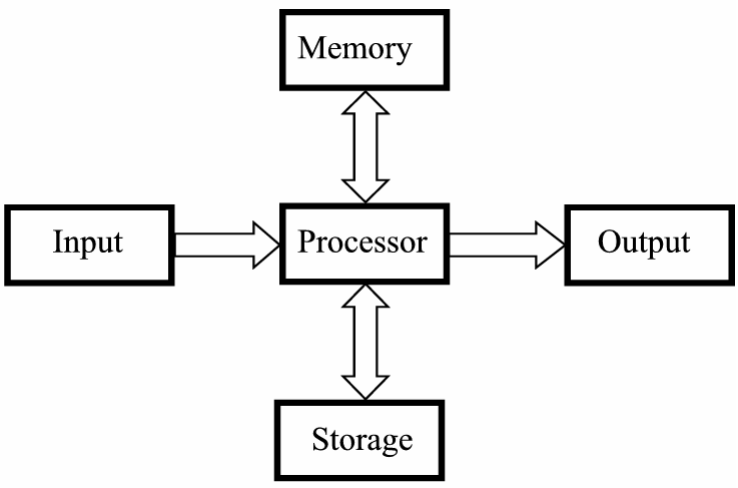
Computer Hardware: A Quick Overview

- **In this section of notes you will learn about what are the basic parts of a computer, how they work and how it applies to everyday usage.**

Section I: Basic Overview Of A Computer

In this section you will learn what are the basic components of a computer.

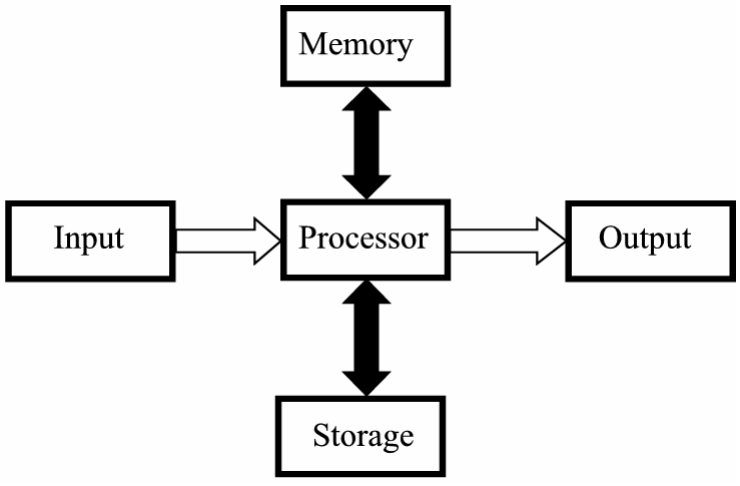
High Level View Of A Computer



James Tam

Computer Buses

•Connect the different parts of the computer together



James Tam

Types Of Buses

Data buses

- Are used to transmit information to the different parts of the computer

Address buses

- Indicate where the information is supposed go

Buses

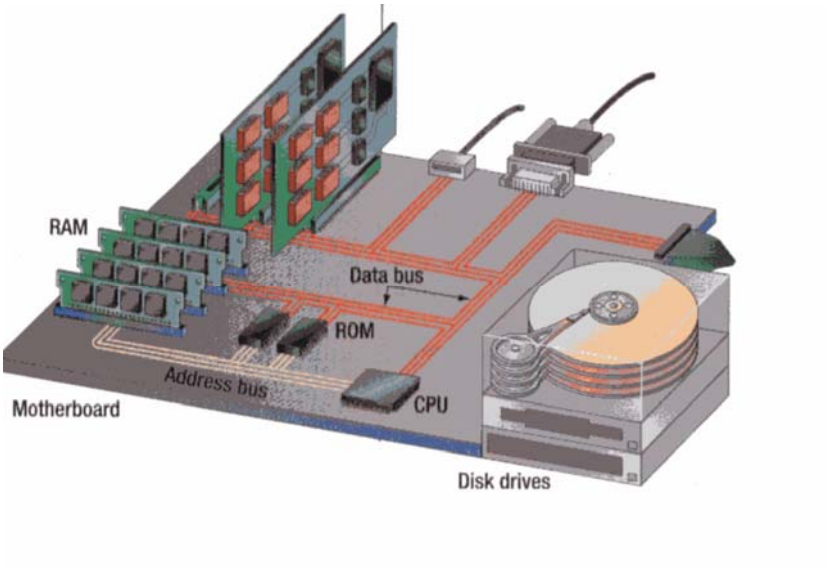
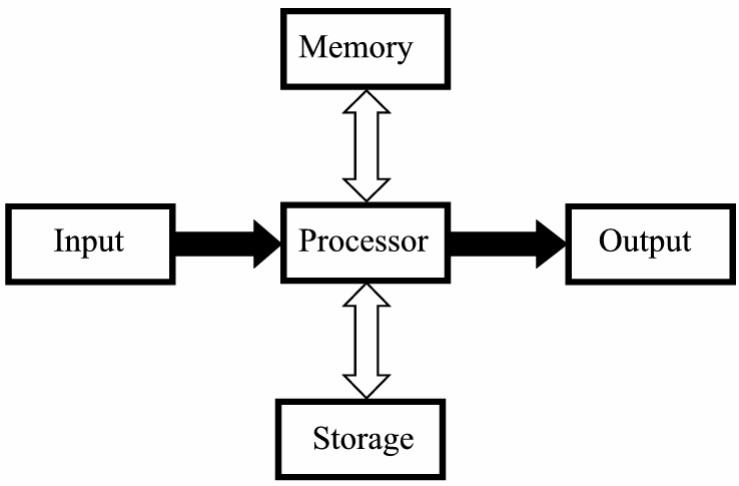


Image from Peter Norton's Computing Fundamentals (3rd Edition) by Norton P.

Ports

Connects the computer to the outside



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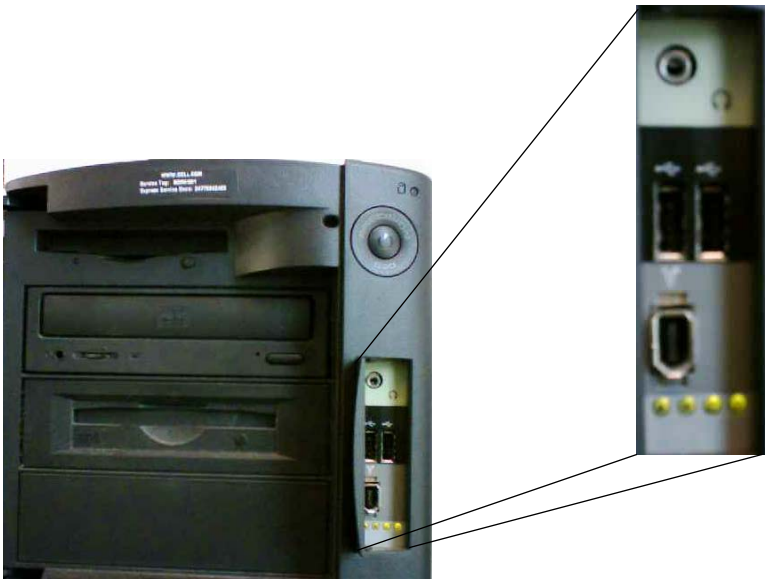
Ports



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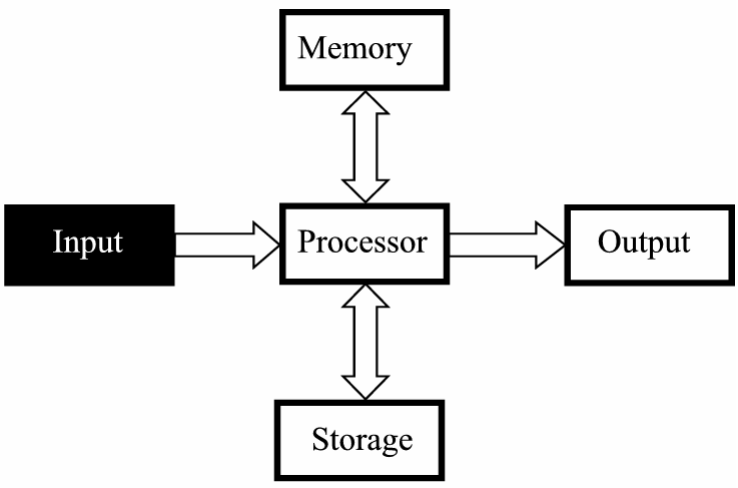
Input



Input Devices

Used by a person to communicate to a computer.

Person to computer

Example Input Devices

Keyboard 

Mouse 

Stylus 

Touch screen 

Input Devices Need Not Be Mundane

The ‘Jouse’

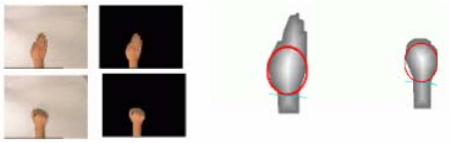
From http://www.jouse.com/

The Wii ‘Nunchuk’

Ed Kaiser, The Journal

Input Devices: The Future?

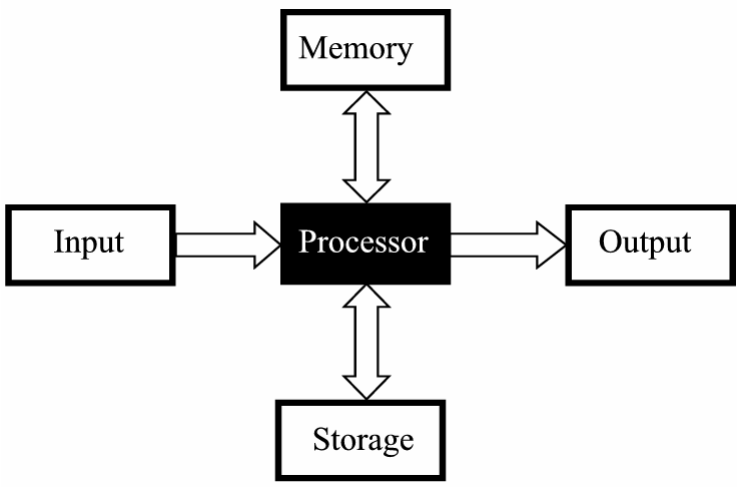
Unobtrusive input



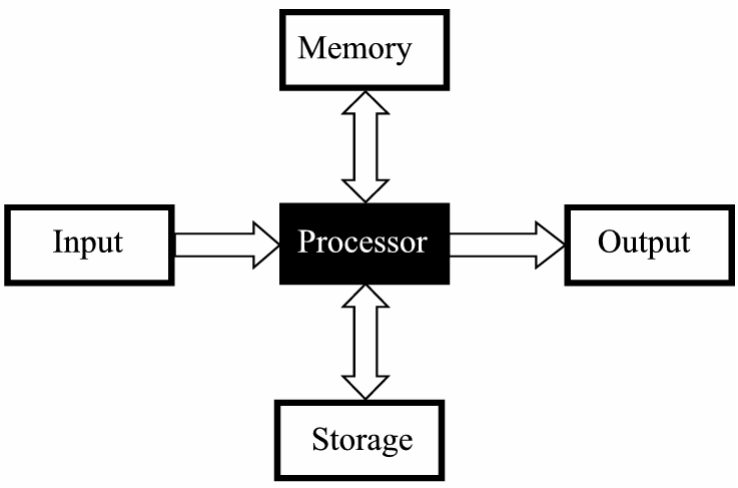
Parker, J.R., Baumback, M., *Visual Hand Pose Identification for Intelligent User Interfaces*,Vision Interface 2003, Halifax, Nova Scotia, Canada Jun 11-13, 2003

Direct input

Processor



Processor



Processor

•The brains of a computer

...maybe not...

•A common desktop processor

The Processor And The Computer

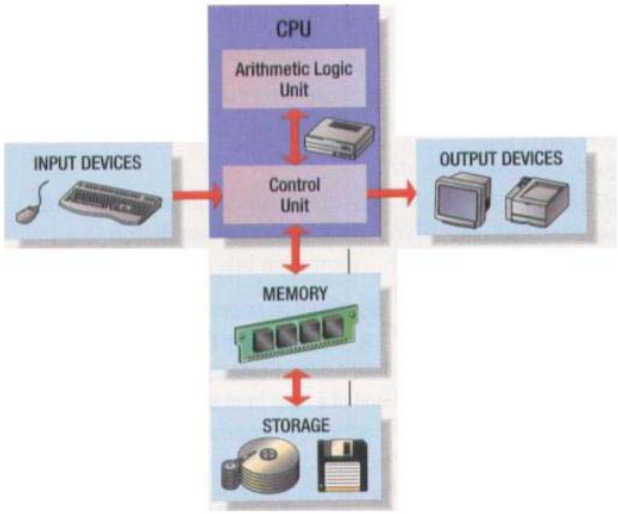
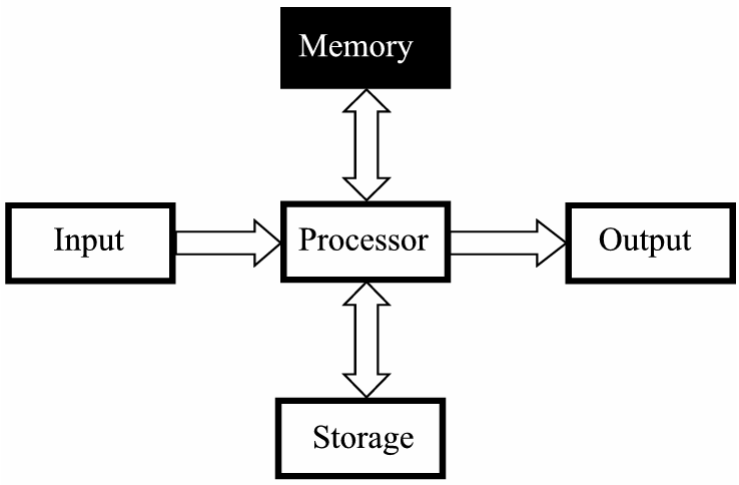


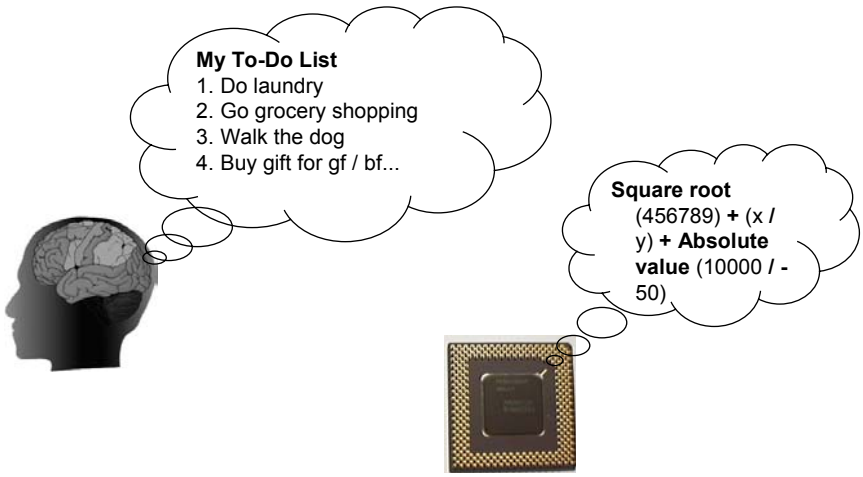
Image from Peter Norton's Computing Fundamentals (3rd Edition) by Norton P.

Memory



Memory

The processor has a small amount of memory that is fast but very low in capacity



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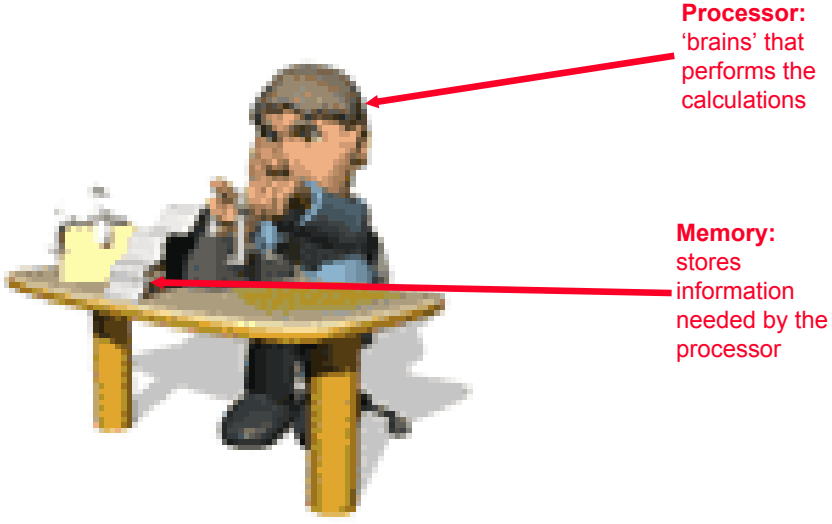
Memory

It is used as temporary storage for the computer:



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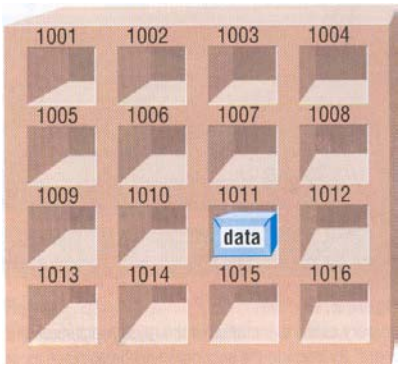
Memory

The most common type of memory in the computer is RAM (*R*andom *A*ccess *M*emory):

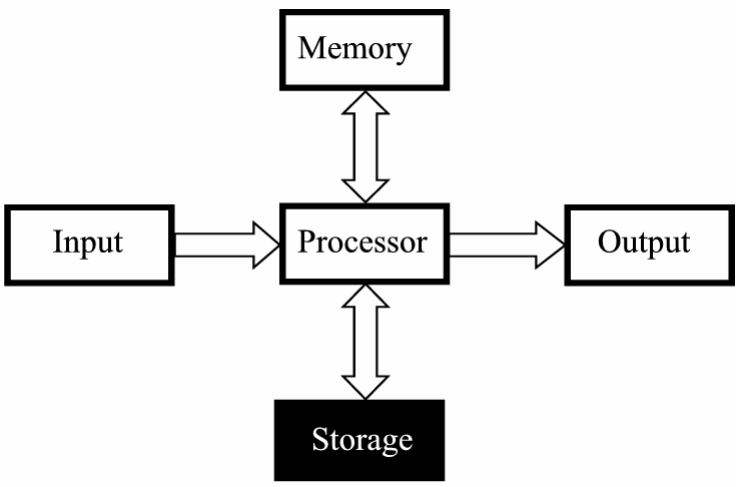


Random access doesn't mean chaotic or haphazard but it means that access does not have to be sequential but can occur anywhere

Picture from Computers in your future by Pfaffenberger B

Also note that RAM is volatile (information is stored so long as there is power).

Storage



Storage Vs. Memory

Memory (e.g., RAM)
- The information stored is needed now
- Keep the information for a shorter period of time (usually volatile)
- Faster
- More expensive
- Low storage capacity (e.g., 1/4 to 1 DVD)

Storage (e.g., Hard disk)
- The information stored is not needed immediately
- The information is retained longer (non-volatile)
- Slower
- Cheaper
- Higher storage capacity (~50 – 200 DVDs)

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Common Types Of Storage

1. Magnetic
   - Floppy disks
   - Zip disks
   - Hard drives
2. Optical
   - CD-ROM
   - DVD

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Magnetic Storage Devices

•Include floppy disks, zip disks, hard drives

•All use magnetism to store information:

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Optical Storage Devices

Use lasers to store and retrieve information (CD's and DVD's)

Categories:

- Can only read information off the disc (CD-ROM, DVD-ROM)
- Can read and also *r*ecord information to the disk (CD-R, DVD-R, DVD+R)
- Can read, record and also *r*e-*w*rite information multiple times (CD-RW, DVD-RW, DVD+RW)

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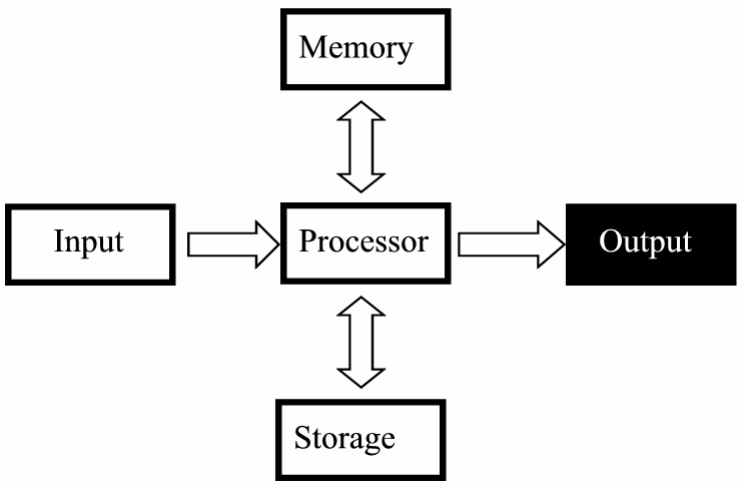
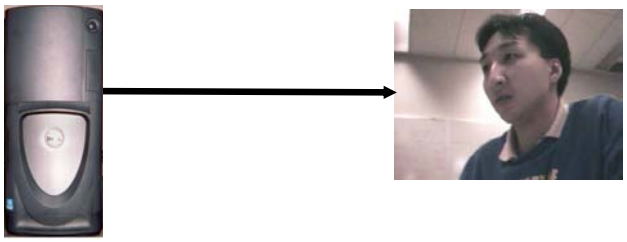
Output



Output Devices

Communicating information from the computer.



The Most Common Output Device: The Monitor

The Most Common Output Device: The Monitor

Common monitor technologies:

1. CRT (Cathode Ray Tube)

2. LCD (Liquid Crystal Display)

3. Plasma displays

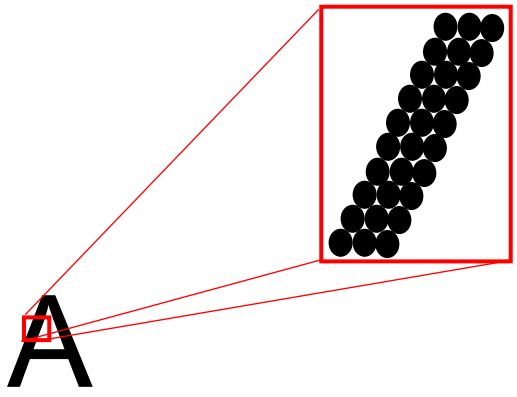
How Images Are Drawn On Monitors

Images and text are drawn with tiny dots (Pixels: *Pi*cture *el*ement*s)*

A

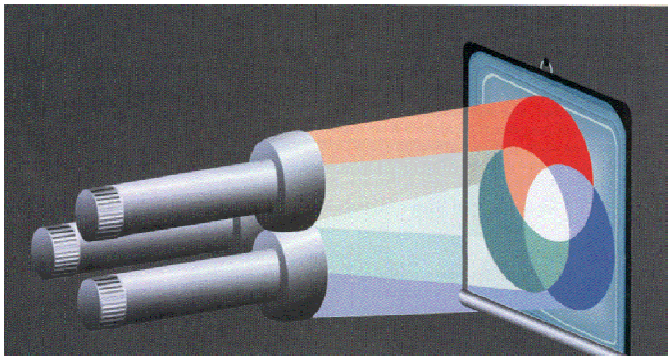
How Images Are Drawn On Monitors

Images and text are drawn with tiny dots (Pixels: *Pi*cture *el*ement*s)*



1. CRT Monitors

The pixels are drawn with light ‘guns’

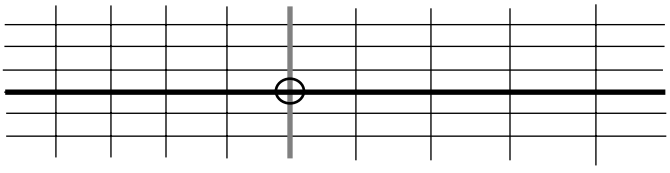


Picture from Computer Confluence by Beekman G.

2. LCD Monitors

Employ a conductive grid for each row and column

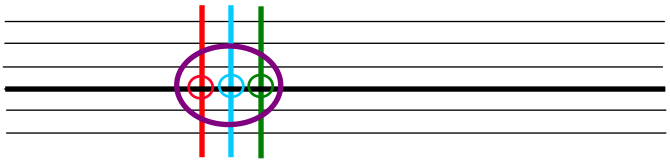
The meeting of a row and column allows light to be emitted (a pixel can be seen)



2. Colour LCD Monitors

Use three sub pixels:

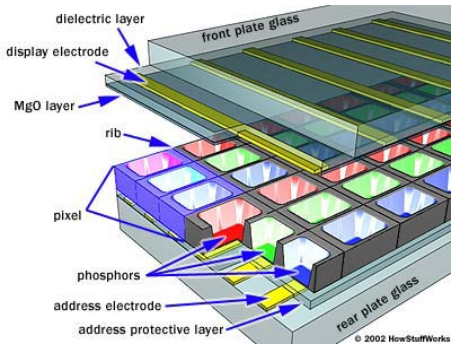
- One wire for each row
- One wire for each sub-pixel
- One colour filter for each colour (red, blue, green)

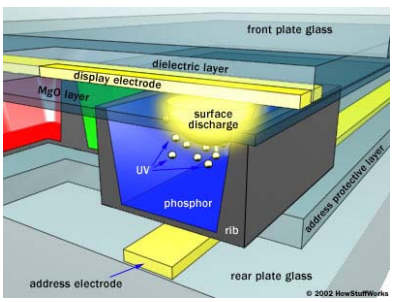


3. Plasma Monitors

Sub-pixels are "drawn" by passing an electrical current through a gas.

Again each pixel is formed by three sub-pixels





Images from www.howstuffworks.com

The Basic Parts Together

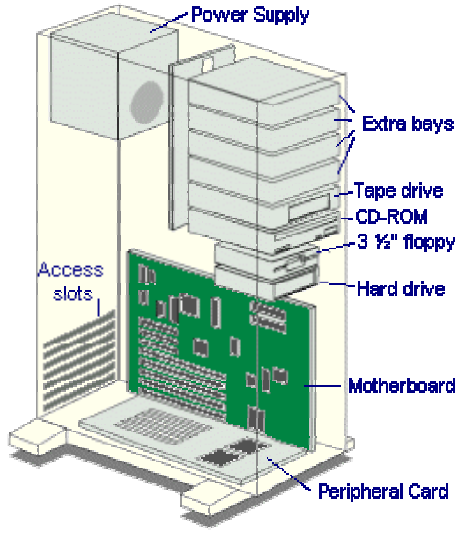
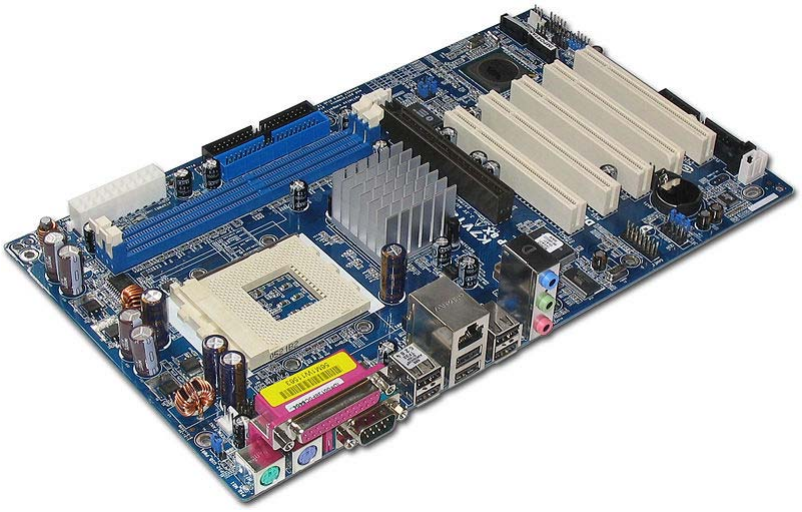


Diagram from http://www.jegsworks.com

James Tam

The Motherboard



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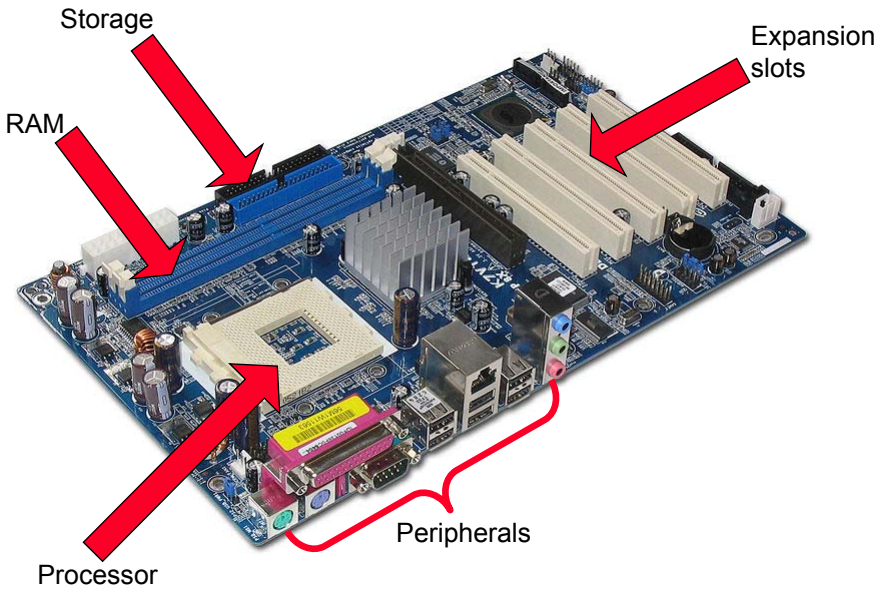
The Motherboard



James Tam

An Important Peripheral: A Printer

Common types

- Inkjet

- Laser

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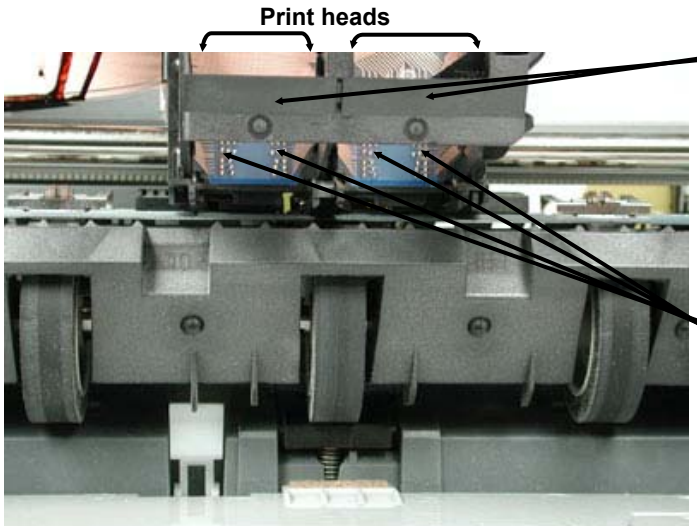
How Inkjet Printers Work.

Use a series of nozzles to spray drops of ink directly on the paper



Picture from www.howstuffworks.com

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How Laser Printers Work

Use a laser to produce patterns on an ink drum using static electricity.

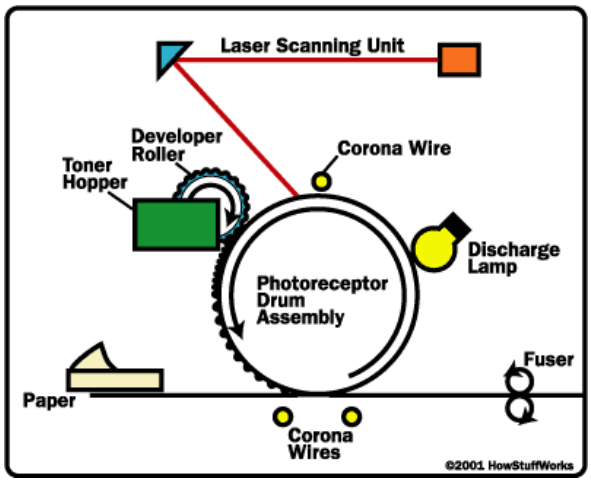


Diagram from www.howstuffworks.com

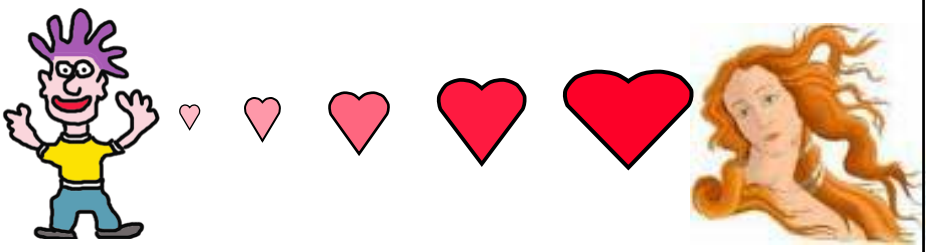
James Tam

Section II: How Does A Computer Work

In this section you will learn that the operation of a computer is typically based on a two state model.

How Does A Person Work?

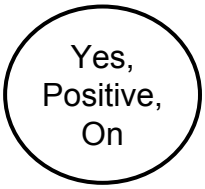
In many shades of grey (subtleties and ambiguities can exist)

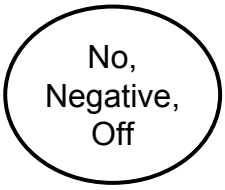


...i.e., people are complex with many possible states (some of which may be conflicting)

How Does A Computer Work?

Simple: something is either in one state or another.



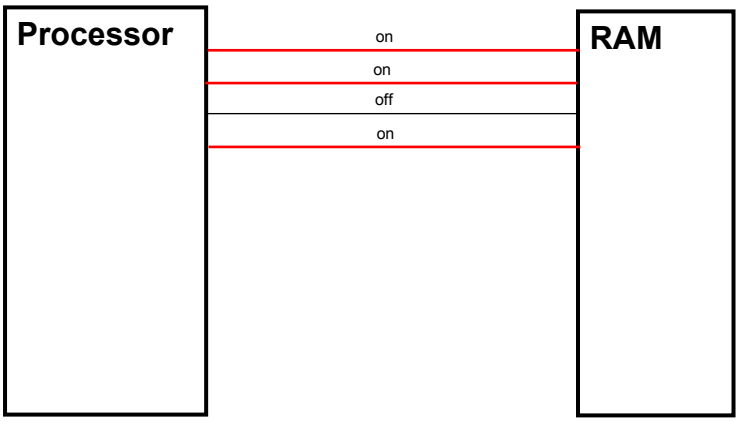


All parts of modern computers work this way.

Computer Buses: How Information Is Transmitted

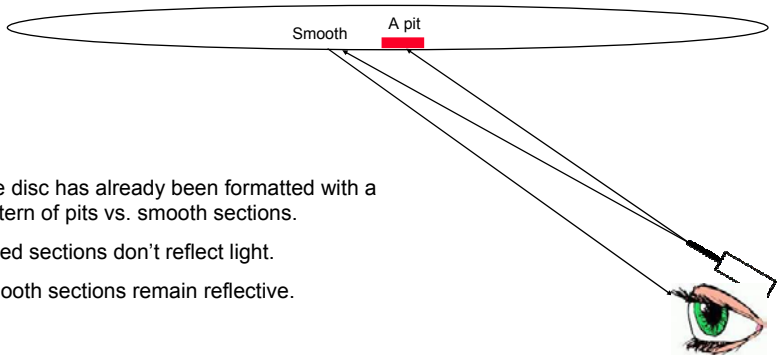
•Carries information between the different parts of the computer.

•Information is transmitted via electrical currents on wires.



Optical Drives: Reading Information

CD-ROM, DVD-ROM

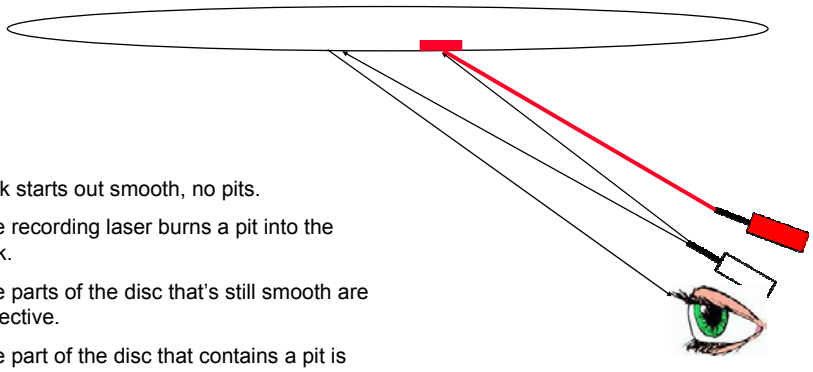


- The disc has already been formatted with a pattern of pits vs. smooth sections.
- Pitted sections don't reflect light.
- Smooth sections remain reflective.

James Tam

Optical Drives: *R*ecording And Reading Information

CD-R, DVD-R, DVD+R

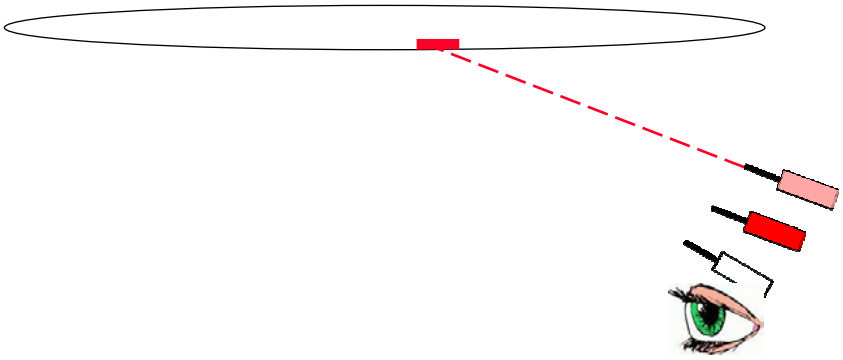


- Disk starts out smooth, no pits.
- The recording laser burns a pit into the disk.
- The parts of the disc that's still smooth are reflective.
- The part of the disc that contains a pit is non-reflective.

James Tam

Optical Drives: *R*e-*W*riting

CD-RW, DVD-RW, DVD+RW



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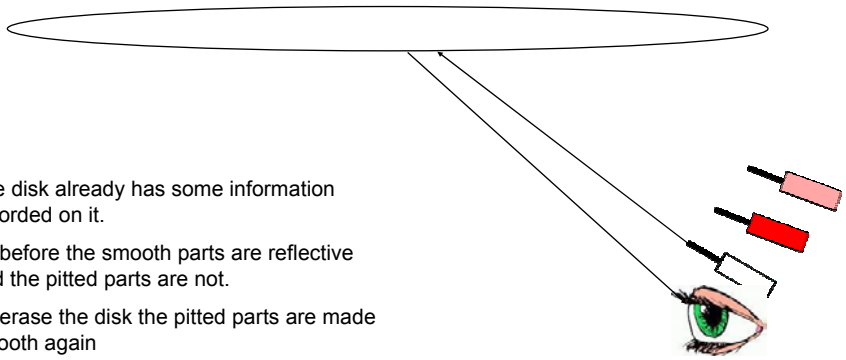
Optical Drives: *R*e-*W*riting

CD-RW, DVD-RW, DVD+RW



- The disk already has some information recorded on it.
- As before the smooth parts are reflective and the pitted parts are not.
- To erase the disk the pitted parts are made smooth again

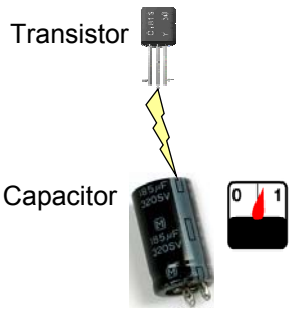
James Tam

RAM: Storing Information

Information is stored in RAM based on power levels (on or off)

The smallest unit of storage is a bit (*bi*nary digi*t*)

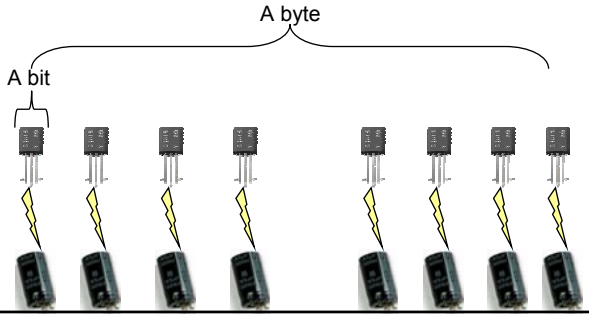
- *Bi*nary: A bit can have two states (on/off)
- Information about a particular bit is stored in a capacitor (stores electricity)
- Power to the capacitor is controlled through a transistor



James Tam

RAM: Storing Information

- By itself a bit is useless (it can't store a useful amount of information = 2 possible states)
- Bits must be combined together before information can be stored
  - Q: How many states can be represented with 2 bits? 3 bits? 4 bits?
- The next unit of storage is a byte = 8 bits (256 possibilities)



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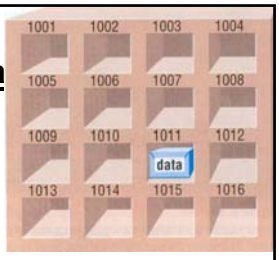
RAM: Storing Information



- RAM is a collection of 'slots' where information is stored.
- Each slot is a collection of bits.
- The number of bits that are grouped together at a location is typically 8 bits (byte).
  - e.g., a 1 Gigabyte stick of RAM has ~1 billion slots with each slot consisting of a byte

Storing Text Information In RAM

- Text is stored in using the *A*merican *S*tandard *C*ode for *I*nformation *I*nterchange (ASCII)
- Eight bits/one byte (256 combinations) is used to store information about a single text character:

Combination number	Bit pattern	Value represented at that combination
48 - 57	00110000 - 00111001	'0' to '9'
65 – 90	01000001 – 01011010	'A' to 'Z'
97 – 122	01100001 - 01111010	'a' to 'z'

Section III: Buying A Computer System

In this section you will learn about *some* of the important technical characters involved in a purchasing decision.

- The processor
- RAM
- CD/DVD
- Monitors
- The video/graphics card

Small Units Of Measurement (Processor And Memory Speed)

Millisecond (ms) – a thousandth of a second ($1/1{,}000 = 10^{-3}$)

Microsecond (μs) - a millionth of a second ($1/1{,}000{,}000 = 10^{-6}$)

Nanosecond (ns) – a billionth of a second ($1/1{,}000{,}000{,}000 = 10^{-9}$)

Processor Speed

Traditionally determined by:

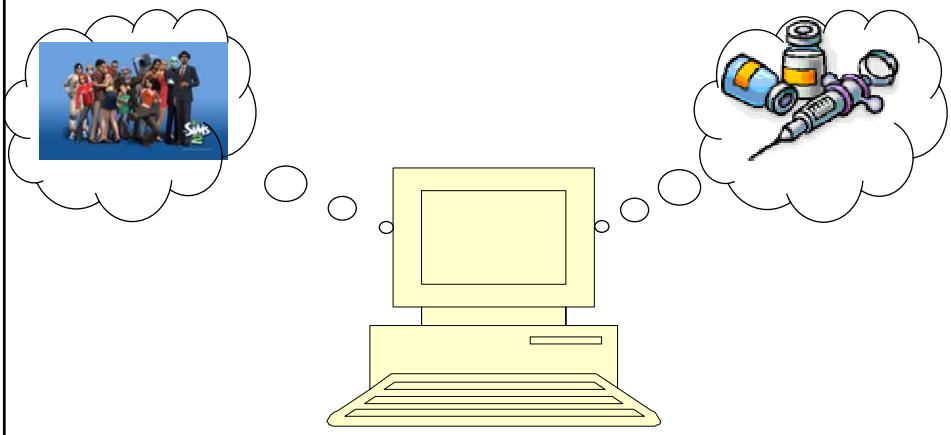
1. Type of processor e.g., Intel: Celeron, Pentium; AMD: Athlon
2. Clock speed
   - 1 Hz = 1 pulse is sent out each second (1 second passes between each pulse)
   - 10 Hz = 10 pulses are sent out each second (0.1 seconds passes between each pulse)
   - :
   - 25 MHz = 25 million pulses sent out each second (0.000 000 04 seconds between each pulse or 40 ns between pulses)
   - 3.8 Ghz = 3.8 billion pulses sent out each second (0.26 ns between pulses)

Other Important Characteristics Of Processors

- Hyper-threading technology
- Multi (e.g., Dual) core technology
- Speed of the (Front side) bus
- The cache size

Processors Without Hyper-Threading, Single Core Processor

- Execution may be slower because when multiple programs are running the processor must switch it's attention between them.
- Example running a game and an anti-virus program:



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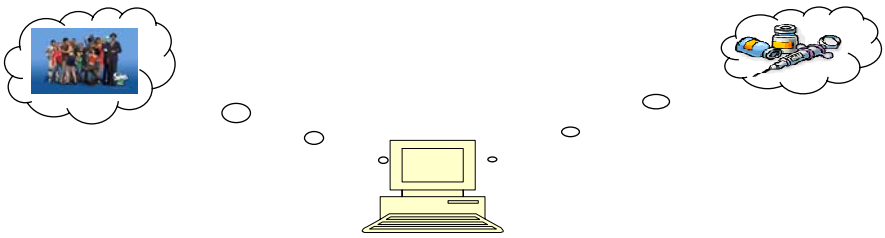
Hyper-Threading Technology

- Splits instructions to be executed by the processor which may increase the speed of the computer (multiple applications).
- Example running a game and an anti-virus program:



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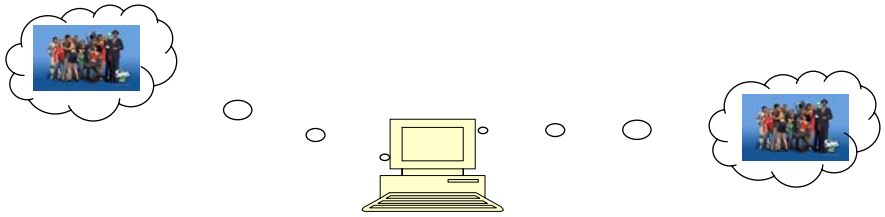

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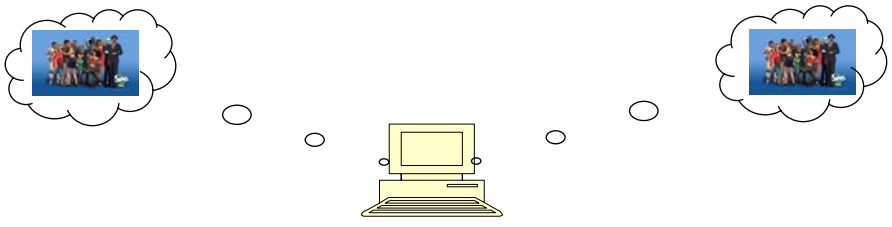
Multi-Core Technology

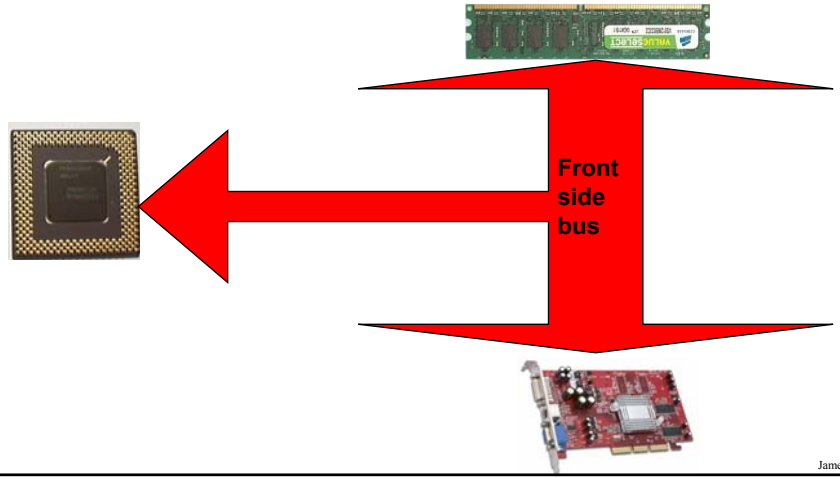
- A core is the part of the processor that's capable of executing instructions.
- The processor is split into multiple (dual = two, quad = four) cores.
- Each core is capable of executing it's own set of instructions.



James Tam

Front-Side Bus Speed

- Determines how quickly information can be transferred to/from some of the other parts of the computer to the processor.
- Measured in MHz



James Tam

Example: Front-Side Bus Speeds

Celeron: 533 – 800 MHz

Celeron D: 533 MHz

Pentium 4: 533 MHz – 800 MHz

Pentium dual core: 533 MHz – 800 MHz

Pentium Core 2 extreme: 800 MHz – 1333 MHz

James Tam

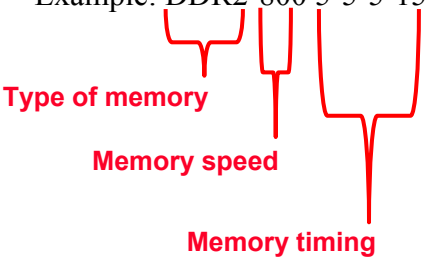
The Processor Cache

- The cache is fast memory that's on either on the processor or near it on the motherboard.
- Bridges the processor and RAM
- Example sizes
  - Celeron: when it first came out it had no cache, now it ranges ~256KB – 512 KB
  - Pentium 4: 1 MB – 2 MB
  - Pentium dual core: 1 MB
  - Pentium Core: 2 MB – 8 MB

James Tam

Deciphering The Notations Used When Buying Memory

Example: DDR2-800 5-5-5-15



James Tam

Basic Units Of Measurement

Bit  on OR off

- *Bi*nary digi*t*
- Smallest unit of measurement
- Two possible values

Byte 

- 8 bits

Word

- The word size of a computer is the number of adjacent bits that can be stored and manipulated as a unit
- 32, 64 for home computers, 128 for faster machines or specialized systems

James Tam

Types Of RAM

1. SD-RAM (Synchronous dynamic random access memory)
   - Widely available since the 1990's
   - Timed with the processor
2. DDR (Double data rate) SD-RAM
   - 2001+
   - Doubles the transfer rate of regular SD-RAM
3. DDR2 SD-RAM
   - 2003+
   - Doubles again the transfer rate of DDR SD-RAM
4. DDR3 SD-RAM
   - Latter half of 2007
   - Doubles again the transfer rate of DDR2 SD-RAM

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Memory Speeds: DDR RAM

Name	Speed
PC-1600	100 MHz
PC-2100	133 MHz
PC-2700	166 MHz
PC-3200	200 MHz

James Tam

Memory Speeds: DDR2 RAM

Name	Speed
PC2-3200	200 MHz
PC2-4200	266 MHz
PC2-5300	333 MHz
PC2-6400	400 MHz
PC2-8500	533 MHz

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Memory Speeds: DDR3 RAM

Name	Speed
PC3-6400	400 MHz
PC3-8500	533 MHz
PC3-10600	667 MHz
PC3-12800	800 MHz

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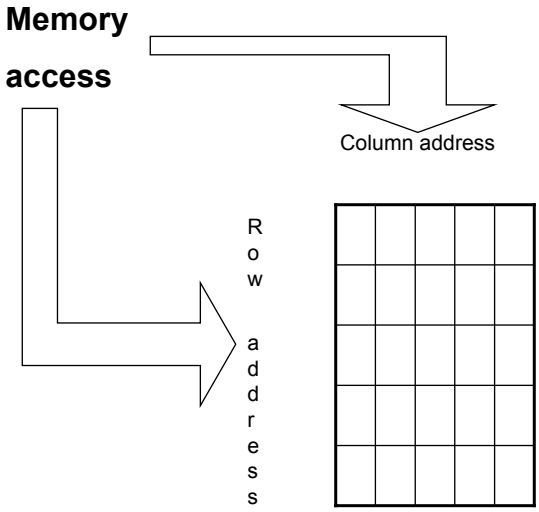
Memory Timing Values

•RAM chips are laid out in rows and columns:



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Memory Timing Values (2)

- Stated in the form of 4 numbers *CAS-RCD-RP-RAS*
  - tCL (sometimes referred to as the *CAS*) is the time to access a column (time *Column Access*)
  - t*RCD* is the time delay that occurs from when the row is strobed to when the column can be strobed (*time Row-Column delay*)
  - t*RP* is the time needed to move to the next row – close access to the previous row, begin access to the next row (time for *row pre-charging*)
  - t*RAS* is the time needed to access the information stored on a row (time Row Access)

Note: time is measured in clock cycles.

CD/DVD Drives

Some considerations:

- Speed
- Single layer/single sided and dual layer/double sided
- Next generation DVD: Blu-ray, HD-DVD

CD/DVD: Speed

CD Speeds:

- Stated in the form of 3 numbers e.g., 52x32x52
- These three numbers state the maximums for:
  - (Write speed) x (Re-write speed) x (Read speed)

DVD Speeds:

- Sometimes they are listed in the same format as CD speeds
- Other times they are listed in the form of two numbers e.g., 16x16
  - (Write speed with 'plus' DVD discs) x (Write speed with 'minus' DVD discs)
- Or they may be listed as a single number e.g., x16
  - (Write speed with 'plus' or 'minus' DVD discs

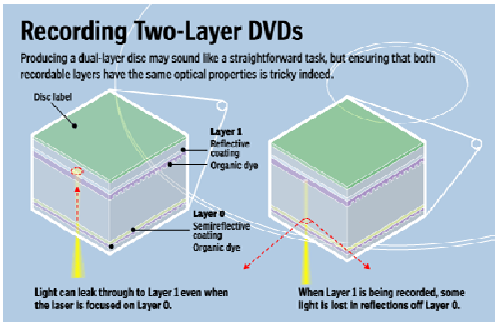
CD/DVD: Multi-Layer, Multi-Sided

Double sided:

- Allows information to be written on both sides of the disc

Dual layer ("-DL")

- An extra layer of dye is added to allow for double the amount of information to be written



www.pcmag.com

Large Units Of Measurement (Memory, Storage)

Note: powers of two are used because computer memory and storage are based on the basic unit (bit).

Kilobyte (KB) – a thousand bytes ($1,024 = 2^{10}$)

Megabyte (MB) - a million ($1,048,576 = 2^{20}$)

Gigabyte (GB) – a billion ($1,073,741,824 = 2^{30}$)

~ A complete set of encyclopedias requires about 700 MB of storage

~ 30 minutes of video (~1/4 of the information stored on a typical DVD)

Terabyte (TB) – a trillion ($1,099,511,627,776 = 2^{40}$)

~ 20 million four-drawer filing cabinets full of text

~ 200 DVD's of information

DVD: Multi-Layer, Multi-Sided (2)

Type	Capacity
Single sided, single layer	4.7GB
Single sided, dual layer	8.5GB
Double sided, single layer	8.75GB
Double sided, dual layer on one side	9.4 GB
Double sided, dual layer on both sides	15.9GB

A Next Generation DVD Format: Blu-Ray

- Uses a different light frequency for the laser
- Results in high capacity storage:
  - 25 GB (single layer)
  - 50 GB (dual layer)
- Backward (but not forward) compatibility is possible

James Tam

A Next Generation DVD Format: HD-DVD

- Uses a different light frequency for the laser
- Results in high capacity storage:
  - Pre-recorded content:
    - 15 GB (single layer)
    - 30 GB (dual layer)
  - Home recording
    - 20 GB Single-layer
    - 35 GB Dual Layer
    - 40 GB Double-Sided Disc
- Backward (but not forward) compatibility is possible

James Tam

Some Determinants Of The Quality Of Monitors

1) Size
2) Resolution
3) Color depth
4) Dot pitch

1) Monitor Quality (Size)

Measured diagonally

2) Monitor Quality (Resolution)

Columns of pixels x Rows of pixels

Col 1, Row 1	Col 2, Row 1	Col 3, Row 1	…	Col [c], Row 1
Col 1, Row 2				Col [c], Row 2
Col 1, Row 3				Col [c], Row 3
:				:
Col 1, Row [r]	Col 2, Row [r]	Col 3, Row [r]	…	Col[c], Row[r]

For a given monitor size, the higher the resolution the sharper the image

James Tam

3) Monitor Quality (Color Depth)

The number of possible colors that can be displayed for each pixel.

e.g. monochrome (single color) 1

2 possible values

Uses up 1 bit of space

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3) Monitor Quality (Effects Of Color Depth)

2 colors

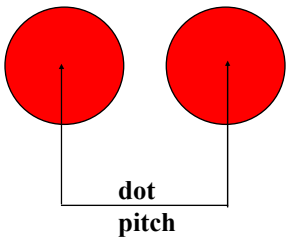
16 colors

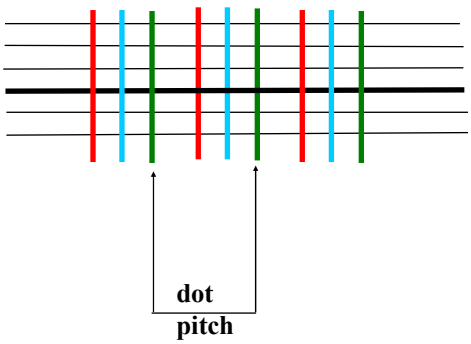
256 colors

16 million colours

4) Monitor Quality (Dot Pitch)

Dot pitch is the distance between picture elements e.g., the center of each color dot (mm)





Refresh Rate Of Monitors

How fast the screen is redrawn

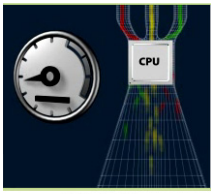
(70 Hz / 70 times per second is usually a good minimum)

The Video/Graphics Card

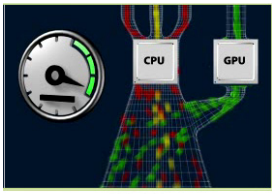
- Drawing high quality graphics and producing realistic looking animations is obviously crucial for running some of the new games.
- However graphics is also important for some productivity software e.g., 3D drawing programs, video editing, CAD programs etc.
- Also it can be an important consideration if you upgrade your operating system to Windows Vista.

Some Important Considerations When Buying A Video Card

1. It's mostly about U...The GPU



Without a GPU



With a GPU

Images from Nvidia

2. Don't forget about memory.
   a) Video cards also have dedicated memory
   b) All things being equal a video card with a fast GPU will deliver better performance than one with a slower GPU but more memory.
   c) However with GPU's being equal the video card with additional memory may deliver superior performance

Some Important Considerations When Buying A Video Card (2)

3. DirectX 10 support...possibly if you have Vista.

Relating The Speed Of The Computer To Its Components

Storage:
Hard drive

Memory:
RAM

Processor
cache

James Tam

You Should Now Know

- What are the 5 parts of the high-level computer
- How buses and ports connects the inner parts of the computer and the computer to the outside (respectively)
- What are some common (and not so common) input devices
- The role that the processor plays in the computer
- The purpose of memory (RAM) in the computer
- What are different types of computer storage and how does each one work
- What is the difference between storage and memory

James Tam

You Should Now Know (2)

•What are the different types of monitors and how does each one work

•What is a motherboard and how does it relate to the other parts of the computer

•How do ink-jet and laser printers work

•How computers work on a two-state model

•What are some of the important considerations when buying: a processor, RAM, an optical storage device, a computer monitor and a video card.

•How the speed of a computer is determined by many factors.