I/O System

- This module begins an overview of I/O
  - How computers handle I/O transactions
  - The I/O system infrastructure
    - Device controllers
    - I/O bus systems
- Functionality as well as performance are important
    - Access to networks and the internet
    - The use of a rich variety of devices
    - Digital cameras
    - Music players
    - Video display devices
    - Printers
    - Storage devices

I/O System

- I/O affects the overall system performance
  - I/O devices are even slower than central memory
  - Overlapping I/O with computation can hide the slowness
- Amdahl's Law applies to I/O as well
  - Limiting the amount of I/O boosts performance
- I/O is defined as a subsystem of components
  - These components move coded data
  - The exchange is between external devices and a host system

I/O System Performance

- I/O performance is measured in two ways:
  - I/O throughput or bandwidth
  - I/O transactions per unit time
- Bandwidth (bytes per second)
  - Depends on clock rate and width of data pathways
  - Important when large amounts of data need to be exchanged
- Transactions per second (TPS)
  - Important when numerous small data exchanges are made

I/O System Performance

- Overall system performance depends on the interaction of all of its components
- Improving the most heavily used components is most effective
- This idea is quantified by Amdahl's Law:

$$S = \frac{1}{(1-f) + \frac{f}{k}}$$

S is the overall speedup;
f is the fraction of work performed by a faster component; and
k is the improvement of the faster component
Example: if a component is made 100% faster, then k=2.

Example

Facts:

Processes spend 70% of their time running on the CPU and 30% of their time waiting for disk service

Options:

make the CPU 50% faster for $10,000

make the disk drives 150% faster for $7,000

Question:

Which option would be better based on benefit and cost?

I/O System Performance

- The processor option offers a 30% speedup:

$$f = 0.70, \quad k = 1.5 \qquad S = \frac{1}{(1 - 0.7) + 0.7/1.5} = 1.30$$

- And the disk drive option gives a 22% speedup:

$$f = 0.30, \quad k = 2.5 \qquad S = \frac{1}{(1 - 0.3) + 0.3/2.5} = 1.22$$

- Each 1% of improvement for the processor costs $333 (10000/30), and for the disk a 1% improvement costs $318 (7000/22).