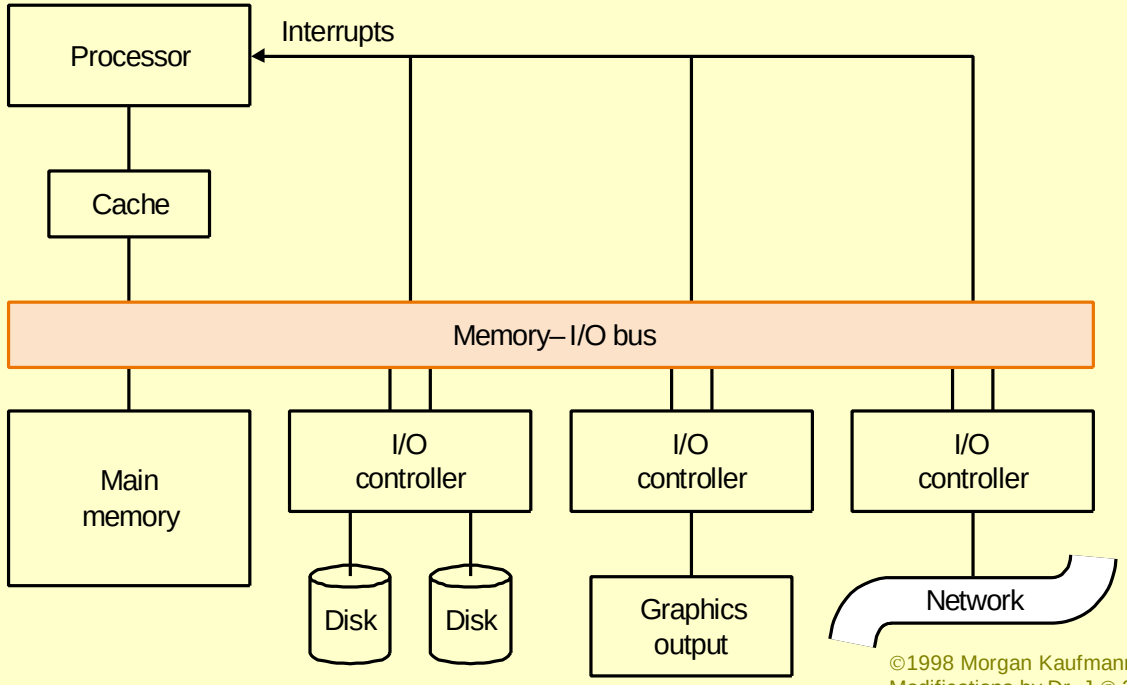
Interfacing Processors and Peripherals

- I/O Design affected by many factors (expandability, resilience)
- Performance:
  - — access latency
  - — throughput
  - — connection between devices and the system
  - — the memory hierarchy
  - — the operating system
- A variety of different users (e.g., banks, supercomputers, engineers)



I/O

- **Important but neglected**

  "The difficulties in assessing and designing I/O systems have often relegated I/O to second class status"

  "courses in every aspect of computing, from programming to computer architecture often ignore I/O or give it scanty coverage"

  "textbooks leave the subject to near the end, making it easier for students and instructors to skip it!"

- **GUILTY!**

  — we won't be looking at I/O in much detail

  — be sure and read Chapter 8 in its entirety.

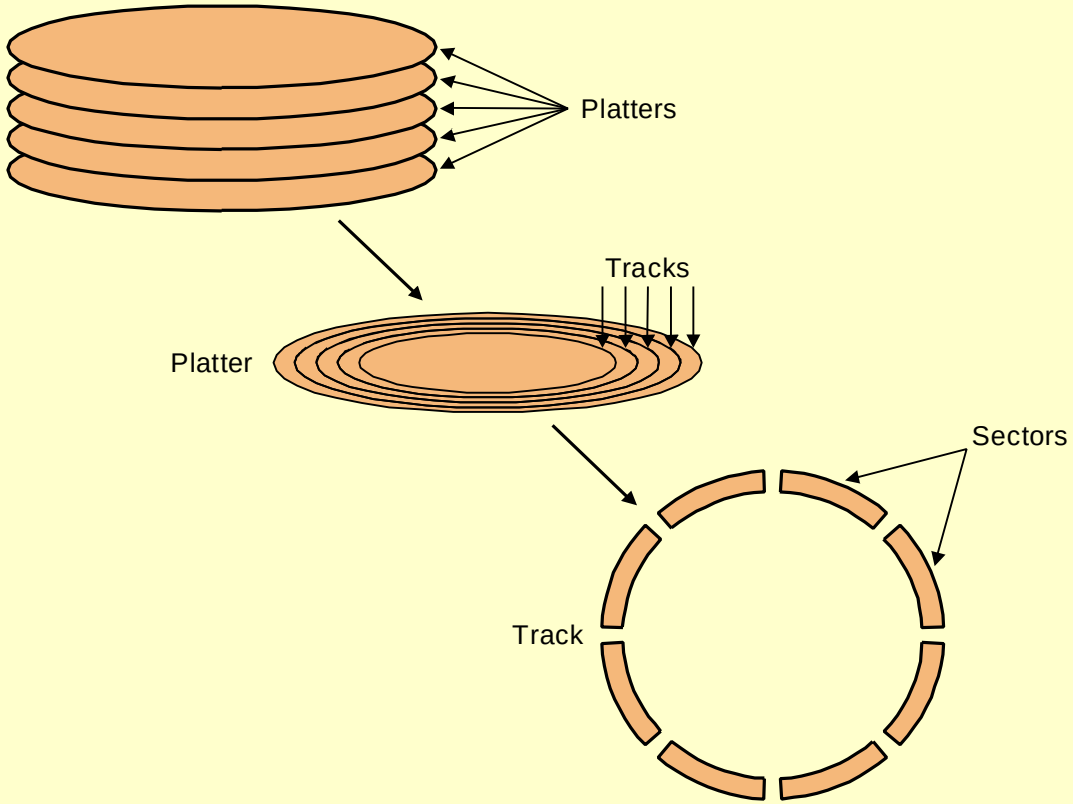
  — you should probably take a networking class!

I/O Devices

- **Very diverse devices**
  - **— behavior (i.e., input vs. output)**
  - **— partner (who is at the other end?)**
  - **— data rate**

Device	Behavior	Partner	Data rate (KB/sec)
Keyboard	input	human	0.01
Mouse	input	human	0.02
Voice input	input	human	0.02
Scanner	input	human	400.00
Voice output	output	human	0.60
Line printer	output	human	1.00
Laser printer	output	human	200.00
Graphics display	output	human	60,000.00
Modem	input or output	machine	2.00-8.00
Network/LAN	input or output	machine	500.00-6000.00
Floppy disk	storage	machine	100.00
Optical disk	storage	machine	1000.00
Magnetic tape	storage	machine	2000.00
Magnetic disk	storage	machine	2000.00-10,000.00

I/O Example: Disk Drives

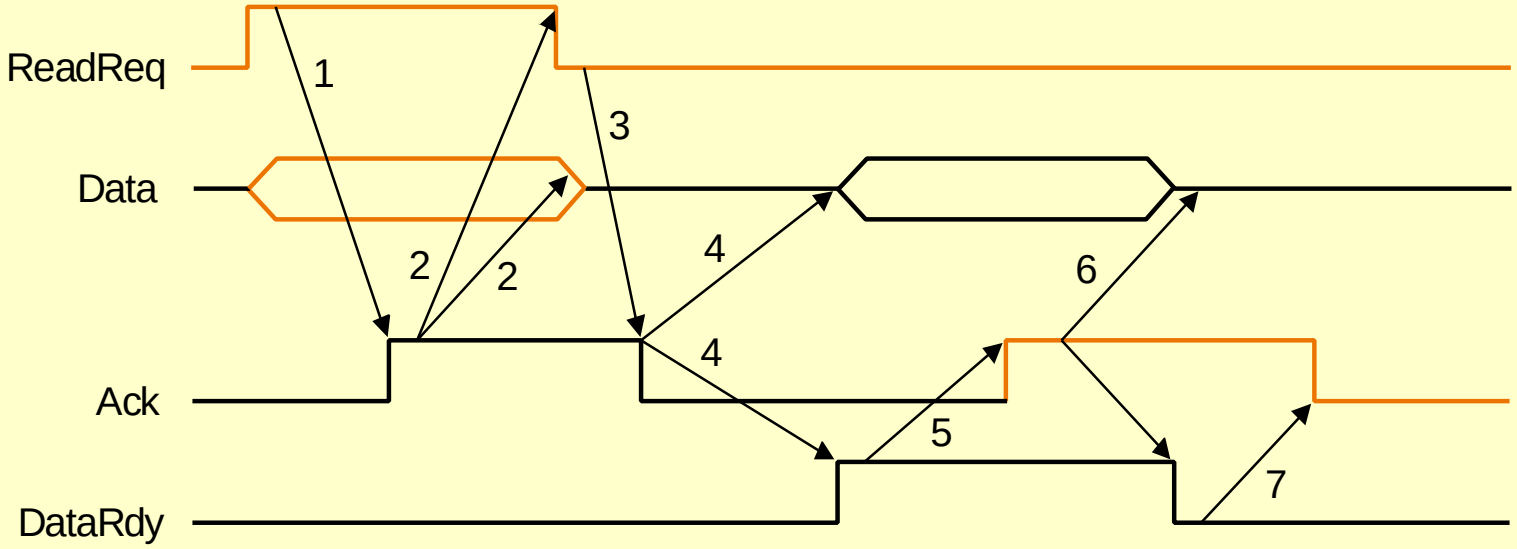


- **To access data:**
  - **— seek: position head over the proper track (8 to 20 ms. avg.)**
  - **— rotational latency: wait for desired sector (.5 / RPM)**
  - **— transfer: grab the data (one or more sectors) 2 to 15 MB/sec**

I/O Example: Buses

- Shared communication link (one or more wires)
- Difficult design:
  - — may be bottleneck
  - — length of the bus
  - — number of devices
  - — tradeoffs (buffers for higher bandwidth increases latency)
  - — support for many different devices
  - — cost
- Types of buses:
  - — processor-memory (short high speed, custom design)
  - — backplane (high speed, often standardized, e.g., PCI)
  - — I/O (lengthy, different devices, standardized, e.g., SCSI)
- Synchronous vs. Asynchronous
  - — use a clock and a synchronous protocol, fast and small
    but every device must operate at same rate and
    clock skew requires the bus to be short
  - — don't use a clock and instead use handshaking

Some Example Problems



- **Let's look at some examples from the text**

  "Performance Analysis of Synchronous vs. Asynchronous"
  "Performance Analysis of Two Bus Schemes"

Other important issues

- **Bus Arbitration:**
  - **— daisy chain arbitration (not very fair)**
  - **— centralized arbitration (requires an arbiter), e.g., PCI**
  - **— self selection, e.g., NuBus used in Macintosh**
  - **— collision detection, e.g., Ethernet**
- **Operating system:**
  - **— polling**
  - **— interrupts**
  - **— DMA**
- **Performance Analysis techniques:**
  - **— queuing theory**
  - **— simulation**
  - **— analysis, i.e., find the weakest link (see "I/O System Design")**
- **Many new developments**