24 April

- **2 to go!**
- **Questions?**
- **Interrupts and I/O devices**

Interrupts

How does the CPU manage SLOW **I/O devices?**

1. **Programmed I/O**
2. **Interrupt Driven I/O**

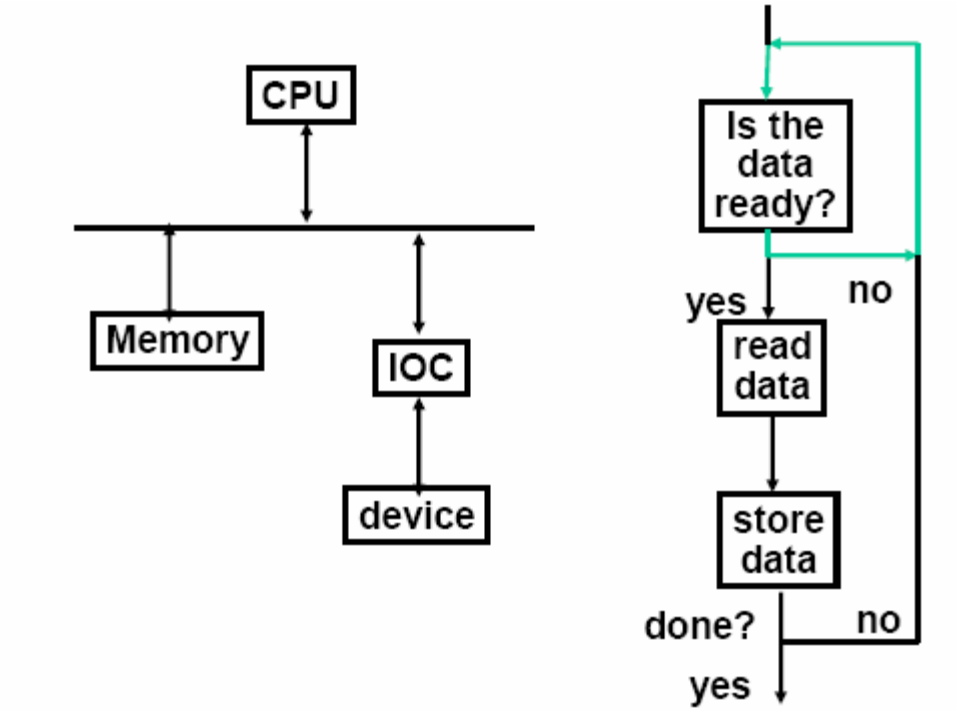
Polling

Advantages

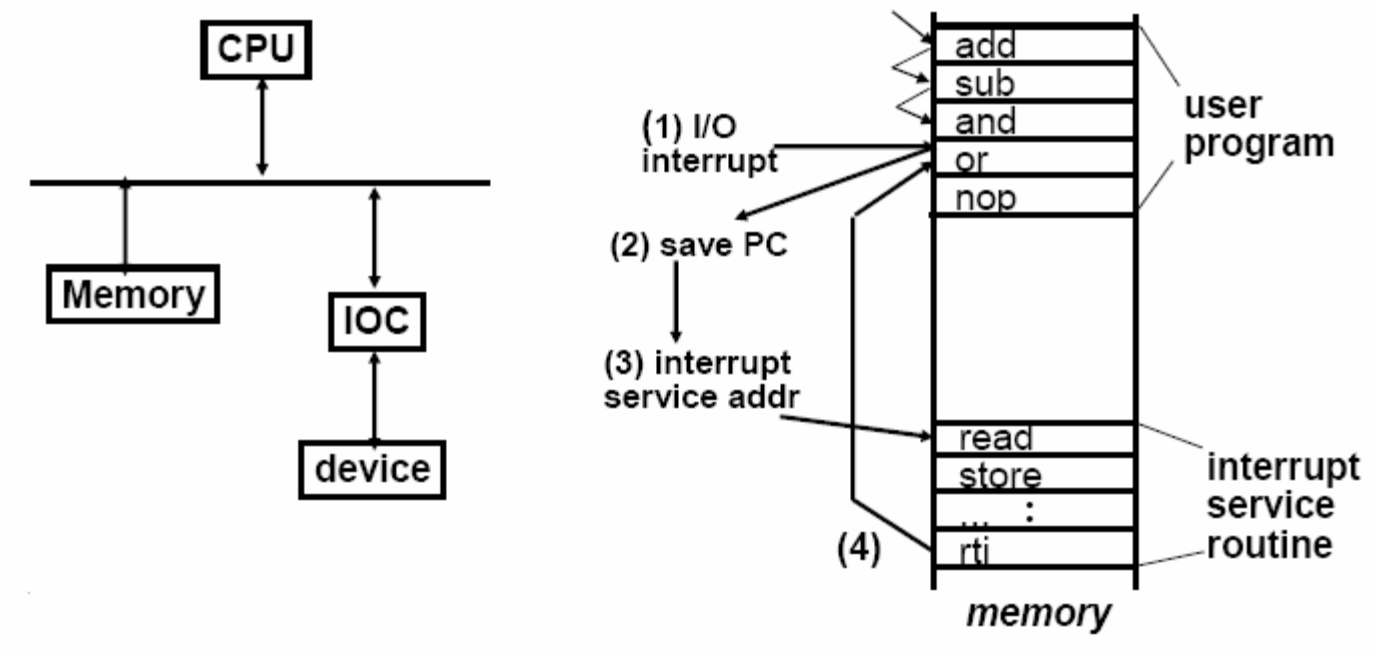
- Simple
- No surprises
- Processor in full control

Disadvantages

- Polling can waste lots of time



Interrupt Driven I/O



Advantage

CPU only bothered when actually needed

Disadvantage

Can occur at surprising or inconvenient times

Have to save and restore state

MIPS Exceptions

- Reset
- Hardware Errors (Check, Bus Error, Cache Error)
- External Interrupt (6 inputs)
- Address Error
- Reserved Instruction
- TLB Miss
- System Call
- Breakpoint
- Trap
- Integer Overflow
- Floating Point Error
- Timer
- And a few more

Exception Processing

1. EPC gets address of faulty instruction or of next instruction depending on type of exception
2. Switch to kernel mode
3. Jump to a new location based on type of exception
   - PC ← FFFF FFFF BFC0 0000 for Reset
   - PC ← FFFF FFFF BFC0 0300 for Hardware error
   - PC ← FFFF FFFF BFC0 0380 for external interrupts
   - PC ← FFFF FFFF BFC0 0400 for …
4. Save registers
5. Examine the "cause" register to find out why you came here
6. Branch to code to do the right thing

Magnetic Disk

Long term, nonvolatile storage

Large, inexpensive, and slow

Rotating platter(s) coated with magnetic material

Use a movable read/write head to access

When magnetized region zips past coils in head, a tiny signal is produced

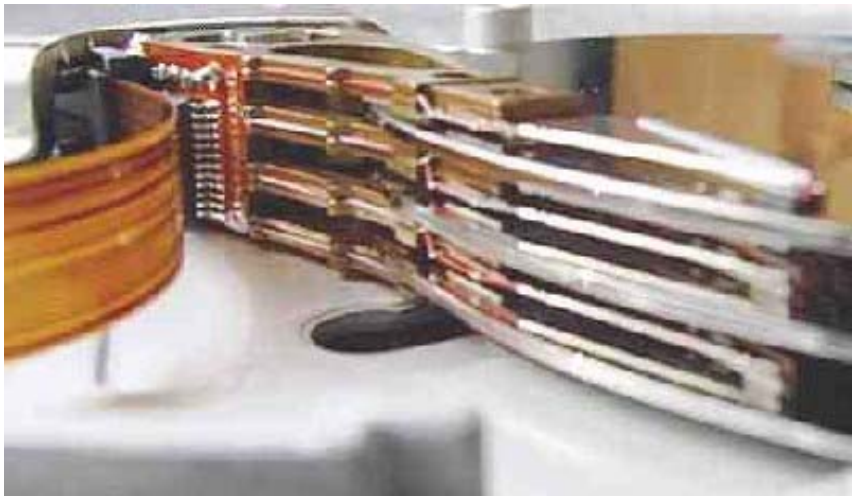
Force current through coils to generate magnetic field to magnetize tiny regions on the disk

Use feedback to keep the head in the right place

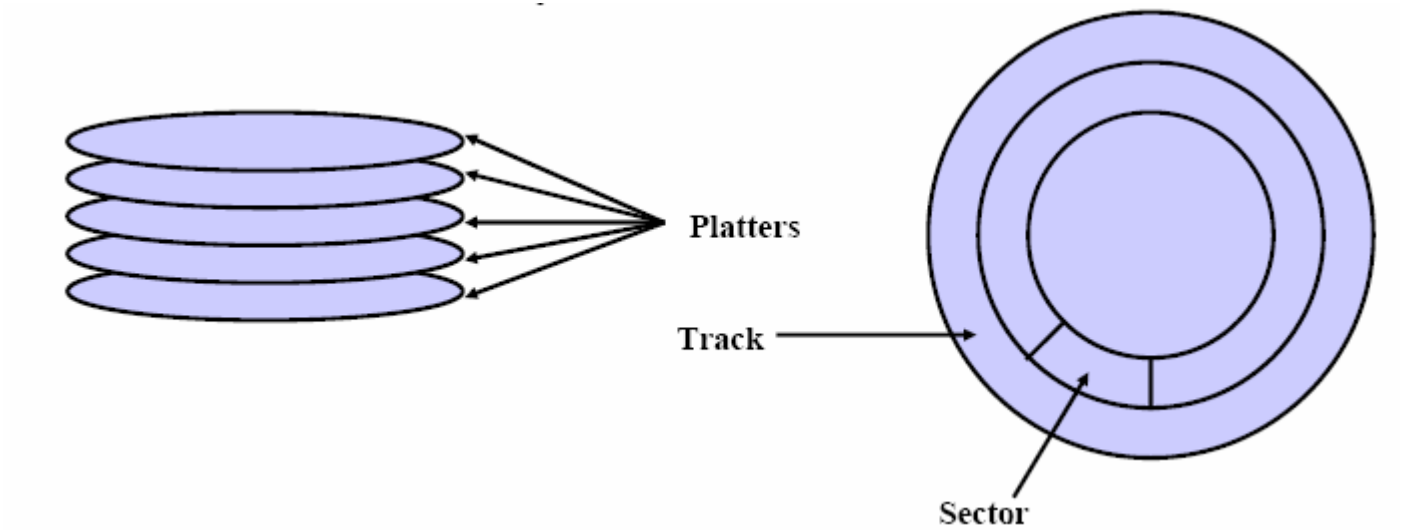
Outside

Inside

Platters and Heads



Magnetic Disk Organization

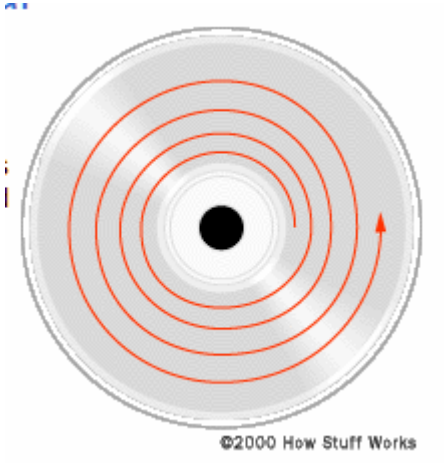


- Cylinder: All tracks under head with arm in a fixed position
- Read/Write time has 3 components
  - Seek time to move the arm
  - Rotational latency: wait for the desired sector to come by
  - Transfer time: transfer bits

Typical Disk Times

- **Average Seek: 8ms to 12ms**
  - **Sum of all possible seek / number of possible seeks**
  - **Locality reduces this to maybe only 25% of average number**
- **Rotational Latency:**
  - **At 5400 RPM → 11 ms**
  - **At 7200 RPM → 8 ms**
  - **At 10000 RPM → 6ms**
- **Transfer time depends on:**
  - **Transfer size (typical 512 bytes)**
  - **Rotation speed**
  - **Recording density**
  - **Diameter**
  - **Typical values: 10 to 40MBytes per second**

CD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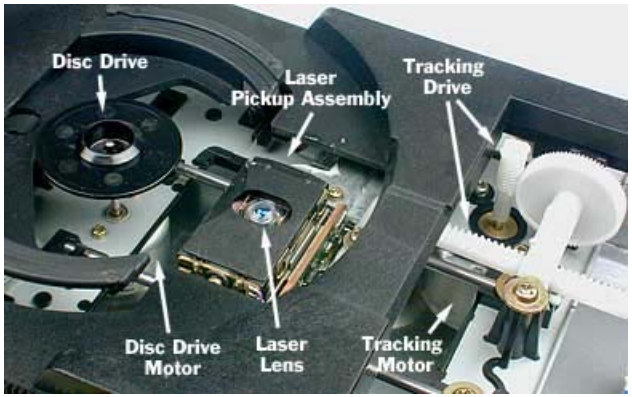
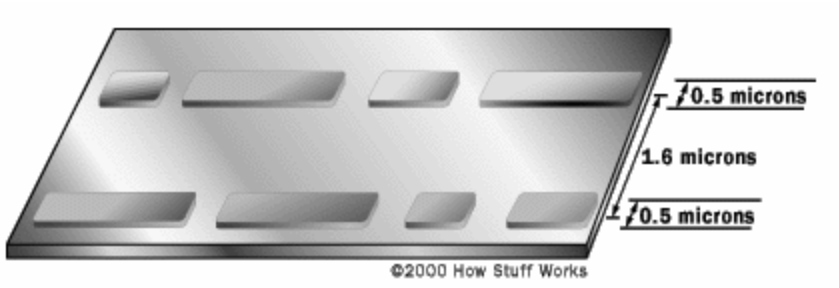
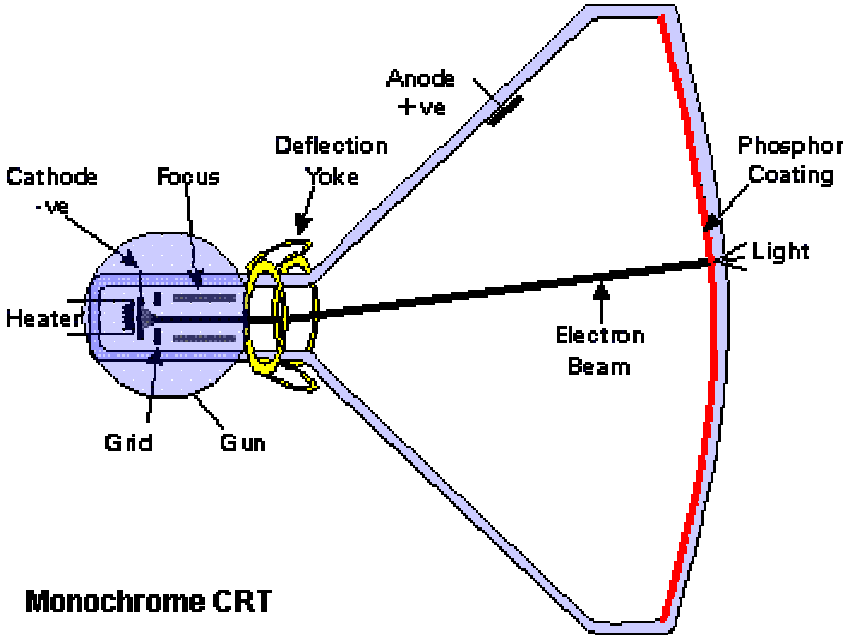
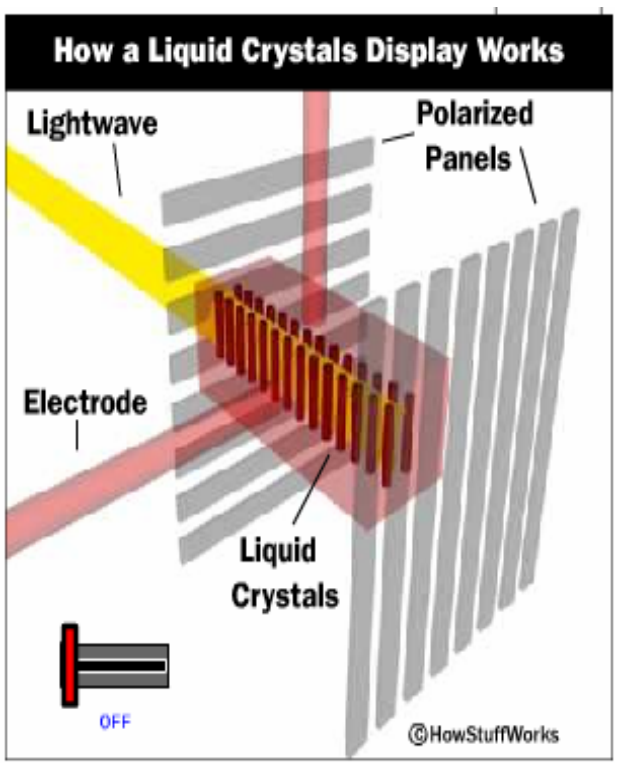

Disc Drive
Laser Pickup Assembly
Tracking Drive
Disc Drive Motor
Laser Lens
Tracking Motor


0.5 microns
1.6 microns
0.5 microns
©2000 How Stuff Works

CRT Display


Anode
+ve
Deflection
Yoke
Phosphor
Coating
Cathode
-ve
Focus
Light
Heater
Electron
Beam
Grid
Gun
Monochrome CRT

LCD


How a Liquid Crystals Display Works
Lightwave
Polarized
Panels
Electrode
Liquid
Crystals
OFF
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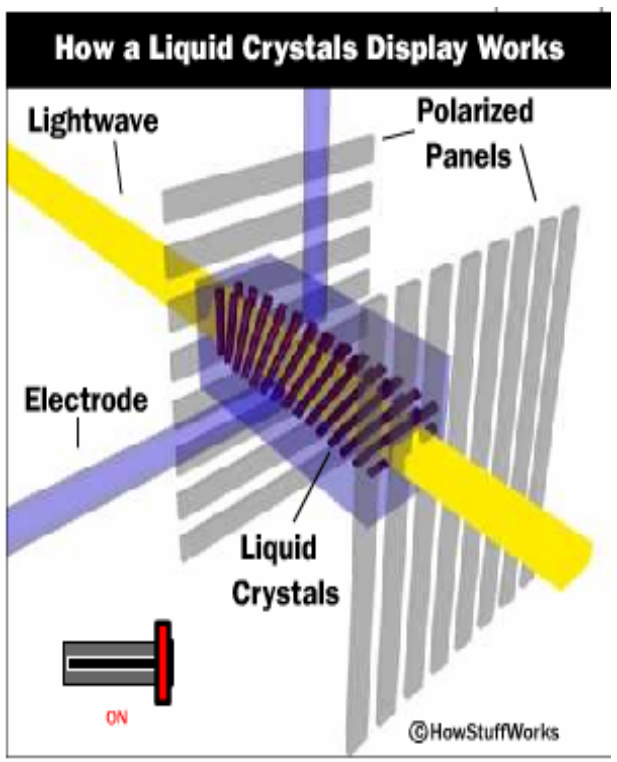
How a Liquid Crystals Display Works
Lightwave
Polarized
Panels
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Liquid
Crystals
ON
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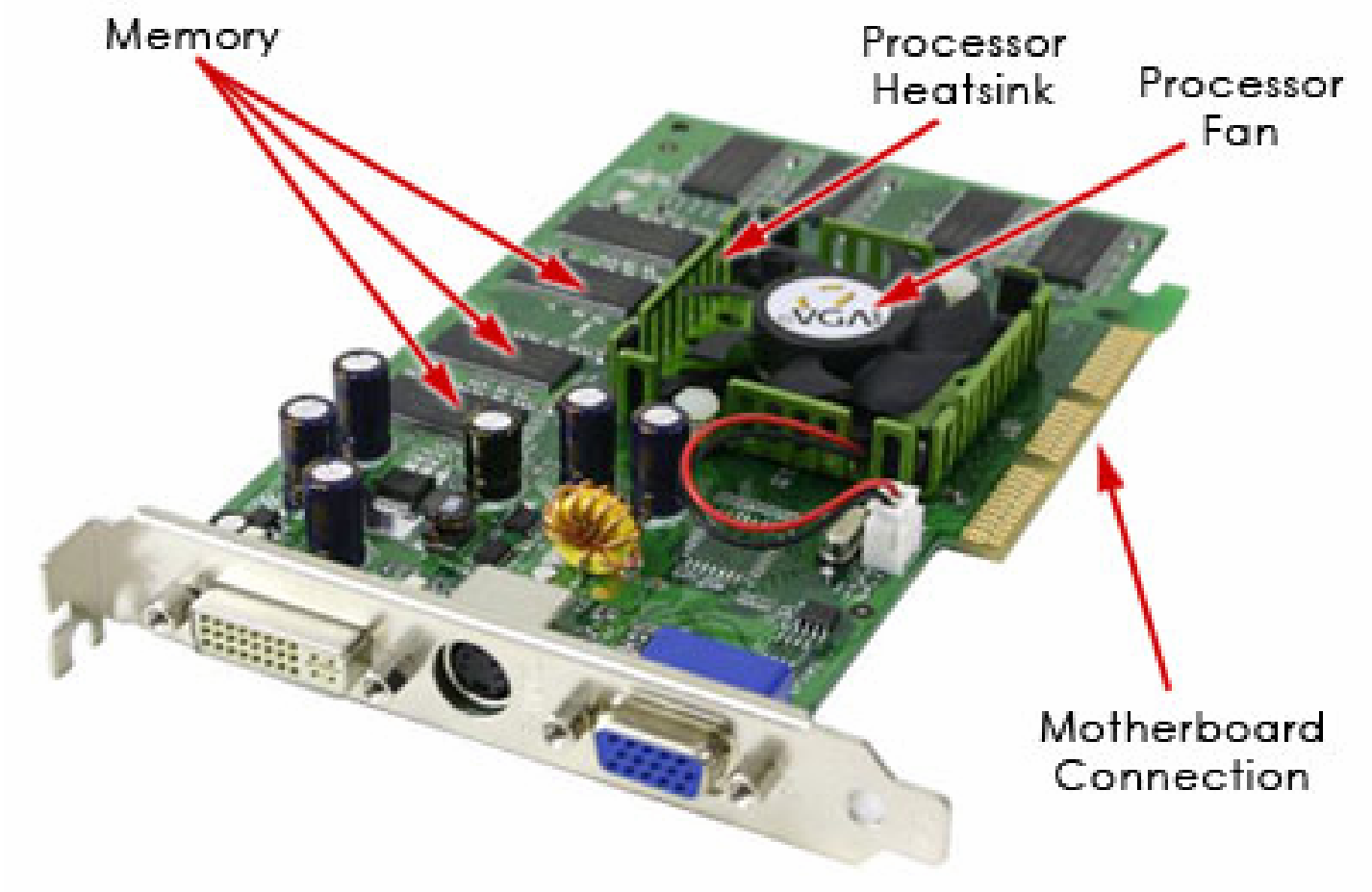
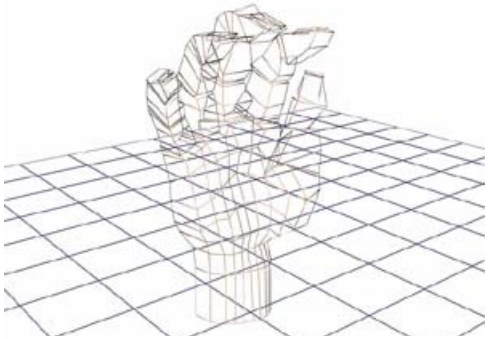
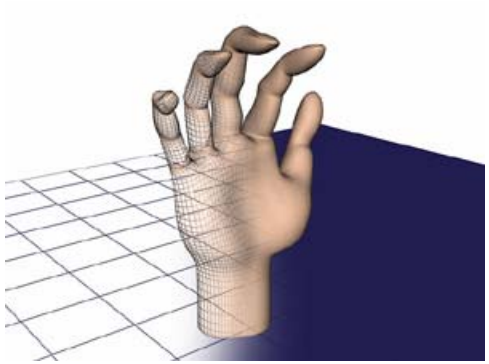
Graphics Cards

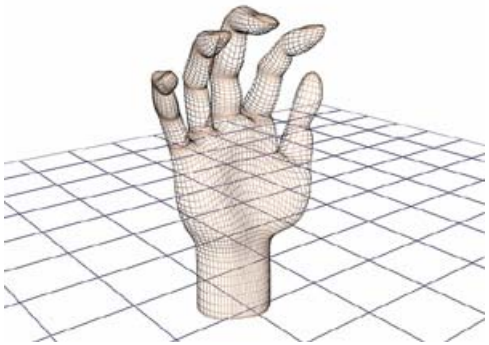


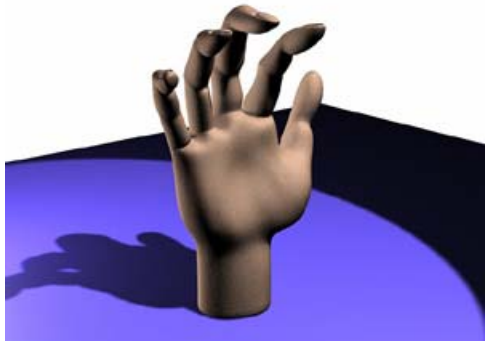
Polygons to Surfaces

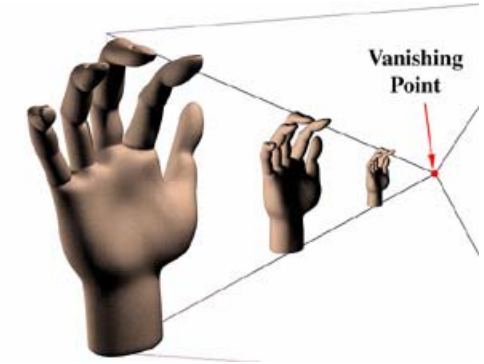
- Numerical coordinates specify vertex positions in 3D
- Matrix multiply transforms 3D coordinates to eye coordinates
- Divide projects 3D to 2D in perspective
- Pixel processors fill polygons with appropriate colors based on lighting model



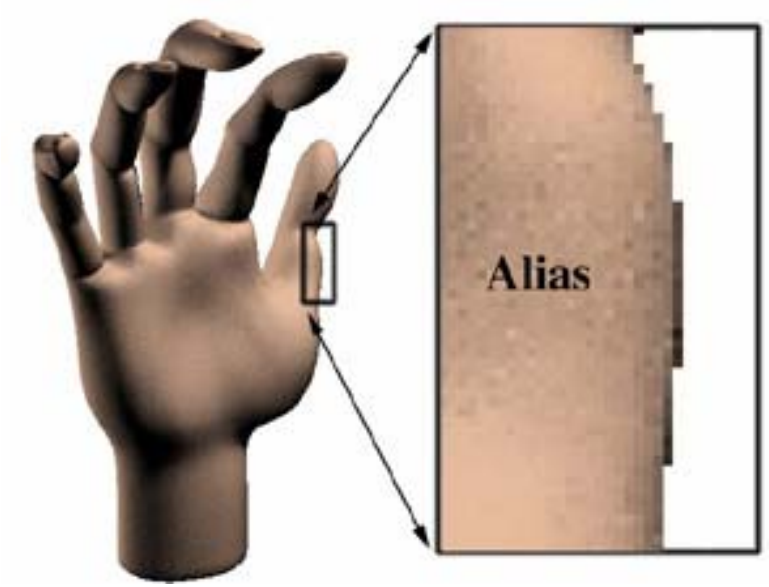


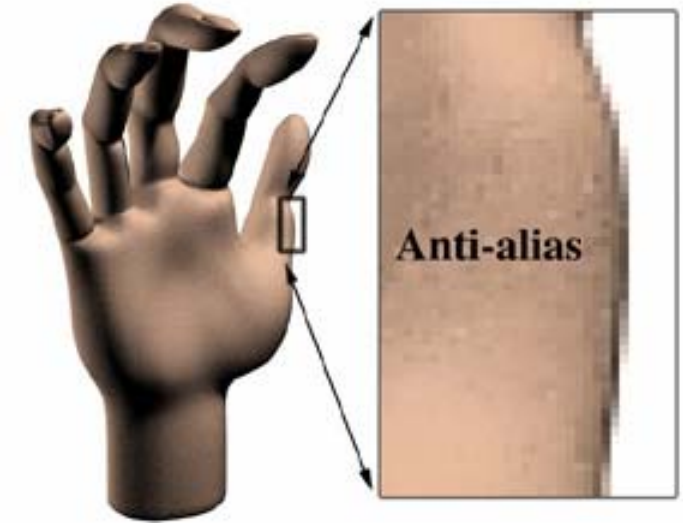




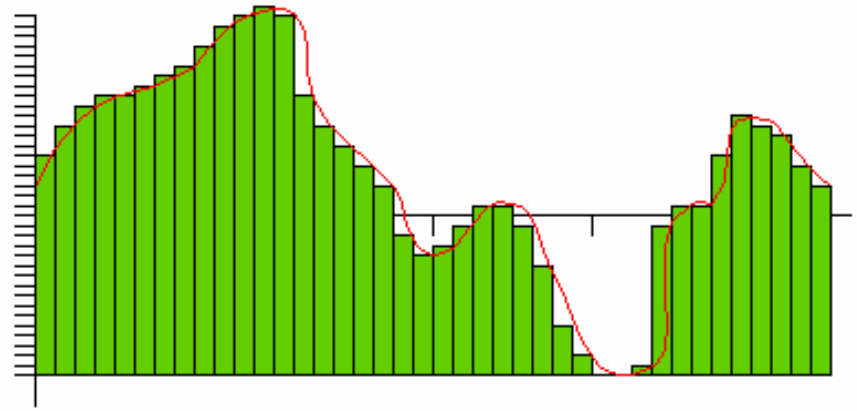


Anti-aliasing





Sound



Sound is variations in air pressure

A microphone converts these into an analog electrical signal

An analog-to-digital converter samples this at frequent intervals

The resulting numbers are stored in a file (.wav)

On playback a digital-to-analog converter changes these numbers into an analog electrical signal

And the moving cone of a speaker converts this into varying air pressure

MP3?

- **The sequence of numbers representing typical sounds is** VERY **redundant**
  - **The next value is closely related to the previous**
  - **Values aren't random cause we don't like noise**
- **Extract this redundancy to get compression**
- **Lossy compression: Throw less important info away cause listener won't notice**