LECTURE 3

HARDWARE

Lecture Outline

- Computer Types
- System Unit
  - Mainboard
  - Central Processing Unit
    - Control Unit
    - Arithmetic Logic Unit
    - Registers
  - Main Memory
  - Buses, Ports, Connectors
  - Secondary Storage Devices
- Input/Output Devices

Desktop / Laptop PCs

- They are the most widely used Personal Computers.
- Windows or Linux operating system is installed.
- Usually Intel CPU (or equivalent) are used.

Hand-held PCs

- They provide personal organizer functions.
- Windows CE (Consumer Electronics) operating system is installed.
- Tablet PC allows you to write on the screen using a special digital pen. Hand Recognition software can turn your writings into regular text.

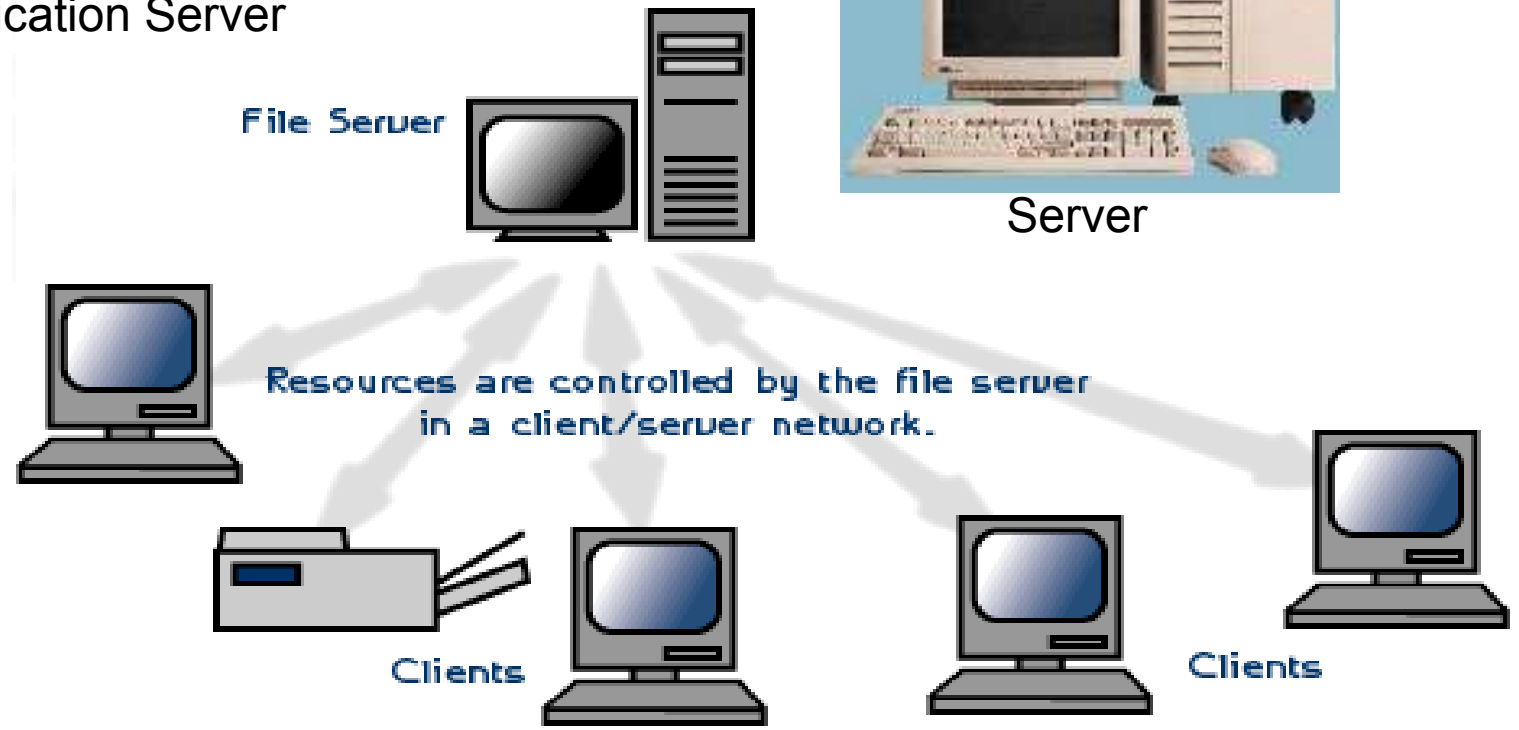
Personal Digital Assistant (PDA)

Tablet PC

Servers

- A server is a computer which controls access to network resources and provides centralized storage. It handles the sharing of equipment like printers and the communication between computers on the network.
- Server Types:
  - File Server (Login server)
  - Web Server
  - Database Server
  - Application Server

Server



Workstation

- A workstation is a computer connected to a network and generally have more memory, storage space, speed.
- They are used in engineering and medical areas which requires high speed graphics.

SGI (Silicon Graphics Interface)

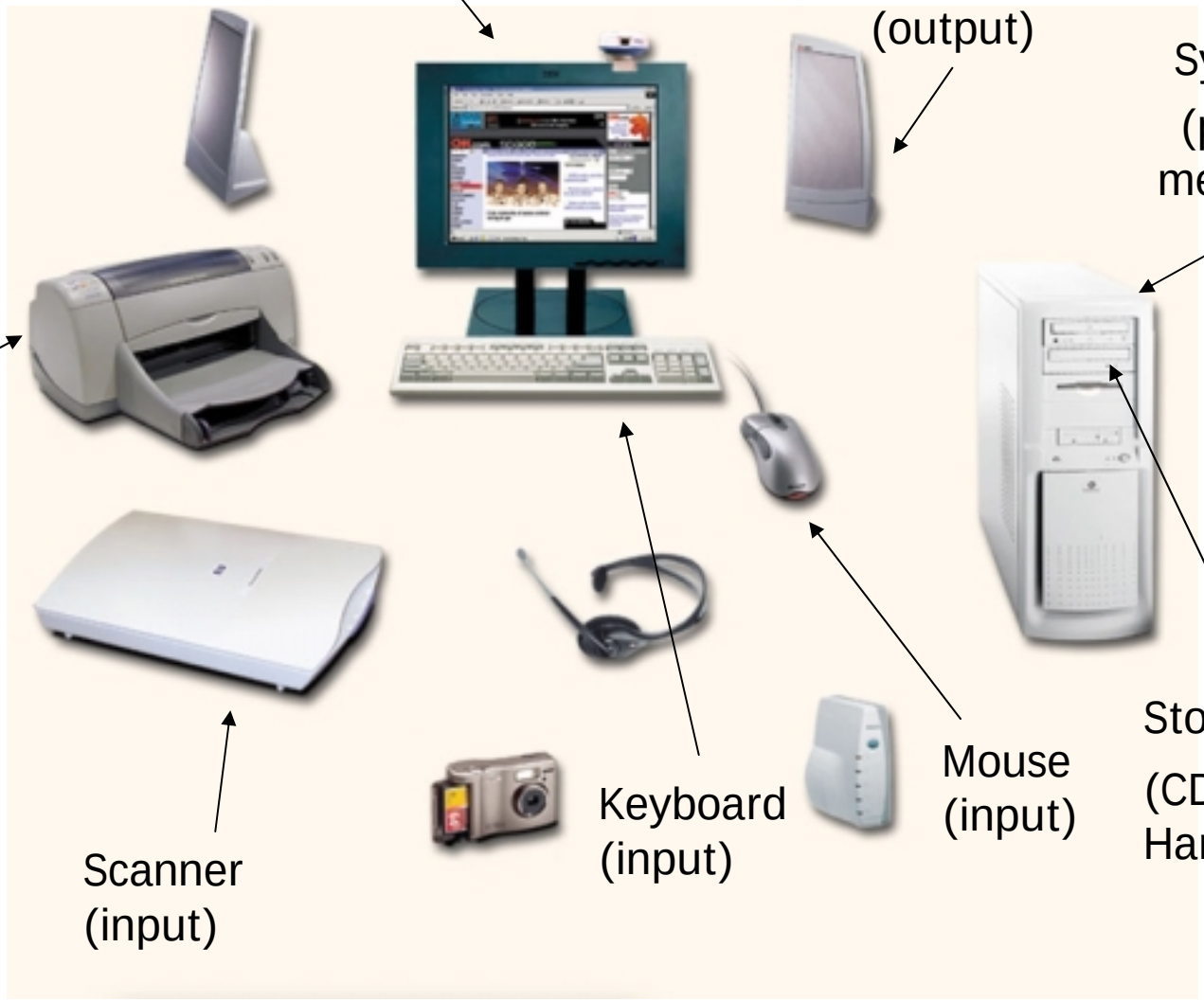
Mainframe

- Mainframe is a very powerful, expensive computer that supports thousands of connected users.

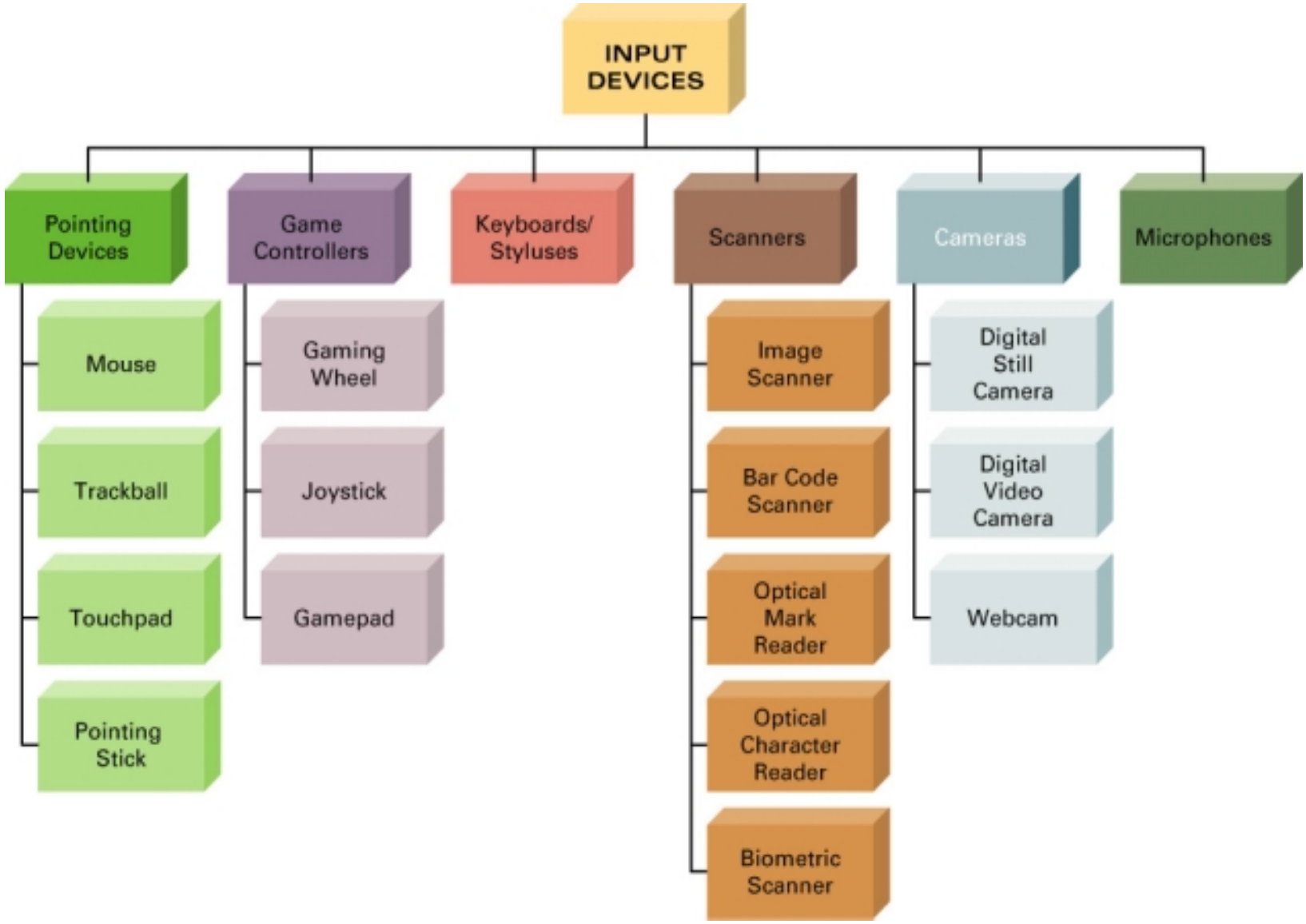
Super Computer

- Supercomputers are the fastest, most powerful, most expensive computers. Used for applications requiring complex mathematical calculations.

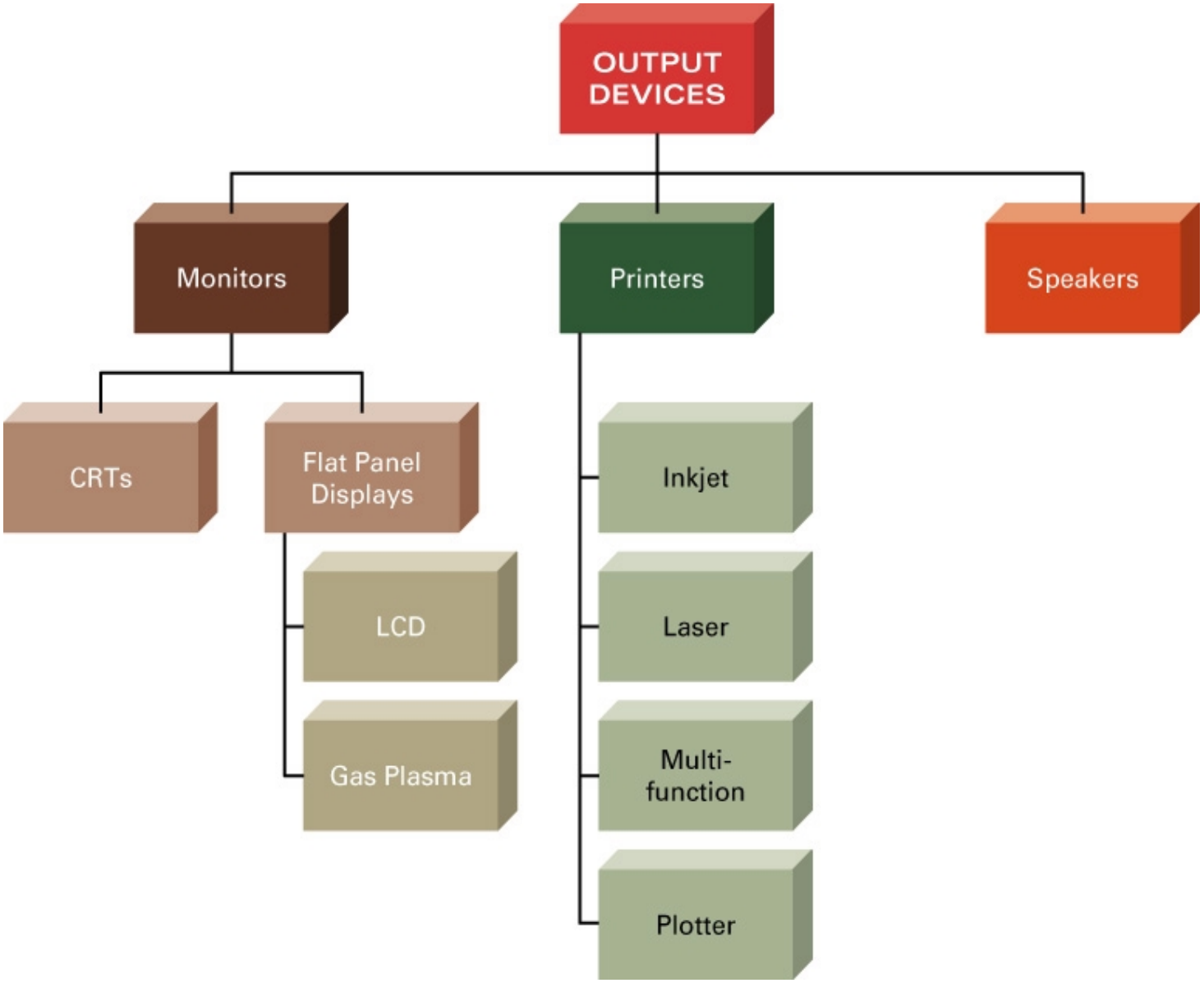
Desktop PC Hardware



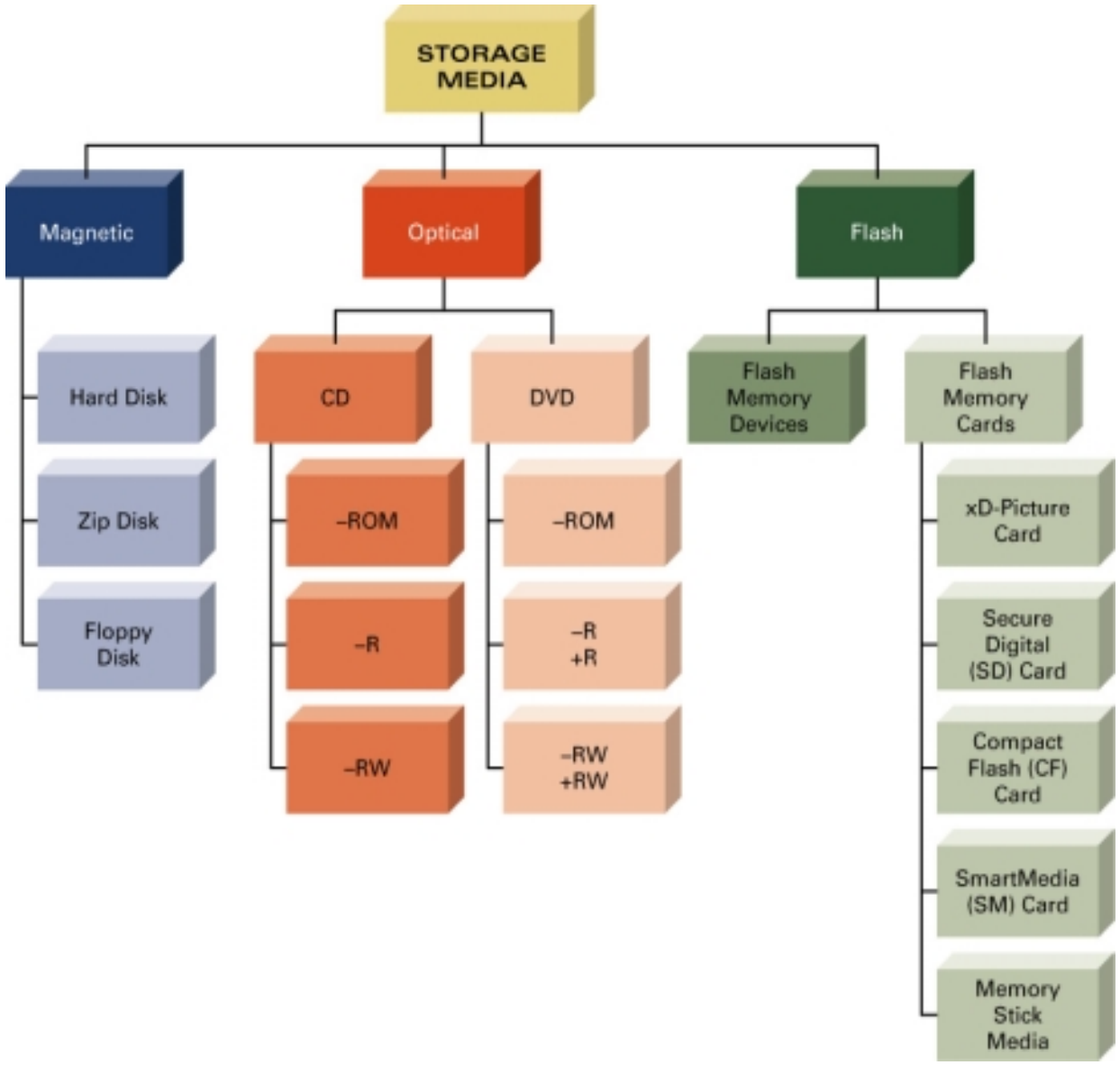
Input Devices



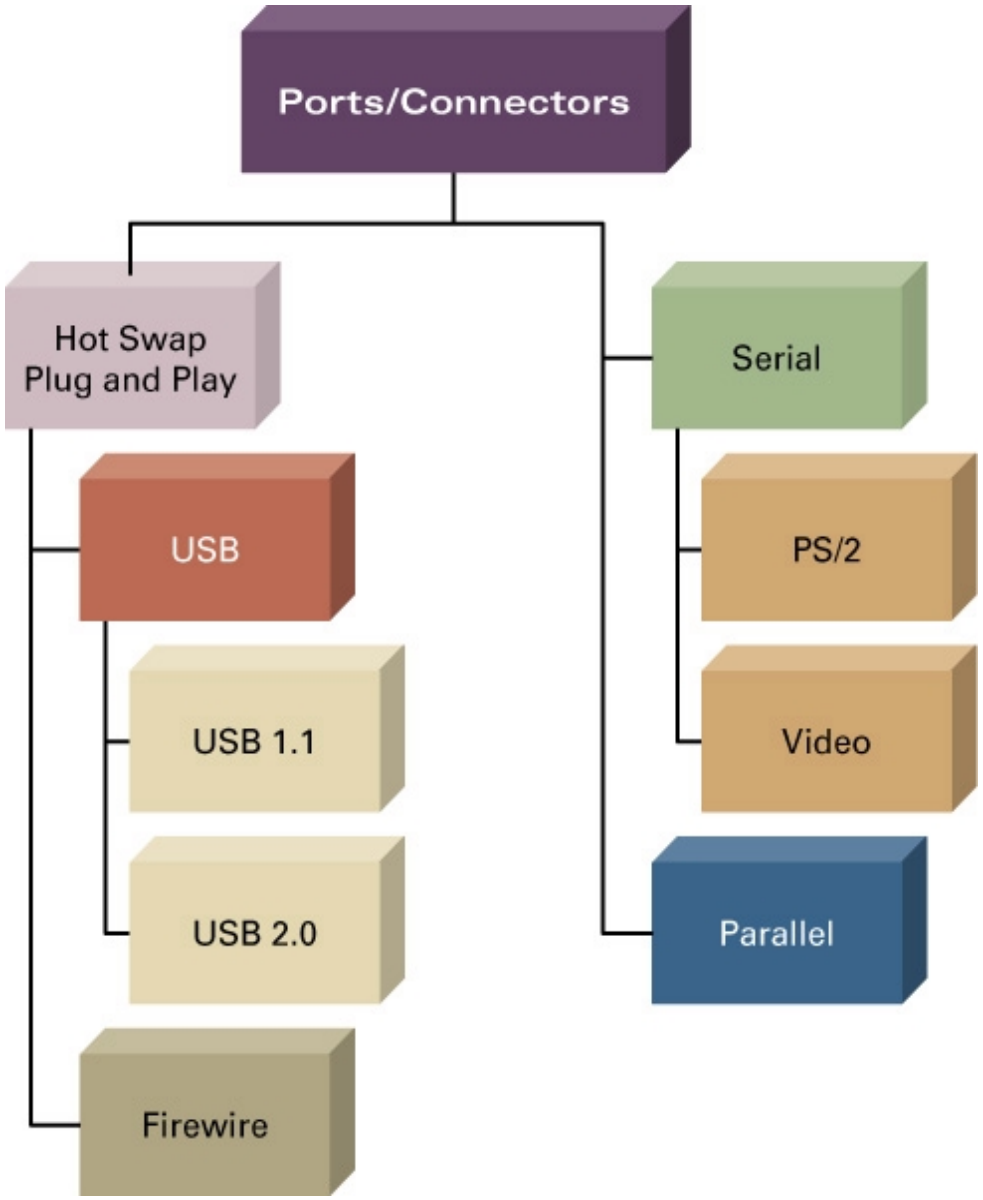
Output Devices



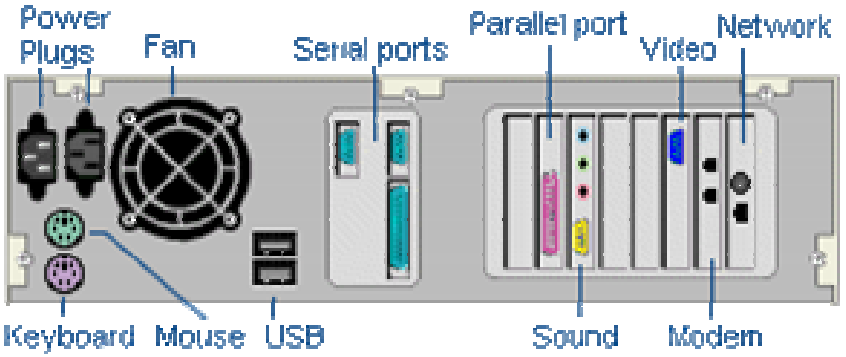
Storage Devices

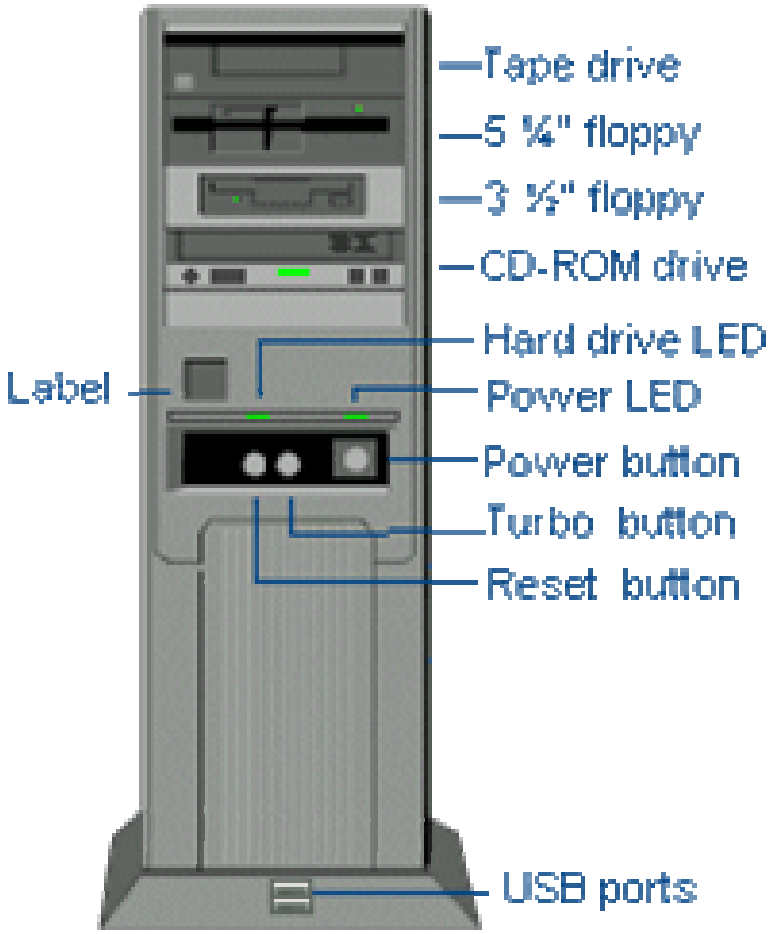


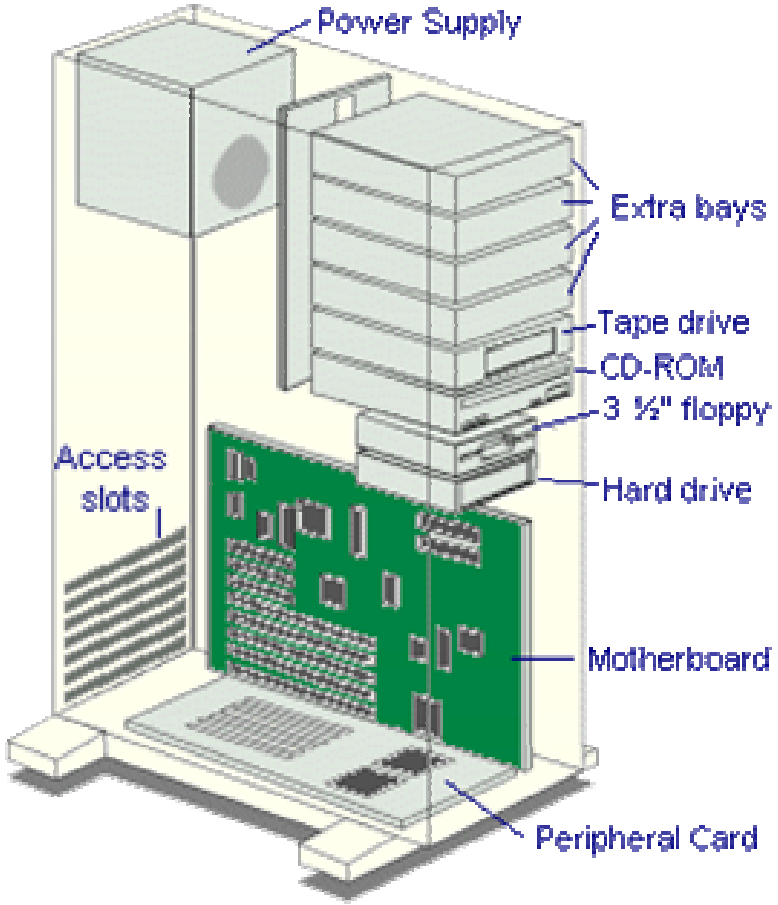
Connectors and Ports



System Unit


Power Plugs
Fan
Serial ports
Parallel port
Video
Network
Keyboard
Mouse
USB
Sound
Modem


Tape drive
5 ¼" floppy
3 ½" floppy
CD-ROM drive
Hard drive LED
Label
Power LED
Power button
Turbo button
Reset button
USB ports


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

Inside the System Unit

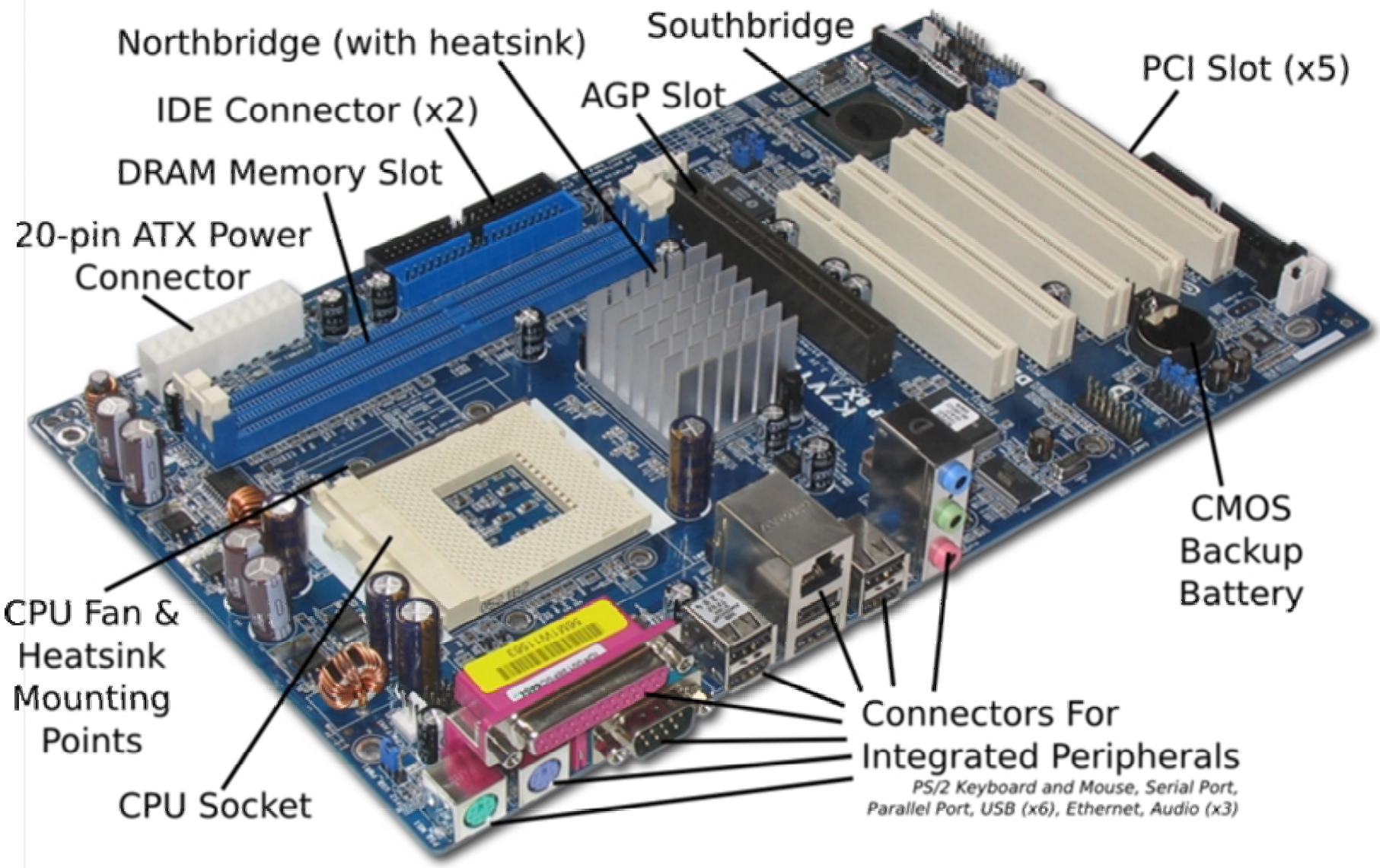
- Mainboard : Large printed circuit board with thousands of electrical circuits.
- Power supply : Transforms alternating current (AC) from wall outlets to direct current (DC) needed by the computer.
- Extension Slots: For cards such as network, modem, etc.
- Cooling fan : Keeps the system unit cool.
- Secondary storage drives : Hard disk, Floppy diskett, CD-ROM / DVD-ROM.

Mainboard

- A mainboard is the primary large **Printed Circuit Board** making up the backbone of a computer.

- It holds electronic components and interconnects, as well as physical connectors (sockets, slots) into which other computer components may be inserted or attached.

Mainboard Example



Component Abbreviations

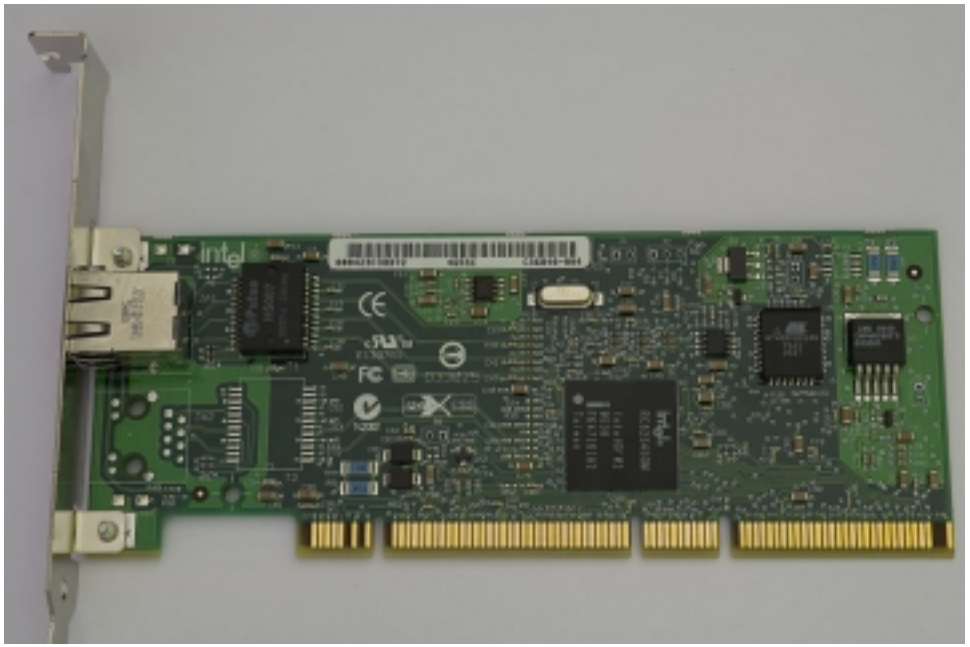
Short name	Long name	Explanation
CPU	Central Processing Unit	Microprocessor chip
AGP	Accelerated Graphics Port	Slot for high speed graphics card
PCI	Peripheral Component Interconnect	Slots for network cards, sound cards, modems, webcam, TV tuner cards, and disk controllers.
DRAM	Dynamic Random Access Memory	Main memory
IDE	Integrated Drive Electronics	Hard disk drive
Northbridge	Memory controller hub	Controller of RAM, AGP
Southbridge	I/O controller hub	Controller of ROM, IDE, USB, PCI

Mainboard Components

- Socket in which a microprocessor (CPU) is installed
- A clock generator which produces the system clock signal to synchronize the various components
- Slots into which the system's main memory is installed (typically in the form of modules containing DRAM chips)
- Slots for expansion cards (these interface to the system via the buses supported by the chipset)
- A chipset which forms an interface between the CPU's front-side bus, main memory, and peripheral buses
- Non-volatile memory chips (ROM) containing the system's firmware (BIOS)
- Power connectors and circuits, which receive electrical power from the computer power supply and distribute it to the CPU, chipset, main memory, and expansion cards

Expansion Cards

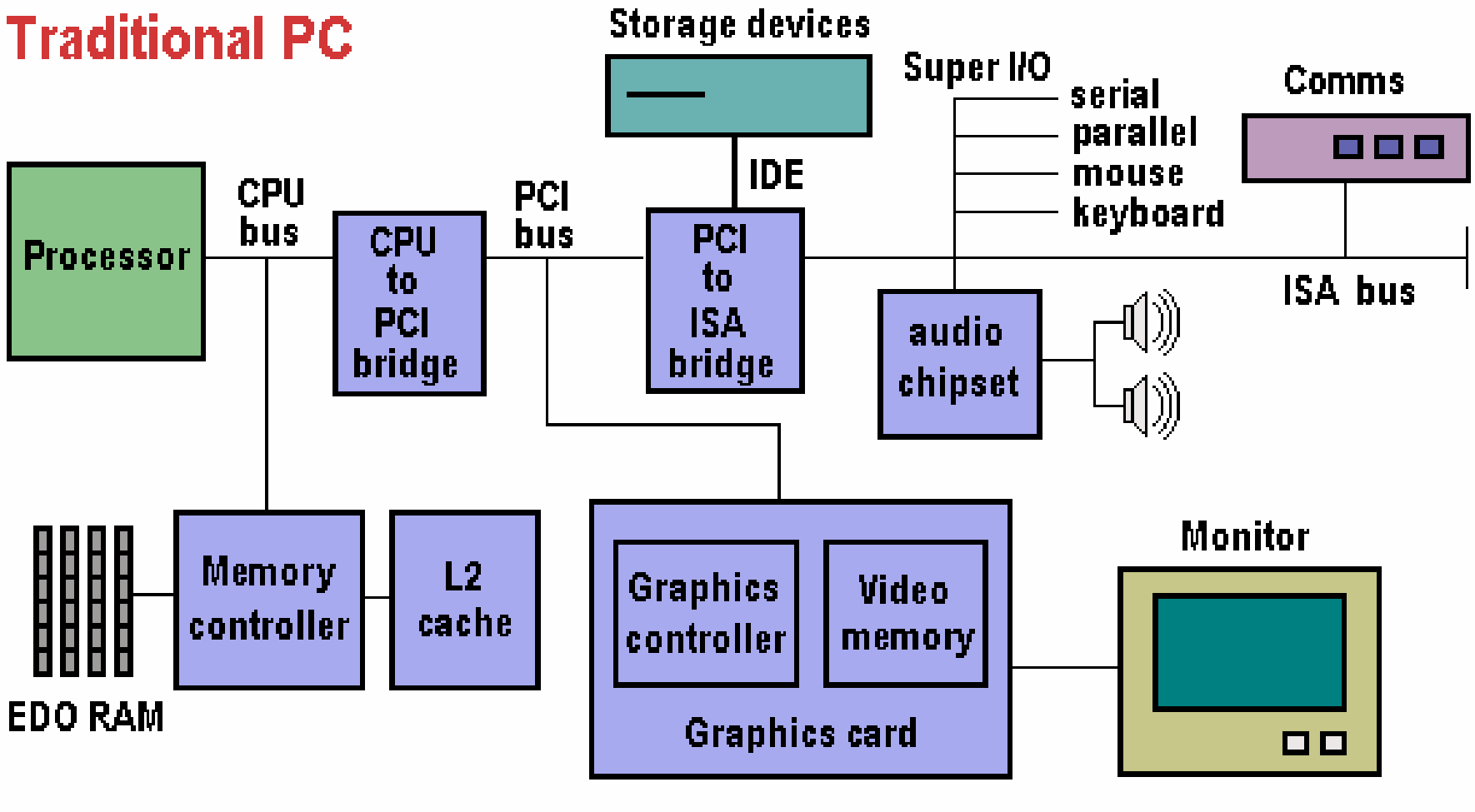
SCSI adapter card



Ethernet card

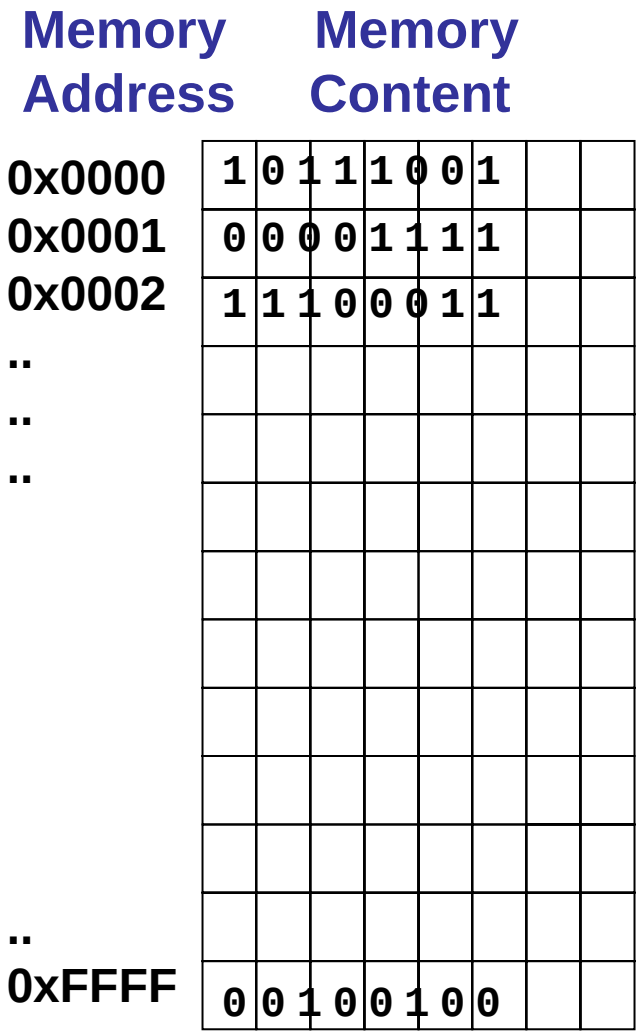
Memory card

Example Configuration



MAIN MEMORY

Memory Addresses



- Memory holds the commands and data (in binary) the computer will process.

- Memory is usually divided into cells of 1 byte (8-bit).

- Each byte cell has assigned a specific address, from 0x0000 to the maximum size of the computer's memory capacity.

- The **size** of a computer's memory is the number of the addressable cells it contains.

- **This example is a 8-bit memory which has a total capacity of 65,535 $(FFFF)_{16}$ bytes.**

Memory Capacity Measures

Byte	8-bits	
Word	32-bits	
Kilobyte - KB	2^{10} = 1KB = 1024 bytes	~ 10^3
Megabyte - MB	2^{20} = 1MB	~ 10^6
Gigabyte - GB	2^{30} = 1GB	~ 10^9
Terabyte - TB	2^{40} = 1TB	~ 10^{12}
Petabyte - PB	2^{50} = 1PB	~ 10^{15}
Exabyte - EB	2^{60} = 1EB	~ 10^{18}

Main Memory: RAM

- Main Memory (Primary Memory) is where the computer stores the data and commands that are currently being used.
- RAM (random access memory) is the computer's main memory and is used to temporarily storage programs and data with which it is working.
- **RAM is a volatile memory because all contents are lost when the power to the computer goes off.**
- The CPU can fetch one piece of data in one machine cycle.
- RAM comes in a variety of types, speeds, and size. Types of RAM include:
  - SRAM
  - DRAM
  - SDRAM
  - DDR SDRAM

Memory Speed and Capacity

- Memory speed measures the time it takes to move data in or out of memory. It is measured differently for different kinds of memory chips:
  - in nanoseconds (ns) (smaller is faster) for EDO and FPM (1 ns = 1 billionth of a second)
  - in megahertz (MHz) (higher is faster) for SDR SDRAM, DDR, SDRAM, and RDRAM.

- The capacity of a memory chip is measured in megabytes or gigabytes. For example, 256 MB of RAM is required to run Windows XP and 512MB is much better.
- Several such memory boards can be installed in the computer to increase the amount of RAM available.

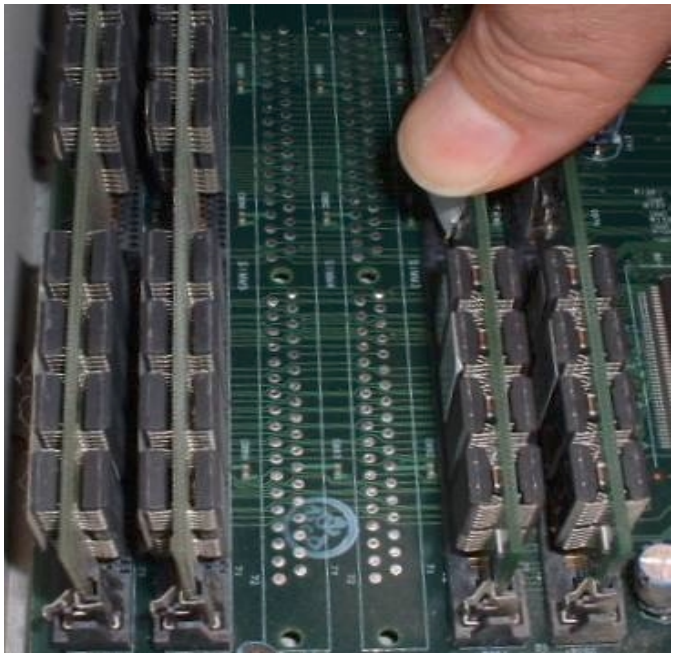
Caches and Registers

- These are volatile memory because content is lost when power is turned off.

- **Cache memory** :Fast memory chips located on or close to the CPU chip.
  - Primary cache (Level 1 or L1) : Located within the CPU chip, it is the memory the microprocessor uses to store frequently used instructions and data.
  - Secondary cache (Level 2 or L2; Backside Cache) : Located near the CPU, it is the memory between the CPU and RAM.
  - Cache is faster than RAM.

- **Registers** : High speed memory built into the CPU.

RAM Examples



RAM components plug into slots on mainboard

RAM

Static RAM (SRAM)

- Fast : ~4 nano seconds access time
- Persistent : Once value is written, it is guaranteed to remain in the memory as long as power is applied. And no refresh required.
- More expensive than DRAM
- 6 transistors / bit
- Stable : High immunity to noise and environmental disturbances
- Technology for caches
- **Used inside CPU**

Dynamic RAM (DRAM)

- Dynamic RAM : A memory chip that needs to be refreshed periodically, or it will lose its data.
- Generally, simpler internal design than SRAM.
- Nonpersistant : every row must be accessed every ~1 ms (refreshed)
- Often hold larger amount of data than SRAM
- Slower than SRAM : access time ~60 nsec
- Cheaper than SRAM
- 1 transistor / bit
- Fragile : electrical noise, light, radiation
- **Used as main memory**

Synchronous DRAM (SDRAM) :
Synchronized with the computer's system clock.

Double Data Rate SDRAM (DDR SDRAM) :
A type of SDRAM that can send and receive data within one clock cycle.

Non-volatile Memory Types

•Contents of non-volatile memory are not erased when power is turned off.

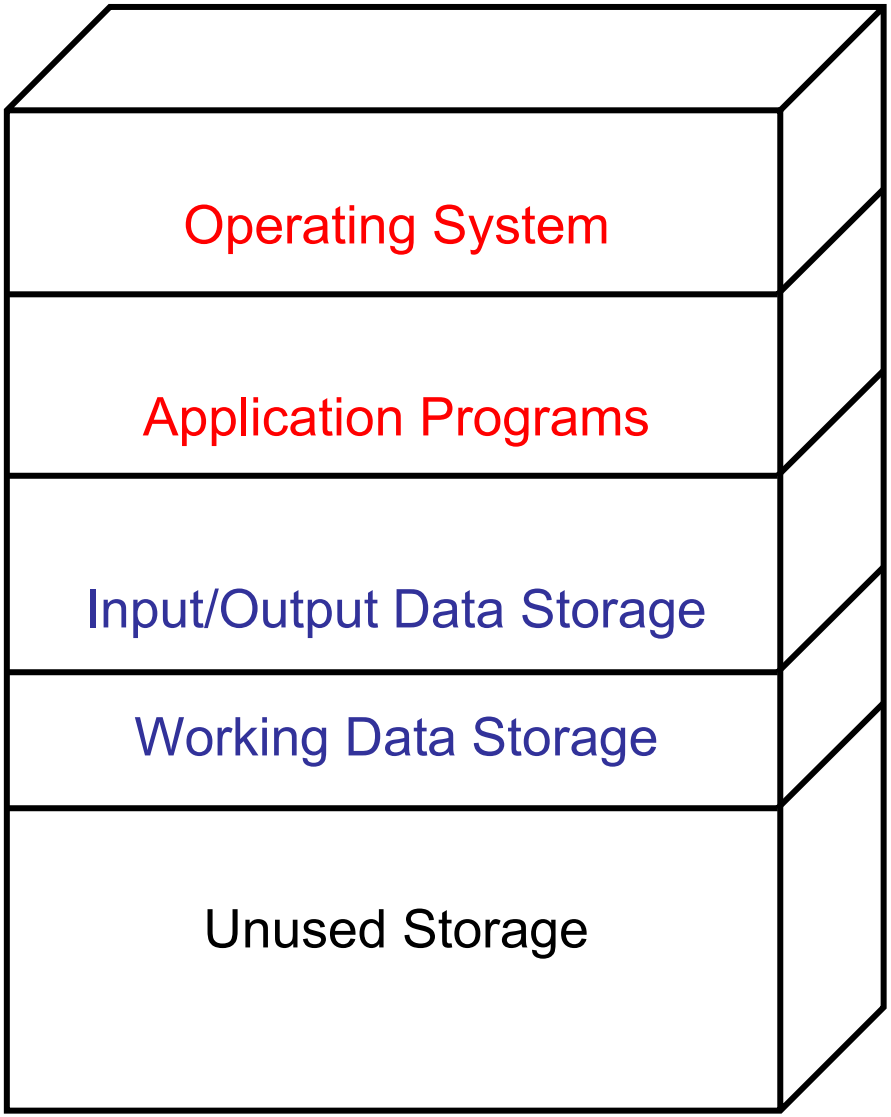
•**ROM (Read Only Memory)** : Provides the instructions to start the computer (BIOS).

•**Flash Memory** : Non-volatile memory that can be erased and reused. Used both within the PC and for portable storage media (e.g digital cameras).

Flash Memory

Memory Stick

Segmented Areas of Main Memory



Segmented Areas of Main Memory (1)

► Operating System

- This is the instructions that the computer uses to tell itself how it "operates".
- Some common operating systems are DOS, Windows, UNIX, Linux. These all have different hardware requirements, so they won't all run on all machines.

► Application Programs

- These are the various programs that are currently running on the computer.
- By taking turns with the Machine Cycle, modern computers can have several different programs running at once. This is called **multi-tasking.**
- Each open application has to have some data stored in Main Memory. Some programs like graphics require a lot of the Main Memory space.

Segmented Areas of Main Memory (2)

► Input/Output Storage

- When you enter new data, the keystrokes must be stored until the computer can do something with the new data.
- When you want data printed out or displayed, it must be stored somewhere handy first.

► Working Storage

- The numbers and characters that are the intermediate results of computer operations must be stored until the final values are calculated. These values "in progress" are kept in temporary locations.

► Unused Storage

- If space runs out in Main Memory, the computer will **crash**, that is, stop working. A crash can mean a lot of lost work.
- When the space is getting short, the user could close some of the open applications to free up more space in Main Memory.

CENTRAL PROCESSING UNIT

CPU (Central Processing Unit)

- CPU is the heart of a computer.
- Also called the processor or microprocessor.
- CPU has two sub components:

- **Control Unit:** Controls and coordinates the computer's operations.
  - Execute programs/instructions: the assembly language
  - Move data from one memory location to another
  - Communicate between other parts of a PC

- **Arithmetic Logic Unit (ALU):** Performs all arithmetic computations and logic operations.
  - Basic arithmetic operations: add, subtract, multiply, divide
  - Basic logic operations: and, or, not, xor
  - Floating point operations: real number manipulation

CPU Speed

• CPU synchronizes its operations by the regular pulses emitted by an electronic device called a clock. There are two types of speed measures.

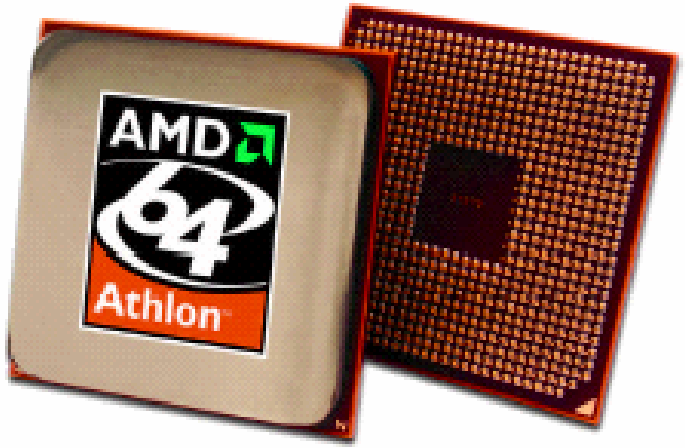
• **Clock Speeed** : Its unit is Hertz, or cycles per second.
1 Mega hertz (MHz) = 1 million cycles per second
1 Giga hertz (GHz) = 1 billion cycles per second

For example, Pentium 4 has a speed of 3.8 GHz, which means 3.8 billion cycles per second.

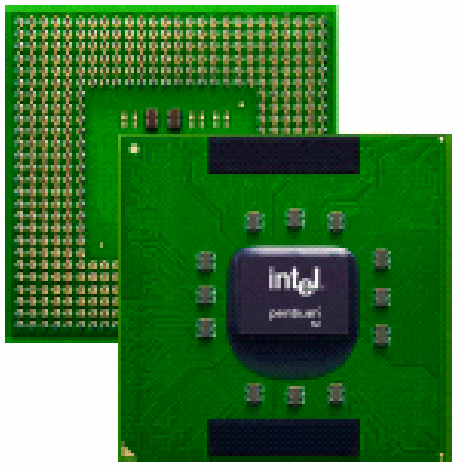
• **MIPS** (million instructions per second) : It is the unit of time it takes to execute one instruction.

Various CPU Examples

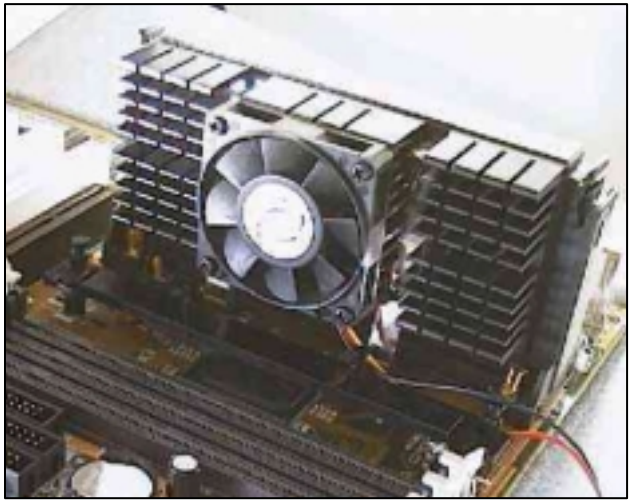
INTEL PENTIUM 4



AMD ATHLON 64



INTEL PENTIUM M



A CPU with a cooling fan and a heat sink

Inside the CPU

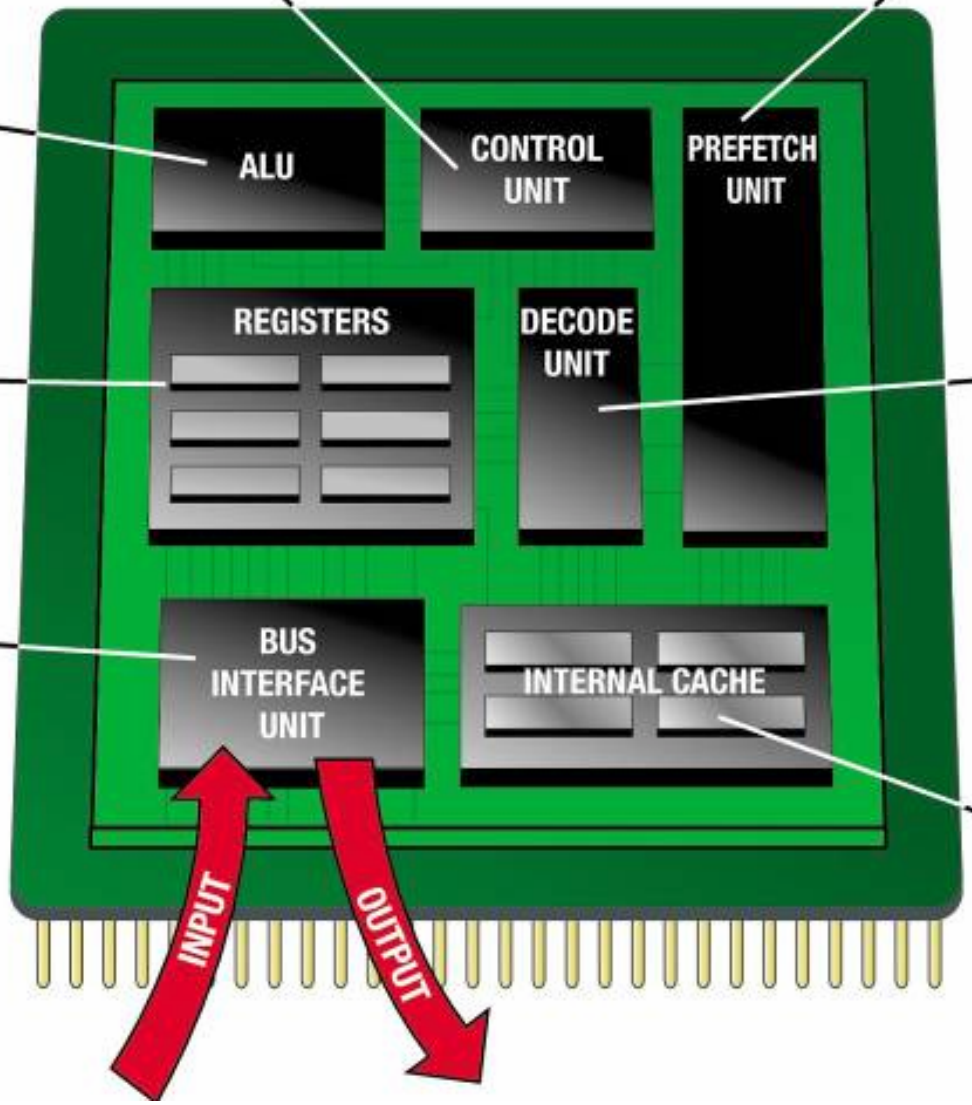
CONTROL UNIT
Is in charge of the entire process, making sure everything happens at the right time. Based on instructions from the decode unit, it instructs the ALU and the registers what to do.

PREFETCH UNIT
Requests instructions and data from cache or RAM based on what is happening at the moment and makes sure they are in the proper order for processing. It attempts to fetch instructions and data ahead of time, so that the other components don't have to wait for the next instruction or piece of data.

ARITHMETIC/LOGIC UNIT
Performs the arithmetic and logical operations, as directed by the control unit.

REGISTERS
Memory used to hold data needed by the ALU for processing.

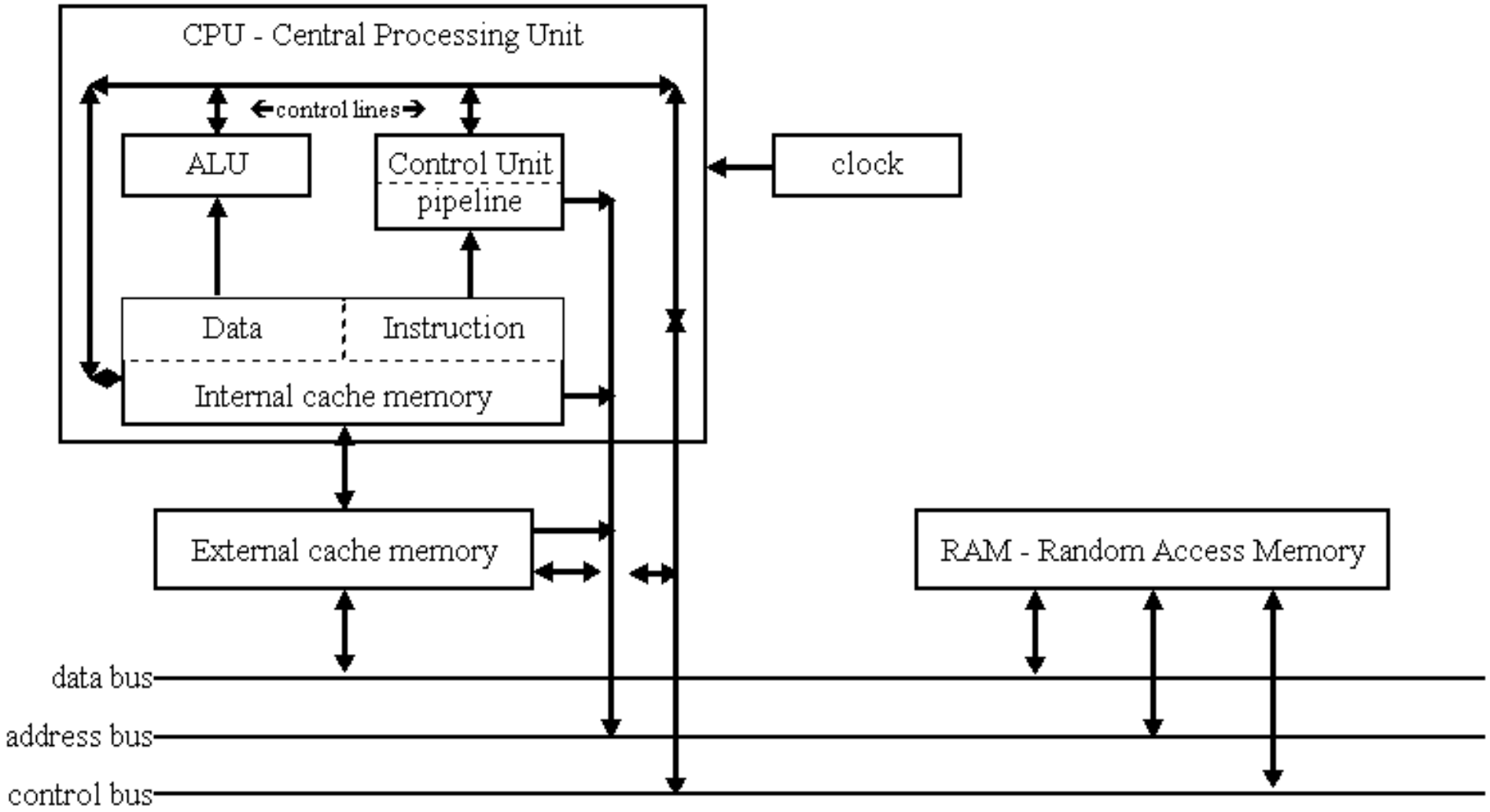
BUS INTERFACE UNIT
The place where data and instructions enter or leave the CPU on their way from or to external cache and RAM.



DECODE UNIT
Takes instructions from the prefetch unit and translates them into a form that the control unit can understand.

INTERNAL CACHE
Is used to store frequently used data and/or instructions to speed up the time required to get that information to the prefetch unit.

CPU and RAM


CPU - Central Processing Unit
control lines
ALU
Control Unit
pipeline
clock
Data
Instruction
Internal cache memory
External cache memory
RAM - Random Access Memory
data bus
address bus
control bus

Control Unit

- The computer can only do one thing at a time. Each action must be broken down into the most basic steps. One round of steps from getting an instruction back to getting the next instruction is called the **Machine Cycle**.

- CU is the part of the computer that controls the Machine Cycle. At each system clock signal, CPU performs a Machine-Cycle. It takes numerous cycles to do even a simple addition of two numbers.

- CU controls and coordinates the computer's operations.
- CU has two counters:

- **Program Counter (PC) :**
  Contains the memory address of the instruction that is currently being executed.
- **Instruction Counter (IC) :**
  Contains the instruction currently being processed.

Arithmetic Logical Unit (ALU)

- ALU is the part that executes the computer's commands.

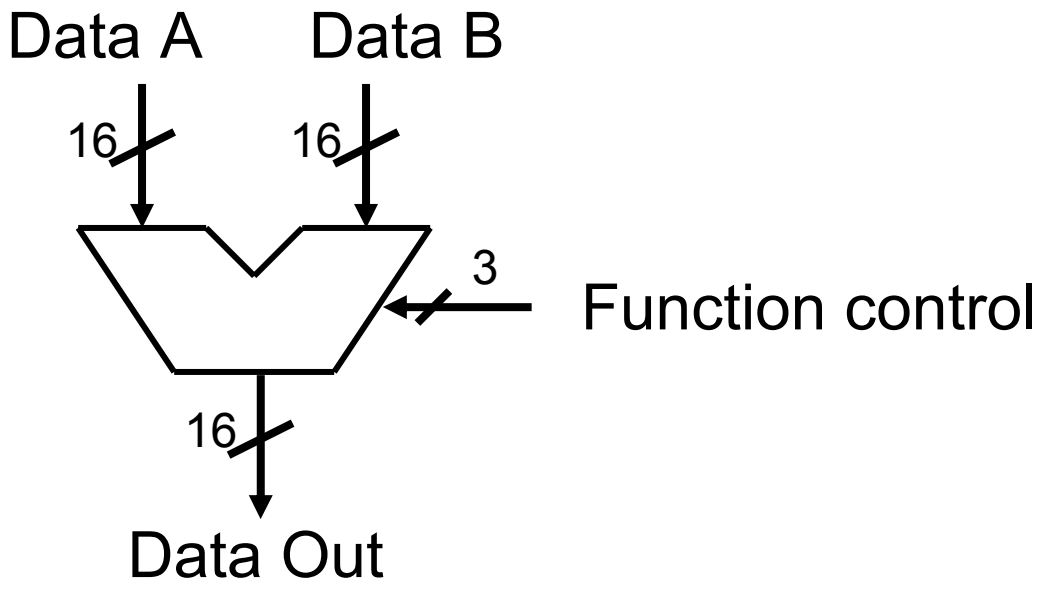
- A command must be either a basic arithmetic operation, or one of the logical comparisons.
- Arithmetic operations: Add, subtract, multiply, divide (+ - * /)
- Logical comparisons: > < = not = (Result is either True or False)

- Everything else has to be broken down into these few operations. Only one operation is done in each Machine Cycle.
- ALU can only do one thing at a time but can work very, very fast.

- ALU contains special memory cells, known as registers, in which the arithmetic/logic operations is carried out.
- ALU also contains circuits such as adders, subtractors, shifters, etc.

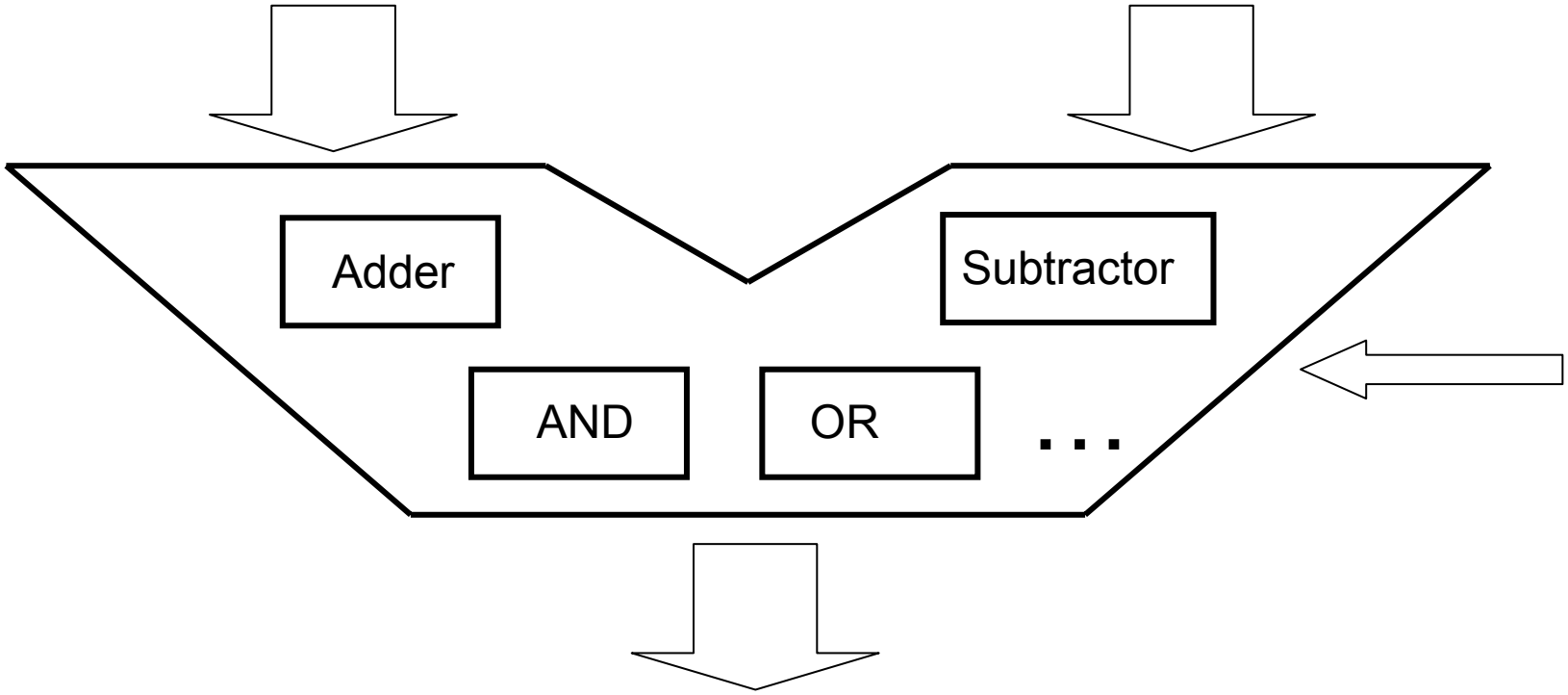
Arithmetic Logical Unit (ALU)

- ALU takes the following inputs:
  - Two data (each 16-bits)
  - Function control code (3-bits) which indicates the action (e.g. AND, OR, NOT, NEGATE, ADD, SUBTRACT, etc.)
- ALU generates the following output:
  - Result of action (DataOut) which is also 16-bits.



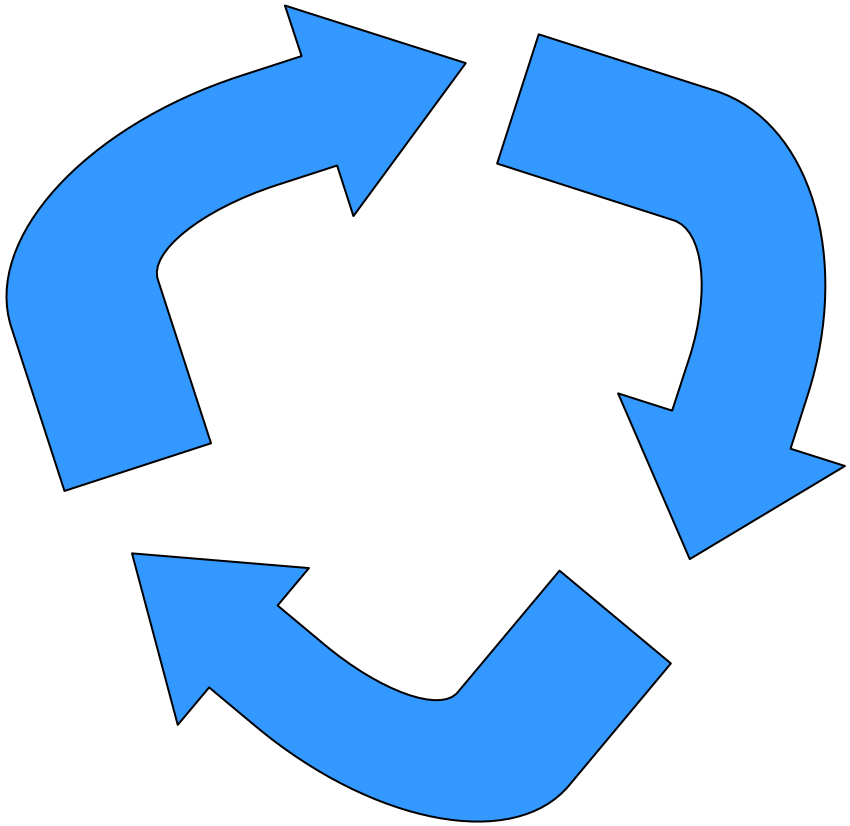
Arithmetic Logical Unit (ALU)

• ALU can be considered as a colection of arithmetic and logic blocks in a single box.



Machine Cycle

1. FETCH :
The next instruction is fetched from RAM.



2. DECODE :
The instruction is decoded into a form the Control Unit can understand.

3. EXECUTE :
The Control Unit executes the instruction.

Machine Cycle : Fetch and Decode

- **FETCH:**
  - Retrieve the next instruction from memory where the command is located (address) in Program Counter.
  - Update the Program Counter to the address of the next instruction.
  - The instruction just Fetched is placed in Instruction Counter.

- **DECODE:**
  - Decode the bit pattern in the Instruction Counter.

Machine Cycle: Execute

- **EXECUTE:**
  - Having decoded the instruction, the control unit enters the execute phase.
  - Control unit activates the correct circuitry to perform the requested task.
    - If the instruction is a “Load” from memory, the Control Unit causes the load to occur.
    - If the instruction is for an arithmetic operation, the control unit activates the appropriate circuitry in the ALU with the correct input data stored in registers.
    - When the instruction has been executed, the control unit again begins the machine cycle.

Program execution

1. Each computer has a unique instruction set determined by the designers of its architecture. Each instruction includes a code that specifies the operation to be performed, and the memory address of the data value to be acted on.

2. All the operations of a computer are directed by a set of instructions, known as a program, which is loaded in the computer's main memory during execution.

3. The control unit locates the appropriate instructions, controls their sequencing, and executes them by activating appropriate circuitry.

Machine Language (1)

- Machine language is the binary-based code used to represent program instructions.
- Generally programmers do not write their programs directly in machine language due to its difficulties.
- Instead programmers use the assembly language or a high-level language such C or Java. Then a special translator program (called compiler) is used to translate the written program into the machine language.

Machine Language (2)

- Machine language is very specific to the hardware and the Operating System being used. For example, a program compiled on Windows OS wil run only on Windows systems, it will not run on Linux OS.

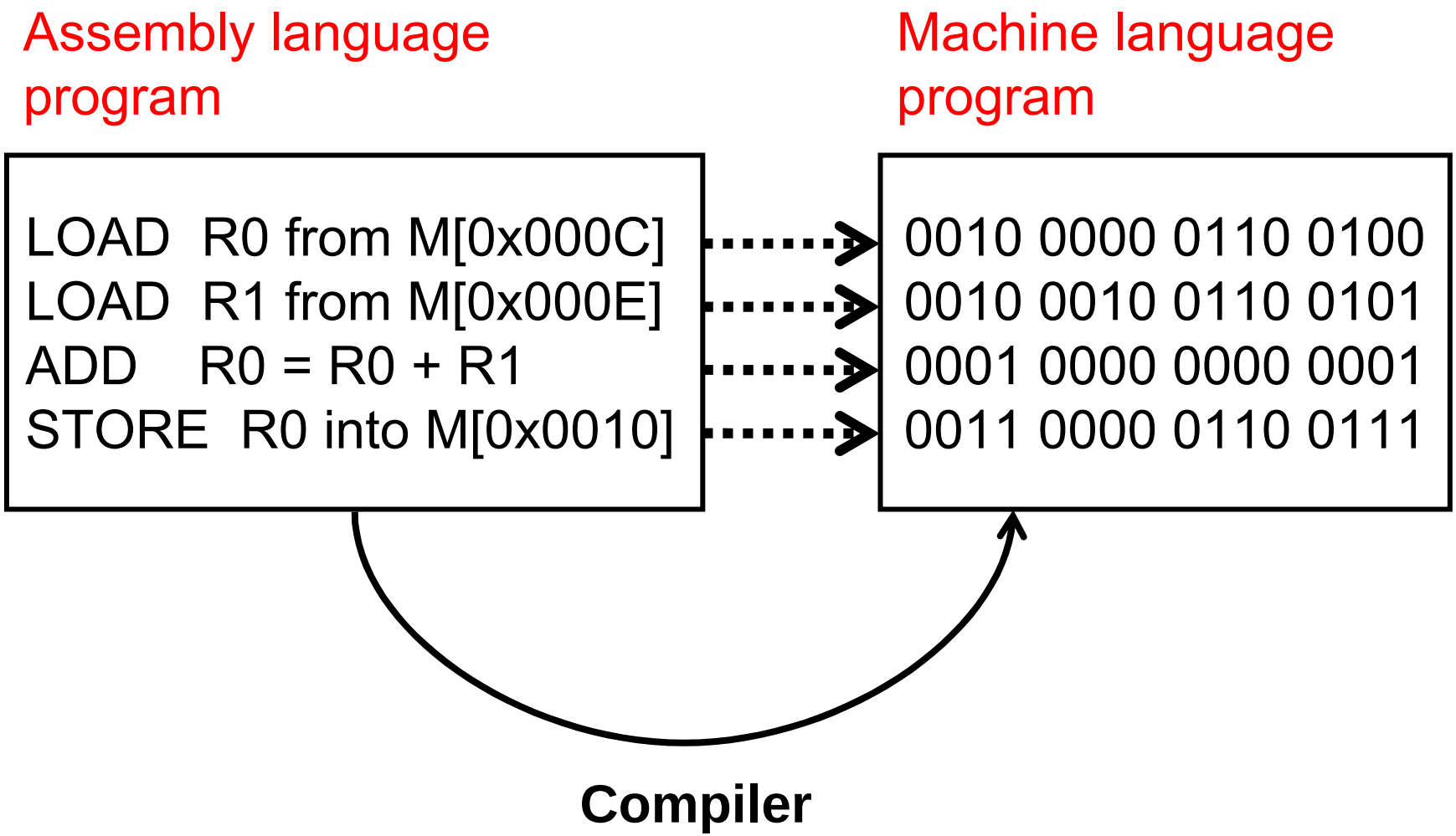
- In computer books and manual documents, memory addresses and memory contents are shown usually as hexadecimal numbers (Example: 0x000C).

Instruction Sets

- Instruction set is the basic set of machine language instructions that a CPU can understand.

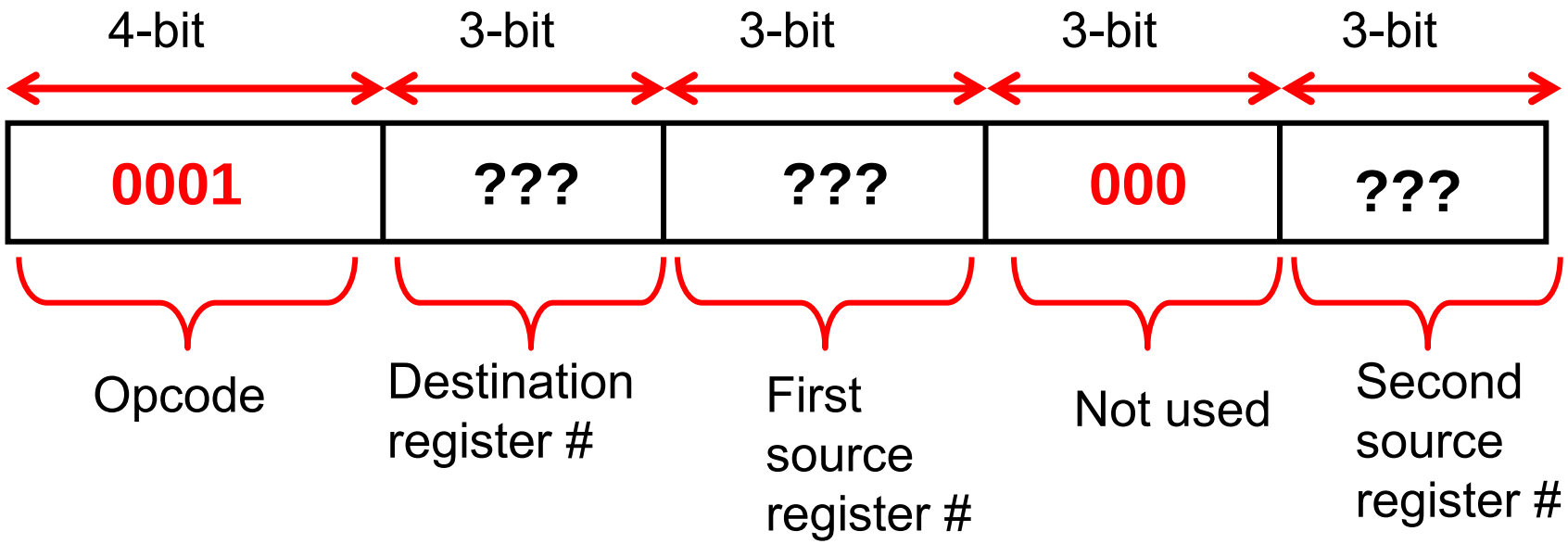
- There are standard instructions in a set such as followings:
  - **LOAD:** Copies a data from a memory location (RAM) to an internal register (which is a 16-bit special cash memory) within the CPU.
  - **ADD:** Adds the content of a register to another register.
  - **STORE:** Copies the content of a register to a memory location (RAM).
  - Etc.

Generating the Machine language program



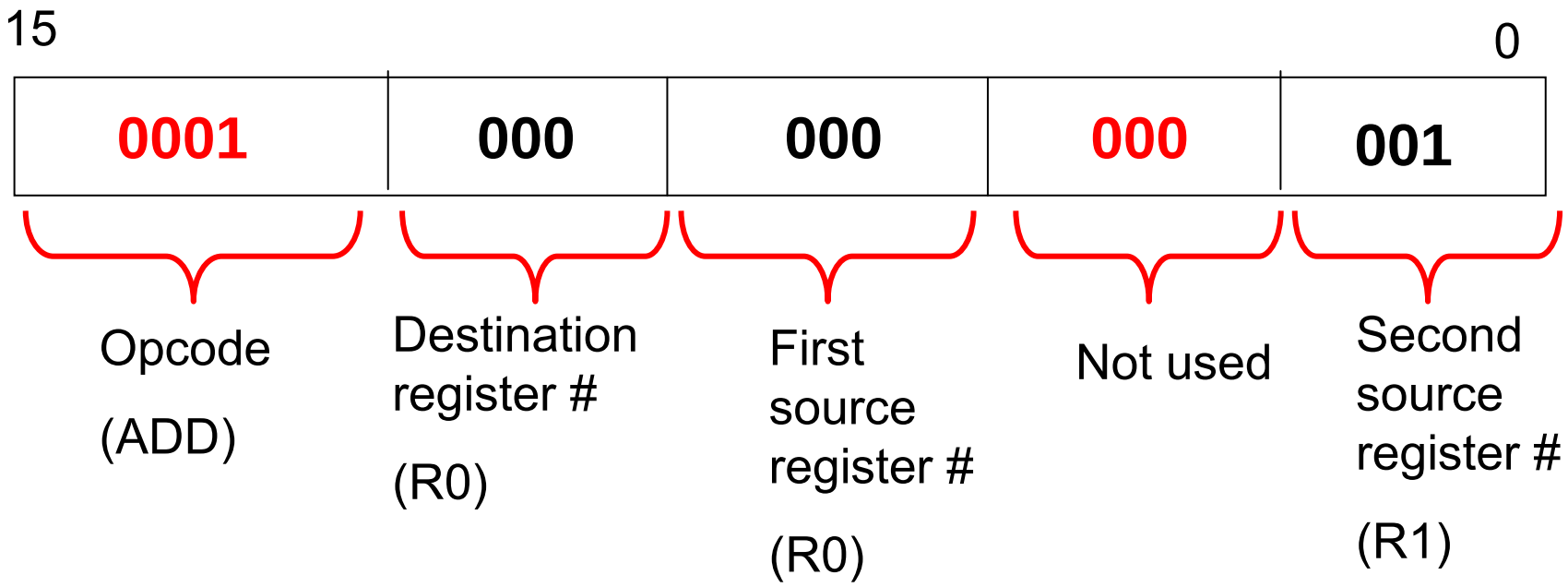
General Format for Instructions

- All of the possible instructions are encoded as a bit pattern (16-bit)
  - 4 bits for “opcode”
  - The remaining 12 bits depend on the type of instruction
  - Up to 9 bits specify source/destination operand registers



Format for the ADD Instruction

The following is the decoding of **ADD R0 = R0 + R1** instruction.



Example Program

Algorithm

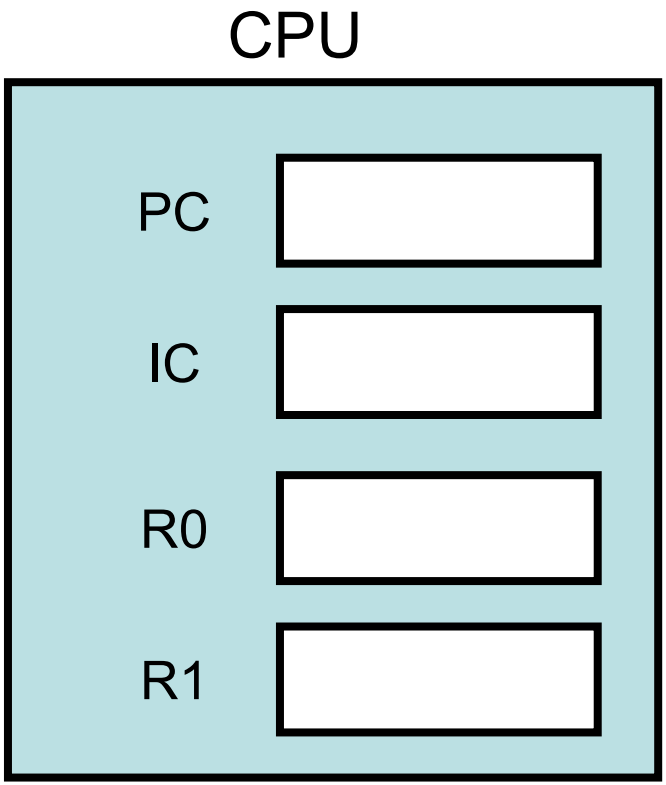
1. Load memory location 0x000C into Register0
2. Load memory location 0x000E into Register1
3. Add Register0 and Register1, store result in Register0
4. Store Register0 in memory location 0x0010

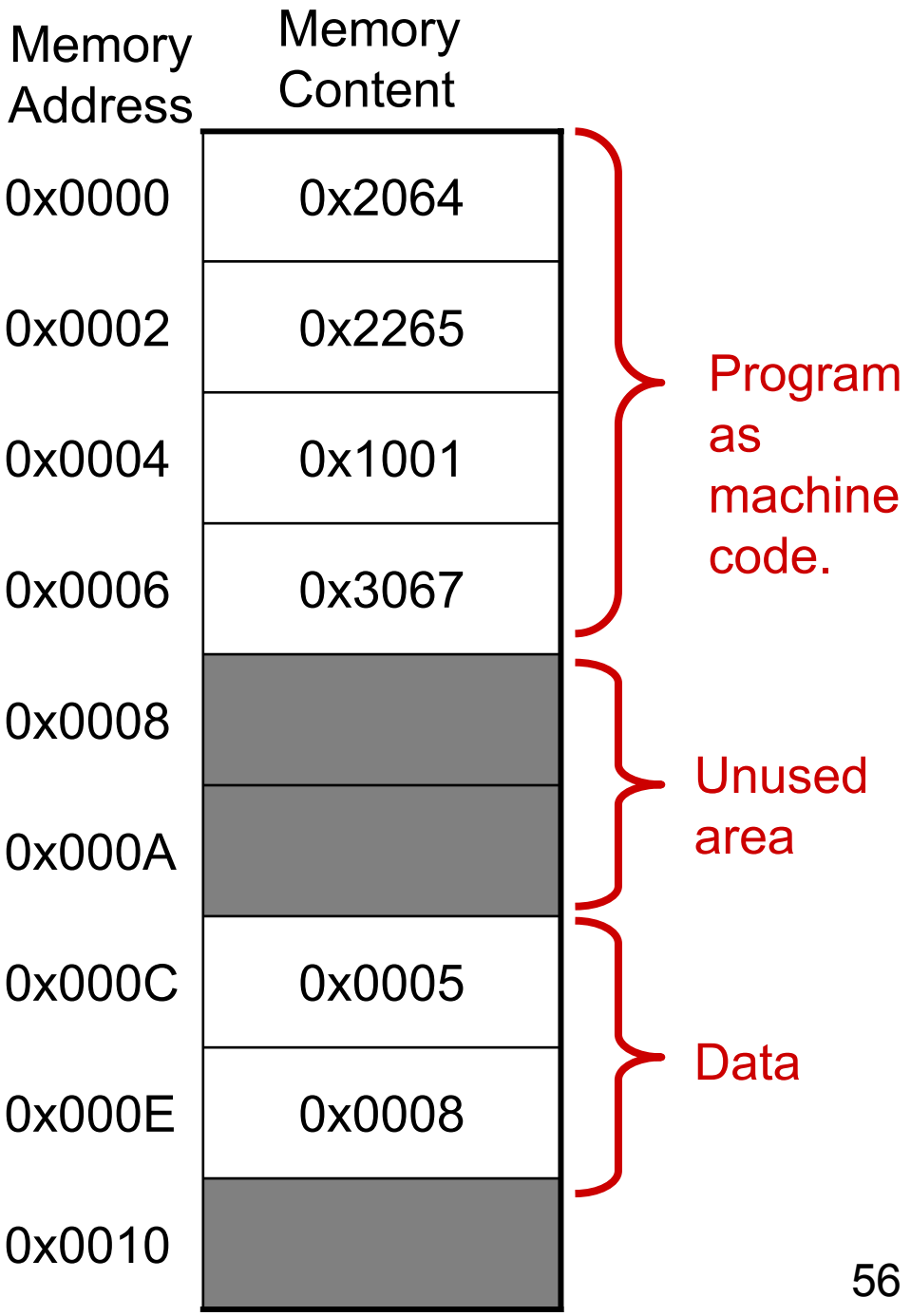
This simple program adds two numbers which are at memory locations 0x000C and 0x000E, then stores the result at memory location 0x0010.

Assembly Language Instructions	Machine Language Instructions
LOAD R0 from M[0x000C]	0x2064
LOAD R1 from M[0x000E]	0x2265
ADD R0 = R0 + R1	0x1001
STORE R0 into M[0x0010]	0x3067

STEP 1)

Program machine code and initial data is loaded from hard disk to RAM memory.(Note here the RAM is an 16-bit memory, which means every location has 16 bits.)

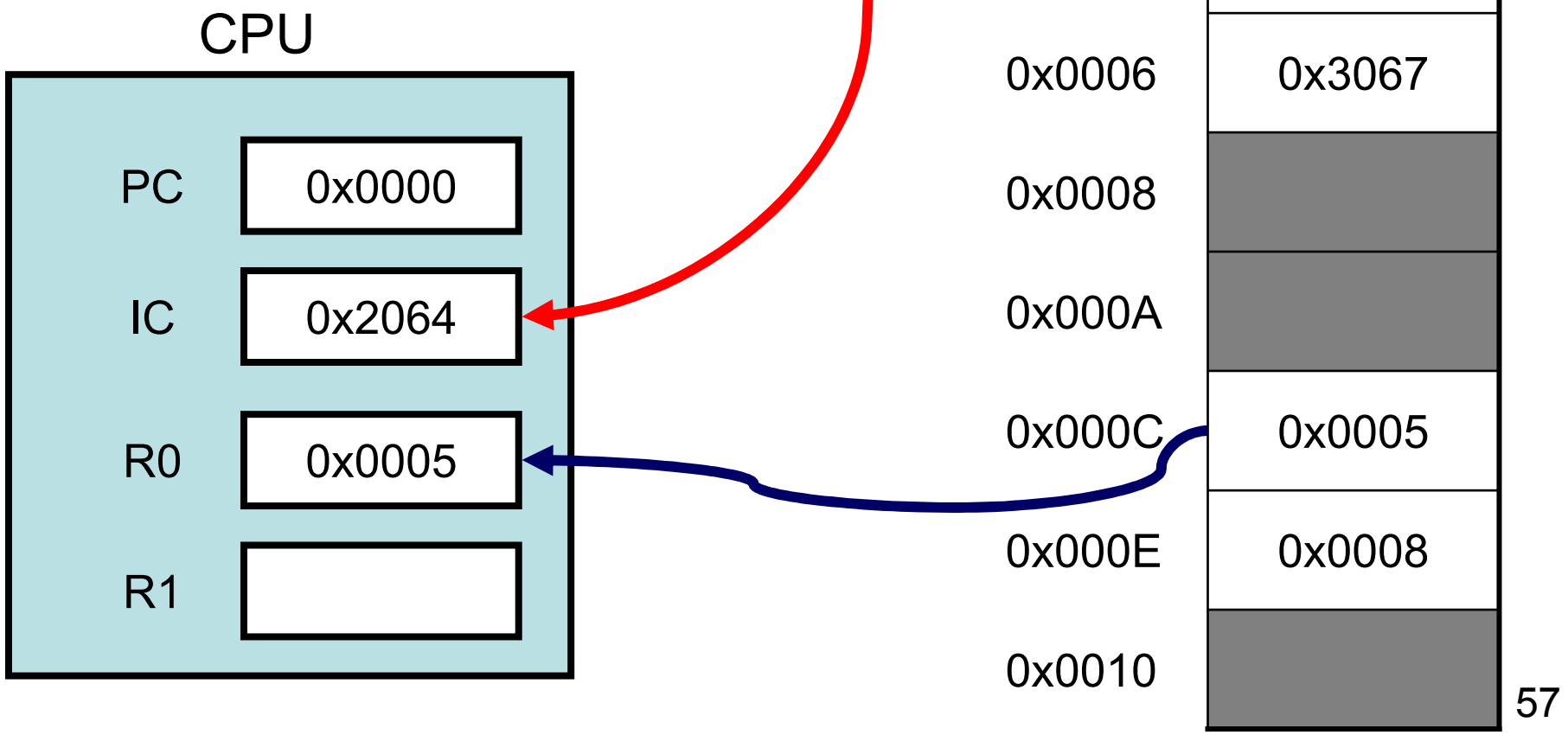




STEP 2)

CPU gets and executes the first instruction at location 0x0000.

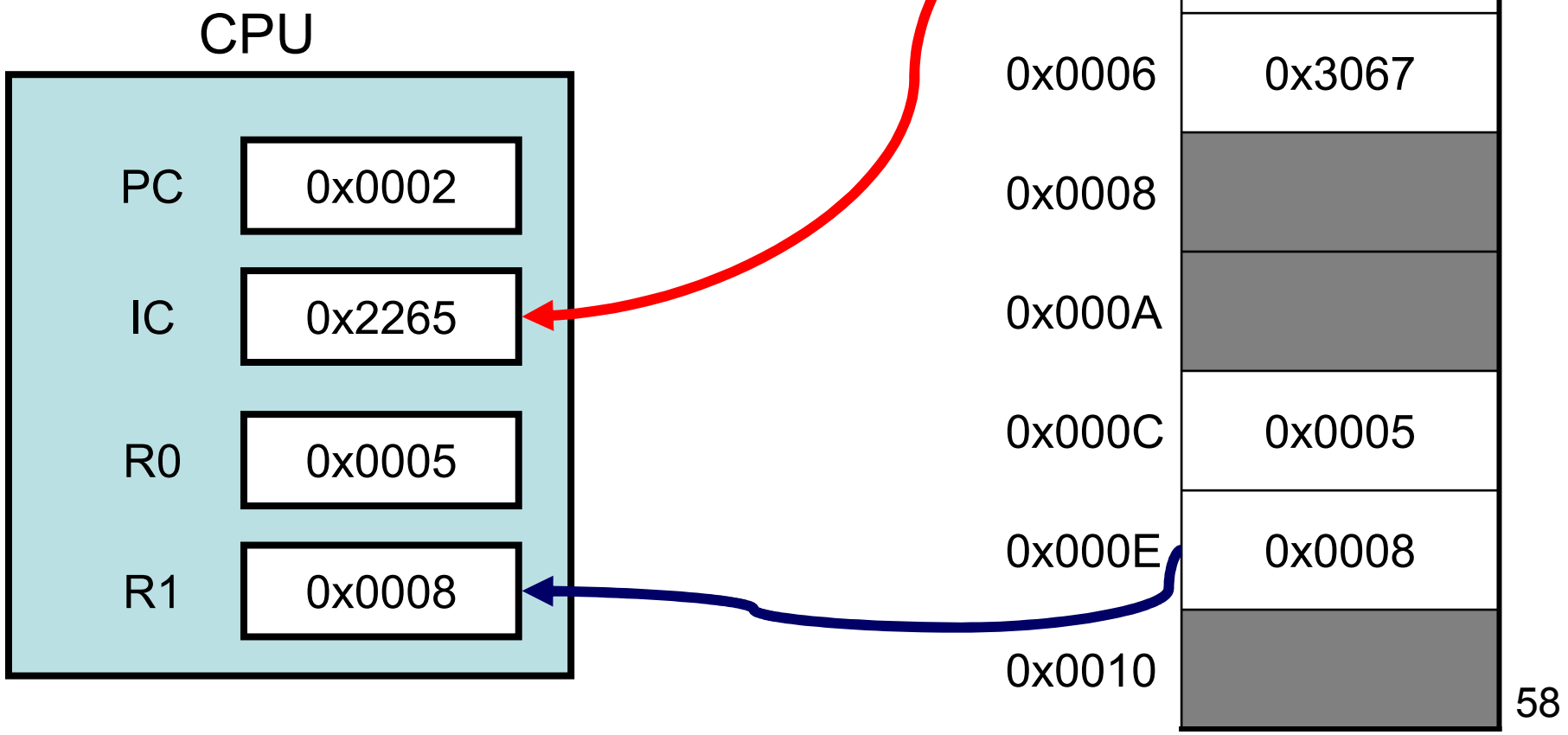
Data at location 0x000C is loaded (i.e. copied) to internal register R0.



STEP 3)

CPU gets and executes the next instruction at location 0x0002.

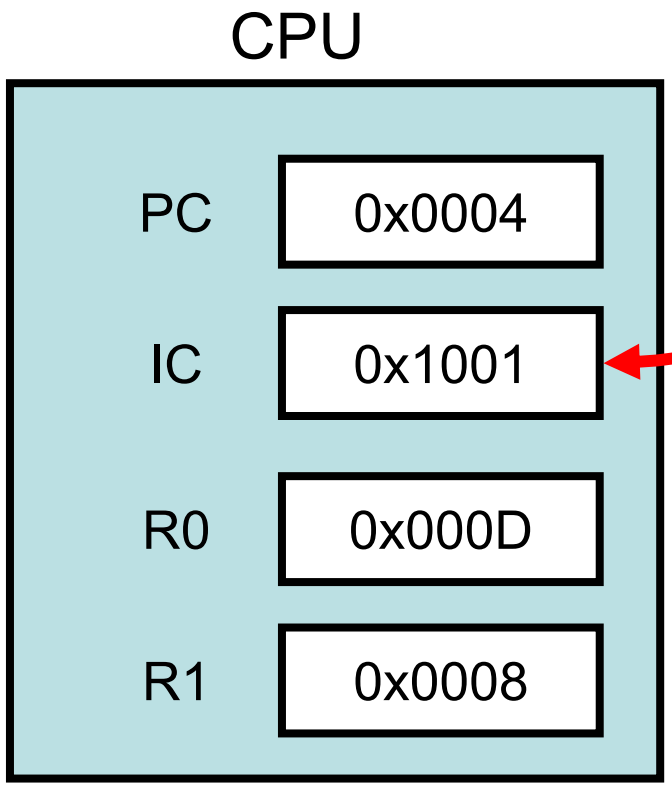
Data at location 0x000E is loaded (i.e. copied) to internal register R1.



STEP 4)

CPU gets and executes the next instruction at location 0x0004.

CPU adds R0 and R1, the result is now in the R0.

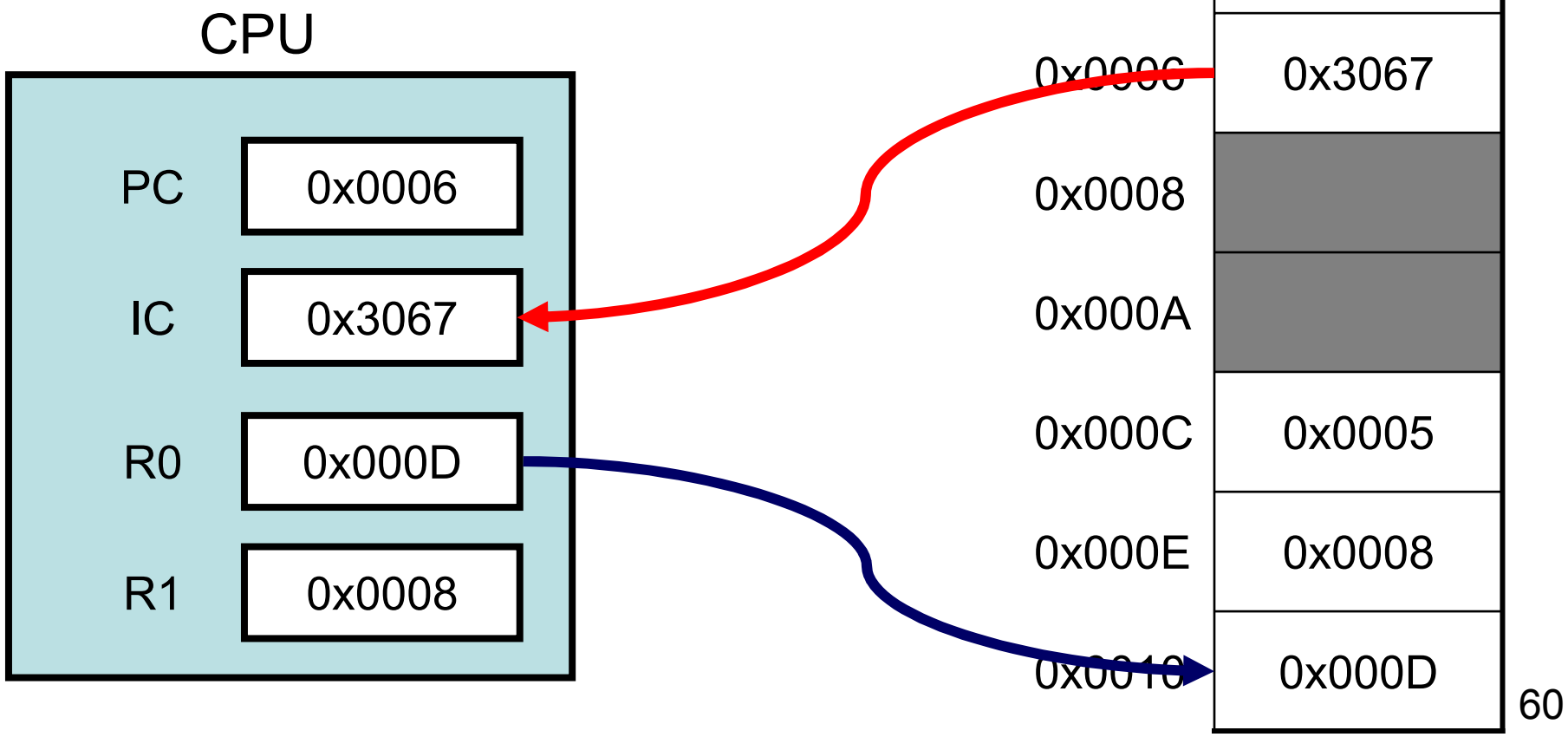


Memory Address	Memory Content
0x0000	0x2064
0x0002	0x2265
0x0004	0x1001
0x0006	0x3067
0x0008	
0x000A	
0x000C	0x0005
0x000E	0x0008
0x0010	

STEP 5)

CPU gets and executes the instruction at location 0x0006.

The result in the R0 is stored (i.e. copied) to memory location 0x0010. Then program stops.



BUSES,
PORTS,
CONNECTORS

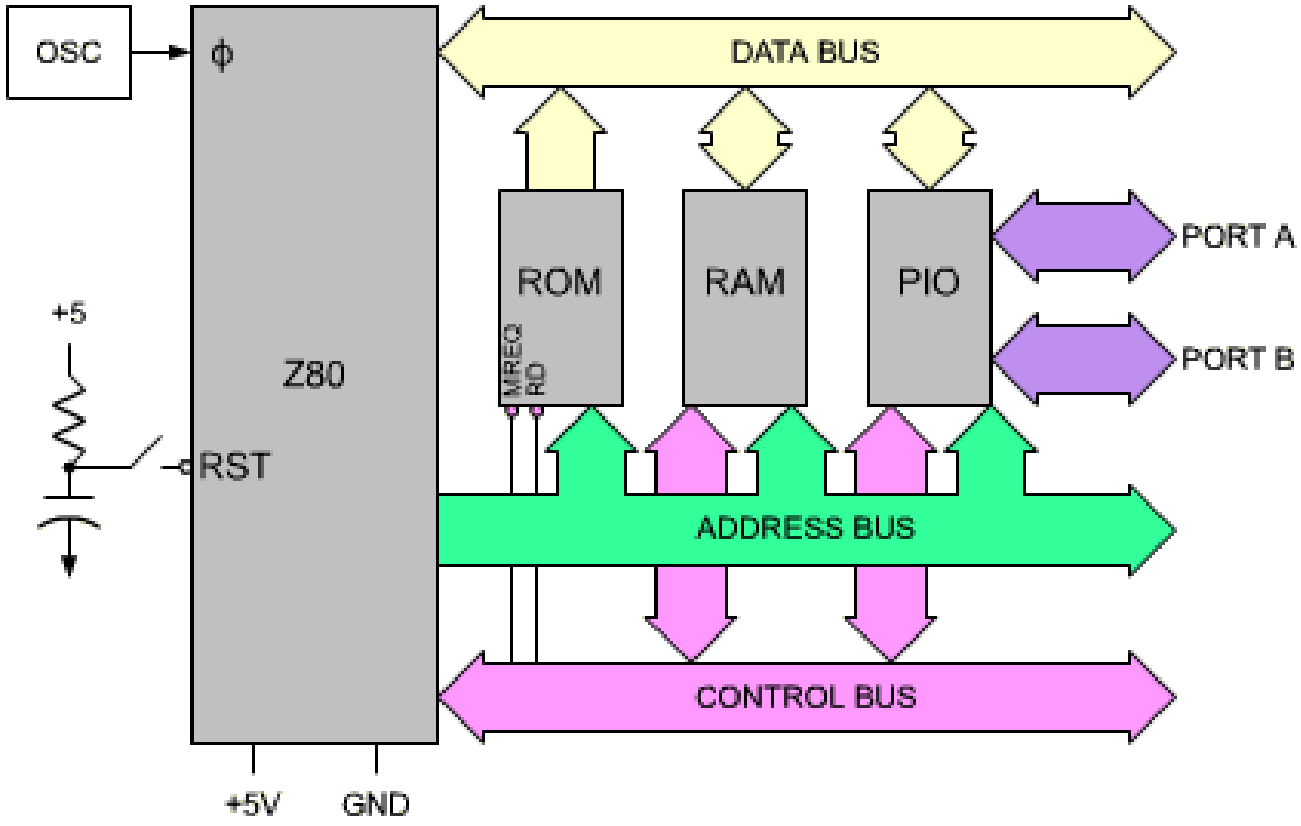
Internal Buses

- A bus is an electrical pathway through which a computer processor communicates with some of its parts and/or peripherals.
- Physically, a bus is a set of parallel tracks that can carry digital signals; it may take the form of copper tracks laid down on the computer's mainboard, or of an external cable or connection.
- A computer typically has three internal buses laid down on its main circuit board:

  - **Data bus**, which carries data between the components of the computer.
  - **Address bus,** which selects the route to be followed by any particular data item travelling along the data bus.
  - **Control bus,** which is used to decide whether data is written to or read from the data bus.

- Bus width = The amount of data the CPU can transmit at a time to main memory and to input and output devices. An 8-bit bus moves 8 bits of data at a time. Bus width can be 8, 16, 32, 64, 128, etc.

Example: Z80 Microprocessor



External Buses

- An external expansion bus (I/O bus) is used for linking the computer processor to peripheral devices, such as modems and printers.
- Typically the buses contain slots, called expansion slots, in which expansion cards are inserted.

USB (Universal Serial Bus)	Designed to replace all low- speed peripheral device connections including keyboard, mouse, modem, printer, joystick, audio, monitor, etc.
Firewire	Designed to replace all external high-speed peripheral connections including hard hisk, CDROM, DVD, graphics card, high-speed scanner, direct video, and monitor.
PCI (Peripheral Component Interconnect)	For attaching peripheral devices to Mainboard, such as network cards, sound cards, modems, extra ports such as USB or serial, TV tuner cards and disk controllers. Now, it has replaced the ISA bus.
Parallel port	For old-style printers, now outdated.
Serial port	For old-style monitors, now outdated.
ISA (Industry Standard Architecture)	For old-style peripherals, now replaced by PCI.
SCSI (Small Computer System Interface)	For old-style hard disks, now outdated.
PS/2	For old-style mouse and keyboards, now replaced by USB.

Universal Serial Bus (USB)

- USB connections can support flash memory, keyboard, mouse, printer, scanner, CD burner, etc.
- Allows up to 127 devices to be connected to the computer at one time.
- It supports plug and play.
- USB 2.0 can transfer data at a theoretical speed of 480 megabits per second.
- The more devices using USB the less speed each device is allocated, although the minimum speed any device is allocated is 1.5 mbps.

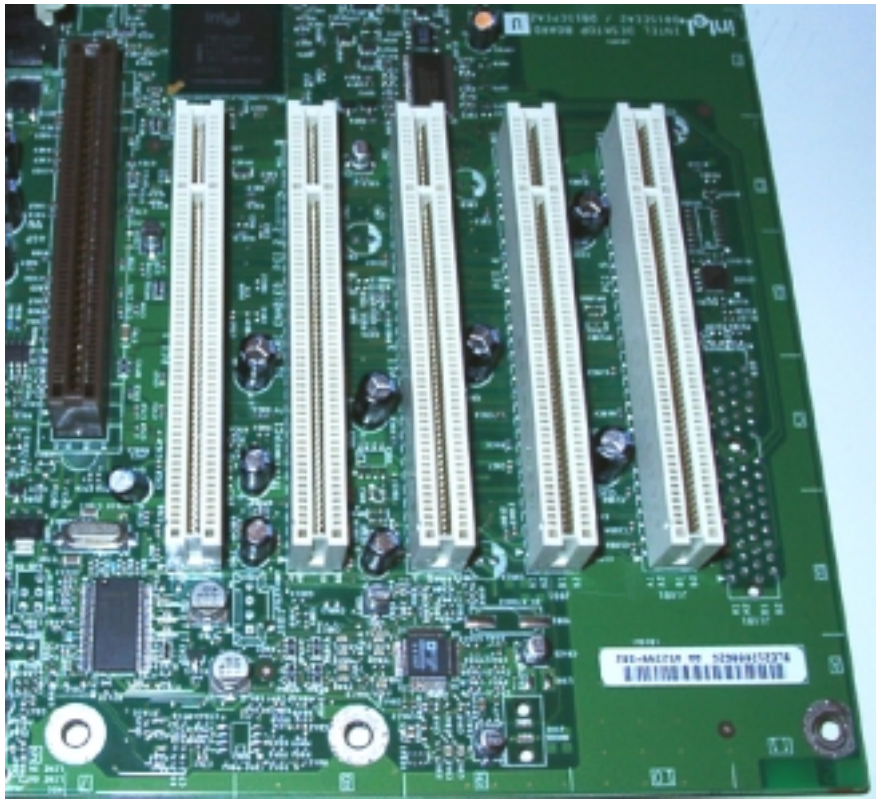
USB hub with 4 ports

FireWire Port

- This is a very high speed port used to transfer large amounts of data quickly.
- Usually camcorders and other video equipment use this port.
- Transfer speed is up to 400 megabits per second.
- Unlike USB, FireWire is good for large, continuous transfer.
- IEEE 1394 connectors can be used to connect up to 63 external devices to a single machine.

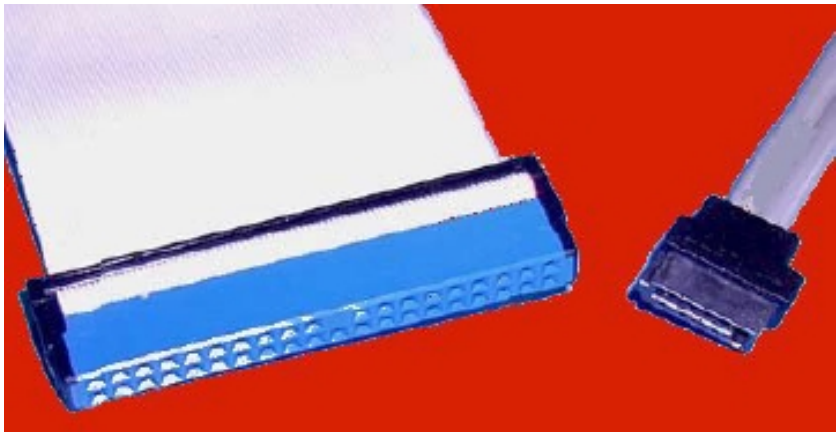
PCI Bus Slots

- Typical PCI bus parameters:
  - Bus Width: 64 bits
  - Bus Speed: 133 MHz
  - MB/sec : 1 GBps



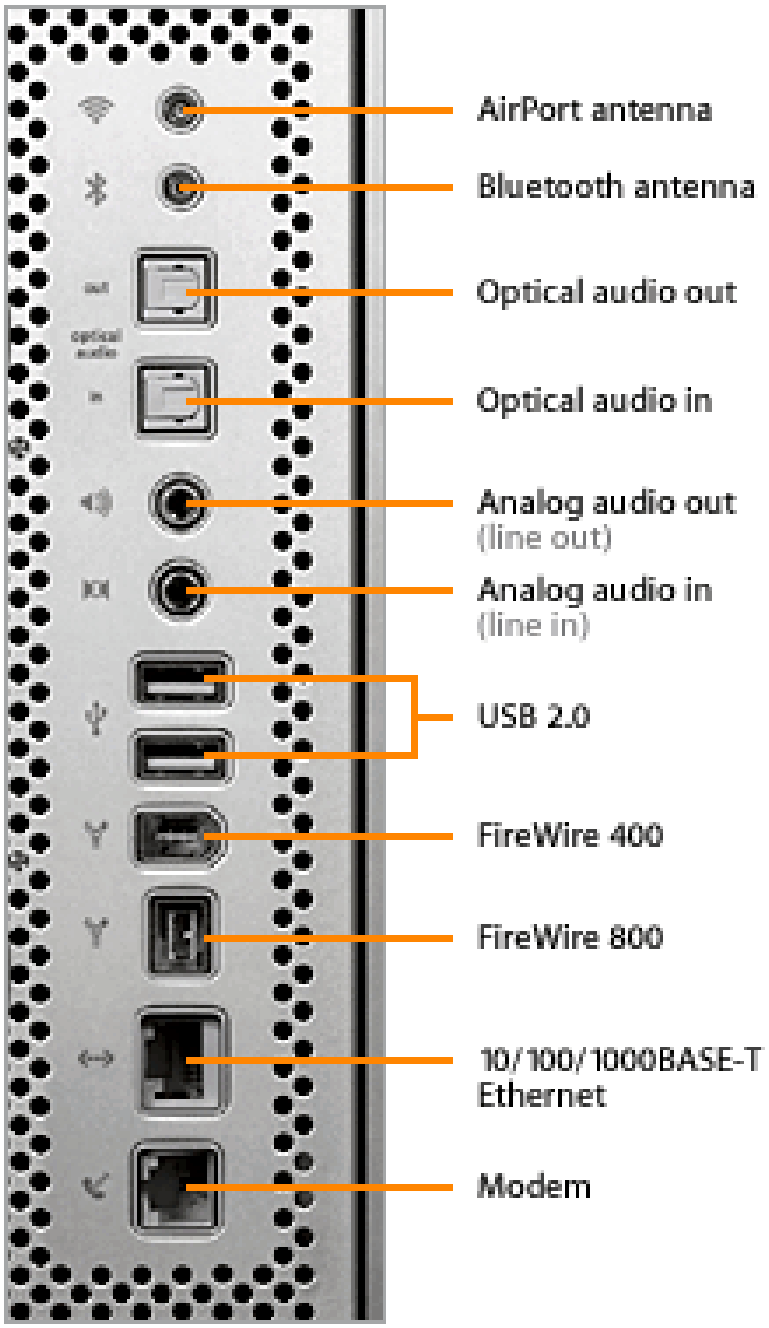
System Buses for Hard Disk Controllers

- **IDE** featured a 40-pin parallel connector with a theoretical transfer speed of 100 or 133 mbps. This is the same connector used in most types of consumer PCs today.



- **Serial ATA**, a much smaller, compact connector featuring only 7 pins, running in serial transfer modes at up to 150 mbps, with future applications approaching 300 or even 600 mbps.

Port Examples



Communication Ports

- **Modem Port**
  - Modem is a device which connects the computer to a WAN network via phone line.
  - A modem port looks like a standard RJ-14 North American telephone jack.
  - Modern modems have a theoretical limitation of 56 kbps.

- **Ethernet Port**
  - Ethernet is a network line which connects the computer to a LAN network via a cable.
  - Ethernet usually uses a standard RJ-45 connector.
  - The most common forms of Ethernet can transmit between 10 and 100 mbps, with the
  - fastest technology of today running at 1000 mbps.

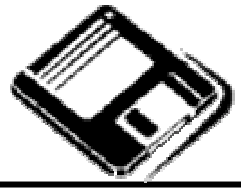
Power Supply

• The power supply converts the electricity from the wall outlet (220 Volts, AC current) into the computer usage (5 Volts, DC current).

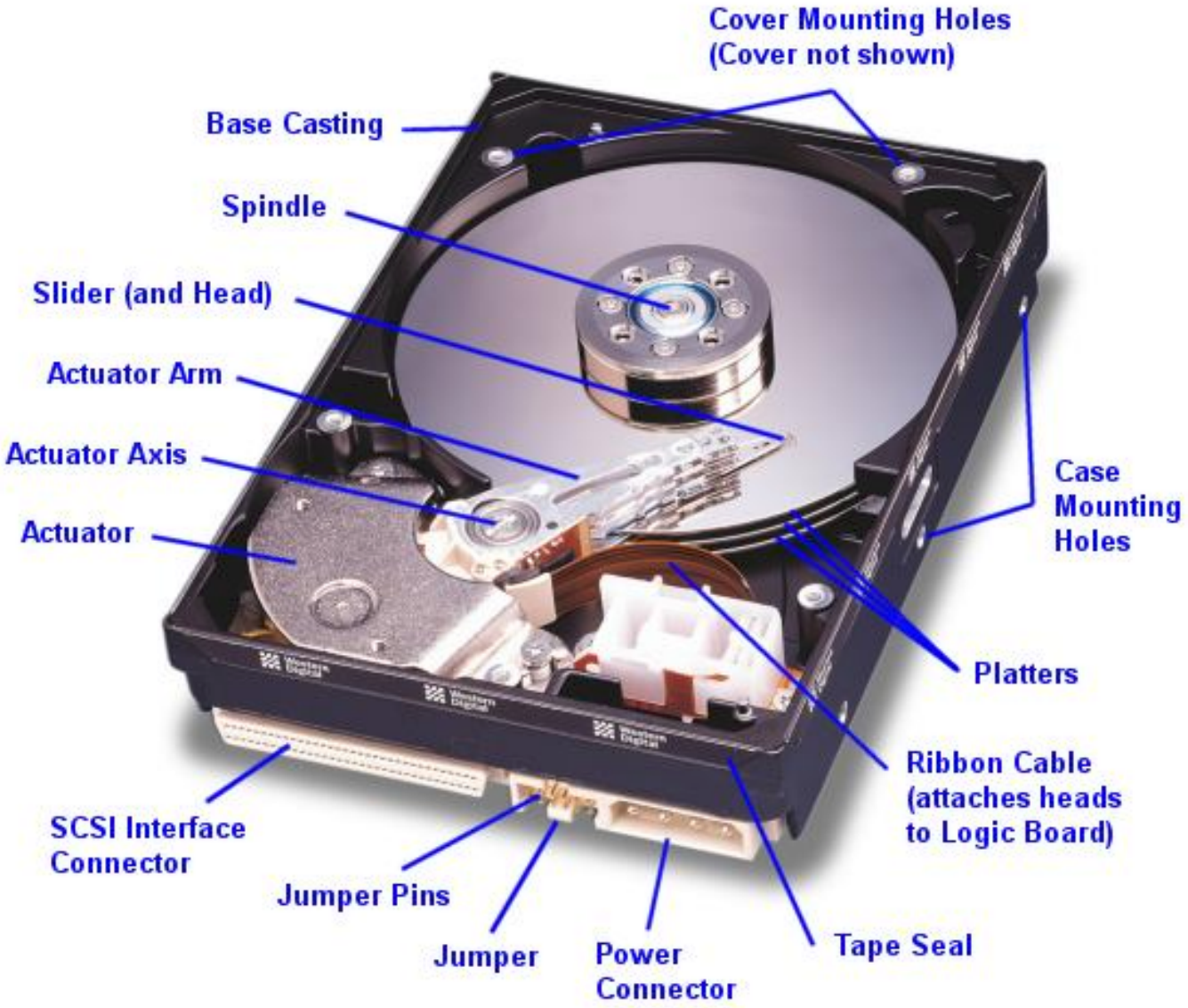
SECONDARY STORAGE DEVICES

Secondary Storage Types

• Secondary Storage Devices are **non-volatile**, high capacity storage devices.

Storage Type	Storage Purposes	Example
Hard Disk (Magnetic)	Operating system, application software, user data and information	
Optical Disks (CD and DVD)	Software, backups, movie, music	
Floppy Diskett (Magnetic)	Small files to be transported	

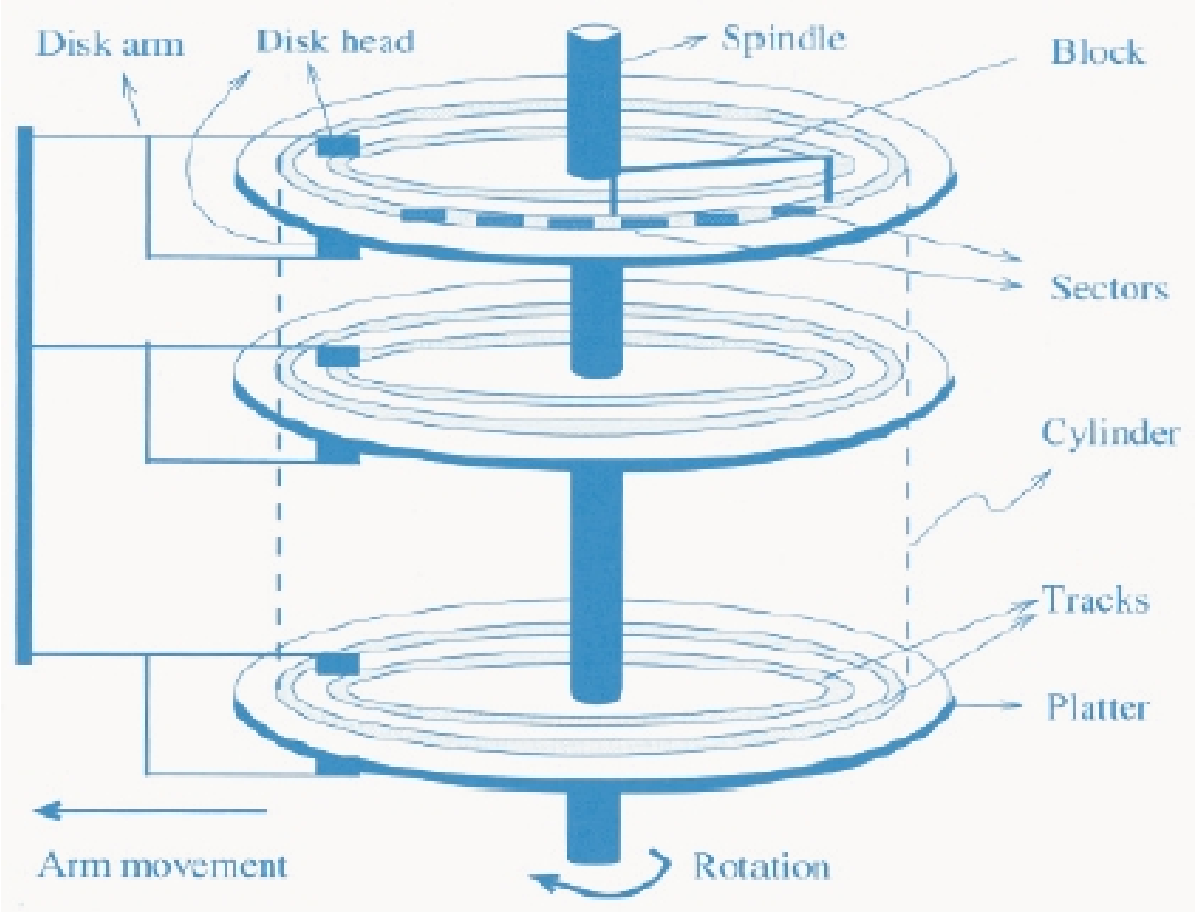
Hard Disk Unit



Structure of Hard Disk

- Magnetic disks support direct access to a desired location.

- Structure of disk:
  - Disk blocks
  - Tracks
  - Platters
  - Cylinder
  - Sectors
  - Disk heads
  - Disk Controller



Disk Arm Assembly

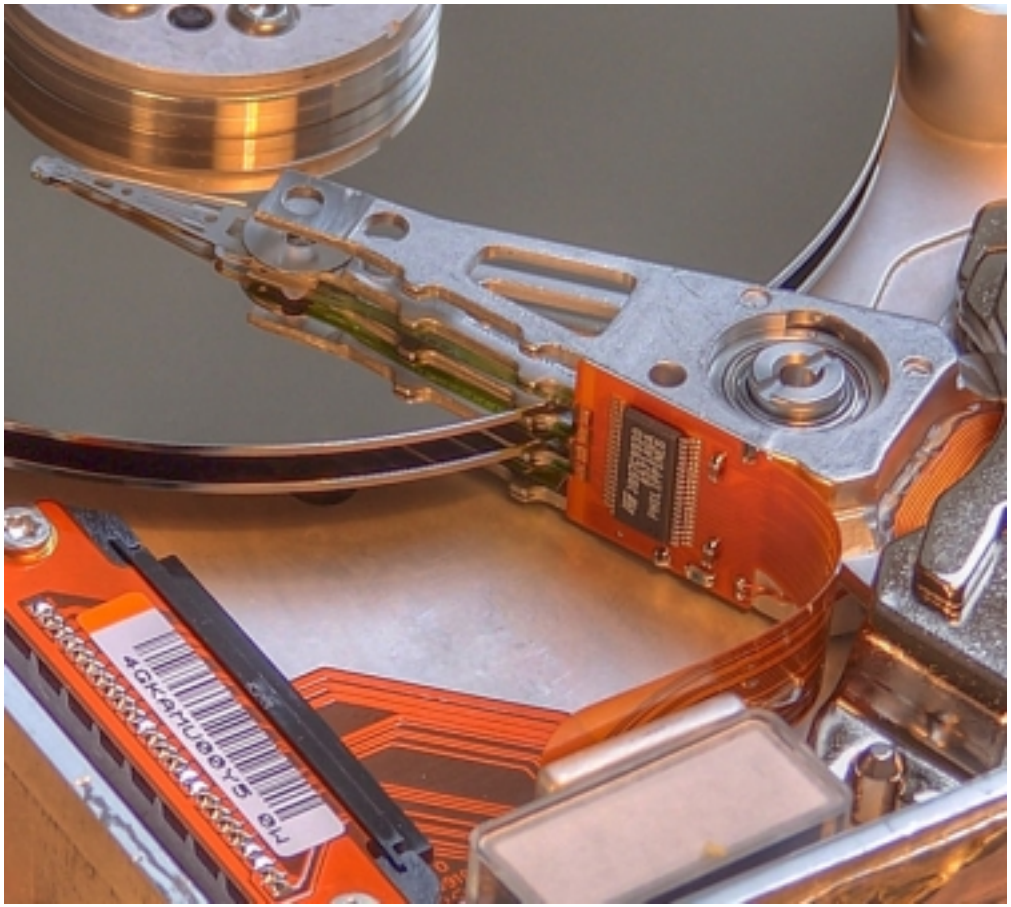
•The platters spin at a speed of 7200 rpm (rounds per minute)

•The arm assembly is moved in or out to position a head on a desired track.

•Only one head reads/writes at any one time.

•Block size is a multiple of sector size (which is fixed).

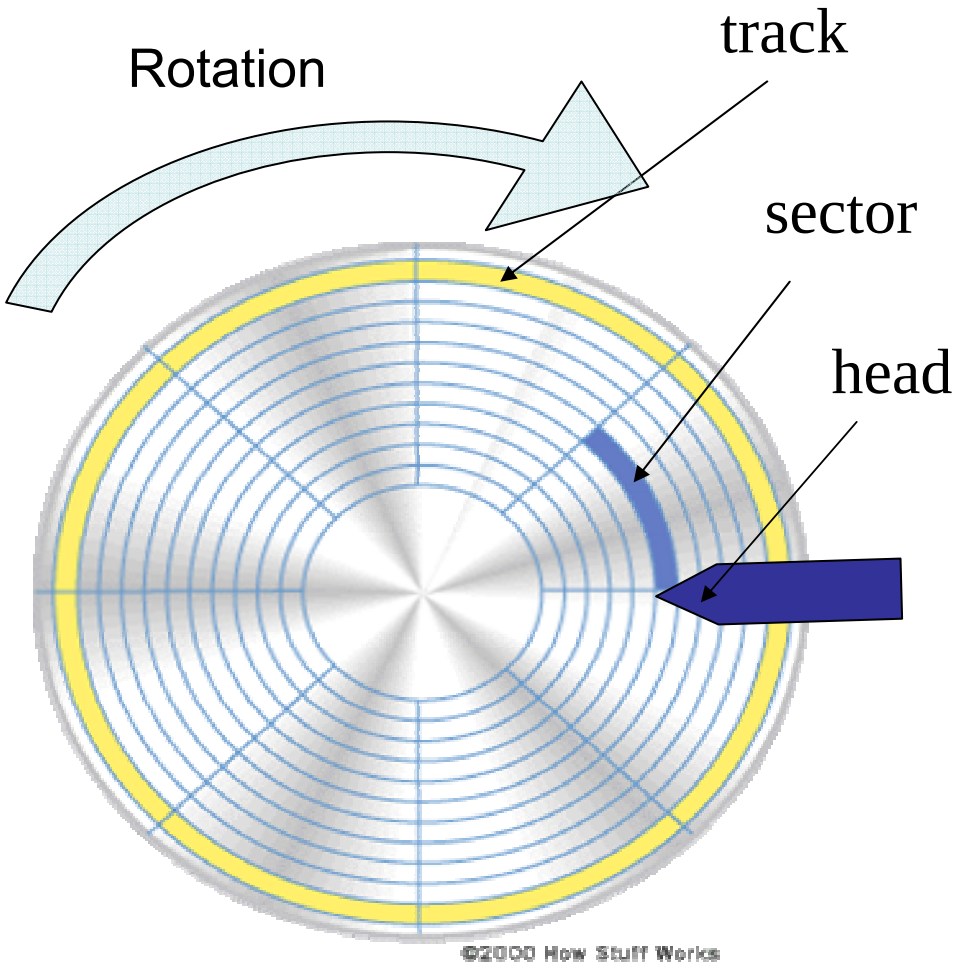
•Typical capacity is 60 GB



2 Platters, 4 Heads

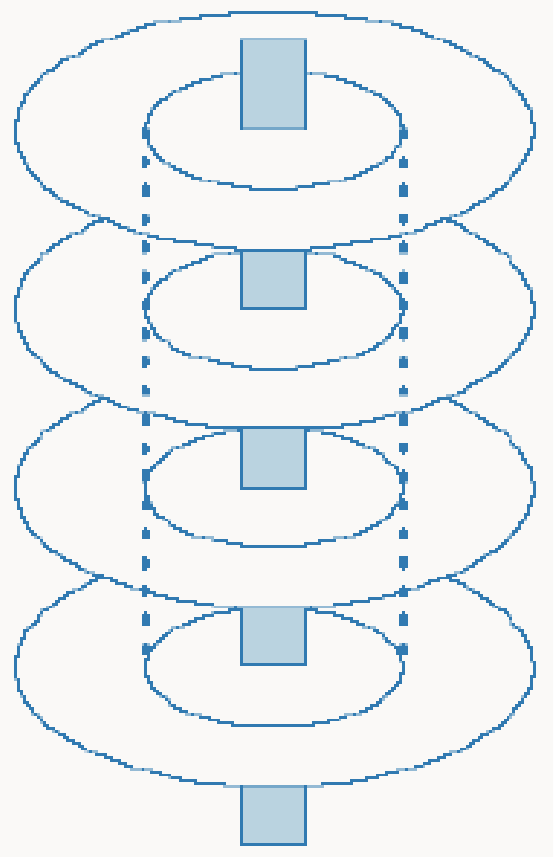
Disk Surface

- Disk contains concentric tracks
- Tracks are divided into sectors
- A sector is the smallest addressable unit in disk



Disk Cylinder

- Cylinder: the set of tracks on a disk that are directly above/below each other.
- All the information on a cylinder can be accessed without moving the read/write arm (seeking).



Disk Capacity Example

Parameter	Count
Number of Platters	12
Surfaces per Platter	2
Number of tracks	6962
Number of sectors per track	213
Bytes per sector	512
TOTAL BYTES	18,221,948,928 (≈ 18 GB)

Disk Operations

- Operations: Read or write the complete sector

- Seek
  - Position head over proper track
  - Typically 6-9 ms

- Rotational Latency
  - Wait until desired sector passes under head
  - Worst case: complete rotation 10,025 RPM takes 6 ms

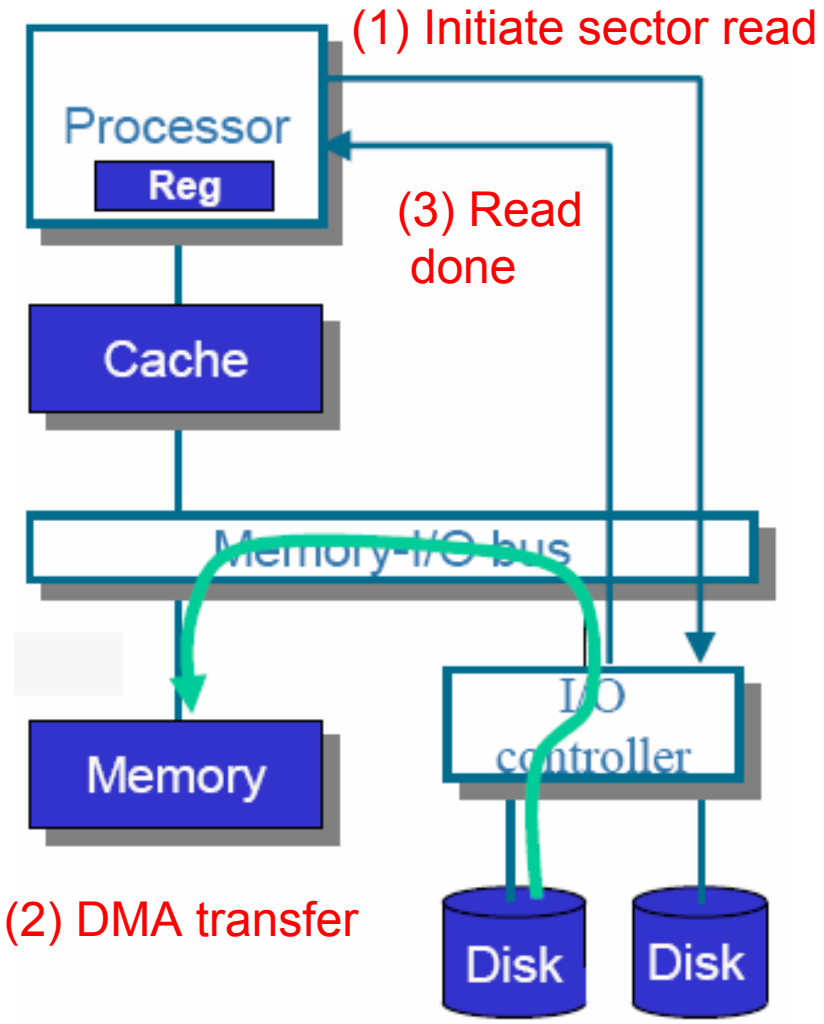
- Read or Write Bits
  - Transfer rate depends on number of bits per track and rotational speed
  - e.g., 213 * 512 bytes at 10,025 RPM = 18 MB/sec.
  - Modern disks have external transfer rates of up to 80 MB/sec
    - DRAM caches on disk help sustain these higher rates

Disk Measurements Example

Linear density	52,187 bits per inch
Bit spacing	0.5 microns
Track density	3,047 tracks per inch
Track spacing	8.3 microns
Total tracks	2,707 tracks
Rotational Speed	7200 RPM
Avg Linear Speed	86 kilometers / hour
Head Floating Height	0.13 microns

Interface between Disk and System

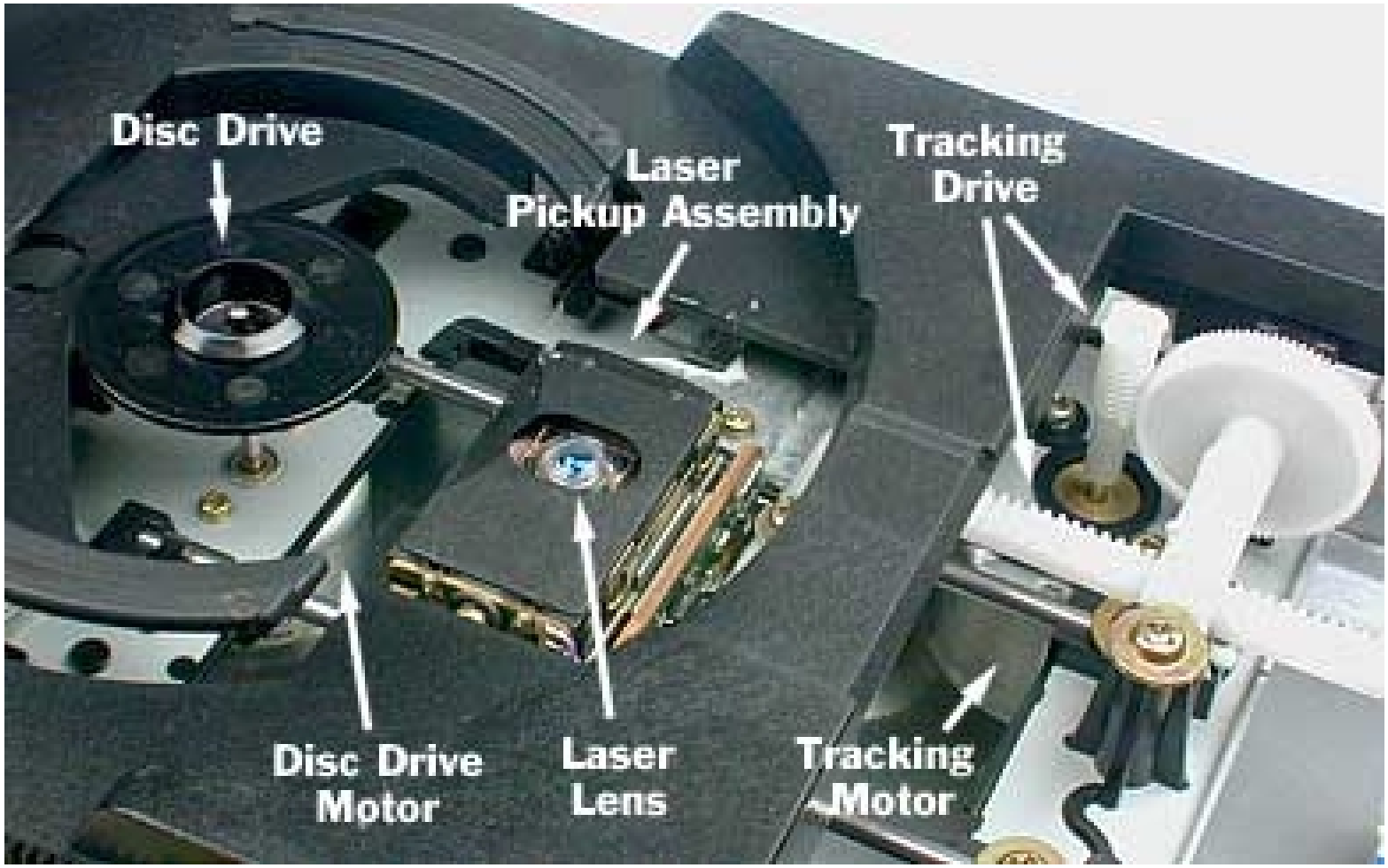
1. Processor Signals Controller
   - Read sector X and store starting at memory address Y
2. Read Occurs
   - "Direct Memory Access" (DMA) transfer
   - Under control of I/O controller
3. I / O Controller Signals Completion
   - Interrupts processor
   - Can resume suspended process



CD (Compact Disc) Drives

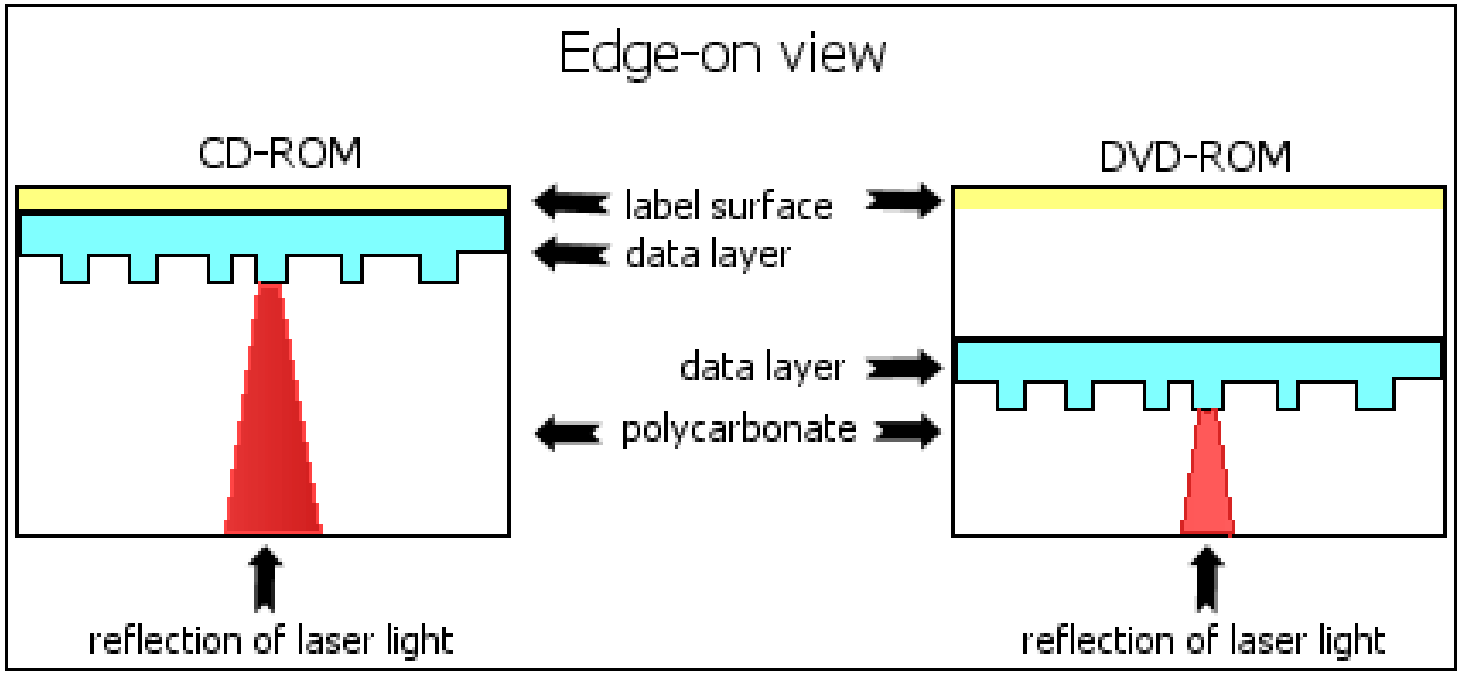
- CD-R Drive
  - Read only
  - Read from both CD-R and CD-RW
  - Read speed, like 54x
- CD-RW Drive
  - Read and Write
  - Read from both CD-R and CD-RW
  - Write to CD-R, Rewrite to CD-RW
  - Read speed, like 12x, 48x

Internal of CD Drive



CD Recording

- An optical disc is made mainly of polycarbonate (a plastic).
- The data is stored on a layer inside the polycarbonate.
- A metal (aluminum) layer reflects the laser light back to a sensor.
- To read the data on a disk, laser light shines through the polycarbonate and hits the data layer.
- When the laser light is reflected it is considered as 1.
- When the laser light is absorbed it is considered as 0.



CDROM Capacity

- CDROM (Compact Disk Read Only Memory = CD-R)
- Optical recording technology originally developed for audio CDs
  - 74 minutes playing time
  - 44,100 samples / second
  - 32-bits / sample (Stereo)
  - Bit rate for 1X speed CDROM = 150 KB / second
  - For 12X CDROM = 150 * 12 / 1024 ≈ 1.76 MB / second

- Capacity Formula =
  74 Minutes*60 seconds/minute*150 KB/second= 650 MB

INPUT AND OUTPUT DEVICES

Keyboard

- The most commonly used input device is the keyboard on which data is entered by manually keying in or typing certain keys.

- A keyboard typically has 101 or 105 keys. (Q or F type)

Inside the Keyboard

There is a special microprocessor inside the keyboard which reads the keys pressed, buffers them, and sends them to CPU.

Key Matrix

Mouse

- It is a pointing input device which is used to control the movement of a mouse pointer on the screen to make selections from the screen.
- A mouse has one to five buttons.
- The bottom of the mouse is flat and contains a mechanism that detects movement of the mouse.

Mechanical mouse:
Uses roller ball to track motion

Optical mouse:
Uses tiny camera and a LED (red light beamer) to track the motion

Monitor Types

CRT	**Cathode Ray Tube.** Basic big monitor. Cheapest, but produce heat and are big and clunky. Consumes 110 watts per hour.	
LCD	**Liquid Crystal Display.** Flat Panel – Thin, light, take up less space, less heat, but costs more. Consumes 30-40 watts per hour.	

Monitor Characteristics

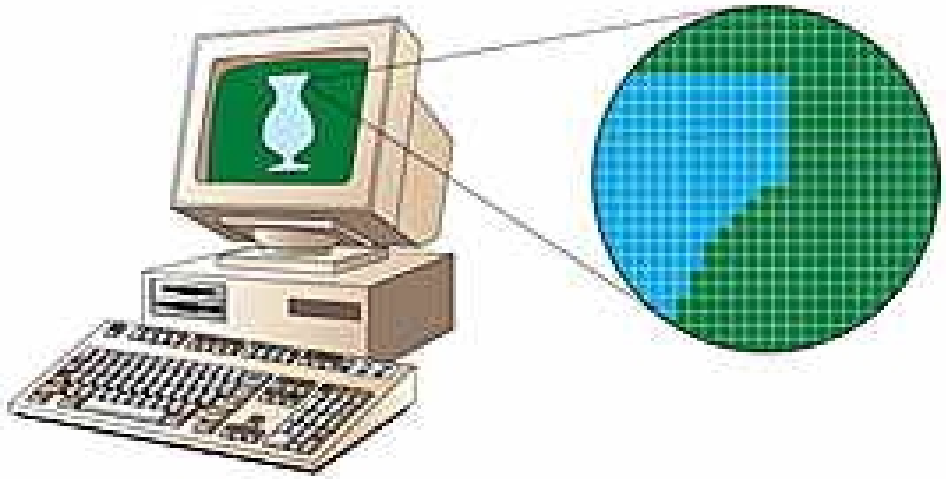
- **Size:** Desktop screens are usually 15 – 21 inches by diagonal measurement.

- **Resolution:** Determines how clear and detailed the image can be. Measured in pixels, Width x Height. (800x600, or 1600x1200 etc).

- **Refresh Rate :** How often the picture is redrawn on the screen. If rate is low, may cause eyestrain or nausea. 75 Hertz or better is ideal.

Pixels in Monitor

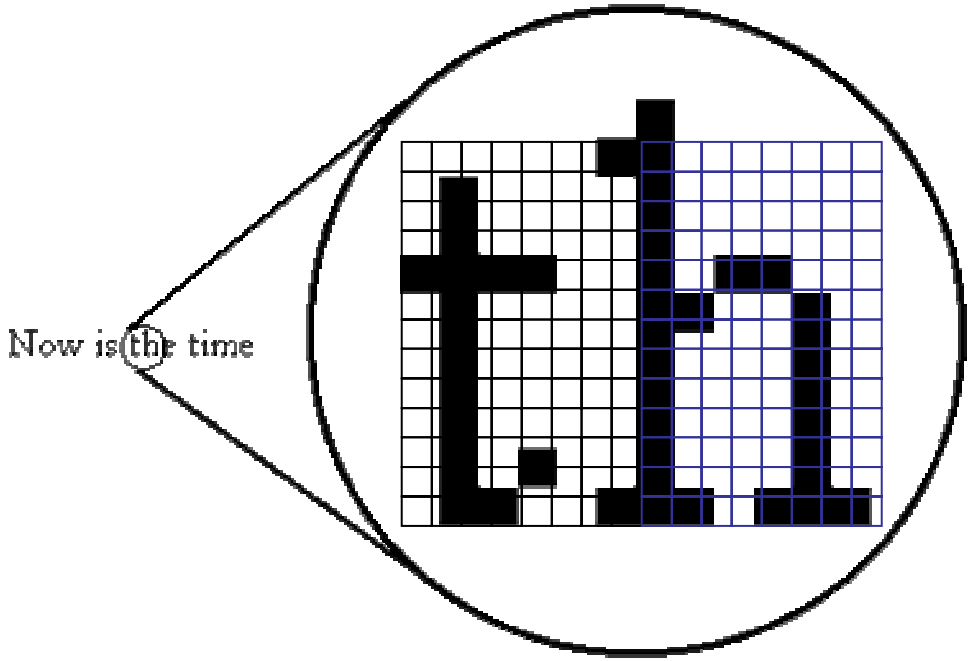
- Screen is composed of dots called pixels.
- Color coding: Each pixel is represented with 32 bits.
- 1 pixel = 3 bytes of color (RGB) + 1 byte alpha channel (transparency)
- 1600x1200x4bytes=7.5 MB



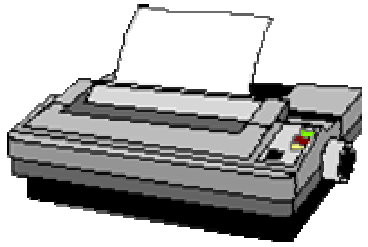
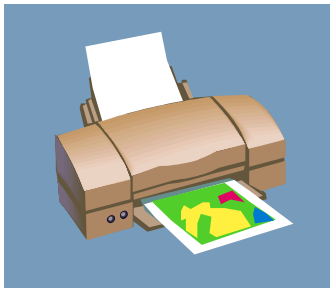
Fonts in Monitor

- Characters are displayed by using Fonts
  - Bitmap
  - Vectors (TrueType, PostScript)

- Fonts are used both for monitors and pinters.



Printer Types

Dot Matrix	Very old and use a printer ribbon for ink.	
Ink Jet	These are the most common and affordable today. Print line by line by spraying ink onto the paper.	
Laser	These are the most expensive and largest. Much like photocopiers, printing a whole page at a time.