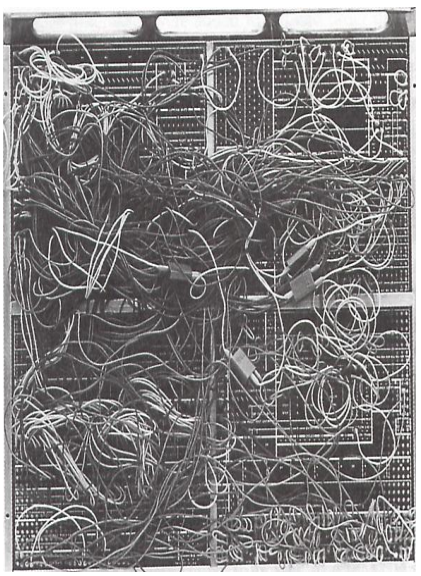
Introduction to computers

You will learn what are the basic components of a computer system and the rudiments of how those components work.

James Tam

Are Computers Really So Confusing?



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How Does A Computer Work?

- Simple: something is either in one state or another.

On / off

Pitted / smooth

- All parts of modern computers work this way.
- This two state approach is referred to as binary (bi = two, binary means 2 states).

Off / on

- A bit (*bi*nary digi*t*) is used to represent this two state model.

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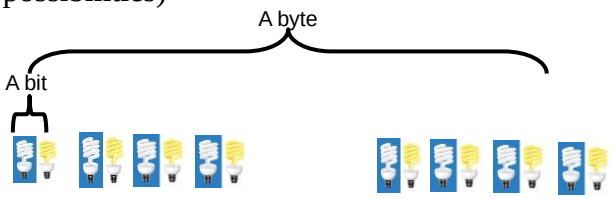
Beyond The Bit

- By itself a bit is useless (it can't store a useful amount of information = only 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 (commonly used) unit of storage is a byte = 8 bits (256 possibilities)



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Counting: Large Units Of Measurement

- Kilo: One thousand 1,000
- Mega: One million 1,000,000
- Giga: One billion 1,000,000,000
- Tera: One trillion 1,000,000,000,000

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The Computer: Large Units Of Measurement

- The amount of information that can be stored and transferred is typically measured in bytes rather than bits.
- Kilobyte (KB) ~ a thousand bytes ($1,024 = 2^{10}$)


X 1,000

  - Low quality preview 'thumbnail' images may range from a few thousand to tens of thousands of bytes in size.

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


X 1,000,000

  - A typical image may range from ~20,000 Bytes / 20 KB to several million bytes (MB).
  - Audio files (e.g., MP3) are several Megabytes in size.
  - Streaming Internet video (compressed) ~several hundred Megabytes for a full movie.

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Large Units Of Measurement (2)

•Gigabyte (GB) ~ a billion bytes (1,073,741,824 = 2^{30})

 X 1,000,000,000

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

•Terabyte (TB) ~ a trillion bytes (1,099,511,627,776 = 2^{40})

 X 1,000,000,000,000

~ 200 regular DVD's (~32 Blu-ray) of information

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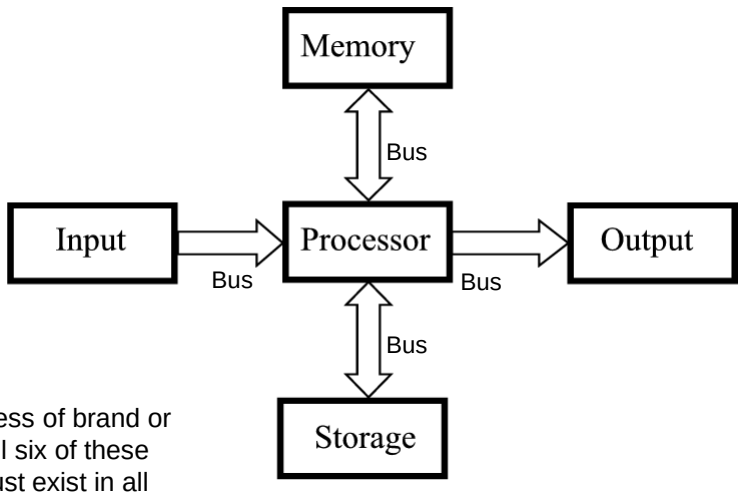
High Level View Of A Computer



Regardless of brand or model all six of these parts must exist in all complete computer systems

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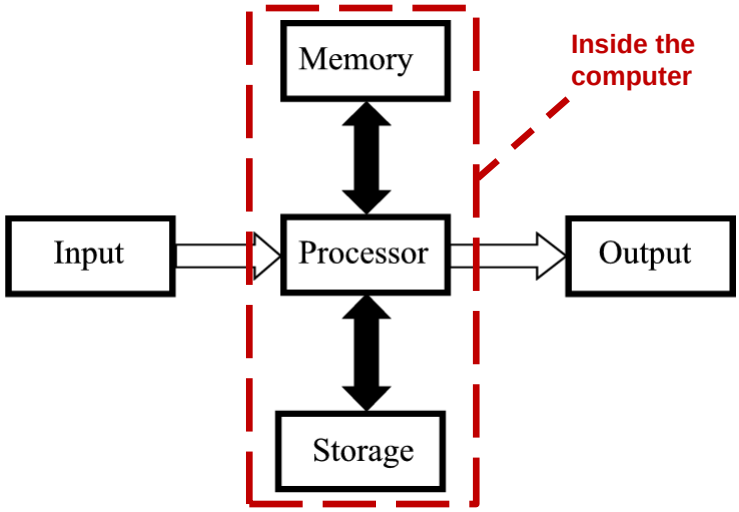
Computer Buses

•Connect the internal parts of the computer



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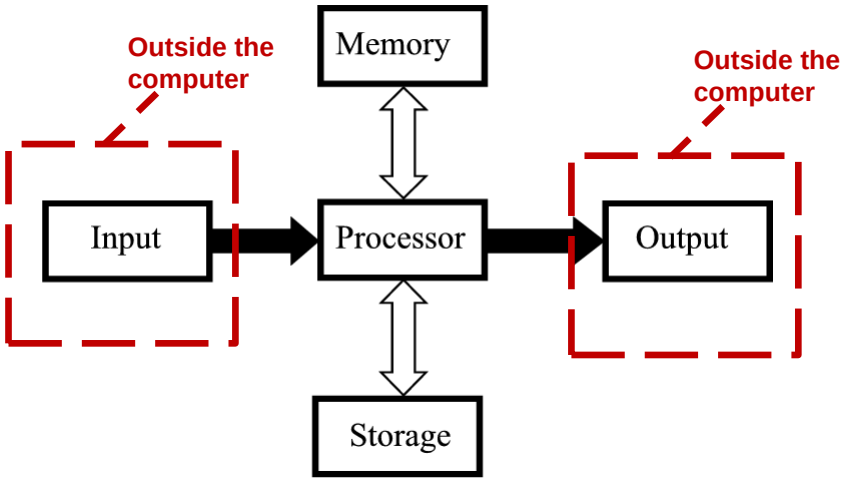
Ports

•Connects the computer to the outside



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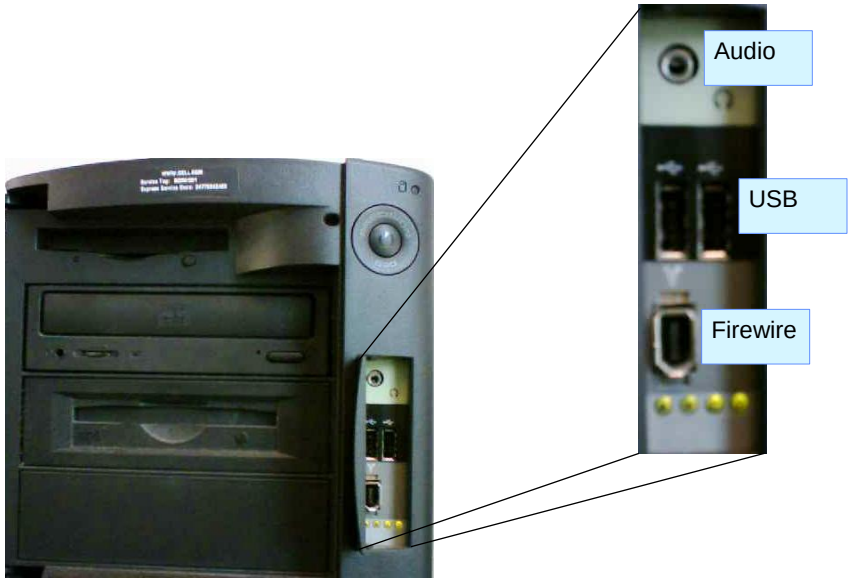
Example Ports (Older)



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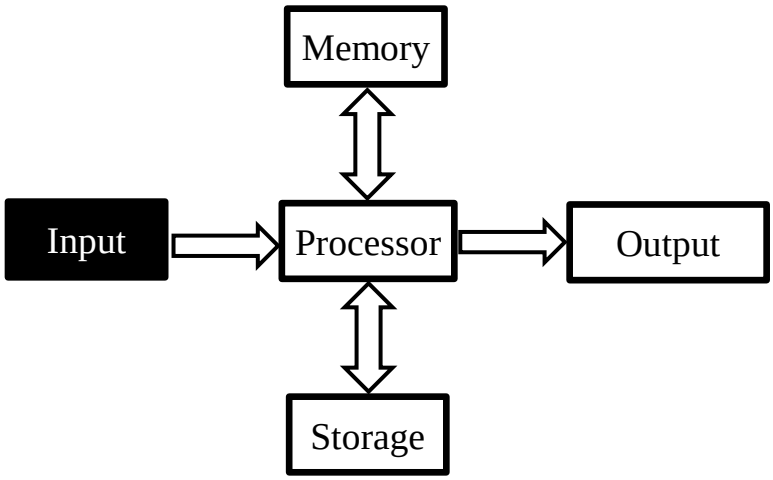
Input



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Input Devices

•Used by a person to communicate to a computer.

Person to computer

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Example Input Devices

•Keyboard

•Mouse

•Stylus

•Touch screen

Input devices don't have to be mundane

Camera: MS-Kinect

Thought-controlled

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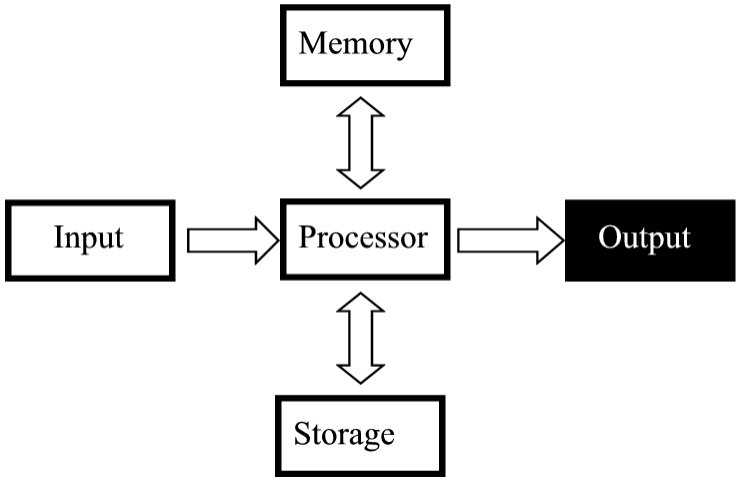
Output



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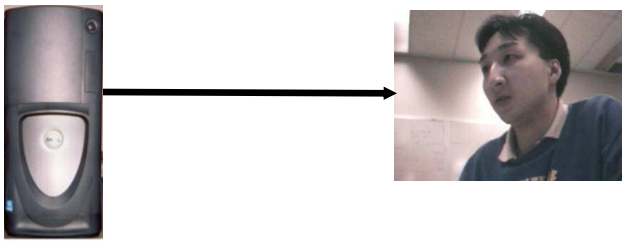
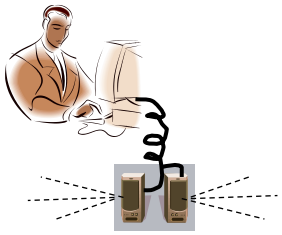
Output Devices

•Communicating information from the computer.





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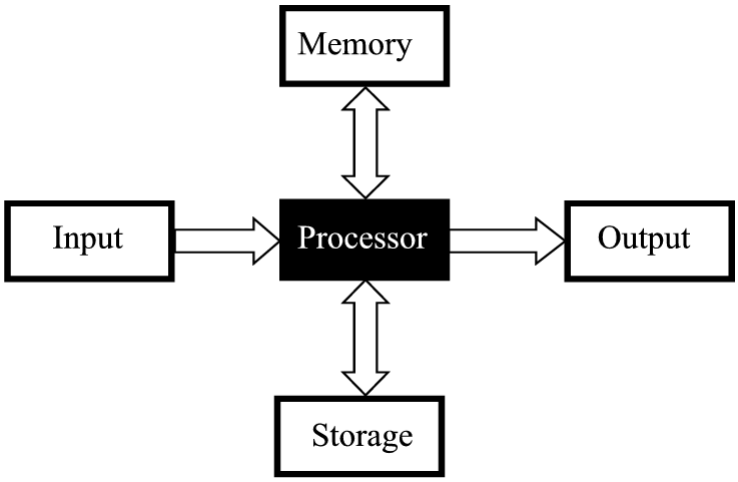
Processor



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Processor (2)

- With desktop and laptops it's commonly referred to as the Central Processing Unit (CPU).
  - There are other processors in a typical desktop or laptop computer.

- Acts as the 'brains' of the computer that comes into play as programs are running e.g., performing calculations on a spreadsheet, playing a video, manipulating files…more details to come.

James Tam

Counting: Small Units Of Measurement

- Milli: one thousandth (1 / 1,000)
- Micro: one millionth (1 / 1,000,000)
- Nano: on billionth (1 / 1,000,000,000)

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Processor Clock Speed

- A common measure of the computational speed of a computer.
- For each clock 'cycle' an instruction[1] is executed (pulsed) by the computer.
  - 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)
  - 4.0 Ghz = 4.0 billion pulses sent out each second (0.25 ns between pulses)

1 To be more specific it's one microinstruction per clock pulse

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Benefits Of A Faster Processor

- Calculations are performed faster (e.g., to evaluate the results of a large spreadsheet)
- Programs are loaded faster (includes the time to start up your computer)
- Viewing videos and ripping music/videos to your computer may be faster and more free of 'glitches'
- Note: there are other processor characteristics that determine processor speed.
- A discussion of most of these topics is beyond the scope of this class but if you are interested here's a few sites that may be of interest:
  - http://www.tomshardware.com/
  - www.howstuffworks.com
  - http://www.pcmag.com/

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Common Processor Clock Speeds

- Budget processors
  - Laptop: ~1.7 GHz ~3 GHz (Cheap netbooks are around 1.6 GHz)
  - Desktop: ~3 GHz - ~4 GHz

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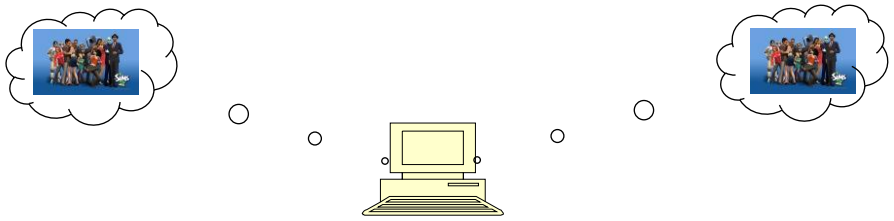
Multi-Core Technology

- One of the newer determinants of processor speed.
- A core is the part of the processor that's capable of executing instructions and has some memory to store information.
- The processor is split into multiple (dual = two, quad = four, six = six) cores.
- Each core is capable of executing it's own set of instructions.



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Do You Need Multiple Processing Cores?

- Going from a single core to a multi-core system *will not* automatically result in an increase in speed. (Nor will increasing the number of processor cores).
- Two situations where speed will increase:
  1. You simultaneously run two or more programs that are processor intensive.
  2. You run a single program that is processor intensive and it is written specifically for a multi-core processor.
- When having multiple/more cores won't increase speed:
  - Opposite of the above:
    - You don't run multiple processor intensive programs at the same time. (You only run a single calculation-heavy program at a time).
    - The single processor intensive program that you do run is not optimized to run on a multi-core processor.

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Do You Need Multiple Processing Cores? (2)

- Examples of processor intensive tasks:
  - Video editing (saving).
  - Playing videos.
  - Ripping CD's / DVD's
  - Running security software (e.g., anti-virus scan).
  - Many of the newer computer games are processor intensive (at least to a degree).

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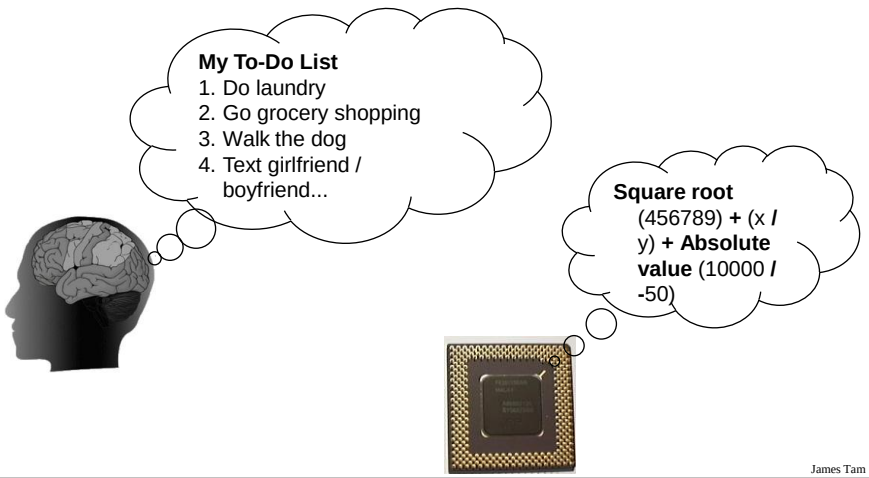
Storage Of Information: Processors

- The processor has a small amount of memory that is fast but very low in storage capacity (analogous to short-term memory)
  - 'Cache' or 'Registers'



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Storage Of Information: Processors (2)

•Very often this limited storage space is insufficient.

People:
Oops forgot to study for the final exam!!!

My To-Do List
1. Do laundry
2. Go grocery shopping
3. Walk the dog
4. Text girlfriend / boyfriend...

Square root (456789) **+** (x **/** y) **+ Absolute value** (10000 **/** -50)

Computers:
No oops allowed!
Something else is needed.

Sound file © "The Simpsons"

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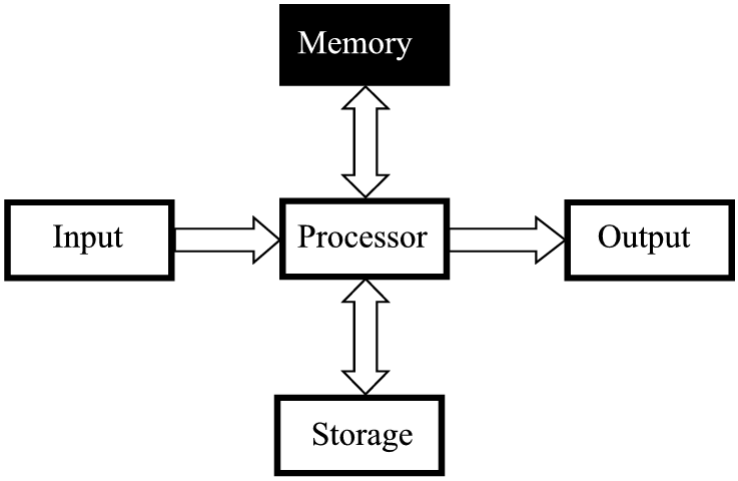
Memory



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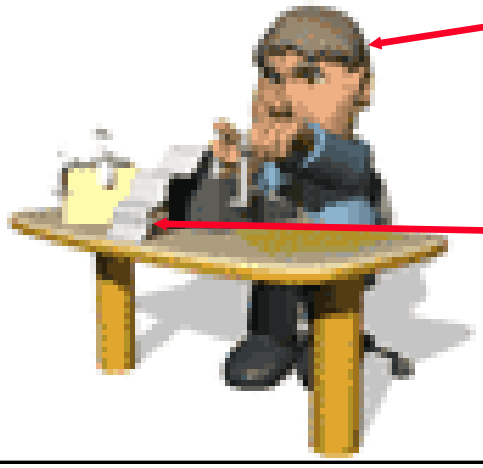
Memory

•It is used as temporary storage for the computer (analogous to scrap paper)



Processor: 'brains' that performs the calculations

Memory: stores information needed by the processor

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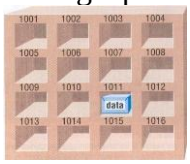
Memory (2)

•Main memory is used to stored information that is currently needed by the computer (e.g., a program running now) but won't fit into the processor's memory.

•A common type of computer memory is RAM (*R*andom *A*ccess *M*emory)

•RAM is volatile (information is stored so long as there is power).

•Memory is organized into numbered 'slots' with each slot storing a piece of information.



Picture from Computers in your future by Pfaffenberger B

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How Much RAM?

- Systems vary widely depending on price but the typical starting values range from 4 GB – 8 GB (values around 16 GB or even 32 GB aren't uncommon however).

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Limitations Of Memory

- It can store more information than the processor's memory but it is still finite in size.
- Example showing memory being used for a computer with 4 GB RAM:
  - Computer is turned on and operating system is loaded (1 GB – 2+ GB of RAM required – depending upon the version of operating system)
  - The user runs a program to play a movie (~30 MB of RAM)
  - The movie player is of typical length, around two hours (~4 GB uncompressed)
  - Total Memory requirements: Over 5 GB of RAM (can't be all stored in RAM)
  - Note: This is a simplified example because most computers will be running many other programs at the same time (e.g., security software to protect the computer against malicious programs).

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Limitations Of Memory (2)

- Also recall that RAM is volatile and information stored there will be lost after the computer is shut off (something else is needed for long term storage)

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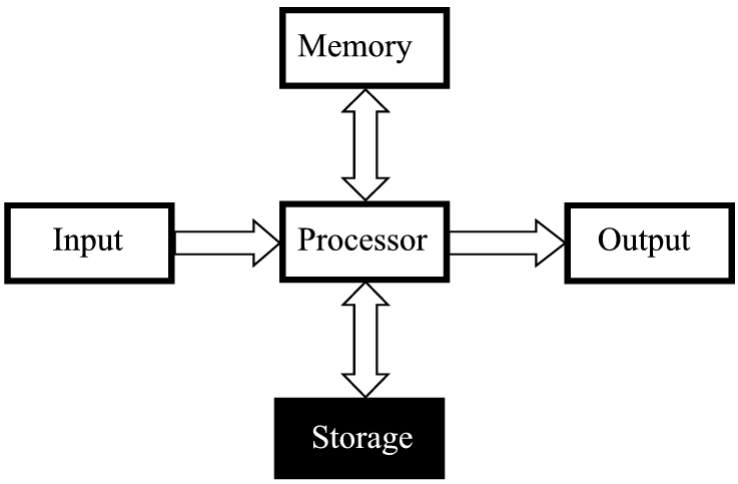
Storage



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Storage Vs. Memory

Storage (e.g., hard drive)

- Information is not needed immediately but will eventually be needed (e.g., a program is installed on the computer in case it's needed)

Memory (RAM)

- Information is required now e.g., a program that is currently running will be stored in memory.

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Storage Vs. Memory (2)

Storage (e.g., hard drive)

- The information is retained longer (e.g., a saved document).

Memory (RAM)

- The information stored here is volatile (e.g., a document you've worked on but not saved is gone when the computer is shut off).

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Storage Vs. Memory (3)

Storage (e.g., hard drive)

- Accessing the information is slower (~1,000,000+ times) but much more information can be stored (x10 to x1000+ times more than RAM).

Memory (RAM)

- Access to the information is fast but far less can be stored here.

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Storage Vs. Memory (4)

Storage (e.g., hard drive)

- Storing information is less expensive ~100 times less.

Memory (RAM)

- Storing information is more expensive.

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Common Forms Of Storage

1. Magnetic
   - Hard drives (includes older types of drives: floppy, zip)
2. Optical
   - CD
   - DVD
3. Solid State
   - USB 'thumb'/'flash' drives
   - Solid state hard drives (SSD)

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1. Magnetic Storage Devices

- Include floppy disks, zip disks, hard drives
- All use magnetism to store information:

- Like other storage devices it's non-volatile but is care must be taken to avoid magnetic fields, dusty or smoky environments, or physical jolts (the latter especially when reading or writing information)

James Tam

1. Magnetic Storage Devices

- Include floppy disks, zip disks, hard drives
- All use magnetism to store information:

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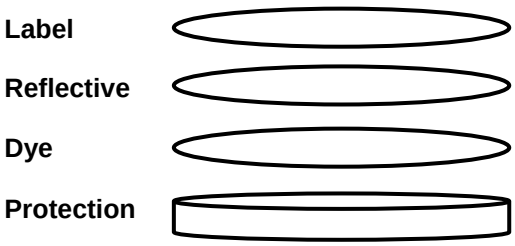
2. Optical Storage Devices

- Use lasers to store and retrieve information (CD's and DVD's).
- The storage capacity difference is approximately 1:8 (CD:DVD).



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2. Optical Storage Devices (2)

- 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).
- Optical storage devices aren't as susceptible to as many problems as magnetic devices but care must be taken not to scratch or otherwise damage the surface.

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3. Solid State Storage Devices

- Portables can store a large amount of information ~8 GB – 64 GB for 'portable' forms)

- Solid state devices are fairly sturdy (come in a protective case) but reasonable care must still be taken e.g., don't remove the device when information is being saved to it, keep the cap on when it's not in use and don't remove a device that's in the middle of a write operation).
- All other things being equal (e.g., two internal storage devices), solid state is faster than magnetic.

James Tam

Buying Storage For Your Computer

- Common storage capacities:
  - (Magnetic) hard drives: several hundred GB to 6+ TB
  - CD's ~600 MB
  - DVD's ~4 GB to 50 GB
  - USB keys and Solid state hard drives ~8 GB (portable) approximately up to the capacity of magnetic hard drive (solid state hard drives): Common max is 256 – 512 GB

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Putting It All Together

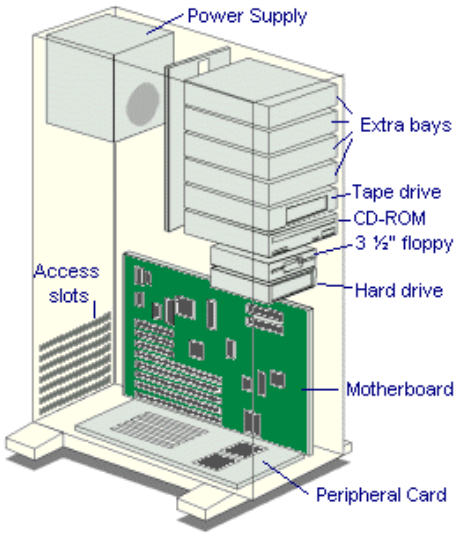

Diagram from http://www.jegsworks.com

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The Motherboard

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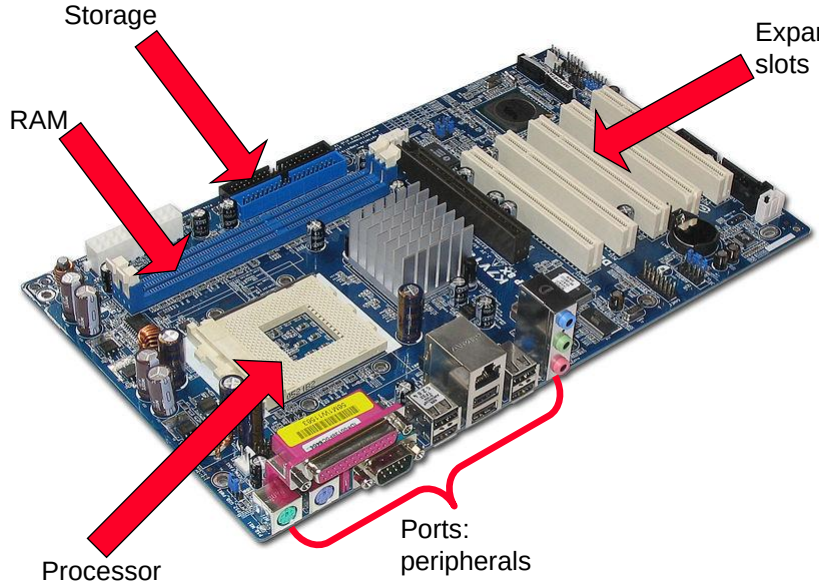
The Motherboard



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Relating The Speed Of The Computer To Its Components

Storage:
Hard drive

Memory:
RAM

Processor
cache

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After This Section You Should Now Know

- What are the six components of the high level conceptual computer and the purpose of each part
- Large and small units of measurement for the computer
- Units of storage on the computer (from bit to Terabyte)
- What is a computer bus and what is a computer port
- How does processor clock speed work
- Approximate clock speeds of modern processors
- Some of the benefits of having a faster processor
- What is memory and its purpose in the computer
- How much memory is found in a typical computer
- The difference between storage and memory

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After This Section You Should Now Know (2)

- What are the common forms of storage and how each one works
- The maximum capacity of the common forms of storage

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