Chapter Six
Storage, Networks, and Other Peripherals

6.1 Introduction

- I/O systems ➔ dependability and cost
- Processor and Memory ➔ Performance and cost
- I/O Characteristics:
  - Behavior (input, output, storage)
  - Partner: used by a human or a machine
  - Data rate: The peak rate at which data can be transferred

  Example: a keyboard is an input device used by a human with a peak data rate of about 10 bytes per seconds.

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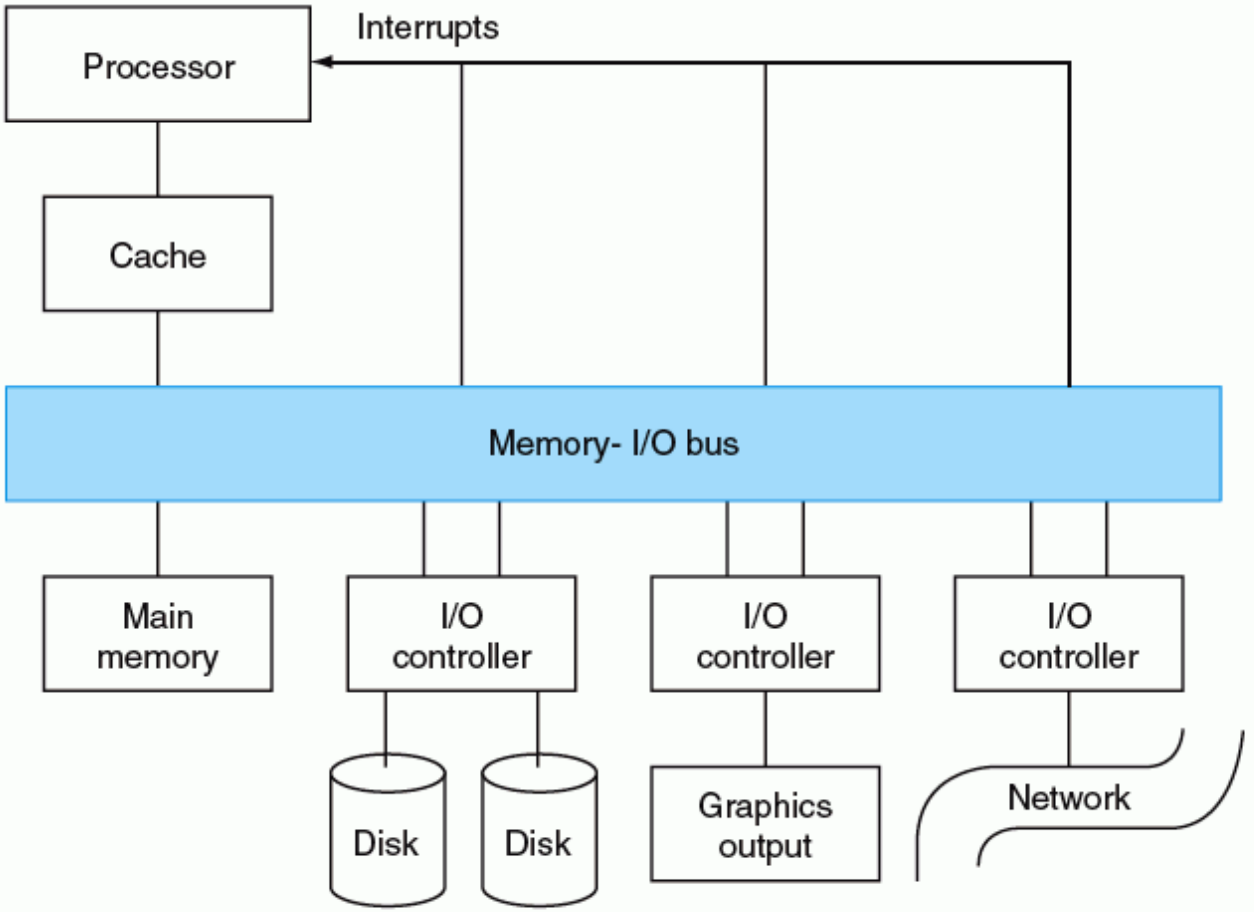

FIGURE 8.1 A typical collection of I/O devices. The connections between the I/O devices, pro-

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Device	Behavior	Partner	Data rate (Mbit/sec)
Keyboard	input	human	0.0001
Mouse	input	human	0.0038
Voice input	input	human	0.2640
Sound input	input	machine	3.0000
Scanner	input	human	3.2000
Voice output	output	human	0.2640
Sound output	output	human	8.0000
Laser printer	output	human	3.2000
Graphics display	output	human	800.0000–8000.0000
Modem	input or output	machine	0.0160–0.0640
Network/LAN	input or output	machine	100.0000–1000.0000
Network/wireless LAN	input or output	machine	11.0000–54.0000
Optical disk	storage	machine	80.0000
Magnetic tape	storage	machine	32.0000
Magnetic disk	storage	machine	240.0000–2560.0000

FIGURE 8.2 The diversity of I/O devices. I/O devices can be distinguished by whether they serve as

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- **I/o performance:**
  - **Throughput**
    1. How much data can we move through the system in a certain time?
    2. How many I/O operations can we do per unit of time?
  - **Response time:** total elapsed time
  - I/O dependability and cost:
    - Desktop and embedded systems are focused on response time and diversity of I/O.
    - Server systems are focused on throughput and expandability of I/O.

6.2 Disk Storage and Dependability

- **Platters: rotated at 5400 to 15000 RPM**
- **Tracks: 10,000 to 50,000 tracks/surface**
- **Sectors: each track may have 100 to 500 sectors. Sectors are 512 bytes**
- **Seek and Seek Time**

As the Disks rotate at 5400 to15000RPM, The Average rotational latency is between:

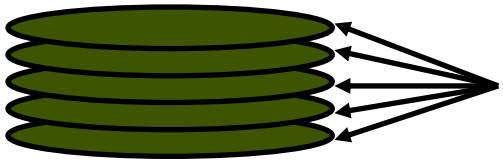
$$\text{Average rotational latency} = \frac{0.5 \text{ rotation}}{5400 \text{ RPM}} = \frac{0.5 \text{ rotation}}{5400 \text{ RPM} / \left(60 \frac{\text{seconds}}{\text{minute}}\right)}$$

$$= 0.0056 \text{ seconds} = 5.6 \text{ ms}$$

and

$$\text{Average rotational latency} = \frac{0.5 \text{ rotation}}{15{,}000 \text{ RPM}} = \frac{0.5 \text{ rotation}}{15{,}000 \text{ RPM} / \left(60 \frac{\text{seconds}}{\text{minute}}\right)}$$

$$= 0.0020 \text{ seconds} = 2.0 \text{ ms}$$



Platters

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Example: What is the average time to read or write a 512-byte sector for a typical disk rotating at 10,000 RPM?The advertised average seek time is 6ms, the transfer rate is 50 MB/sec, and the controller overhead is 0,2 ms.

Average disk access time = Average seek time **+** average rotational delay **+** Transfer time **+** Controller overhead

$$6.0\ \text{ms} + \frac{0.5\ \text{rotation}}{10{,}000\ \text{RPM}} + \frac{0.5\ \text{KB}}{50\ \text{MB/sec}} + 0.2\ \text{ms} = 6.0 + 3.0 + 0.01 + 0.2 = 9.2\ \text{ms}$$

If the measured average seek time is 25% of the advertised average time, the answer is

$$1.5\ \text{ms} + 3.0\ \text{ms} + 0.01\ \text{ms} + 0.2\ \text{ms} = 4.7\ \text{ms}$$

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Dependability, Reliability, and Availability:

- **Dependability**
- **Reliability:**
  - **MTTF**
  - $Failure\ rate = \frac{1}{MTTF}$
  - **MTBF = MTTF + MTTR**
- **If a collection of modules has exponentially distributed lifetimes - meaning that the age of a module is not important in probability of failure – the overall failure rate of the collection is the sum of the failure rates of the modules.**

$$\text{Availability} = \frac{\text{MTTF}}{(\text{MTTF} + \text{MTTR})}$$