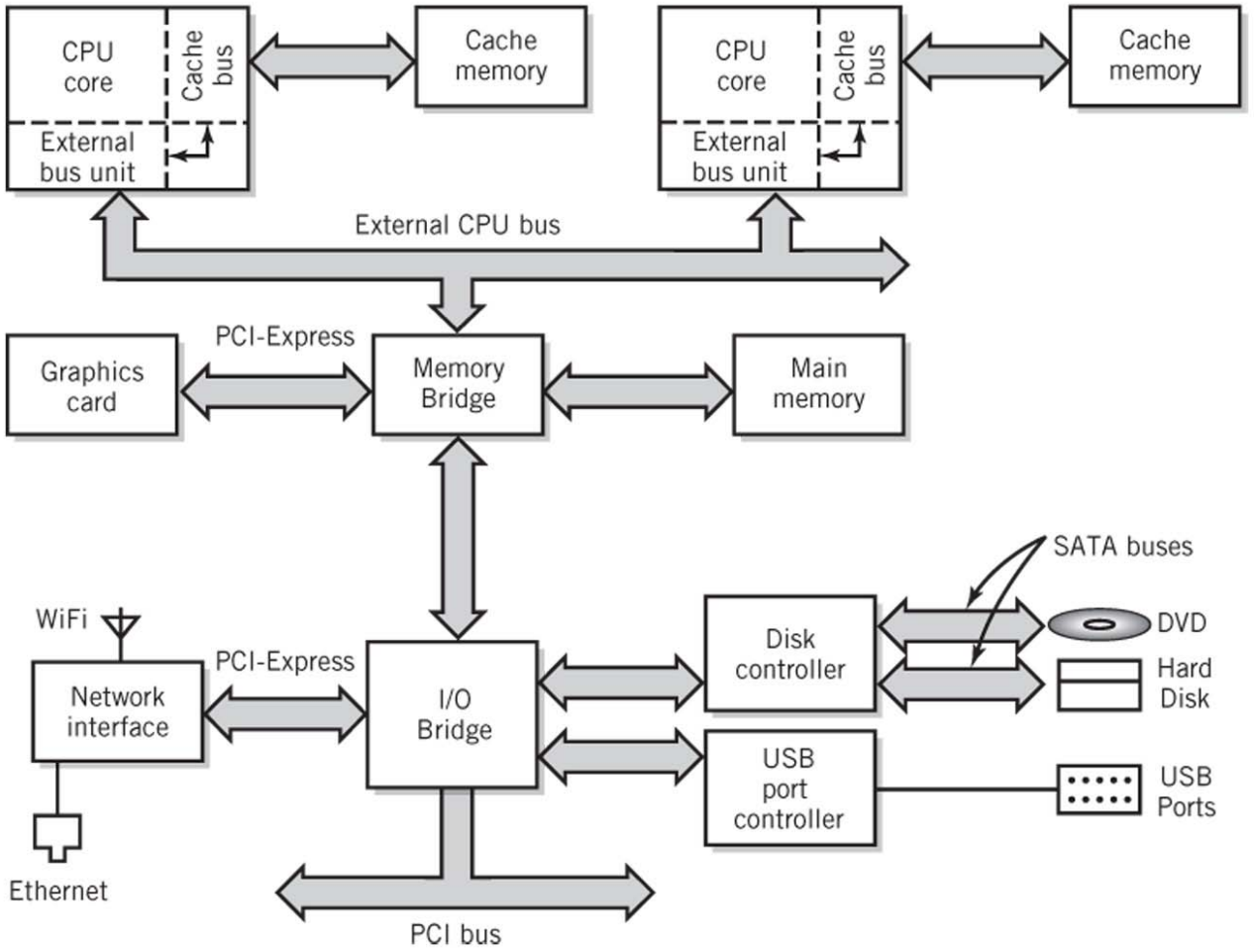
Bus

- Connect CPU and Memory
- I/O peripherals: on same bus as CPU/memory or separate bus
- Physical packaging commonly called *backplane*
  - Also called *system bus* or *external bus*
  - Example of a *broadcast bus*

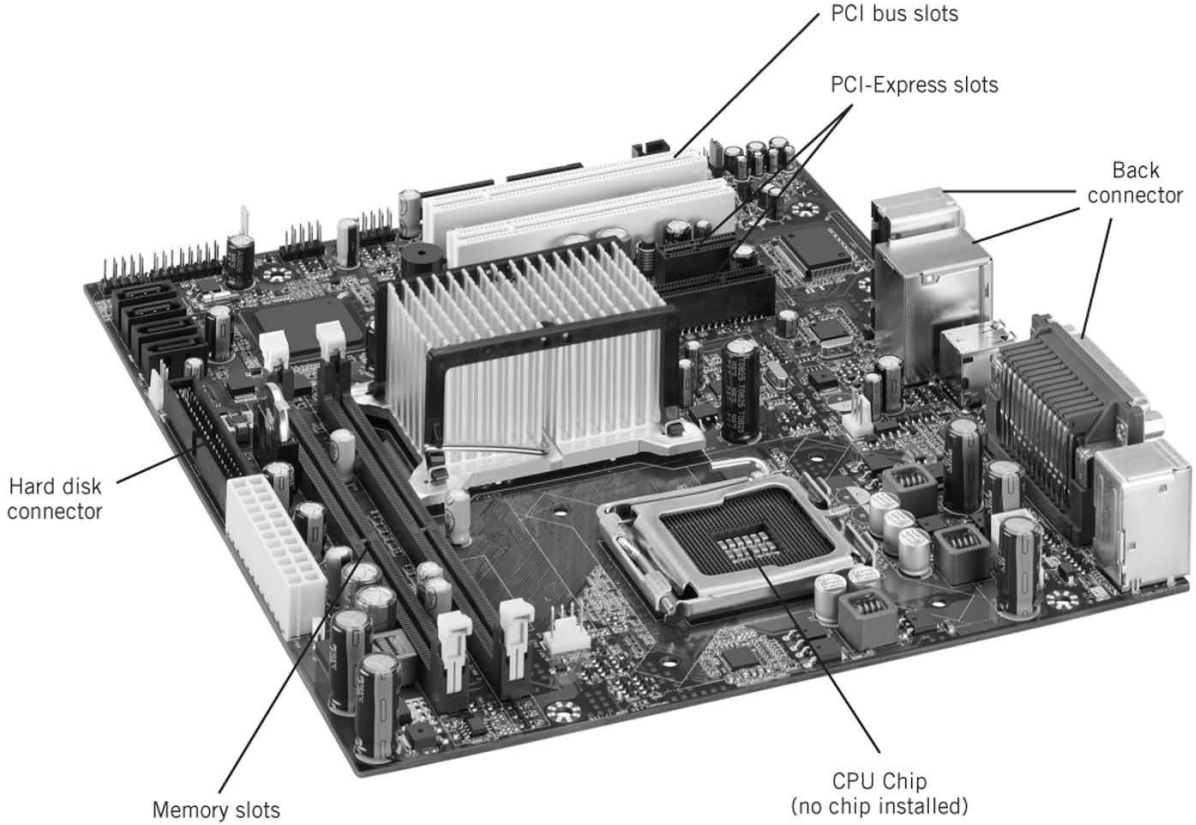
Modern Personal Computer



General Bus Interface Configuration

Motherboard

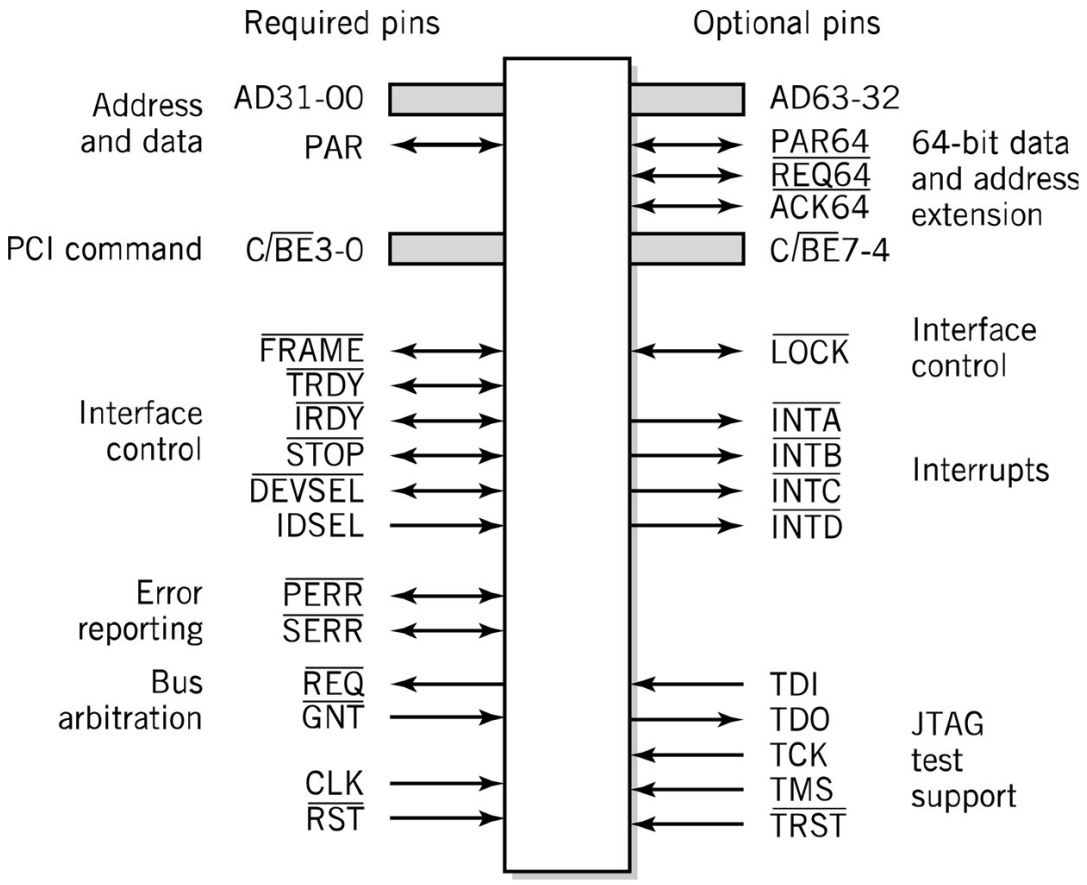
- Printed circuit board that holds CPU and related components including backplane



Bus Hierarchy

- Processor bus: on-chip
- Cache bus (backside bus)
- Memory bus (front-side bus)
  - connects the memory subsystem and processor
- Backplane bus
  - Connects I/O to the CPU and memory
  - Connects all peripheral cards and connectors
  - Examples: PCI-Express, PCI

PCI Bus Connections



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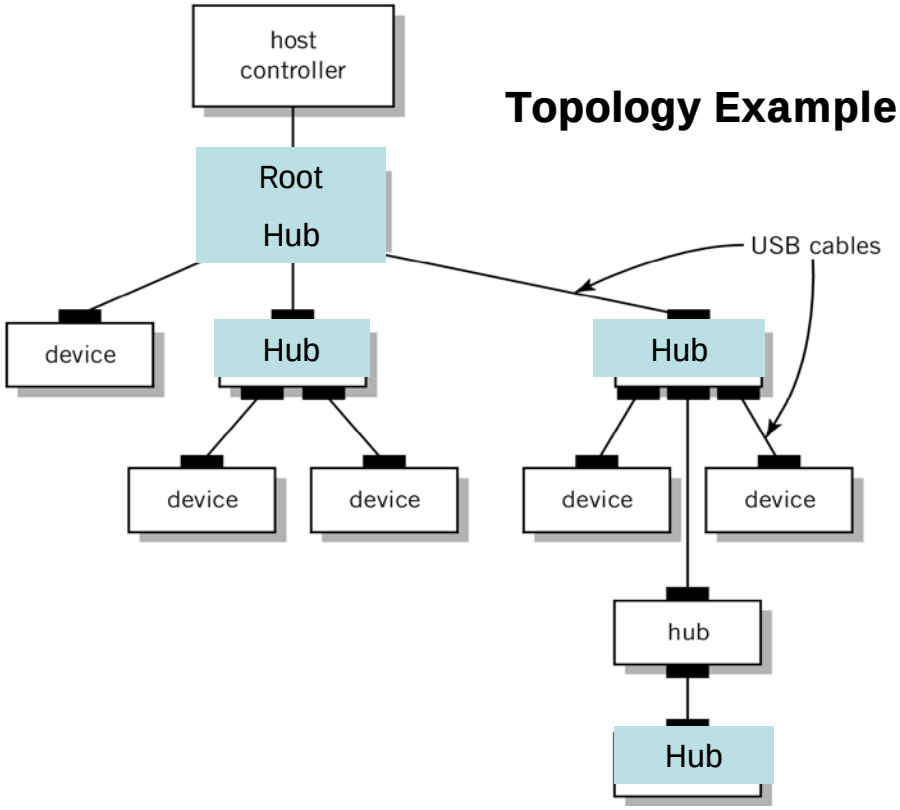
I/O Bus Architecture

- Consists of an I/O device, I/O device controller, system bus, and a device driver
- Device driver
  - Software that controls the I/O devices
- Common interface buses
  - USB – Universal Serial Bus
  - SCSI – Small Computer System Interface
  - SATA – Serial Advanced Technology Attachment
  - IEEE 1394 - Firewire

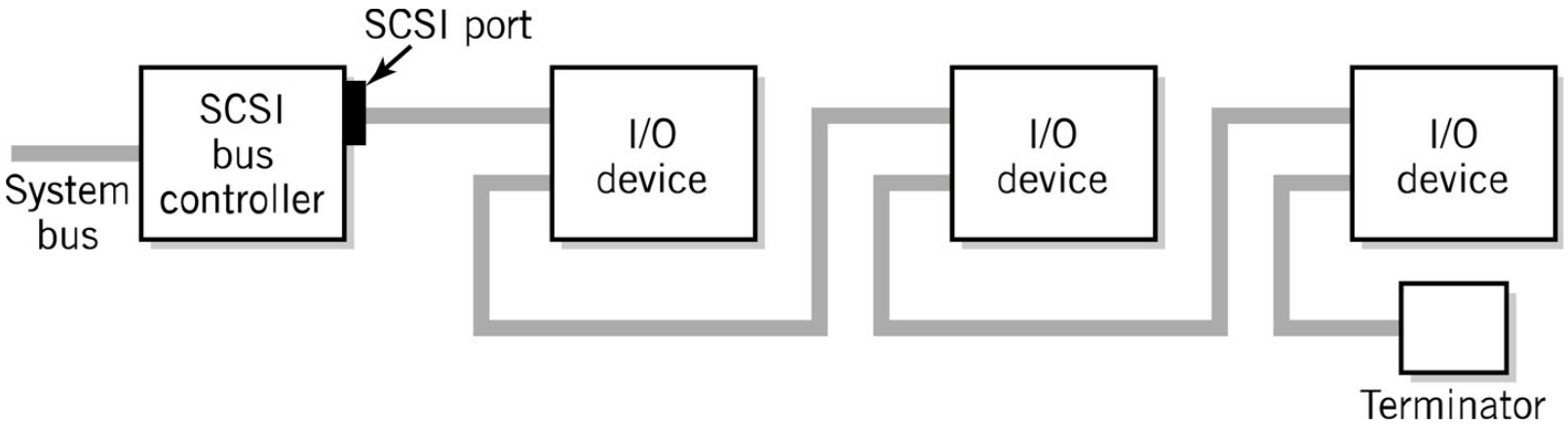
USB

- Multipoint bus
- **Hubs** provide multiple connection points for I/O devices
- Supports up to 127 devices
- USB-2 data transfer rate up to 480 Mbits per second



SCSI Bus

- ANSI standard but multiple variations
- Really an I/O bus rather than simple interface
  - Supports multiple devices from a single SCSI port



USB *and* FireWire (IEEE 1394)

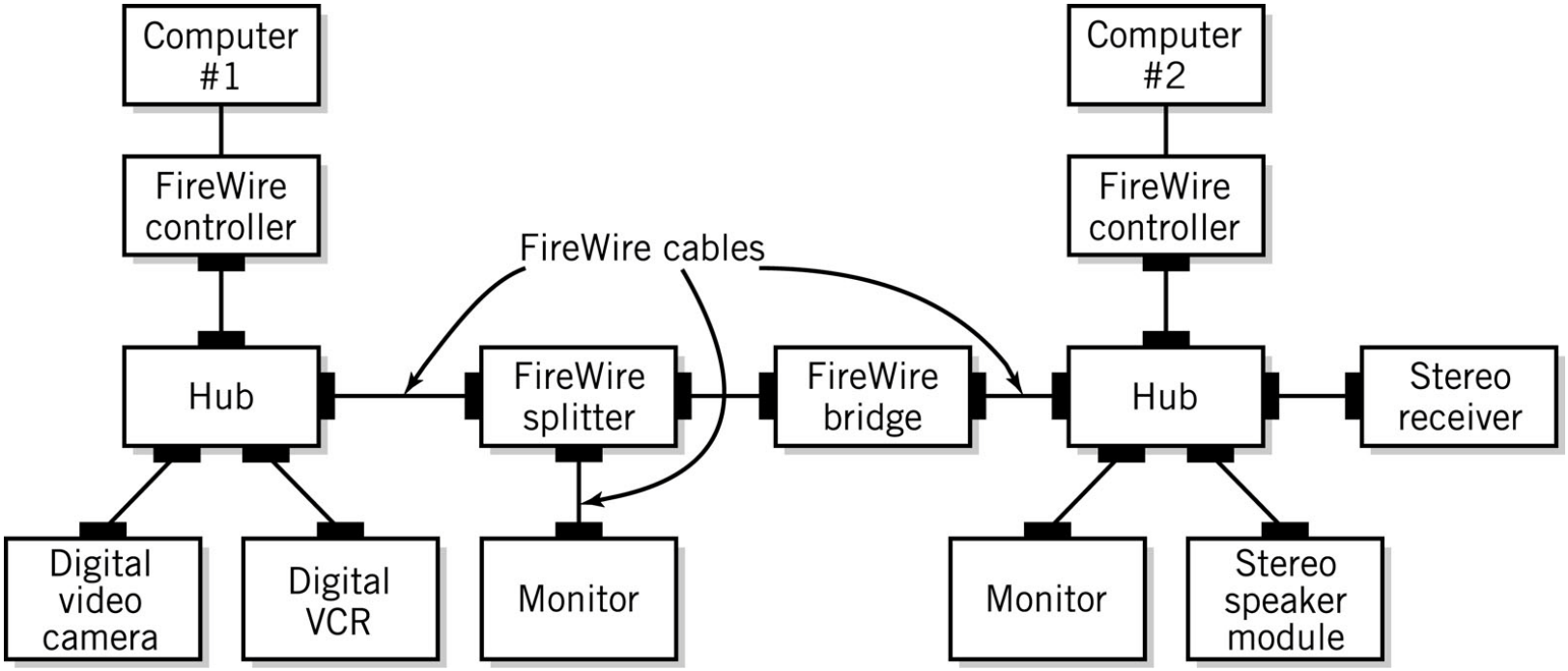
- Both serial, multipoint bus specifications
- Add/remove devices w/o powering down
- Packet protocol for isochronous data transfer
  - Isochronous: delivery at regular time intervals
  - Guarantee specified throughput

USB *vs.* FireWire

- USB-2: high-speed data transfer
  - 480Mbits/sec
- USB-3: proposed standard
  - Data transfer up to 4.8 Gbits per second
- FireWire: high-speed data transfer, i.e., full motion video with sound
  - 400 Mbits/sec to 3.2 Gbits/sec

Typical FireWire Configuration

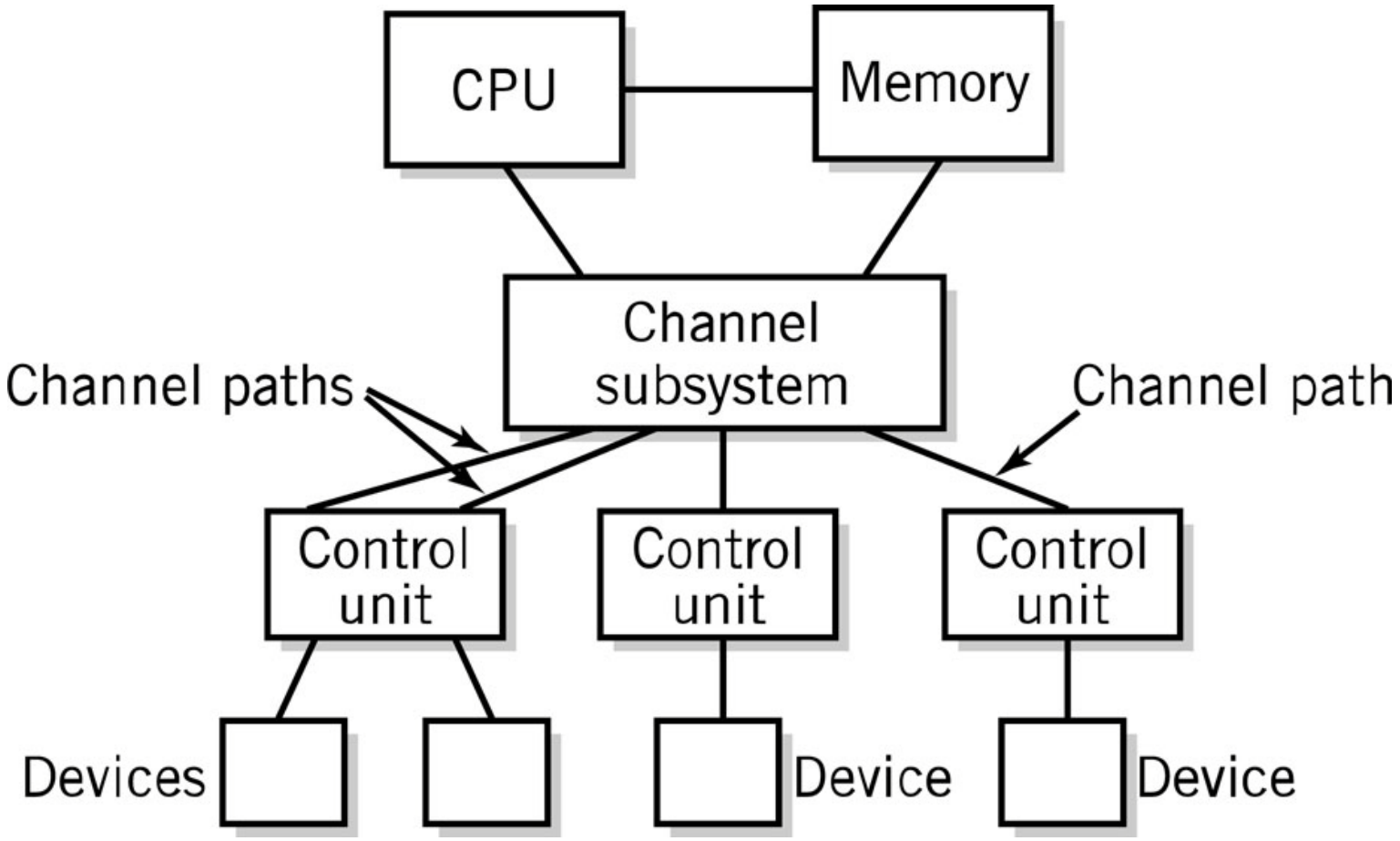
- Network-like characteristics
- Device controllers independent



Channel Architecture

- Used in IBM mainframe computers
- Channel subsystem
  - Separate I/O processor that serves as a CPU for I/O operations
  - Channel control words
  - Programs that transfer data between memory and an I/O device using DMA
- Subchannels
  - Connected to a control unit module through one or more channel paths
  - Similar role to a device controller

I/O Channel Architecture



Clusters

- Multi-computer systems
- Loosely-coupled computers
- Each system has its own CPU, memory, and I/O facilities
- Each system is known as a node of the cluster
- Two ways to configure
  - Shared-nothing model
  - Shared-disk model

Advantages of Clusters

- Increased computing power by combining the power of individual computer systems
  - Inherently scalable
  - Cheaper than using a single large computer
  - Used for high performance computing systems
- Fault-tolerance
  - Failure in one node does not bring down the entire system
  - Failover - processing by failed node is switched to other nodes
- High Availability
- Load Balancing
  - can be attained either through software and/or through geographically distributed location of nodes

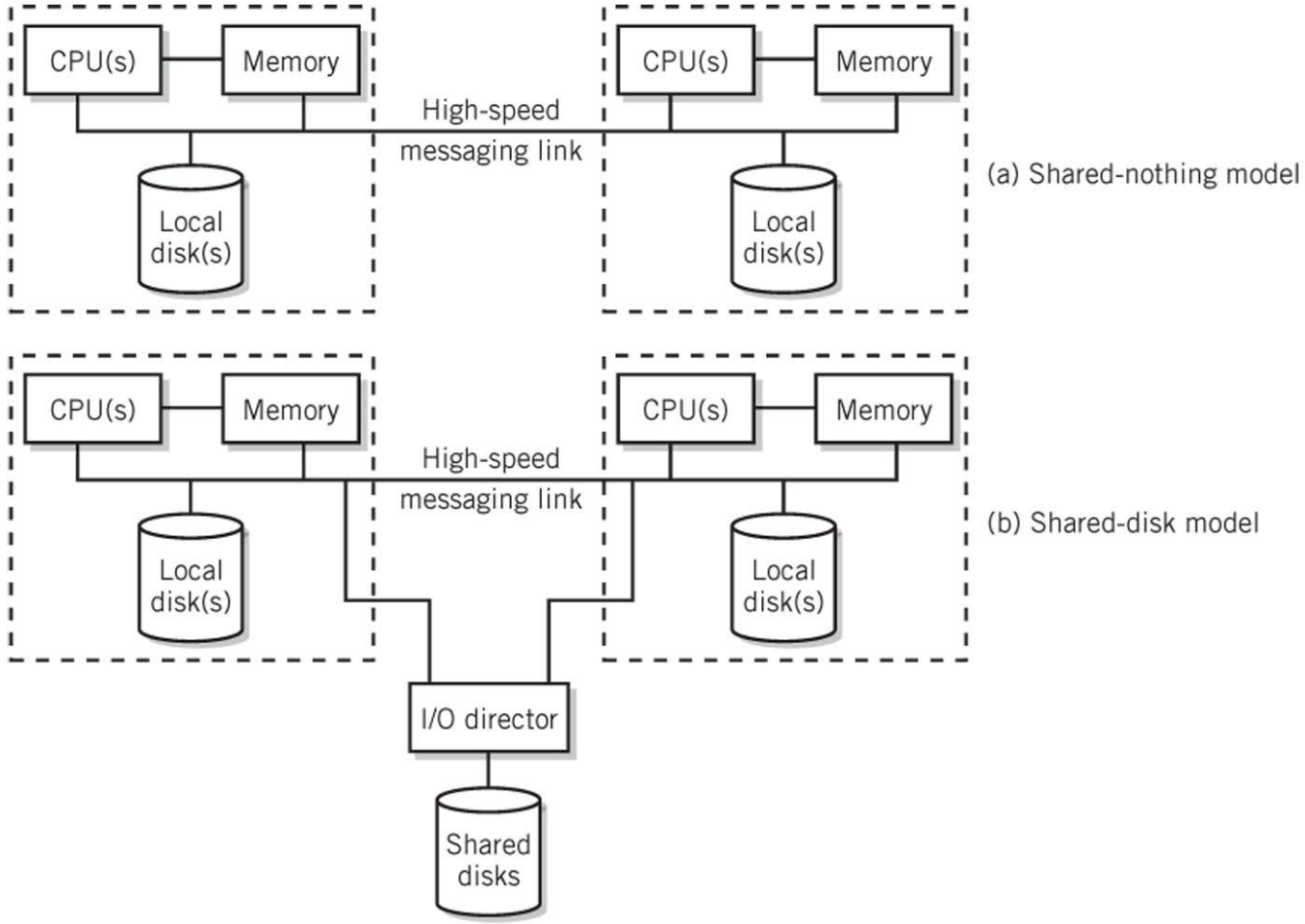
Shared-Nothing Model

- High speed link between nodes
- No sharing of resources
- Partitioning of work through division of data
- Advantage
  - Reduced communication between nodes
- Disadvantage
  - Can result in inefficient division of work

Shared-Disk Model

- High speed link between nodes
- Disk drives are shared between nodes
- Advantage
  - Better load balancing
- Disadvantage
  - Complex software required for transactional processing (lock, commit phases)

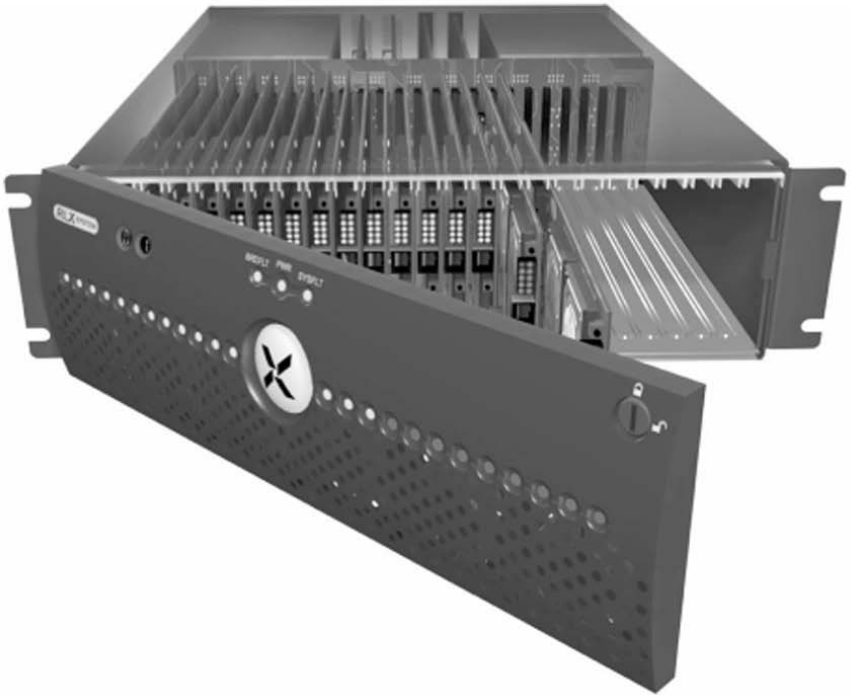
Cluster Models



Beowulf Clusters

- Simple and highly configurable
- Low cost
- Networked
  - Computers connected to one another by a private Ethernet network
  - Connection to an external network is through a single gateway computer
- Configuration
  - COTS – Commodity-off-the-shelf components such as inexpensive computers
  - Blade components – computers mounted on a motherboard that are plugged into connectors on a rack
  - Either shared-disk or shared-nothing model

Blade and Rack of Beowulf Cluster



High Performance Computing

- Also called supercomputing
- Clusters of power machines or larger Beowulf blade clusters
  - Well suited for problems that can be broken into subtasks
- Grid computing
  - Supercomputer performance through distributing CPU processing to the spare CPU cycles of personal computers connected to a network