Introduction To Computers: Hardware and Software

In this section of notes you will learn how the basic parts of a computer work as well what are the fundamental categories of computer programs

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What Is Hardware?

- The physical components of a computer system e.g., a monitor, keyboard, mouse and the computer itself.

Basic Units Of Measurement

Bit

• *bi*nary digi*t*
• smallest unit of measurement
• two possible values

Byte

• 8 bits

Word

• The number of adjacent bits that can be stored and manipulated as a unit

• 32, 64 for home computers, 128 for the most powerful

Large Units Of Measurement (Memory, Storage)

• Note: use powers of two 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 600 MB of storage
• Terabyte (TB) – a trillion ($1,099,511,627,776 = 2^{40}$)
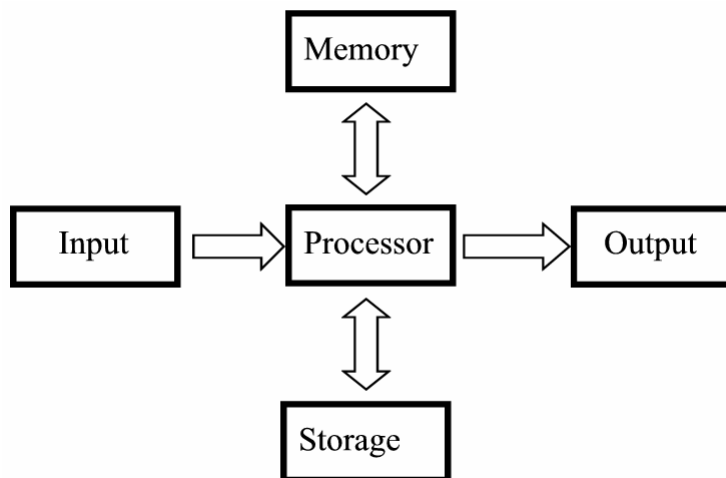 ~ 20 million four-drawer filing cabinets full of text

Small Units Of Measurement (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 ($1/1,000,000,000 = 10^{-9}$)

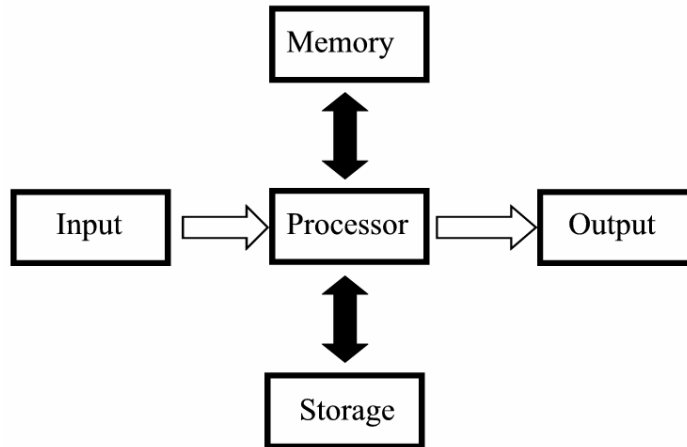# High Level View Of A Computer

```
                    ┌──────────┐
                    │  Memory  │
                    └──────────┘
                         ⇕
┌─────────┐      ┌─────────────┐      ┌──────────┐
│  Input  │ ⇒   │  Processor  │ ⇒    │  Output  │
└─────────┘      └─────────────┘      └──────────┘
                         ⇕
                    ┌──────────┐
                    │ Storage  │
                    └──────────┘
```

Buses

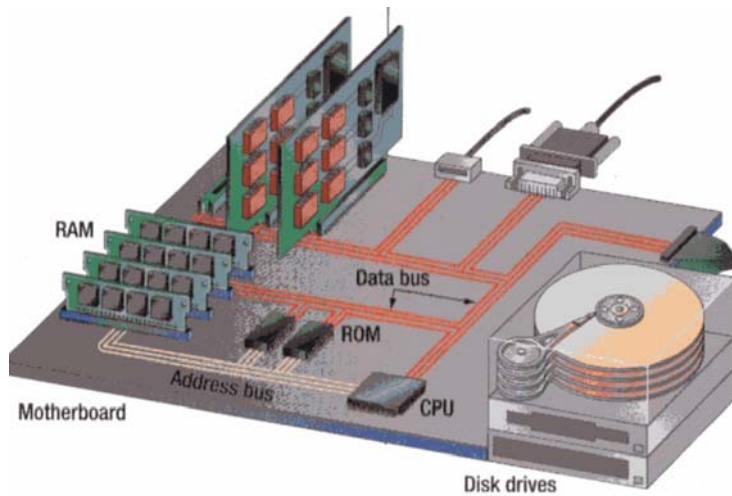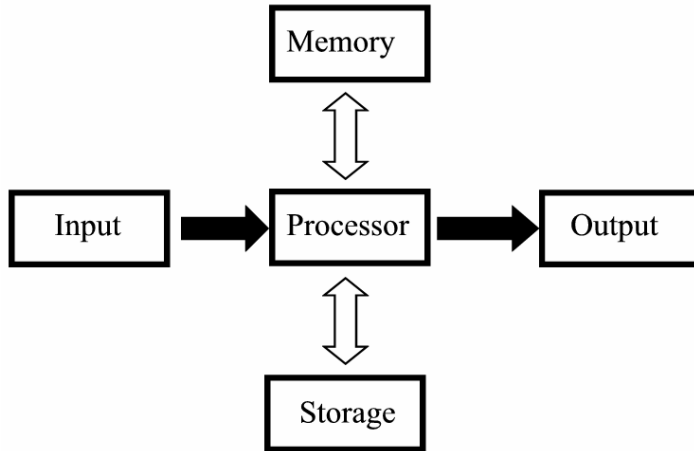•Connect the different parts of the computer together

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Buses (2)

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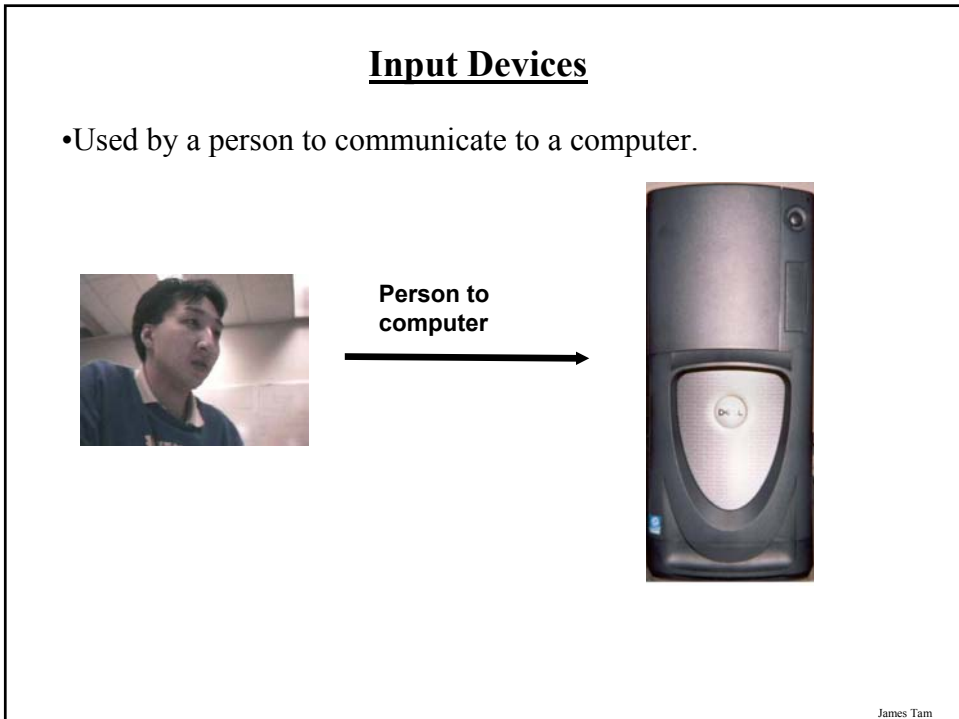
Ports

•Connects the computer to the outside

```
                    ┌──────────┐
                    │  Memory  │
                    └──────────┘
                          ⇕
┌──────────┐        ┌──────────┐        ┌──────────┐
│  Input   │ ──▶    │ Processor│ ──▶    │  Output  │
└──────────┘        └──────────┘        └──────────┘
                          ⇕
                    ┌──────────┐
                    │  Storage │
                    └──────────┘
```
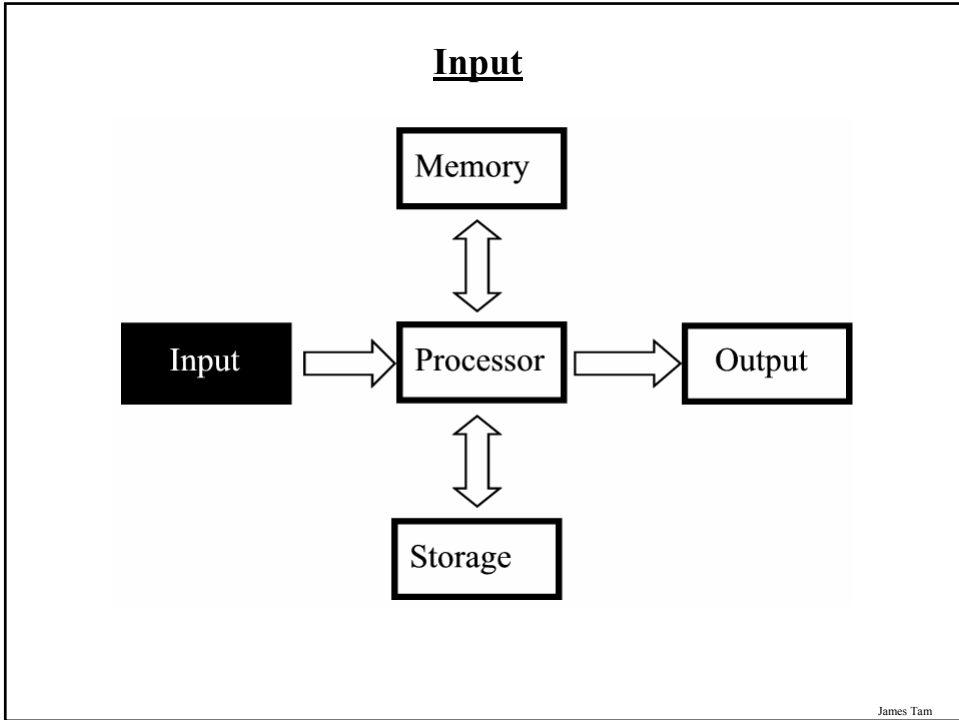
James Tam

Ports

James Tam

Input

```
           ┌──────────┐
           │  Memory  │
           └──────────┘
                ↕
┌─────────┐   ┌──────────┐   ┌──────────┐
│  Input  │ → │ Processor│ → │  Output  │
└─────────┘   └──────────┘   └──────────┘
                ↕
           ┌──────────┐
           │ Storage  │
           └──────────┘
```

Input Devices

• Used by a person to communicate to a computer.

Person to computer →

Example Input Devices

- Keyboard

- Mouse

- Need not be mundane!

From http://www.jouse.com/

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

Processor

```
                    Memory
                      ↕
   Input  →  Processor  →  Output
                      ↕
                   Storage
```
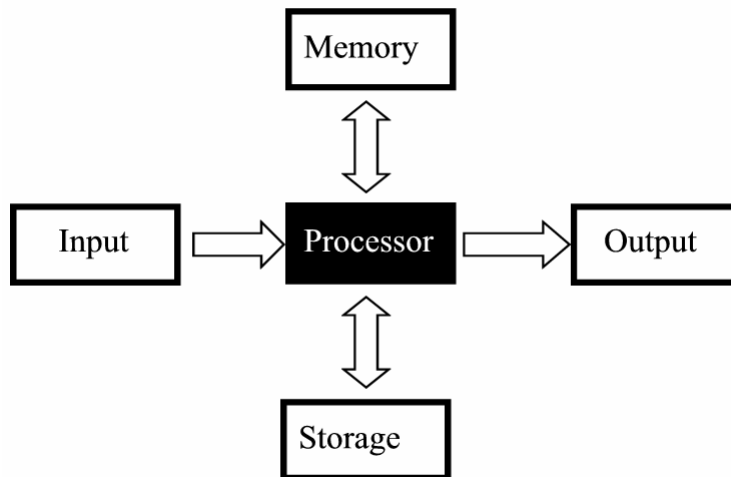
Processor

•The brains of a computer

www.howstuffworks.com

•A common desktop processor

Processor Speed

•Determined by:
- Type of processor e.g., Pentium IV, AMD Athlon 3000+, 3200+
- 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)
  - 3.4 Ghz = 3.4 billion pulses sent out each second (0.29 ns between pulses)

The Processor And The Computer

CPU
Arithmetic Logic Unit
Control Unit

INPUT DEVICES

OUTPUT DEVICES

MEMORY

STORAGE

The Inner Workings Of The ALU

- It works by turning on and off voltage levels in the different parts of the processor.

$X + Y = ?$

X ———→ ▮ ———→ Sum
Y ———→

Registers X   Y
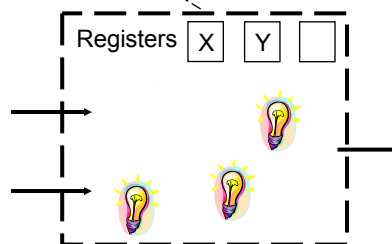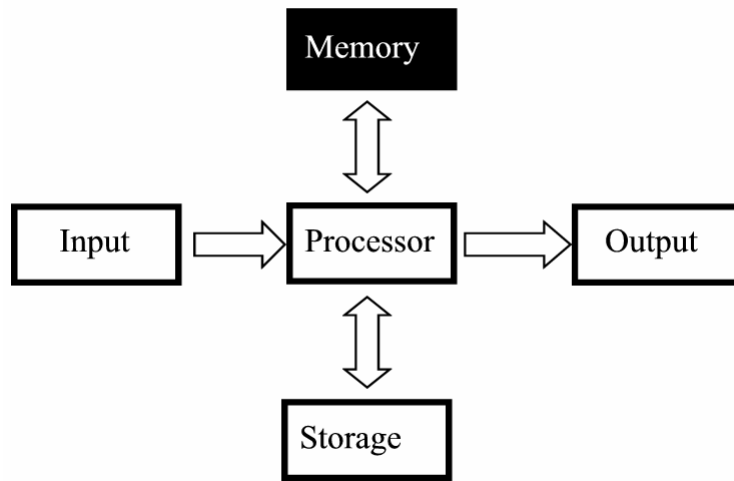
Memory

RAM

- Volatile
- Used for temporary storage
- Typical ranges 256 MB - 4 GB

RAM (2)

•Means direct access to any part of memory
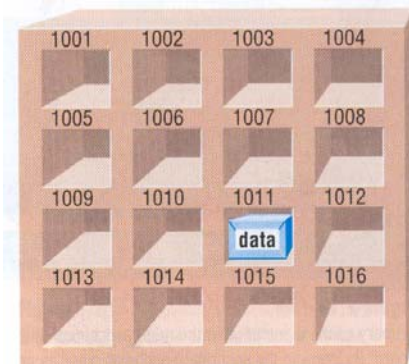
Picture from Computers in your future by Pfaffenberger B

How Does DRAM Work?

•Most RAM is DRAM (Dynamic RAM)
•Acts like a leaky bucket

How Does DRAM Work?

- Most RAM is DRAM (Dynamic RAM)
- Acts like a leaky bucket

Transistor
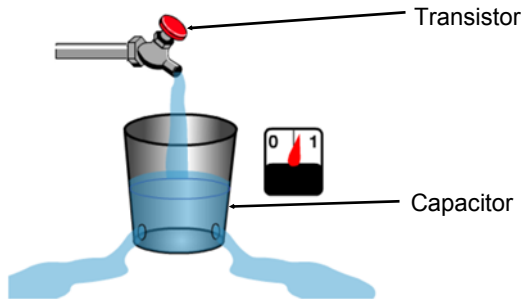
Capacitor

DRAM: A Collection Of Capacitors

A capacitor

Storage

```
        Memory
          ⬍
Input → Processor → Output
          ⬍
       Storage
```
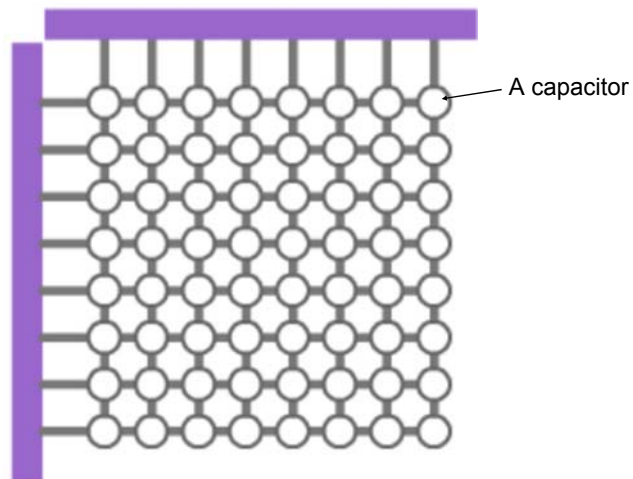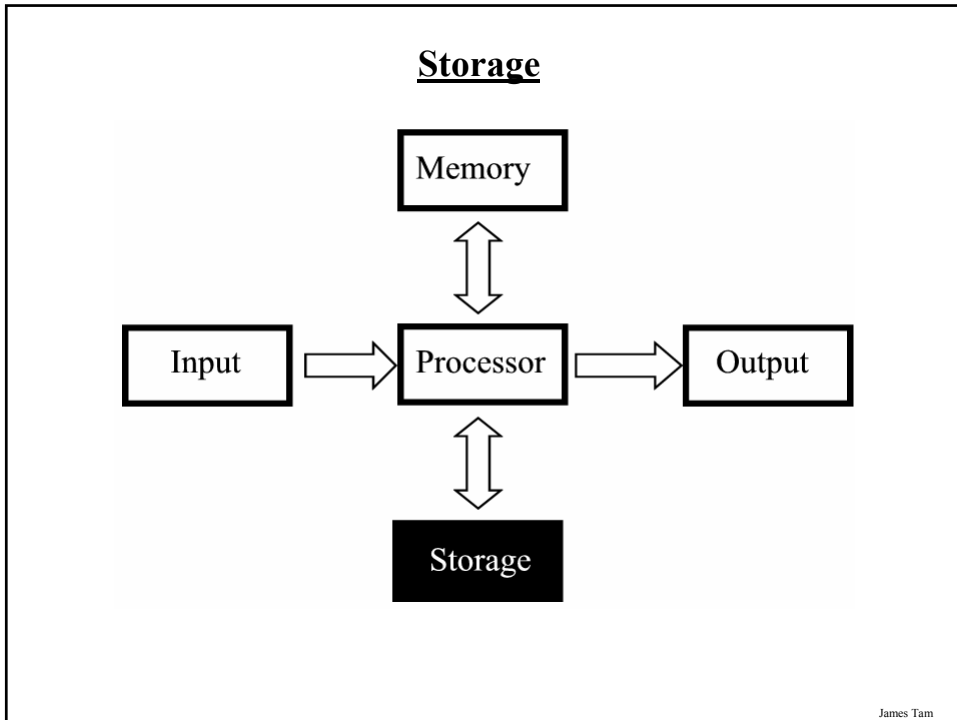
Storage Vs. Memory?

Memory (e.g., RAM)

• Keep the information for a shorter period of time (usually volatile)

• Faster

• More expensive

Storage (e.g., Hard disk)

• The information is retained longer (non-volatile)

• Slower

• Cheaper

Categories Of Storage

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

Magnetic Drives

Magnetic Drives: Storage Capacities

- Floppy disks
  - ~ 1 MB
- Zip disks
  - 100, 250, 750 MB
- Hard drives
  - ~40 – 250 GB

Optical Drives: Reading Information
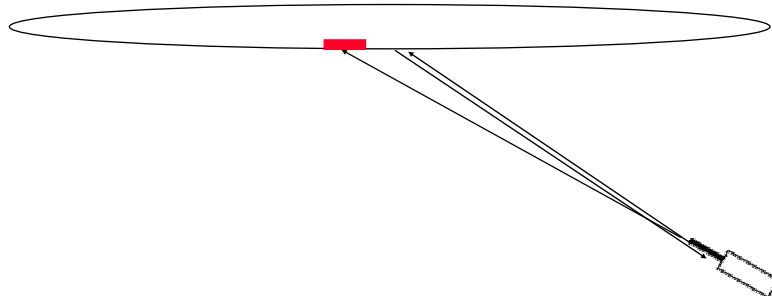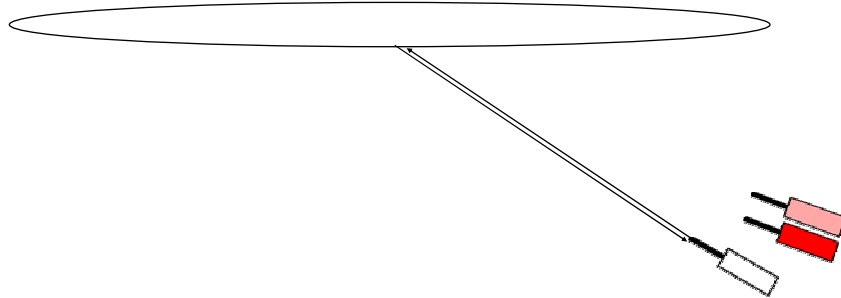
Optical Drives: Recording and Reading Information
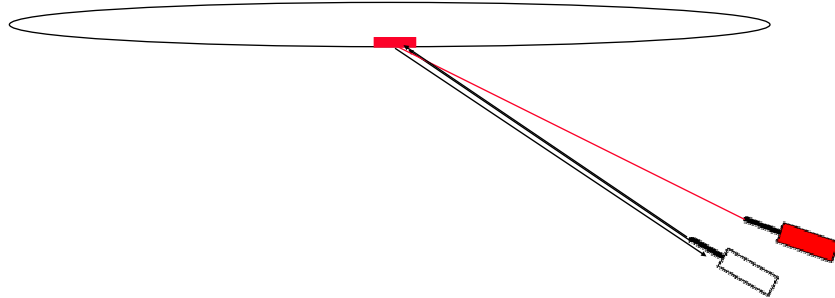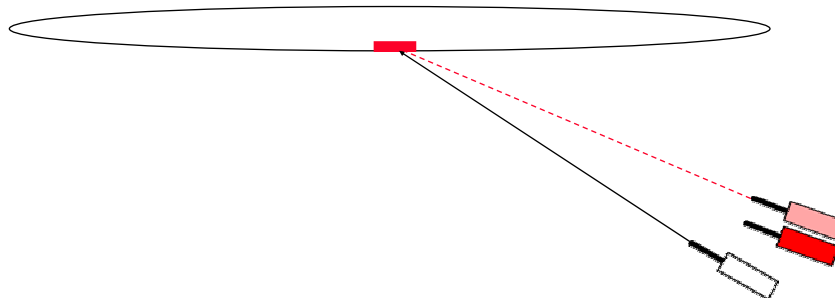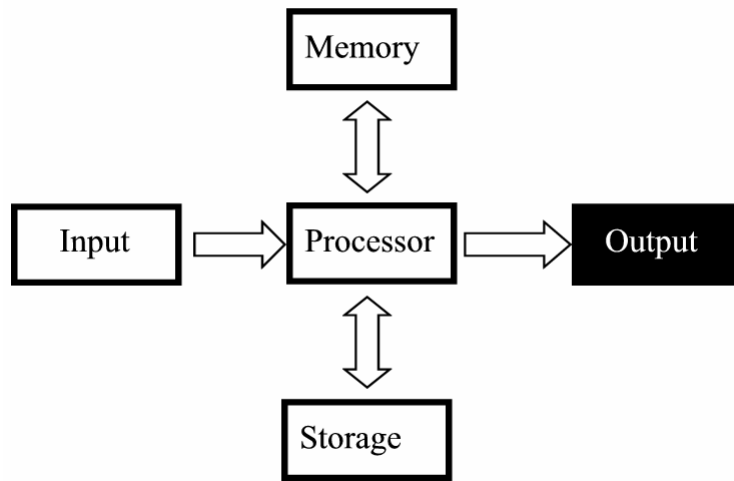
Optical Drives: Re-Writing

Optical Drives: Re-Writing

Optical Drives

•CD's
 - ~ 700 MB storage
 - CD-ROM (read only)
 - CD-R: (**r**ecord) to a CD
 - CD-RW: can write and erase CD to reuse it (**r**e-**w**ritable)

•DVD-ROM
 - Over 4 GB storage (varies with format)
 - DVD- ROM (read only)
 - Many recordable formats (e.g., DVD-R, CD-RW; DVD+R, DVD+RW)

Output

Output Devices

•Displays information from the computer to the a person.

The Most Common Output Device: The Monitor

Types of computer monitors
1) CRT's (Cathode Ray Tube)

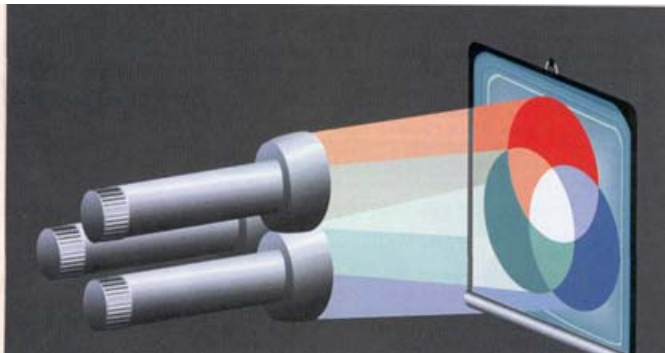2) LCD's (Liquid Crystal Display)

CRT's Monitors

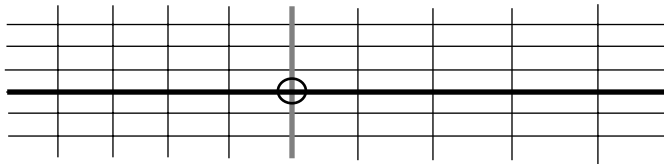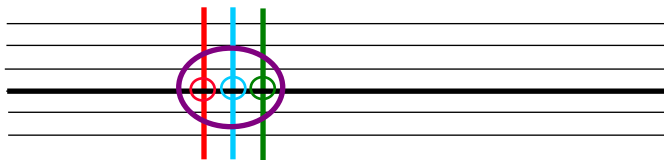•Images are displayed with dots (pixels) drawn with light "guns"

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)

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)

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

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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

3) Monitor Quality (Effects Of Color Depth)

2 colors

16 colors
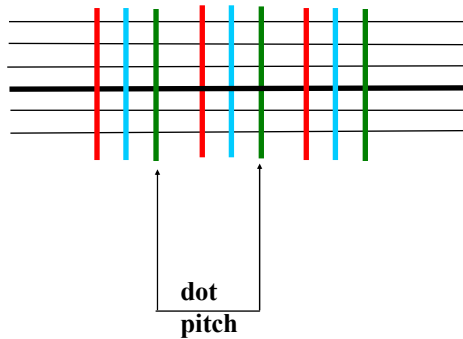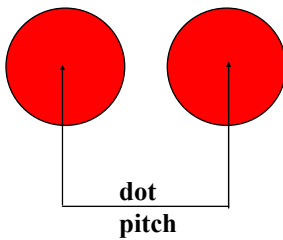

256 colors

16 million colours

James Tam

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4) Monitor Quality (Dot Pitch)

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

dot pitch

dot pitch

James Tam

Refresh Rate Of Monitors

•How fast the screen is redrawn

•(70 Hz / 70 times per second is usually a good minimum)
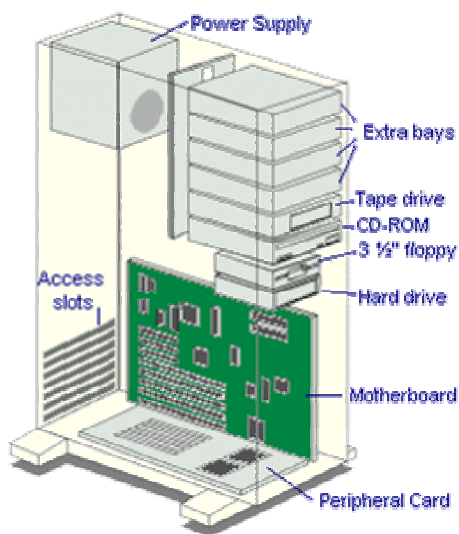
All The Basic Parts Together

- Power Supply
- Extra bays
- Tape drive
- CD-ROM
- 3 ½" floppy
- Hard drive
- Access slots
- Motherboard
- Peripheral Card

The Motherboard

ISA slots — PCI slots — Connectors

Memory chip slots — Keyboard plug — Power connectors

Processor socket
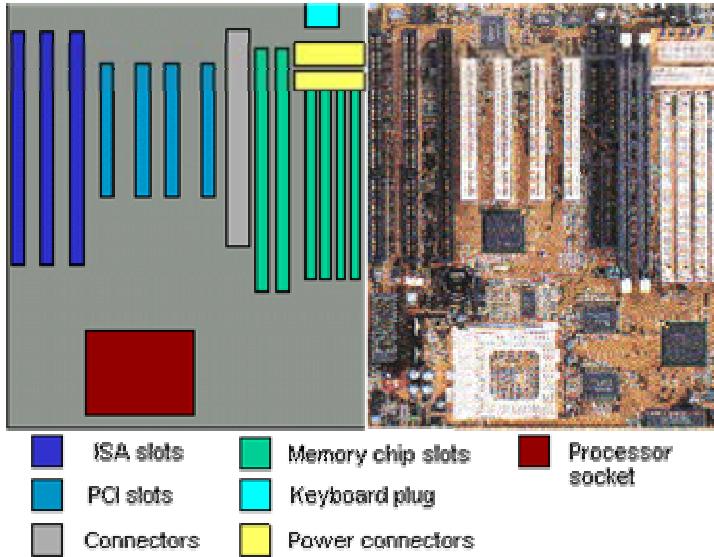
James Tam

Relating The Speed Of The Computer To Its Components

256 MB RAM

512 MB RAM
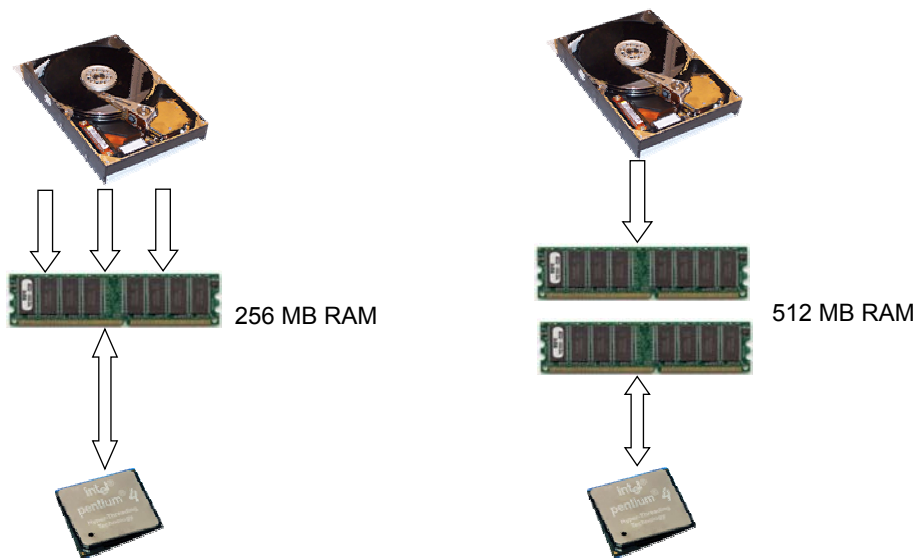
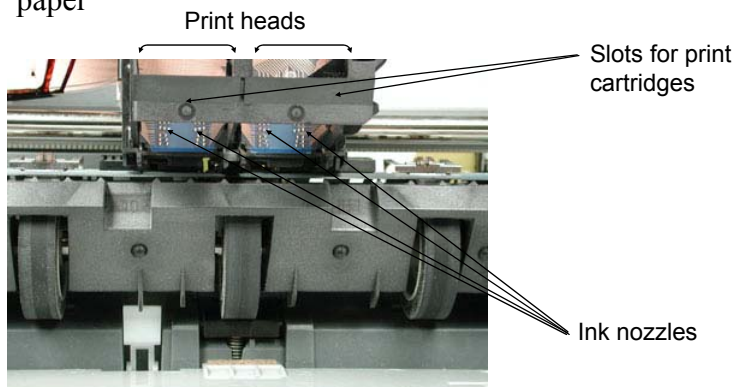James Tam

Printers

•Common types
 - Inkjet

 - Laser

•*Note: By default on the CPSC network you only have access to text-only printers (do not print formatted text or graphics on them!)*

How Inkjet Printers Work.

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

Print heads

Slots for print cartridges

Ink nozzles

How Laser Printers Work

•Uses a laser to produce patterns on an ink drum using static electricity
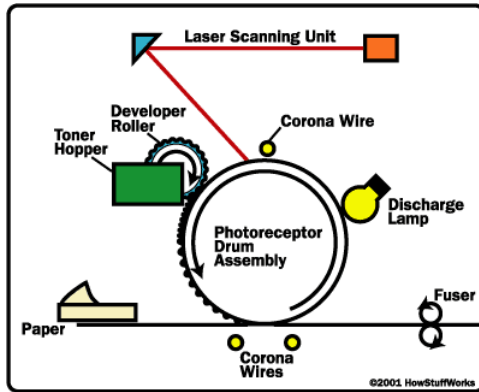
Software

•The instructions that tell the hardware what to do.
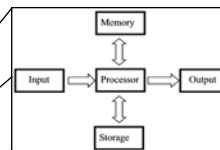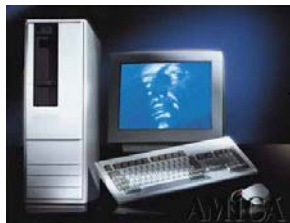
1) Balance my check book.
2) Do the company taxes
3) Print out my resume
4)   :   :

Categories Of Software

1) Application programs (applications)
2) Operating systems
3) Compilers

1) Common Types Of Application Programs

- Word processors
- Spreadsheets
- Databases
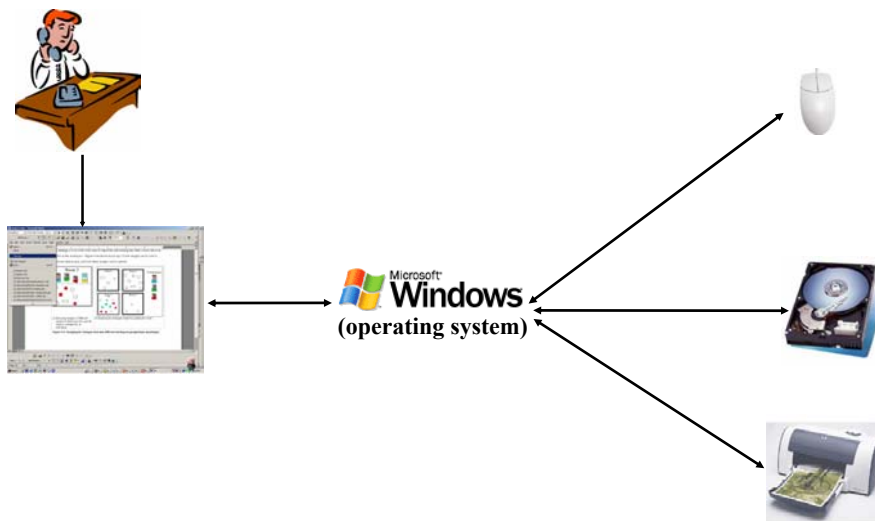- Presentation software
- Web browsers
- Games
- :   :

2) Operating Systems: What Do They Do?

- Act an an intermediary between the user and the hardware
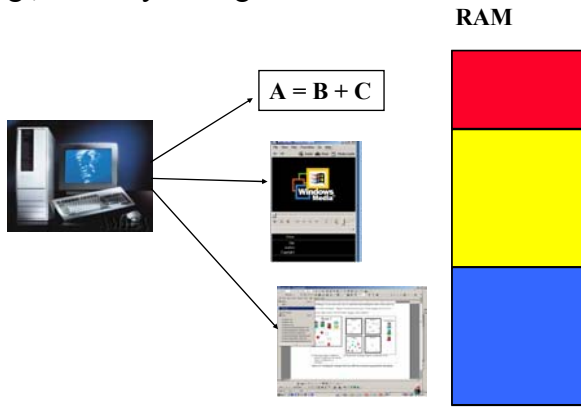
- Manage the resources of the computer

Operating Systems: The Intermediary Between The User And The Hardware

Windows
(operating system)

Operating Systems: Manage System Resources

•e.g., Memory management

RAM

A = B + C

Operating Systems: Manage System Resources (2)

•e.g., Processor time

A = B + C
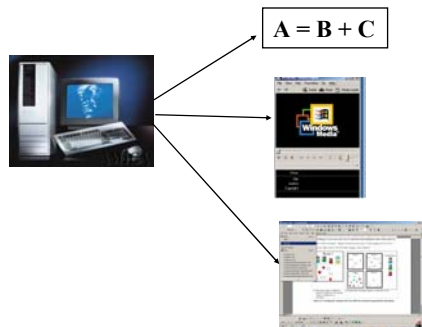
3) Compilers (Real-World)

Real life translation

圣诞快乐和新年好!

Same to you buddy!
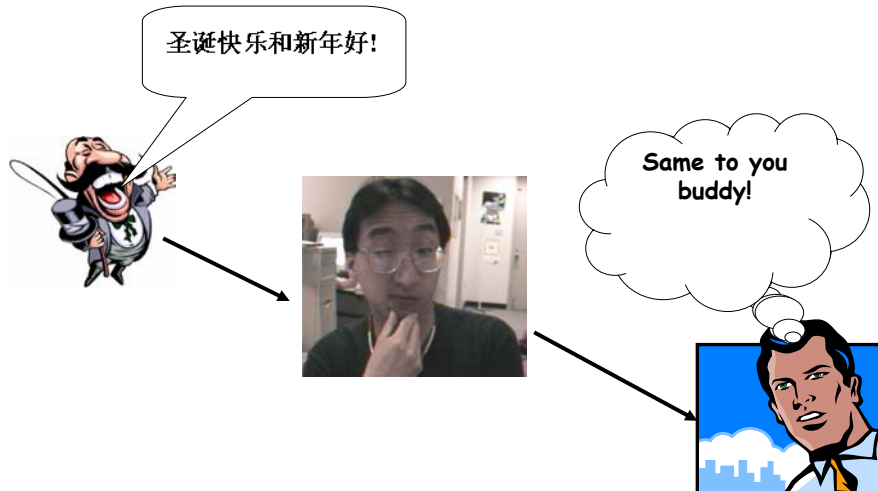
Computer Programs

Binary is the language of the computer

1) A programmer writes a computer program

2) The compiler translates the program into a form that the computer can understand

3) An executable program is created

4. Anybody who has this executable installed on their computer can then run (use) it.
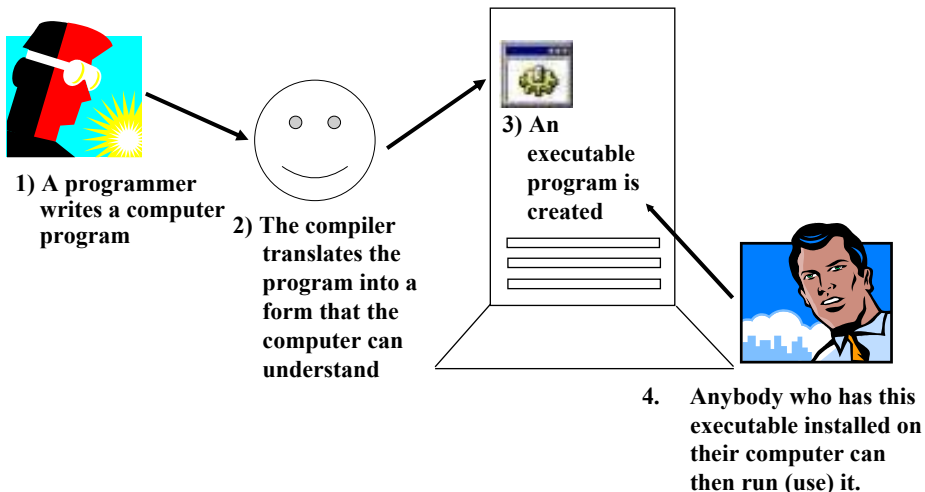
Relating Hardware And Software
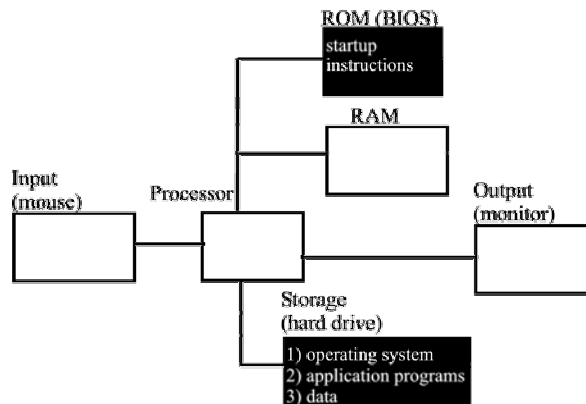
High level static view of a computer
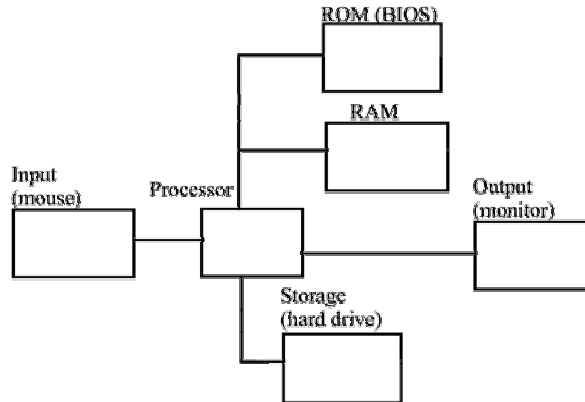
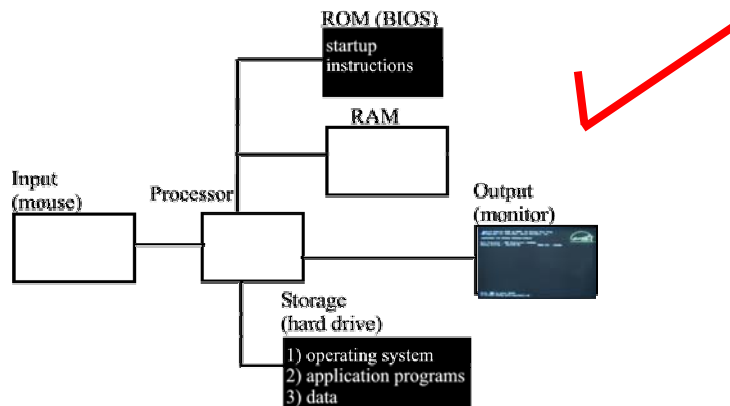# Relating Hardware And Software (2)

The computer turned off

Relating Hardware And Software: Starting The Computer

1) Self test

2) Look for the operating system

3) Load the operating system

Relating Hardware And Software: Starting The Computer (2)

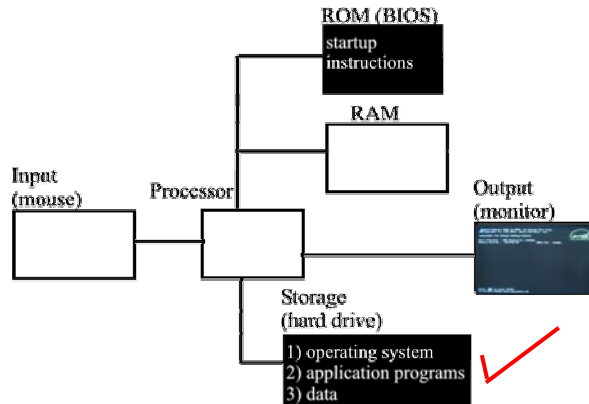1) Self test

Relating Hardware And Software: Starting The Computer (3)
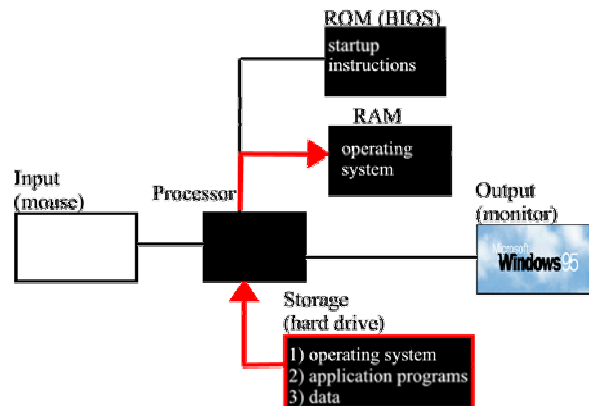
2) Look for the operating system

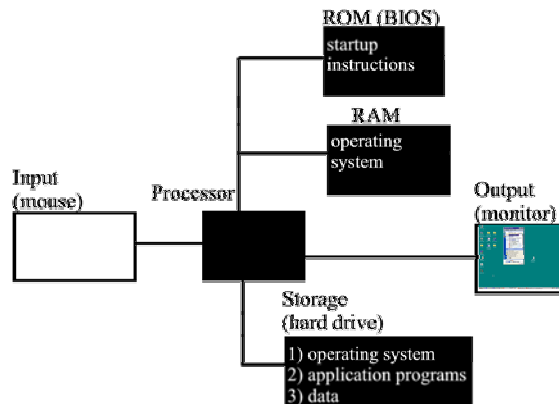# Relating Hardware And Software: Starting The Computer (4)

3) Load the operating system

Operating System Loaded

ROM (BIOS)
startup instructions

RAM
operating system

Input
(mouse)

Processor

Output
(monitor)

Storage
(hard drive)
1) operating system
2) application programs
3) data

Relating Hardware And Software:
While The Computer Is Running

1. The user selects a folder to open
2. The operating system sends an interrupt to the processor
3. The processor pauses its current task
4. The operating system tells the processor to retrieve the names of the files stored in the folder.
5. The processor retrieves the names of the files in the folder.
6. The operating system intercepts the list of file names retrieved from disk and displays it onscreen.
7. Sometime during this operation the operating system tells the processor to resume the paused task

The User Selects A Folder To Open

Operating system

Processor

Hard drive

The Operating System Sends An Interrupt Request To The Processor

Operating system

Processor

Hard drive

The Processor Pauses The Current Task

Operating system

Processor

Hard drive

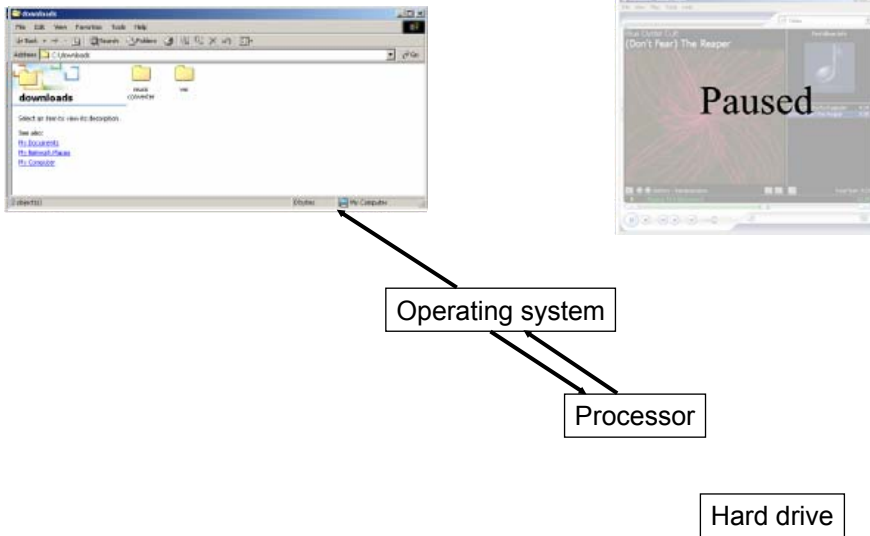# The Processor Retrieves The File Names From Disk

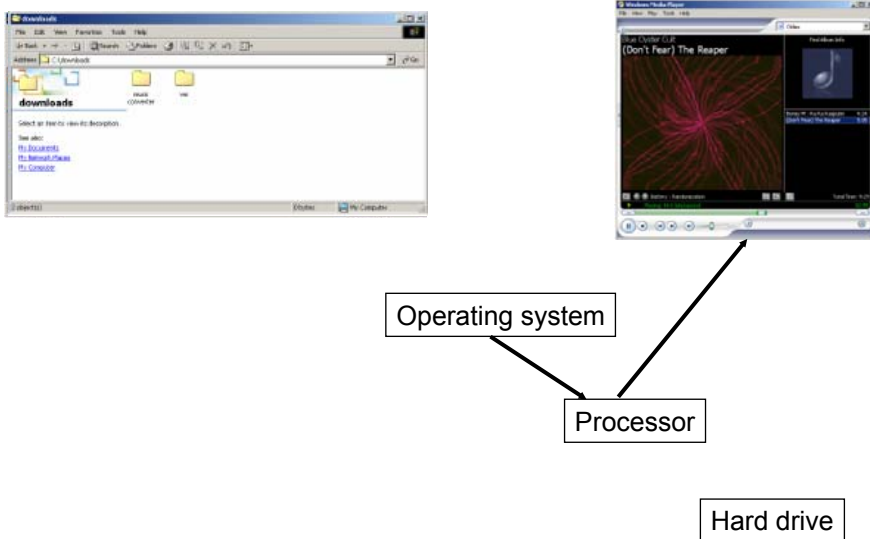Operating system

File1
File 2
:

Processor

Hard drive

The Operating System Displays The Names Of The Files

Operating system

Processor

Hard drive

James Tam

The Paused Operation Is Resumed

Operating system

Processor

Hard drive

James Tam

You Should Now Know

•Hardware
- The basic units of measurement for the computer
- What are the basic parts of the high level view of a computer
- Example input devices
- The role of the processor in a computer
- Determinants of processor speed
- What are the characteristics of RAM memory
- How does DRAM work
- The difference between storage and memory
- What are the different categories of storage devices as well as common examples of each
- The approximate storage capacity of different storage devices
- How do different storage devices work
- How do computer monitors work
- What determines the quality of a computer monitor
- How hardware affects speed
- How do computer printers work

You Should Now Know (2)

•Software
- What are the basic categories software
- What is the role of operating systems
- What do compilers do

•Relating hardware and software
- What happens during the startup process of a computer
- An example of how is user input interpreted by the computer