2 Computer Hardware

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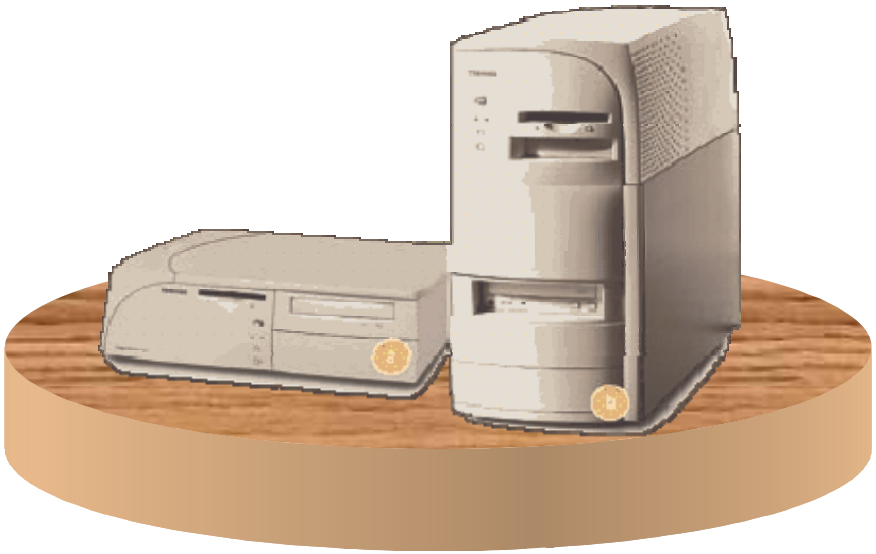
Content

- Computer Systems
- CPU
- Memory
- Input/Output
- Secondary Storage Devices

Type of Computers

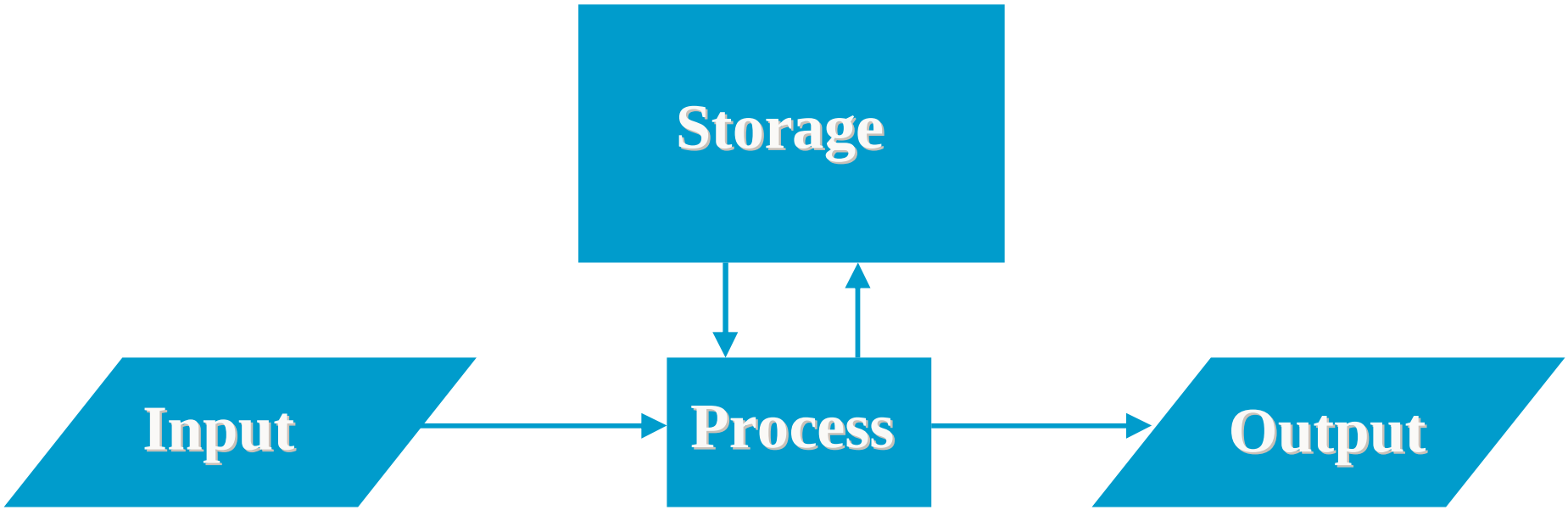
Desktop



Notebook

Personal Digital Assistant

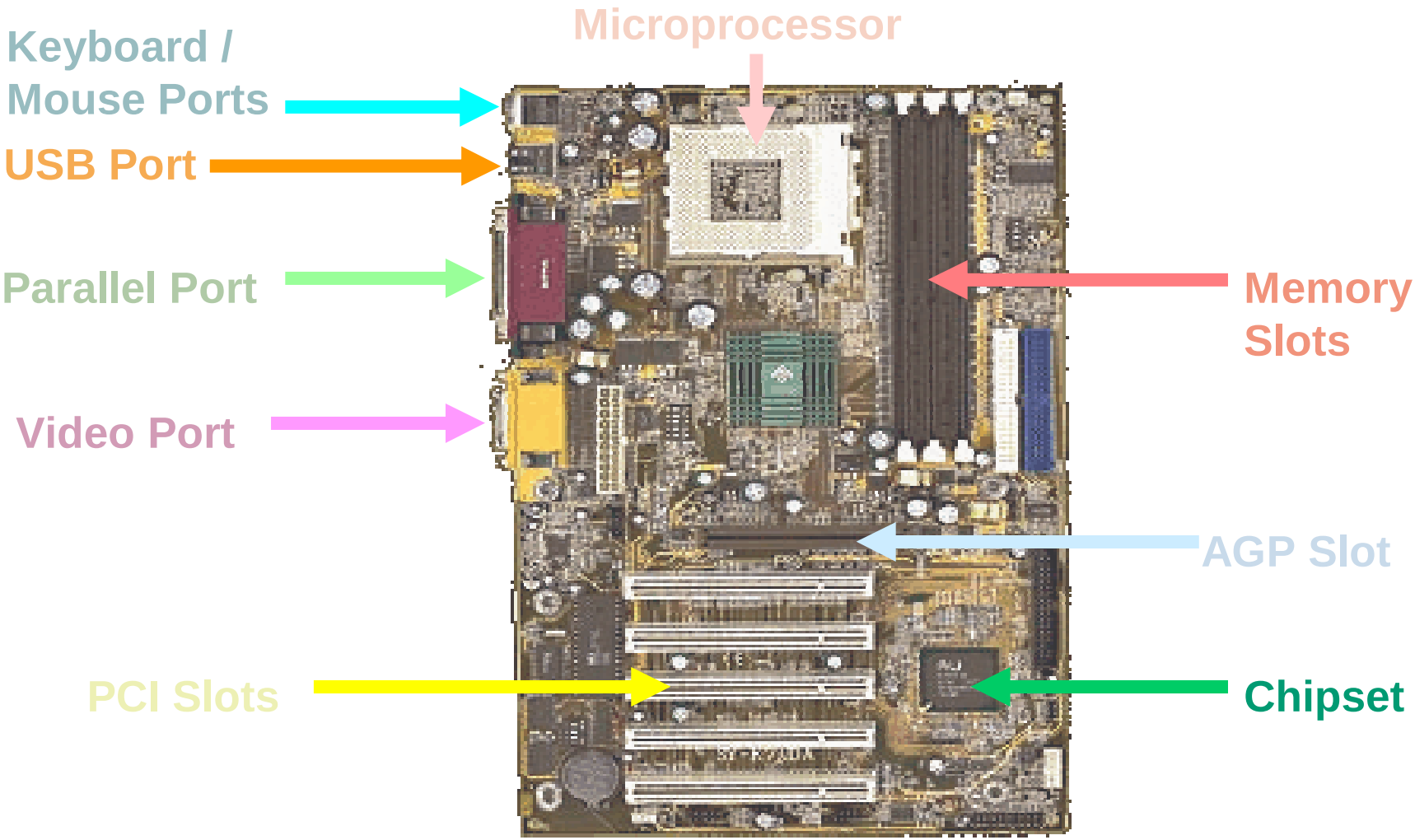
User Point of View



Inside

1. Motherboard (mainboard)– Large printed circuit board with thousands of electrical circuits
2. Power supply– Transforms alternating current (AC) from wall outlets to direct current (DC) needed by the computer
3. Extension Slots
4. Cooling fan– Keeps the system unit cool
5. Drive bays– Housing for the computer's hard drive, floppy drive, and CD-ROM / DVD-ROM drives

The Motherboard



CPU: Central Processing Unit

- CPU is the heart of a computer.
  - Control unit
    - Control and coordinate the computer's operations.
  - Arithmetic/Logic Unit (ALU)
    - performs all arithmetic computations and logic operations.

Control unit

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.

Control unit

Program execution

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.

Control unit

Program execution

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

Control unit (cont.)

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

Control unit (cont.)

- *Hardware characteristics*
  - CPU synchronizes its operations by the regular pulses emitted by an electronic device called a clock.
  - The speed of a computer can be quoted as:
    - Clock speed, e.g. 100MHz means 100 million cycles per second.
    - MIPS, a million instructions per second, or the unit of time it takes to execute one instruction.

Arithmetic/Logical Unit

- *ALU performs all arithmetic computations and logical operations.*
- *Arithmetic - Add, subtract, multiply, divide, exponentiation etc.*
- *Logical -Testing for relationships.*

  A<B;

  name == “ali”;

  c>=10;

  – *possible Answers? True or False*

The ALU contains special memory cells, known as **registers**, in which the arithmetic is carried out.

CPU reads the individual program instructions from main memory. Executes one instruction at a time until completion

Machine Cycle

Fetch - Decode - Execute

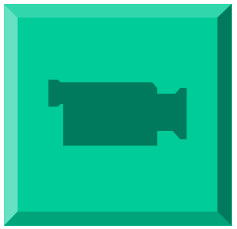
The machine cycle algorithm is continuously repeated until program termination.

- *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 register.

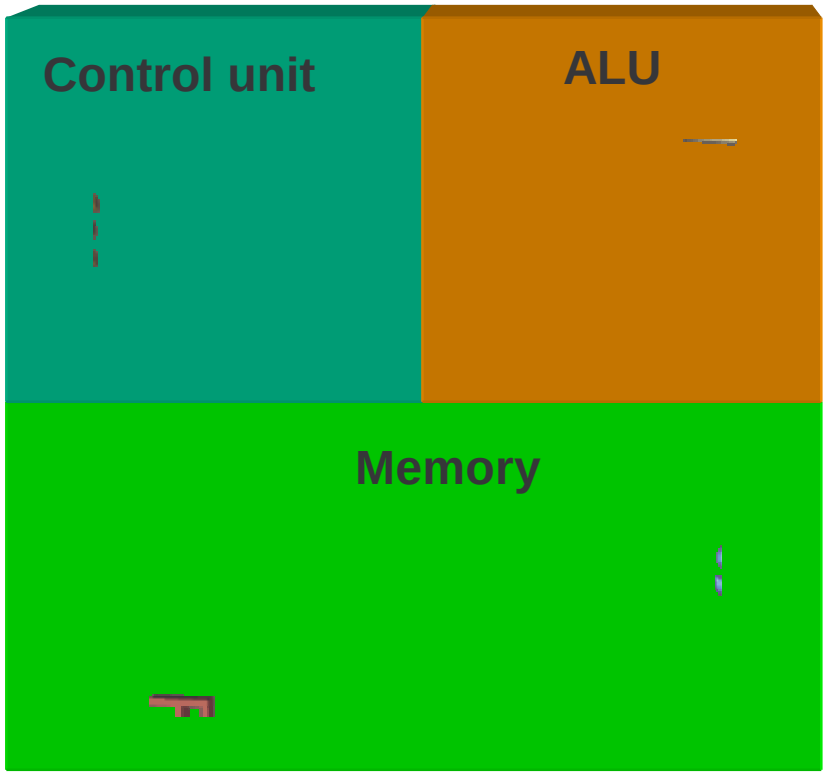
Decode: Decode the Bit pattern in the register

Execute: Having decoded the instruction, the control unit enters the execute phase. It 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 stored in registers.
- When the instruction has been executed, the control unit again begins the machine cycle with the Fetch cmd (the address of the next cmd is in the program counter).



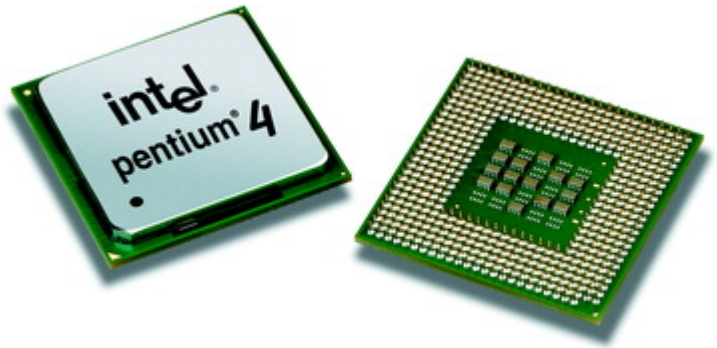
The Processing Cycle



Popular CPUs

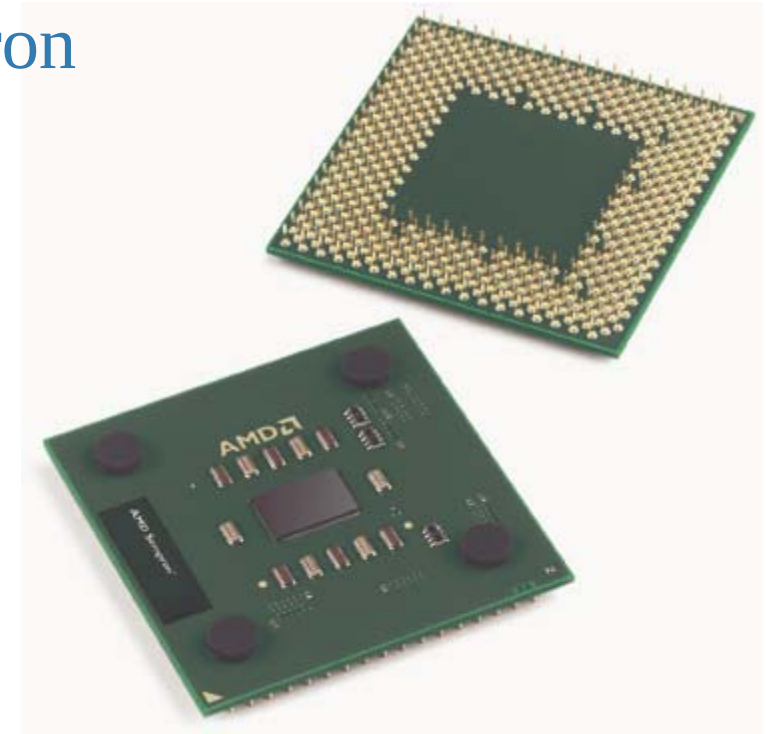
Intel

P4



Advanced Micro Devices (AMD)

Athlon
Sempron
Duron



AMD's XP processors

- The flagship of the AMD line, the XP processor differs from the Intel processor in several ways:
  - During a single clock cycle, AMD's processors have less instructions that an Intel machine, thereby making them more efficient.
  - AMD's chips are generally less expensive than Intel's and are not sold by a megahertz rating, as are Intel chips.

Intel's Pentium

- Intel's flagship line of processors has had the same name since its inception: the Pentium chip.
- The Pentium currently clocks in at 3.6 GHz, the fastest clock speed on the market. However, the clock cycle on a Pentium chip has many more steps than its competitors, so it is not as efficient as other chips on the market.

Classes of Computers

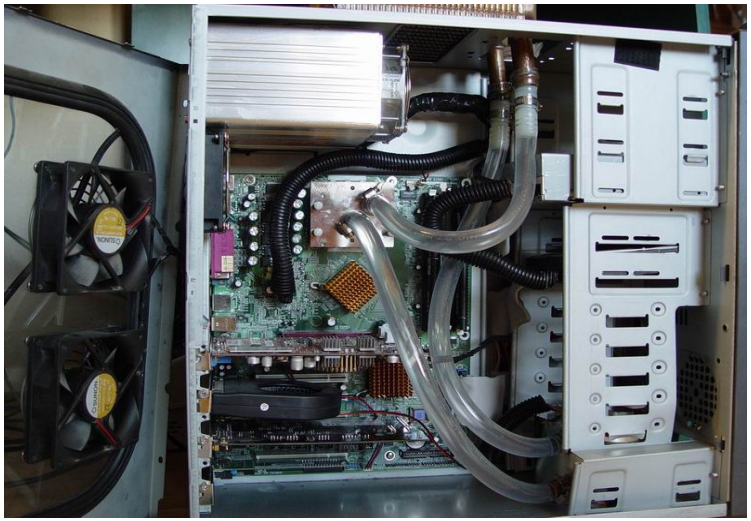
- Microcomputers (PC)
- Minicomputers
  - Designed for specific tasks
  - Distributed DP
- Workstations
  - High speed performance
  - Engineering tasks
  - High End Graphics
  - RISC
- Super Computers

Example: Silicon Graphics' Fuel

Processor	Single 800 MHz or 700MHz MIPS R16000A processor with 4MB L2 cache; 200 MHz front-side bus
Memory	512MB-4GB synchronous double-data rate RAM (DDR SDRAM)
Key Applications	MCAD Medical Imaging Scientific Visualization 3D Animation Visual Simulation Geospatial imaging

Hot Cases and Cool Thinking

- The biggest challenge to making faster processors is keeping the case cool enough for the processor to operate safely.



- Traditionally, a heat sink is attached to the top of the processor and a fan blows hot air off the processor, which mixes with the air flow across the motherboard to vent.
- As any hardcore hardware nerd will tell you, though, a heat sink only goes so far. Liquid cooling is the new wave of cooling technology, lowering temperatures to a cool 35 degrees Celsius.

Secondary Storage

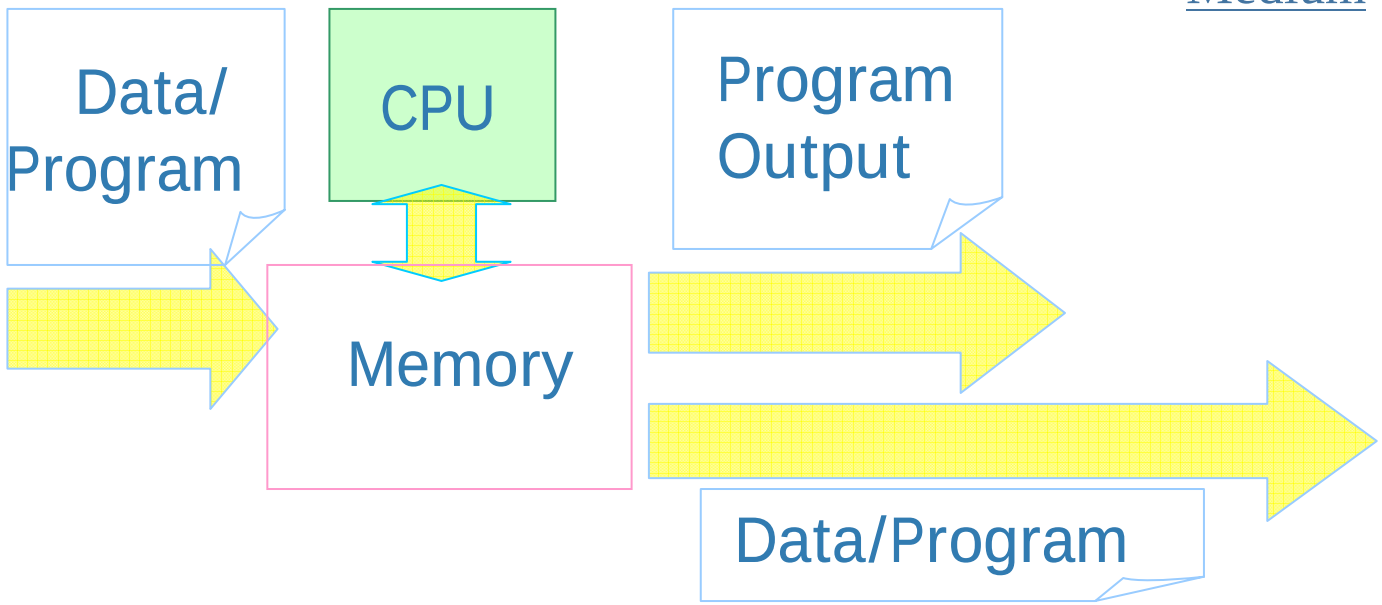
- Mass storage devices
  - Sequential storage: tape.
  - Random storage: floppy disk, zip disk, CD-ROM, etc.
- Indirect addressing.
- Static storage.
- Slower speed.

User Input / Output

- Input
  - Devices: keyboard, mouse, light pen, etc.
  - Data translation: interfaces.
- Output
  - Devices: computer screen, printer (dot matrix, ink jet or laser), etc.
  - Data translation: buffers.

IPOS Cycle

I - Input P - Process O - Output S - Secondary Storage Medium



Main Memory

- It is part of a computer's electronic circuitry which holds the binary data which the computer's program will process.
- Memory is divided into cells.
- Each cell is assigned a specific address, from 0 to the maximum size of the computer's memory capacity.

Main Memory

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

Bit	1
Byte	8 bits
Kilobyte	2^{10} bytes
Megabyte	2^{10} kilobyte
Gigabyte	2^{10} megabyte
Terabyte	2^{10} gigabytes

A 256K bytes of memory have 256*1024=262,144 b

Main Memory

- Random Access
- High-speed
- Read/Write Capability
- Volatility
  - Memory loses its contents when the power is turned off.
- Nonvolatile memory– Contents of memory are not erased when power is turned off.
  - ROM– Read-only memory provides the instructions to start the computer.
  - Flash memory– Memory that can be rewritten.

Static RAM (SRAM)

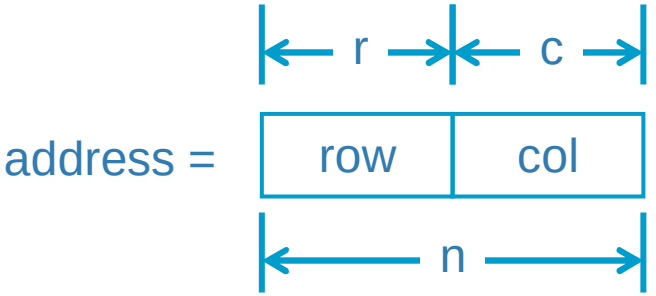
- Fast
  - ~4 nsec access time
- Persistent
  - as long as power is supplied
  - no refresh required
- Expensive
  - ~$100/MByte
  - 6 transistors/bit
- Stable
  - High immunity to noise and environmental disturbances
- Technology for caches

Dynamic RAM (DRAM)

- Slower than SRAM
  - access time ~60 nsec
- Nonpersistant
  - every row must be accessed every ~1 ms (refreshed)
- Cheaper than SRAM
  - ~$1.50 / MByte
  - 1 transistor/bit
- Fragile
  - electrical noise, light, radiation
- Workhorse memory technology

Addressing Arrays with Bits

- Array Size
  - R rows, $R = 2^r$
  - C columns, $C = 2^c$
  - $N = R * C$ bits of memory



- Addressing
  - Addresses are n bits, where $N = 2^n$
  - row(address) = address / C
    - leftmost r bits of address
  - col(address) = address % C
    - rightmost bits of address

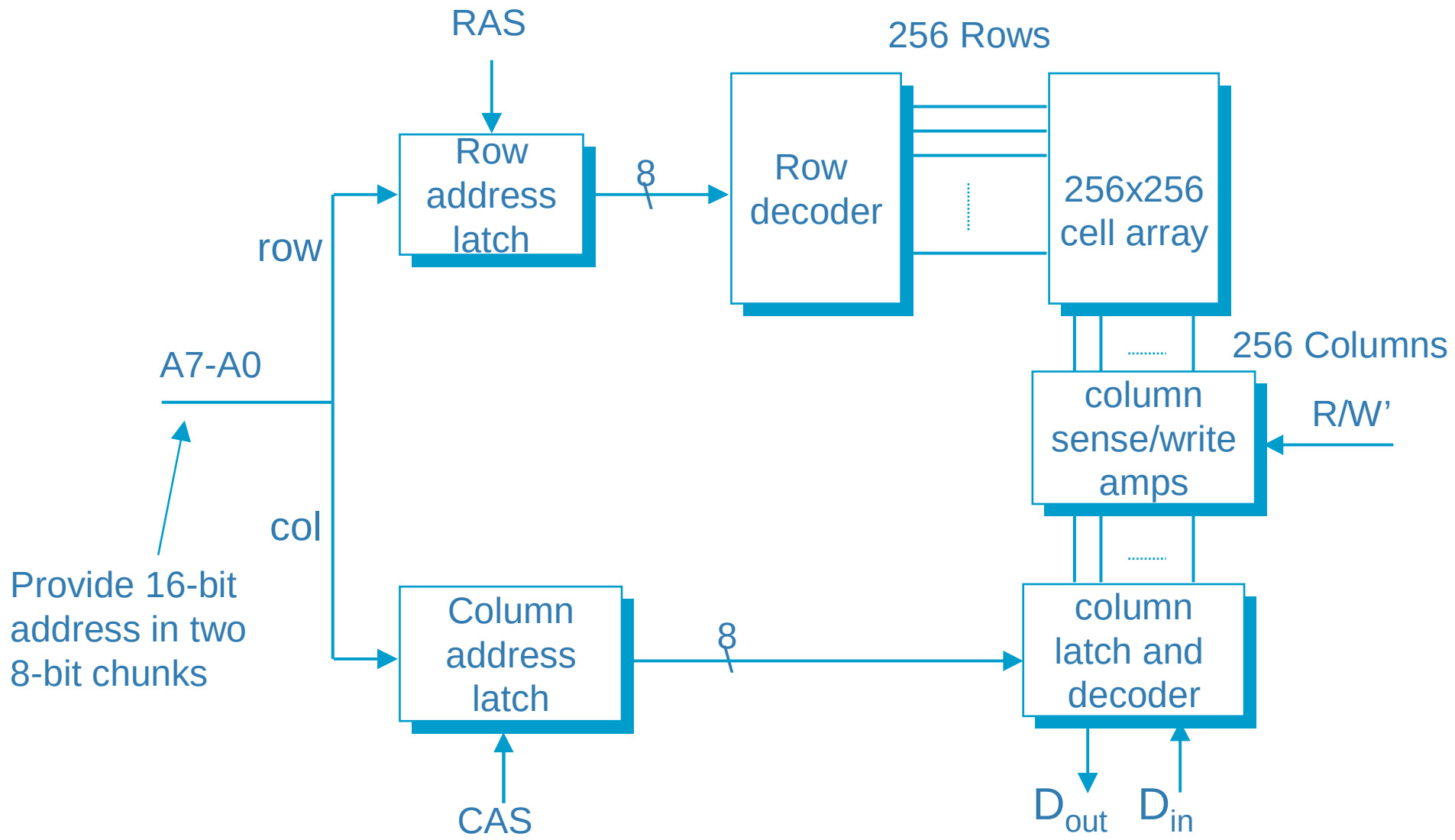
	0	1	2	3
0	000	001	010	011
1	100	101	110	111

row 1

col 2

- Example (R=2,C=4,address=6)

Example – Level Decode DRAM (64Kx1)



DRAM Operation

- Row Address (~50ns)
  - Set Row address on address lines & strobe RAS
  - Entire row read & stored in column latches
  - Contents of row of memory cells destroyed
- Column Address (~10ns)
  - Set Column address on address lines & strobe CAS
  - Access selected bit
    - READ: transfer from selected column latch to Dout
    - WRITE: Set selected column latch to Din
- Rewrite (~30ns)
  - Write back entire row

Observations About DRAMs

- Timing
  - Access time (= 60ns) < cycle time (= 90ns)
  - Need to rewrite row
- Must Refresh Periodically
  - Perform complete memory cycle for each row
  - Approximately once every 1ms
  - Sqrt(n) cycles
  - Handled in background by memory controller
- Inefficient Way to Get a Single Bit
  - Effectively read entire row of Sqrt(n) bits

Type of RAMs

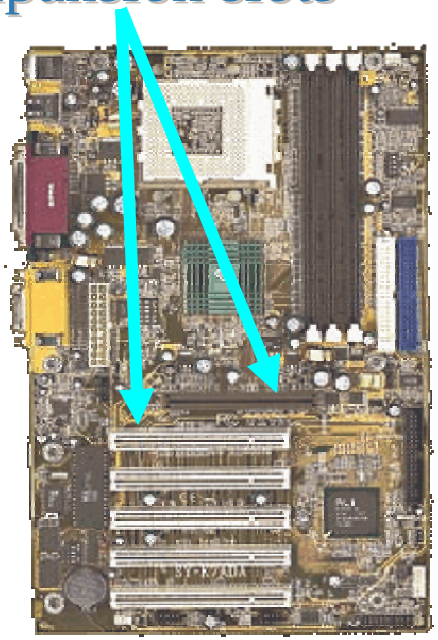
- Dynamic RAM– A memory chip that needs to be refreshed periodically, or it will lose its data.
  - Synchronous DRAM (SDRAM)– Synchronized with the computer's system clock.
  - Double Data Rate SDRAM (DDR SDRAM)– A type of SDRAM that can send and receive data within one clock cycle.

Cache Memory

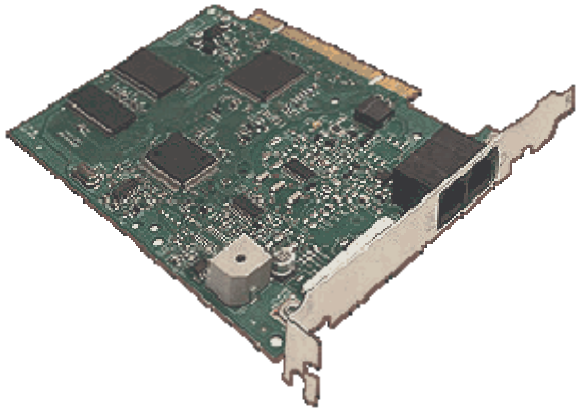
- Primary cache (Level 1 or L1)– Located within the CPU chip, it is the memory the microprocessor uses to store frequently used instructions and data.
- Secondary cache (Level 2 or L2; Backside Cache)– Located near the CPU, it is the memory between the CPU and RAM.
- It is faster than RAM.

Input/Output Buses

Expansion slots



Expansion card



- I/O buses are pathways that enable the CPU to communicate with input/output devices.
- Typically the buses contain slots, called expansion slots, in which expansion cards are inserted.

Ports and Connectors

- Universal Serial Bus
- There are two types of USB technologies, traditional USB, or USB 1.1 and the newer technology of USB 2.0. USB is generally used for bursting chunks of data, but performs poorly for continuous data transfer.

- USB 1.1 can transfer data at a theoretical speed of 12 megabits per second. However, all USB devices draw on this speed, so 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 2.0 reaches theoretical speeds of 480 mbps, yet is still subject to the sharing limitations of its predecessor.

High Speed Computer Ports and Connecters

- IEEE 1394 “FireWire” port
- Used to transfer large amounts of data quickly.
- Usually camcorders and other video equipment use this port
- 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.
- Recently, a new type of FireWire burst onto the scene, termed FireWire 800. Just like its name implies, FireWire 800 transfers data at twice the speed of its predecessor.

Telephony Computer Ports and Connecters

Modem Port

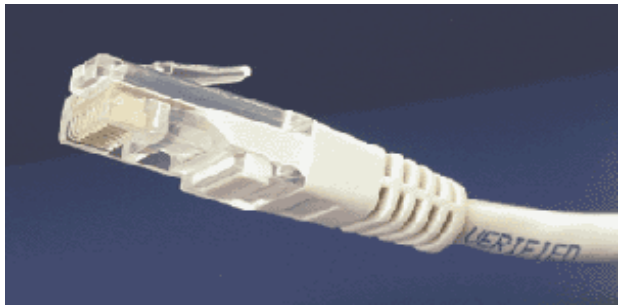
►A modem port looks like a standard RJ14 North American telephone jack.

►Modern modems have a theoretical limitation of 56 kbps

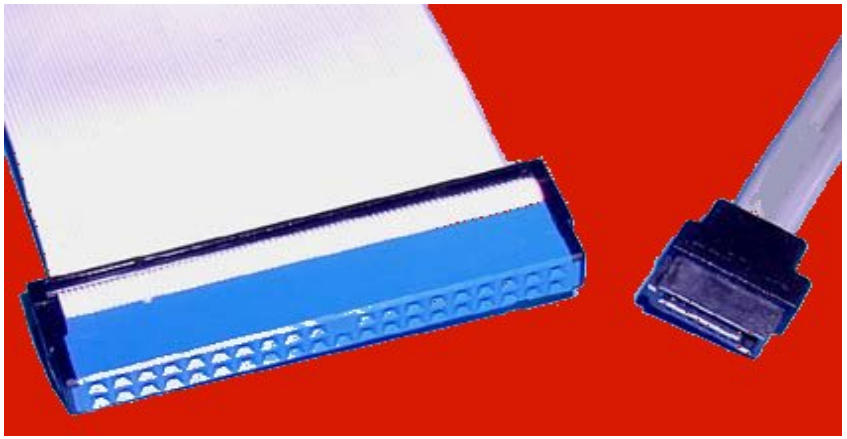
Ethernet Port

►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.



System Buses



► 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.

► Serial ATA also features the ability to hot-plug devices, which allows a device to be universally plug and play compatible.

Type of Buses

- Personal Computer Interface (PCI)
- PCI Express
- Accelerated Graphics Port (AGP)– designed for video adapters.
- Universal Serial Bus (USB)– Allows up to 127 devices to be connected to the computer at one time. It supports plug and play.
- Firewire (IEEE 1394)– Designed especially for digital video transmission

Secondary Storage Devices

- Since secondary storage is different from main memory we have to understand how it works in order to do good file designs.
- Two major types of storage devices
  - Direct Access Storage Devices (DASDs)
    - Magnetic Disks

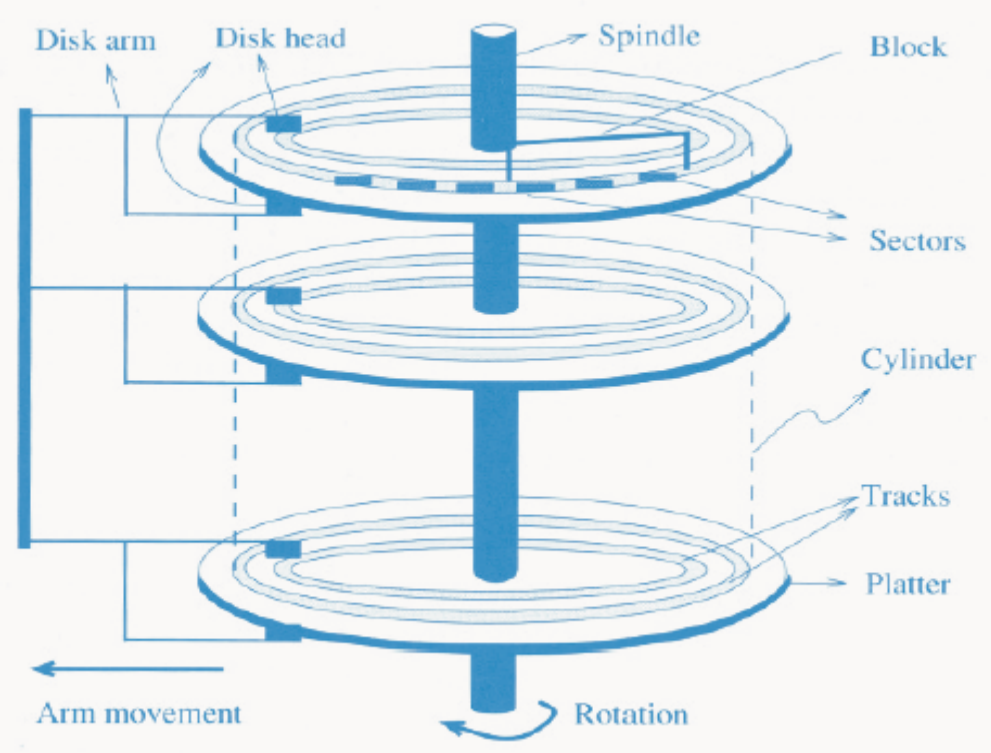
      Hard Disks (high capacity, low cost per bit)
    - Optical Disks

      CD-ROM,DVD-ROM

      (Read-only/write-once, holds a lot of data, cheap)
  - Serial Devices
    - Magnetic Tapes

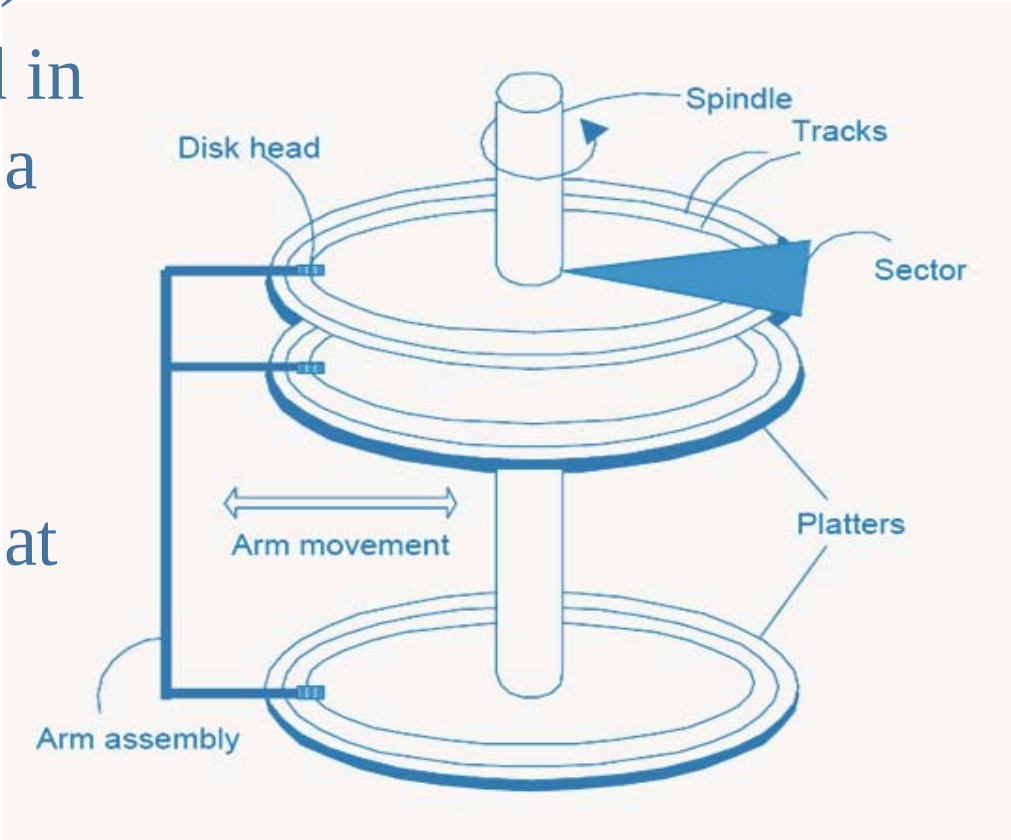
Magnetic Disks

- Magnetic disks support direct access to a desired location
- Simplified structure of a disk
  - Disk blocks
  - Tracks
  - Platters
  - Cylinder
  - Sectors
  - Disk heads
  - Disk Controller
  - Seek Time
  - Rotational delay



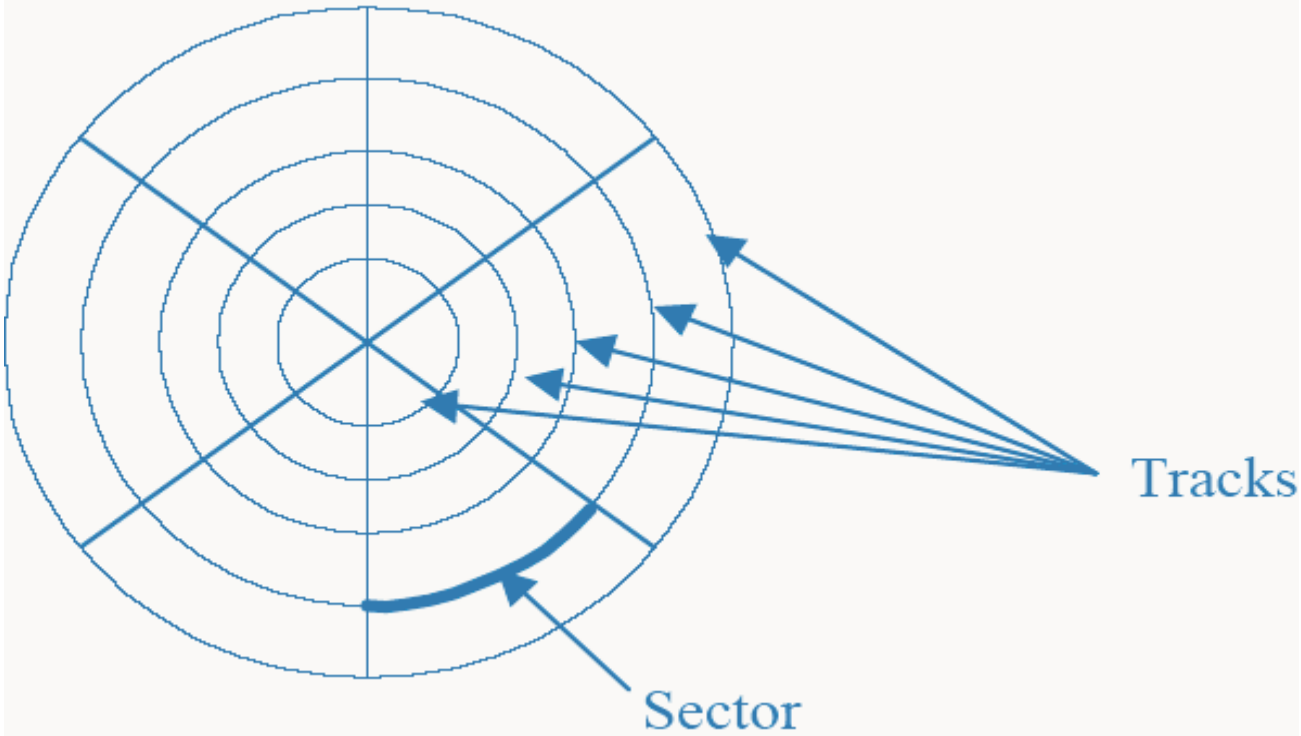
Components of a Disk

- The platters spin (7200 rpm)
- The arm assembly is moved in or out to position a head on a desired track. Tracks under heads make a *cylinder* (imaginary!).
- Only one head reads/writes at any one time
- *Block size* is a multiple of *sector size* (which is fixed)



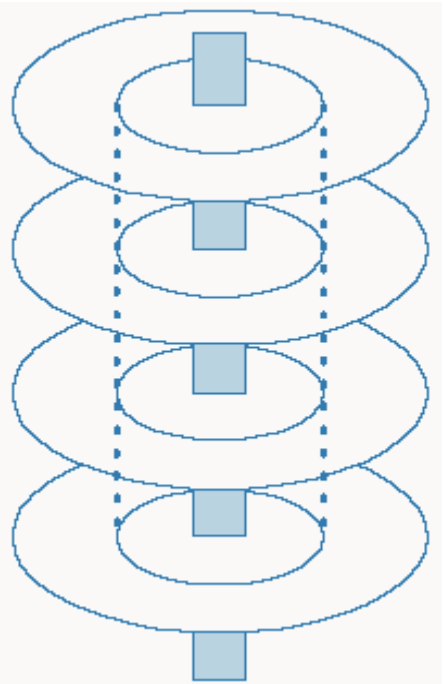
Looking at a Surface

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

Parameter	18GB Example
– Number Platters	12
– Surfaces / Platter	2
– Number of tracks	6962
– Number sectors / track	213
– Bytes / sector	512
Total Bytes	18,221,948,928

Disk Operation

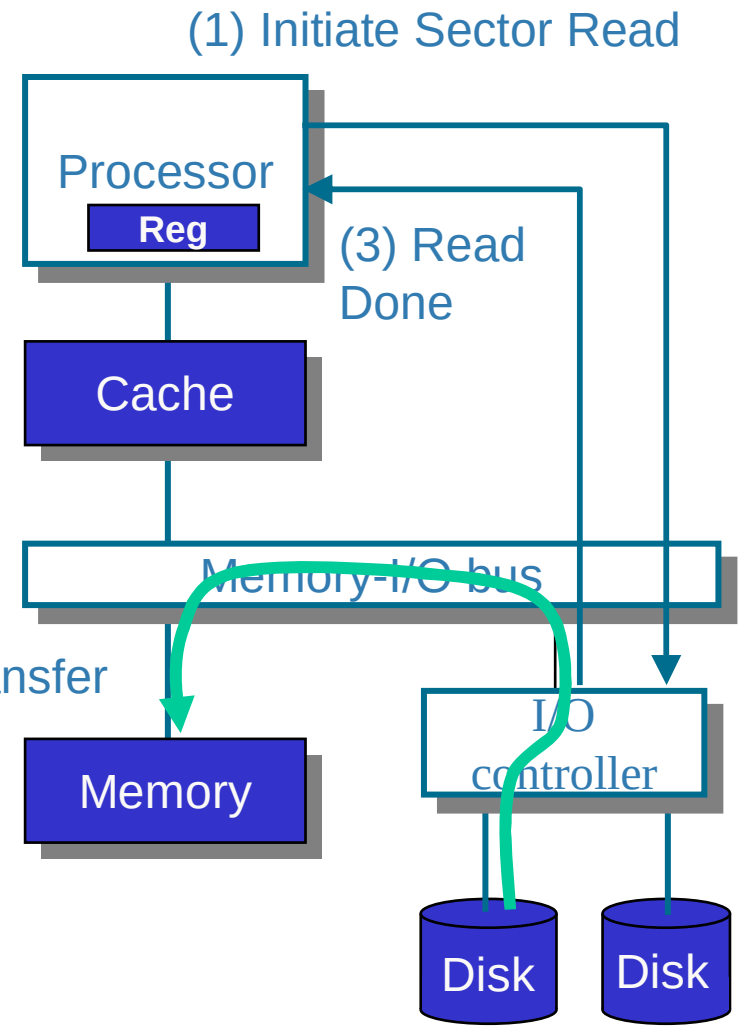
- Operations: Read or write complete sector
- Seek
  - Position head over proper track
  - Typically 6-9ms
- Rotational Latency
  - Wait until desired sector passes under head
  - Worst case: complete rotation 10,025 RPM $\Rightarrow$ 6 ms
- Read or Write Bits
  - Transfer rate depends on # bits per track and rotational speed
  - e.g., 213 * 512 bytes @10,025RPM = 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 Performance

- Getting First Byte
  - Seek + Rotational latency = 7,000 – 19,000 µsec
- Getting Successive Bytes
  - ~ 0.06 µsec each
    - *roughly 100,000 times faster than getting the first byte!*
- Optimizing Performance:
  - Large block transfers are more efficient
  - Try to do other things while waiting for first byte
    - switch context to other computing task
    - processor is interrupted when transfer completes

Disk/System Interface

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



Magnetic Disk Technology

- Seagate ST-12550N Barracuda 2 Disk
  - Linear density 52,187. bits per inch (BPI)
    - Bit spacing 0.5 microns
  - Track density 3,047 tracks per inch (TPI)
    - Track spacing 8.3 microns
  - Total tracks 2,707 tracks
  - Rotational Speed 7200 RPM
  - Avg Linear Speed 86.4 kilometers / hour
  - Head Floating Height 0.13 microns

CD Read Only Memory (CDROM)

- Optical recording technology developed for audio CDs
  - 74 minutes playing time
    - 44,100 samples / second
    - 2 X 16-bits / sample (Stereo)

    ⇒ Raw bit rate = 172 KB / second
  - Add extra 288 bytes of error correction for every 2048 bytes of data, can not tolerate any errors in digital data
- Bit Rate
  - 172 * 2048 / (288 + 2048) = 150 KB / second
    - For 1X CDROM, *N* X CDROM gives bit rate of *N* * 150
    - E.g., 12X CDROM gives 1.76 MB / second
- Capacity 74 Minutes*150 KB/second*60 seconds/minute= 650 MB