

Input / Output

CSE 410 - Computer Systems
October 29, 2001

Readings and References

- Reading
 - Sections 8.1-8.3, *Computer Organization & Design*, Patterson and Hennessy
- Other References

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Why Input and Output?

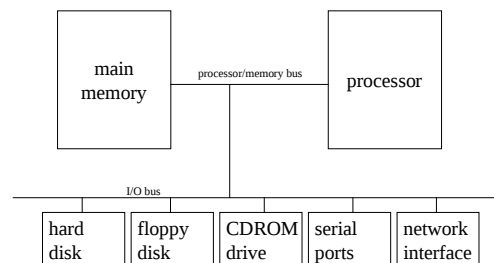
- Everything we have done so far is based on moving data / instructions between main memory and the CPU
- How does the information get into main memory and out to the user?
 - during manufacture: burn it in
 - during operation: input / output

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Types of I/O devices

- Behavior
 - input only (keyboard, mouse, sensor)
 - output only (monitor, LED display, actuator)
 - input and output (network, disk, tape, CD-RW)
- Partner
 - human or machine
- Data rate
 - negligible to KiloBytes/Second to MegaB/S

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Three Characteristic Devices

- Mouse
 - input only; human; .01-.02 KB/s
- Magnetic disks
 - input and output; machine; 100-10,000 KB/s
- Networks
 - input and output; machine; 500-6000 KB/s

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Detecting Mouse Motion

- Mechanical
 - Two perpendicular wheels on the inside connected to potentiometers
- Optical
 - LED and a photodetector on the bottom
- Optomechanical
 - The wheels have slots; an LED shines through them
- Lots of others
 - embedded microprocessor in the mouse

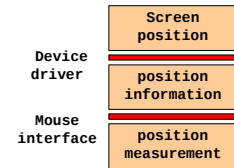
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Mouse Interfaces

- Pointing device must provide
 - Status of each button
 - Position in X and Y
- Software must interpret the input
 - Double clicks
 - Limits to motion, speed

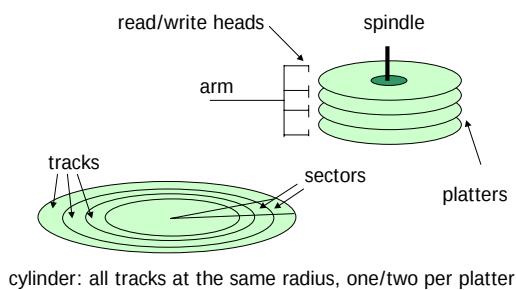


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Anatomy of a Magnetic Disk



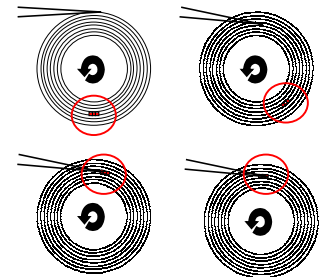
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Accessing Data from a Disk

- First, the disk arm moves over the right cylinder: *seek time*
- Next, wait for the data to rotate under the disk arm: *rotational delay*, (on average half the time for one revolution)
- Finally, read the data from the disk: *transfer time*
- At this point, the data is in the *disk controller* and can be transferred to memory



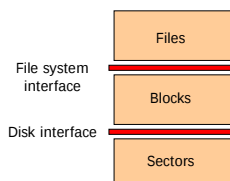
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Disk Interface

- Only two data transfer operations on a disk:
 - read block, write block
- Hidden behind the interface:
 - block ↔ sector mappings
- Unknown to the disk:
 - contents of the blocks/sectors



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Disk Specifications

- Consider the disk in my laptop
 - 5GB IBM DJSA-205 (from device manager)
- Specifications (from IBM data sheet)
 - rotation speed 4200 RPM
 - rotational delay = $60 \times \frac{1}{4200} \times 0.5 = 7.1 \text{ ms}$
 - seek times
 - avg: 12.0 ms, 1 track: 2.5 ms, full stroke: 23.0 ms
 - layout
 - heads: 1, cylinders: 22784 (user), 10336 (actual)
 - sectors per track: 293-560

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Data Transfer Specifications

- Data buffer
 - 512 Kbytes on board the disk
- Media Transfer rate
 - 108.8 to 202.9 Mbits / sec
- Interface Transfer rate
 - Ultra-DMA mode 4: 66.6 Mbytes/sec
 - PIO mode 4: 16.6 Mbytes/sec

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Networks

- The device that lets a system connect to a network: *network interface card*
- Listens for data on the network important to this system
- Bundles the bits into packets and signals the OS when a packet is complete
- Also takes packets from OS and sends them as bits on the wire

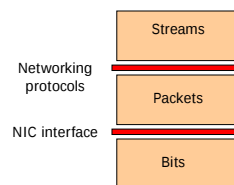
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Networking Interfaces

- OS puts extra packets in to define where stream begins and ends
- NIC puts extra bits in to define where packets begin and end

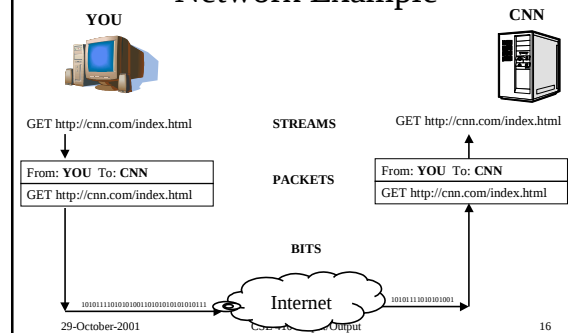


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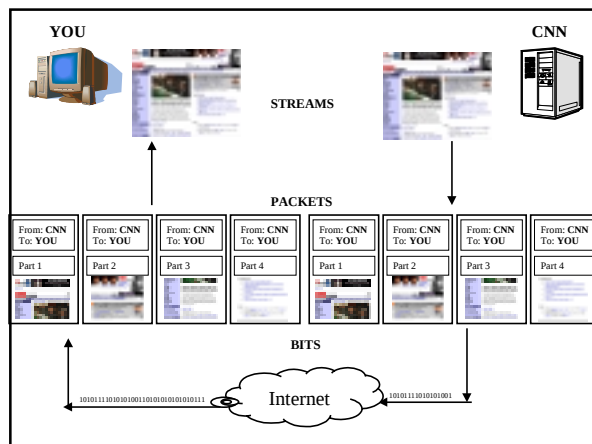
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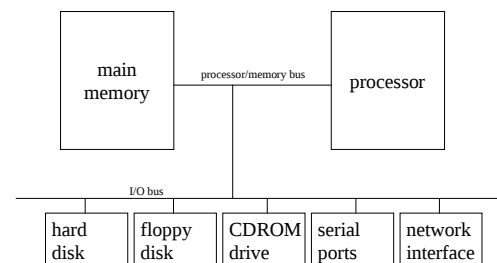
Network Example



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Commands to I/O Devices

- Memory-mapped I/O
 - A special region of memory is set aside for a device
 - Loads and stores to addresses in this region are interpreted as commands to the device
 - Provides easy access control via the memory system
- Special I/O instructions

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Device to Processor

- The device has some information for the processor. Two ways to convey it:
 - Issue an interrupt
 - Wait for the processor to ask for it - *polling*
- Which is better, interrupt-driven I/O or polling? Depends on:
 - time sensitivity of data
 - whether data is expected

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Device to Memory

- *Direct Memory Access (DMA)* allows devices and memory to communicate without involvement of processor
- Processor sets up the transaction
- Device and memory transfer the data
- Device interrupts processor to signal completion
- The processor gets a lot of other work done while transfer is happening

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Performance Issues in I/O

- Processors double in speed every 18 months
- Networks double in speed more slowly, perhaps every 3 years
- Disks improve more slowly, because they are limited by mechanical factors
 - however, bit density has gone up rapidly

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The I/O Bottleneck

- System A: processor speed = 100 MHz; disk transfer takes 10 ms
 - How many clock cycles elapse while disk transfer takes place?
- System B: processor speed = 400 MHz; disk transfer *still* takes 10 ms
 - How many clock cycles now?

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