

Chapter 2: Organization of a Computer System and Evolution of HW/SW Components

- Generations of Computers
- Milestones in Computer HW & SW Development
- Characteristics and Types of Computers *
- Components of the Computer System
- Software Generations and Evolution
- Microcomputer Architecture

Learning Objectives

- Define a computer
- Appreciate the evolution of computer (HW & SW) through five generations
- Identify the characteristics of computers
- Classification of computers*
- Understanding functions of various elements of a computer through block diagrams

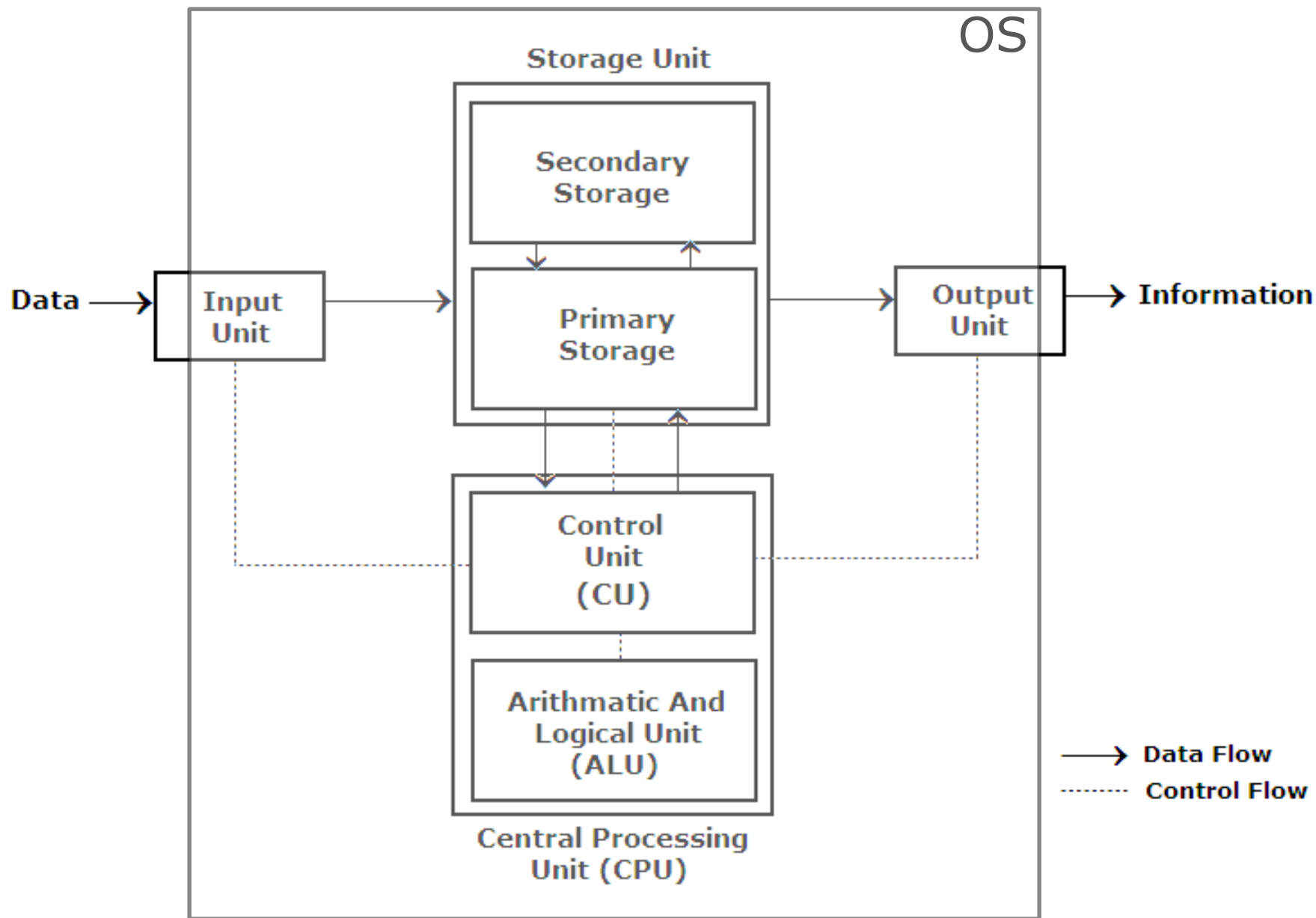
Definition of a Computer

- a general purpose
 - programmable
 - information processor
 - with input and output
-
- Fixed Program Computer (embedded)
 - Stored Program Computer



Definition of Computer --- Continued

- Computer is a programmable machine.
- Computer is a machine that manipulates data according to a set of instructions.
- Computer is any device which assists humans in performing various kinds of computations or calculations.



Basic computer Organization Block Diagram

Anatomy of a Computer

- Every computer has four basic parts, or units:
 - an input unit such as the keyboard, that feeds information into the computer
 - a central processing unit (CPU) that performs the various tasks of the computer
 - an output unit, such as a monitor, that displays the results;
 - a memory that stores information and instructions.

Computer vs Human

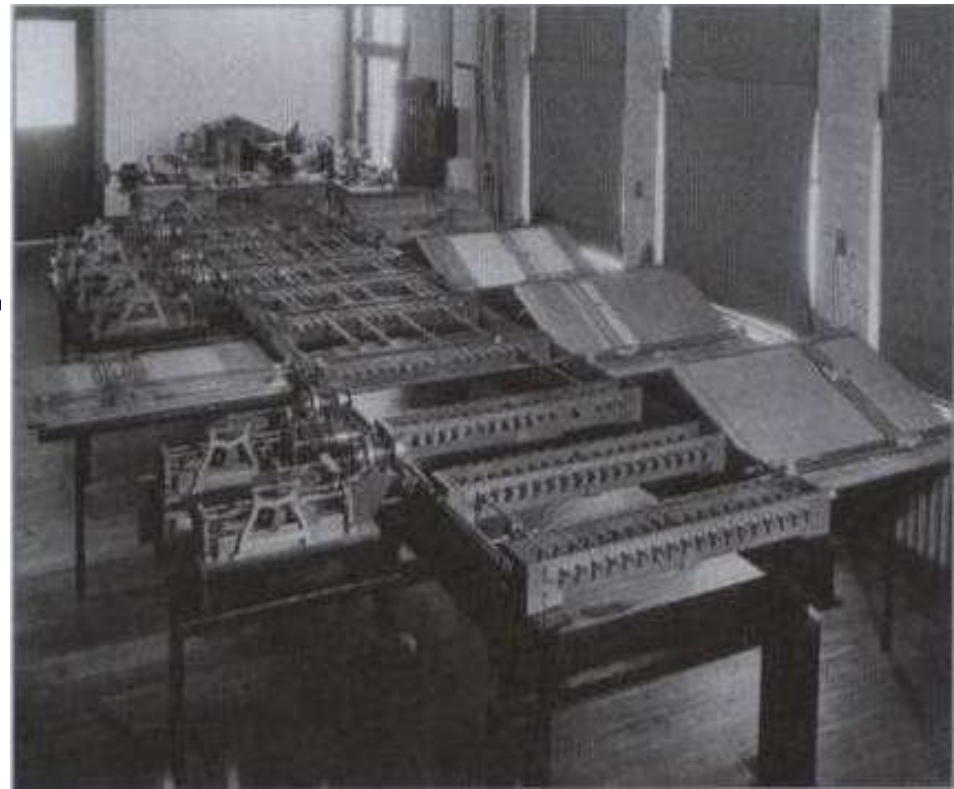
- Input - Five senses
- Central Processing Unit (CPU) - brain
- Output - Body Parts
- Memory - Human memory

- Hardware
 - Physical components
- Software
 - Programs for operations and problem solving

History of Computers

- Older computers were analog
 - represent data as variable points along a continuous spectrum of values.
 - More flexible but not necessarily more precise and reliable

An early analog computer in the late 1920s



Harvard Mark I (1944)

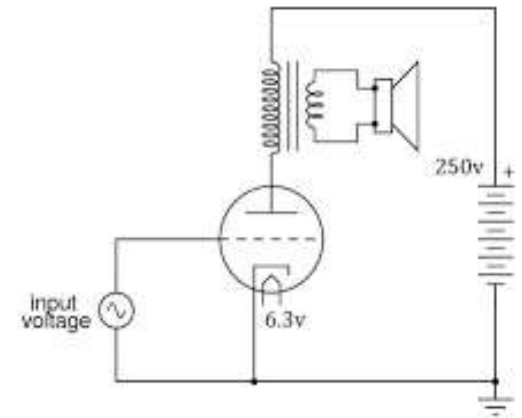
- Built from Switches, Relays, rotating shafts and clutches
- 765,000 components
- Hundreds of meters of wires
- Volume
 - Length (51ft) x Height (8 ft) x Depth (2 ft)
- Weight 4500 kg
- Used decimal number systems
- Called Automatic Sequence Controlled Calculator (ASCC)

ENIAC

- 1946 First general purpose (programmable) electronic computer
- Electronic Numerical Integrator And Computer (ENIAC)

- Technology used

– Vacuum tubes	17,468
– Crystal Diodes	7,200
– Relays	1,500
– Transistors	70,000
– Capacitors	10,000
– Hand soldered joints	1 million



ENIAC

- Weight 30 tons
- Volume 100 ft (L) X 8 ft (H) X 3 ft (D)
- Covers 1800 sq. feet
- Power consumption 150 kW
- Uses punch cards



Manchester Mark I

- 1948
- First **stored program** computer,
- Based on Von Neumann architecture
- Manchester Mark 1 , built in UK. Using valves
- it can perform about **500 operations per second** and has the first RAM .
- It fills a room the **size** of a small office.

Computer Generations

Generation 0: Mechanical Calculators (relays)

Generation 1: Vacuum Tube Computers

Generation 2: Transistor Computers

Generation 3: Integrated Circuits

Generation 4: Microprocessors

Generation 5: Artificial Intelligence

Generation of Computers

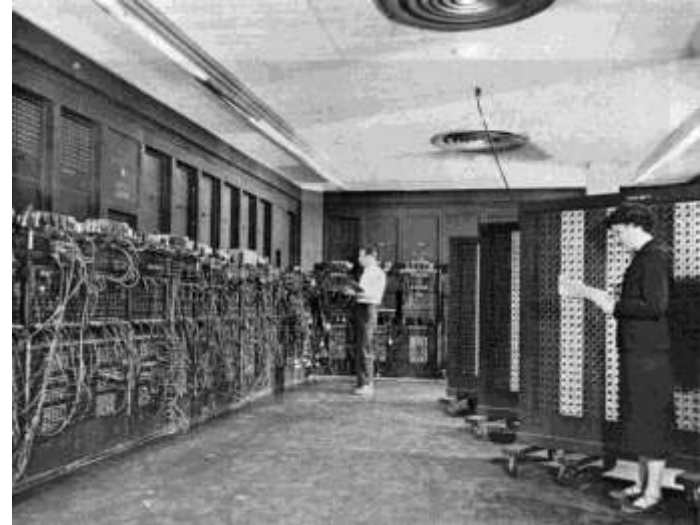
Generation	Dates	Characteristic
1 st	1944-59	Use Valves (Vacuum tubes)
2 nd	1959-64	Use transistors
3 rd	1965-70	Integrated & Large Scale Integrated Circuits
4 th	1970 - 90	Very Large Scale Integrated Circuits
5 th	1990 - Under development	“Artificial Intelligence” based computers

Computer Generations

	First Generation	Second Gen.	Third Gen.	Fourth Gen.
Technology	Vacuum Tubes	Transistors	Integrated Circuits (multiple transistors)	Microchips (millions of transistors)
Size	Filled Whole Buildings	Filled half a room	Smaller	Tiny - Palm Pilot is as powerful as old building sized computer

Generation 1 : ENIAC

The ENIAC (Electronic Numerical Integrator and Computer) was unveiled in 1946: the first all-electronic, general-purpose digital computer



Used machine languages and magnetic tapes



First Generation Hardware

Vacuum Tubes

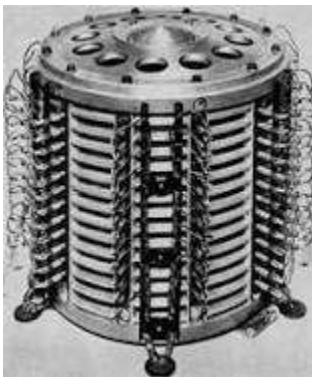
Large, not very reliable, generated a lot of heat

Magnetic Drum

Memory device that rotated under a read/write head

Card Readers → Magnetic Tape Drives

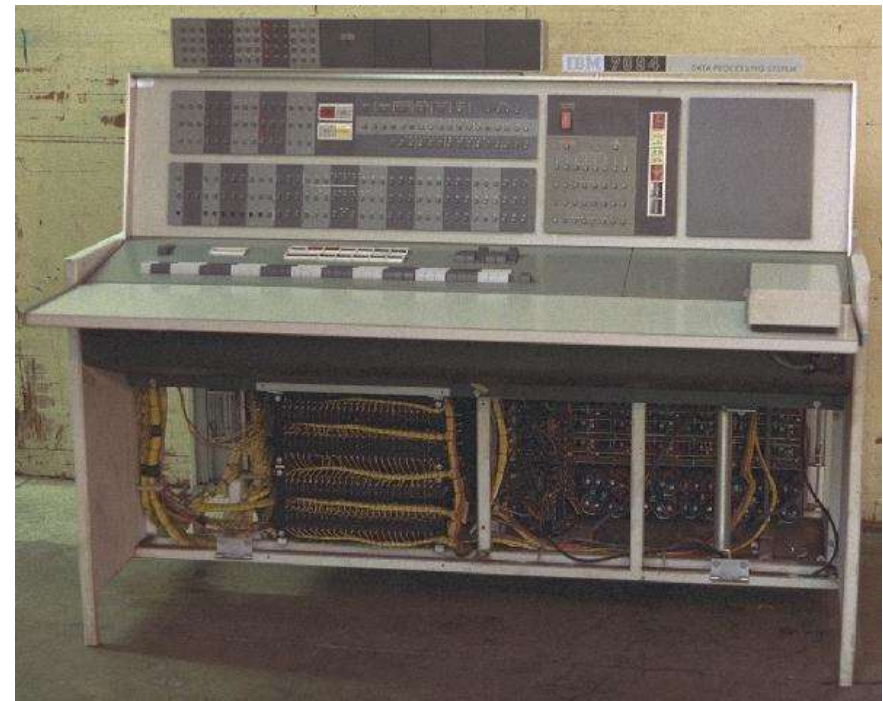
Sequential auxiliary storage devices



Magnetic drum



Generation 2: IBM7094

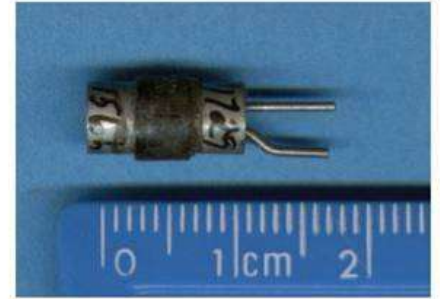


These machines used assembly language.

Second Generation Hardware

Transistor

Replaced vacuum tube, fast, small, durable, cheap, consumes less energy



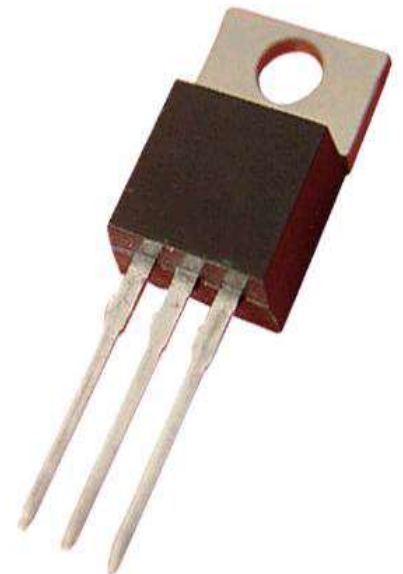
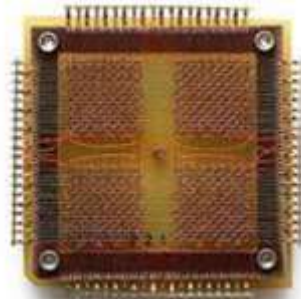
Magnetic Cores

Replaced magnetic drums, information available instantly. How?

Magnetic Disks

Replaced magnetic tapes, data can be accessed directly. What does this mean?

Magnetic core



Generation 3: Integrated Circuits



Seymour Cray created the Cray Research Corporation

Cray-1: \$8.8 million, 160 **million instructions per second** and 8 **Mbytes** of memory

Used high level programming languages

Third Generation Hardware

Integrated Circuits

Replaced circuit boards, smaller, cheaper, faster, more reliable

Transistors

Now used for memory construction

Terminal

An input/output device with a keyboard and screen



Generation 4: VLSI

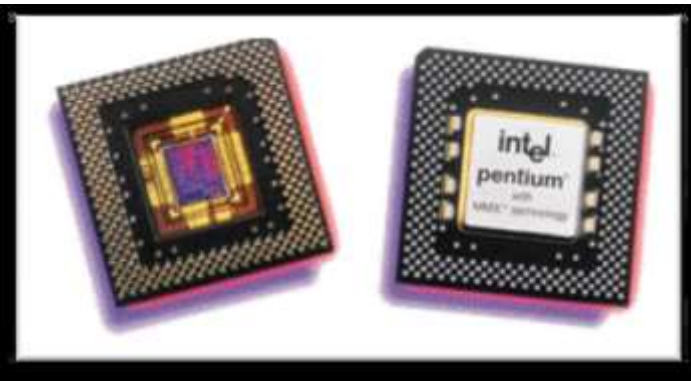
Improvements to IC technology made it possible to integrate more and more transistors in a single chip

SSI (Small Scale Integration): 10 - 100

MSI (Medium Scale Integration): 100 - 1,000

LSI (Large Scale Integration): 1,000 - 10,000

VLSI (Very Large Scale Integration): $> 10,000$



Microprocessors

Fourth Generation Hardware

Very Large-scale Integration

Great advances in chip technology

PCs, the Commercial Market, Workstations

Personal Computers and Workstations emerge

New companies emerge: Apple, Sun, Dell ...

Laptops, Tablet Computers, and Smart Phones

Everyone has his/her own portable computer

The Fifth Generation

- Based on Artificial Intelligence (AI).
- Still in development.
- The use of parallel processing and superconductors is helping to make artificial intelligence a reality.
- The goal is to develop devices that respond to natural language input and are capable of learning and self-organization.
- There are some applications, such as voice recognition, that are being used today.

Generation 5?

The term “Generation 5” is used sometimes to refer to all more or less “sci-fi” future and present developments

- Voice recognition

- Artificial intelligence

- Quantum computing

- Bio computing

- Nano technology

- Learning

- Natural languages

- Parallelism & Networking

Types of computers

- With respect to physical size, speed, storage capacity, and price

- In terms of size

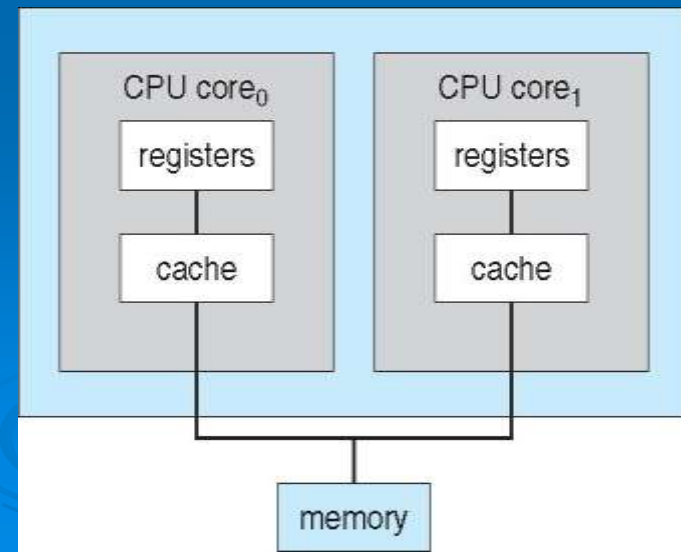
- ✓ ☐ small
- ✓ ☐ medium
- ✓ ☐ large

* The details are left as a Reading Assignment

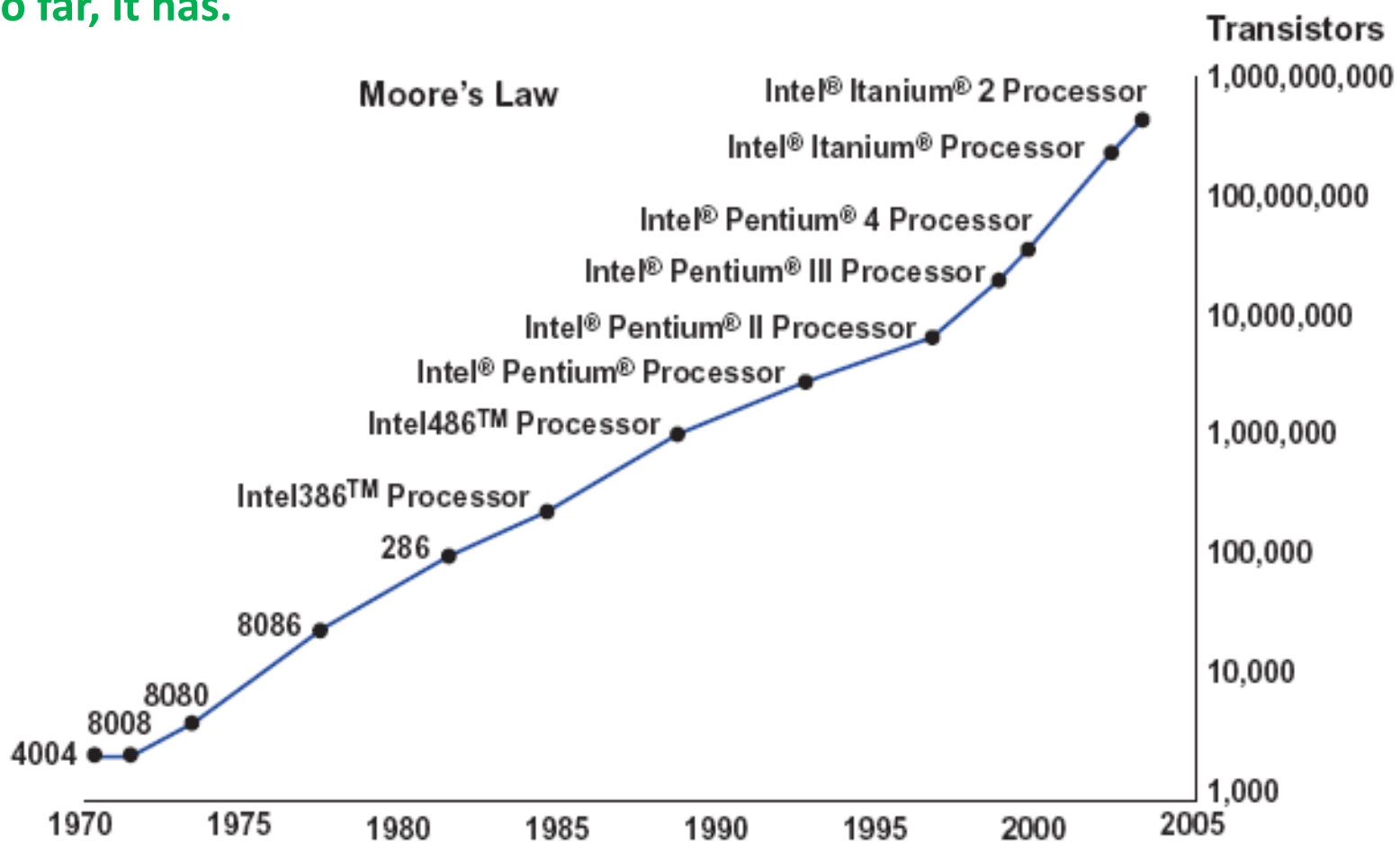
- Microcontrollers
- Microcomputers
- Minicomputers (Workstations)
- Mainframe Computers
- Super computers

- The three directions of computer development are **miniaturization**, **speed**, and **affordability** due to
- **Integration, Mass Production, Core Technology (Multiprocessors);**
Cost reduction by half every 2 years

- The three directions of communications development are **connectivity**, **interactivity**, and **multimedia**



Moore's law suggests that computer power will double every 18 to 24 months. So far, it has.



Curve shows transistor count doubling almost every two years

Computer HW & SW

- Capabilities of Computers
 - Huge Data Storage
 - Input and Output
 - Processing Power
 - *Hardware stores and transmits data, supports software, and software processes data.*
 - *But, a processor (CPU) is a hardware that can also process data!*

Computer HW & SW

Characteristics of Computers

- High Processing Speed
- Accuracy
- Reliability
- Versatility
- Diligence

DILLIGENCE : A Computer can work for long hours with the same accuracy and speed because it is free from problems of boredom or lack of concentration.

VERSATILITY : The working of computer with different types of data is known as versatility.

Reliability: Produces the same or identical result repeatedly for the same input

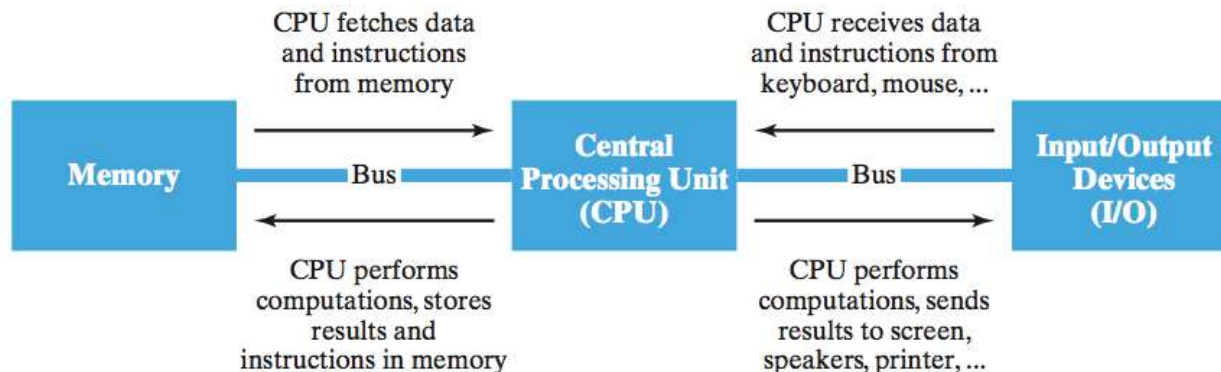
von Neumann Architecture

although specific components may vary, virtually all modern computers have the same underlying structure

- known as the *von Neumann architecture*
- named after computer pioneer, John von Neumann, who popularized the design in the early 1950's

the von Neumann architecture identifies 3 essential components

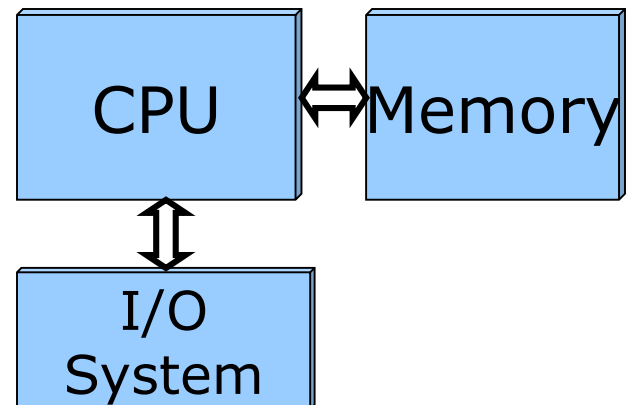
1. *Input/Output Devices (I/O)* allow the user to interact with the computer
2. *Memory* stores information to be processed as well as programs (instructions specifying the steps necessary to complete specific tasks)
3. *Central Processing Unit (CPU)* carries out the instructions to process information



von Neumann popularized the idea of a "stored program" computer

- store both data and programs in Memory
- Central Processing Unit (CPU) executes by loading program instructions from memory and executing them in sequence
- interact with the user via Input / Output devices

virtually all modern machines follow this *von Neumann Architecture*

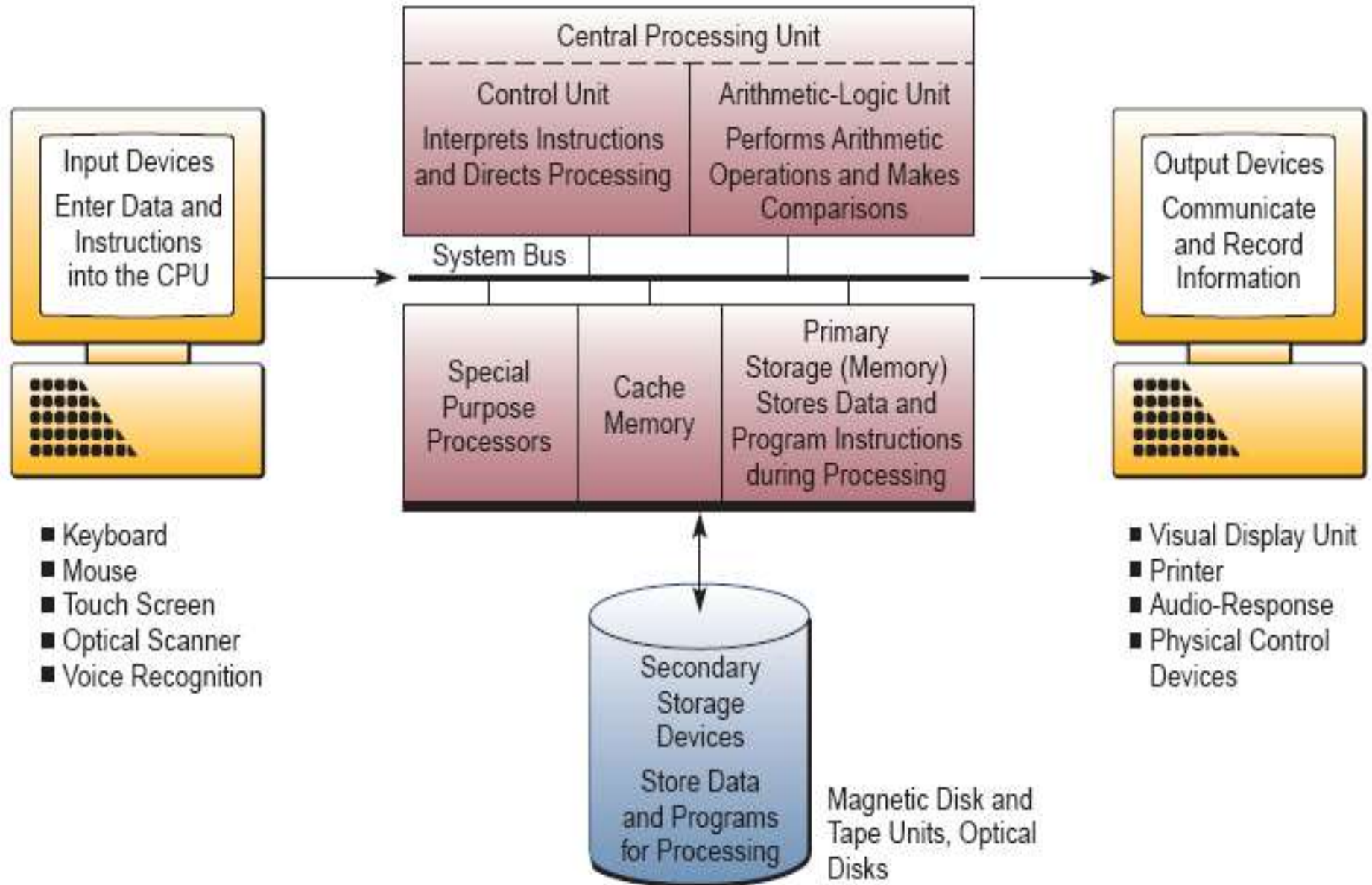


What Hardware Components Contribute to the Speed of a Computer?

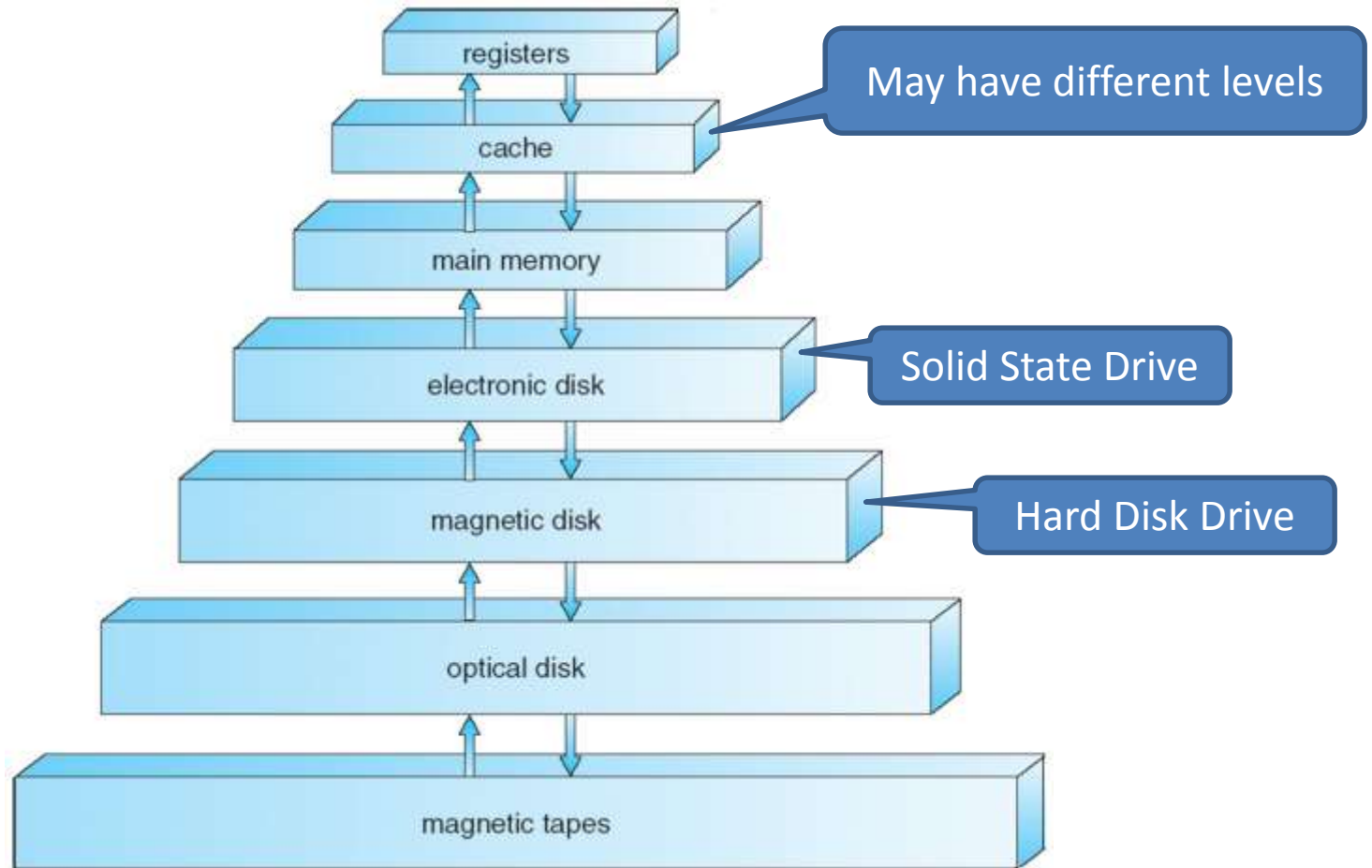
Component	Speed measured by	Units	Description
CPU	Clock speed	GHz	The time it takes to complete a cycle
Motherboard (Data Buses)	Bus speed & (Bus Width)	mHz * Bits	How much data can move across the bus simultaneously /s
RAM	Data transfer rate	MB/s - GB/s	The time it takes for data to be transferred from memory to system.
Hard Disk	Access time	ms	The time it takes before the disk can transfer data.
	Data transfer rate	MBit/s	The time it takes for data to be transferred from disk to system.

The computer system concept

A computer is a system of hardware components and functions

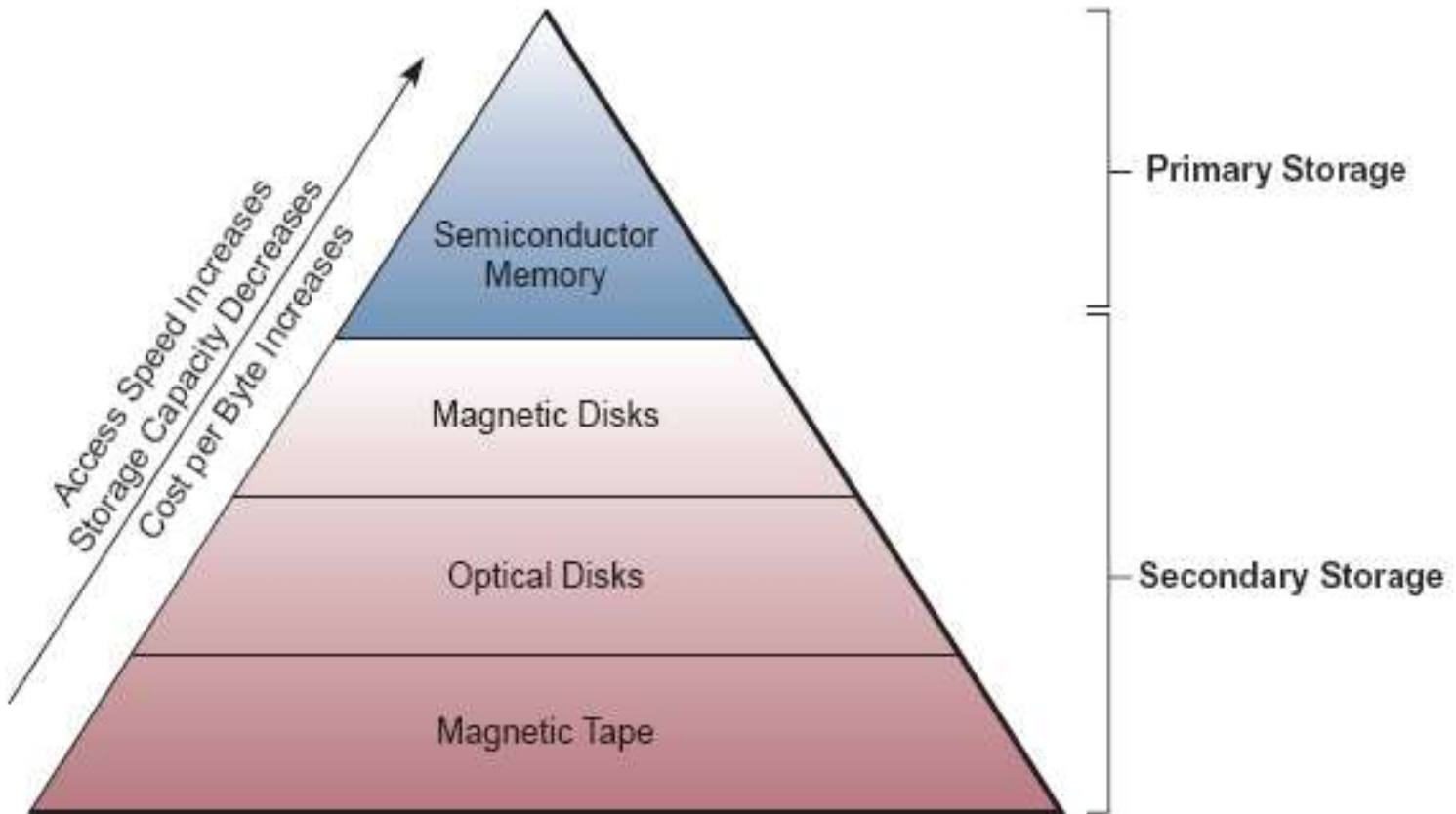


Storage-Device Hierarchy



Storage media cost, speed, and capacity trade-offs.

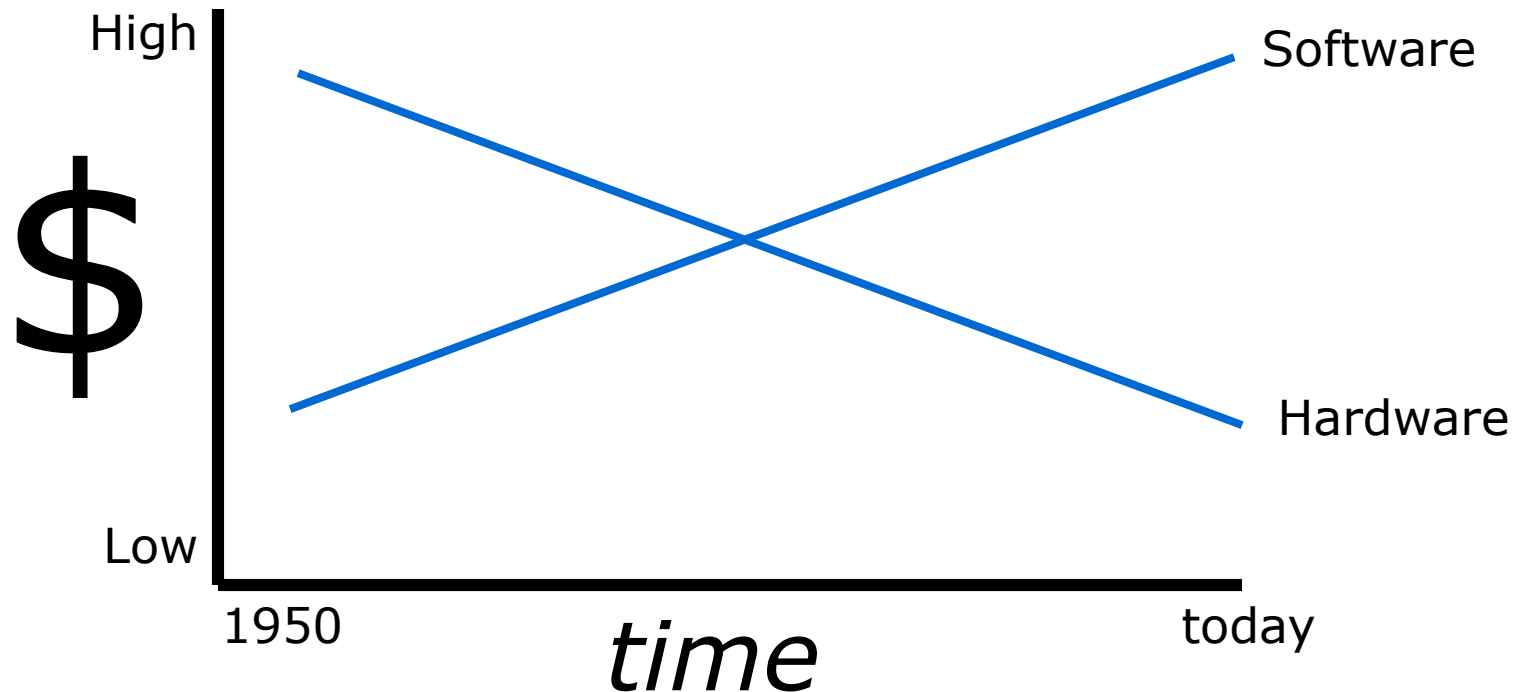
Note how cost increases with faster access speeds but decreases with the increased capacity of storage media.



Performance of Various Levels of Storage

Level	1	2	3	4	5
Name	registers	cache	main memory	solid state disk	magnetic disk
Typical size	< 1 KB	< 16MB	< 64GB	< 1 TB	< 10 TB
Implementation technology	custom memory with multiple ports CMOS	on-chip or off-chip CMOS SRAM	CMOS SRAM	flash memory	magnetic disk
Access time (ns)	0.25 - 0.5	0.5 - 25	80 - 250	25,000 - 50,000	5,000,000
Bandwidth (MB/sec)	20,000 - 100,000	5,000 - 10,000	1,000 - 5,000	500	20 - 150
Managed by	compiler	hardware	operating system	operating system	operating system
Backed by	cache	main memory	disk	disk	disk or tape

Cost against Time graph for Software and Hardware Development



Why is cost for software development always increasing?

Software Generations

Software is the general term for various kinds of programs used to operate and manipulate computers and their peripheral devices. One common way of describing hardware and software is to say that software can be thought of as the **variable** part of a computer and hardware as the **invariable** part.

In the first and second software generations there was **no multitasking**, only **batch programming** was possible.

First Generation Software (1951-1959)

Machine Language

Computer programs written in binary (1s and 0s)

Assembly Languages and Translators

Programs written using mnemonics, which were translated into machine language

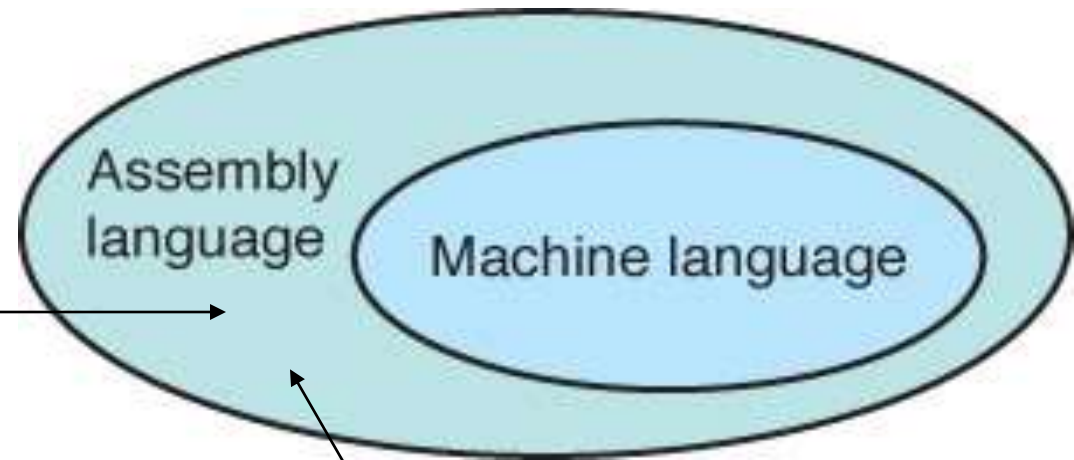
Programmer Changes

Programmers divided into two groups: application programmers and systems programmers

- Computers only for programmers, professionals, expert users
- Not for the general public and novice users (**not affordable and requires skill**)
- Universities, big organizations, military were using computers

First Generation Software Cont...

System programmers
write the assembler
(translator)



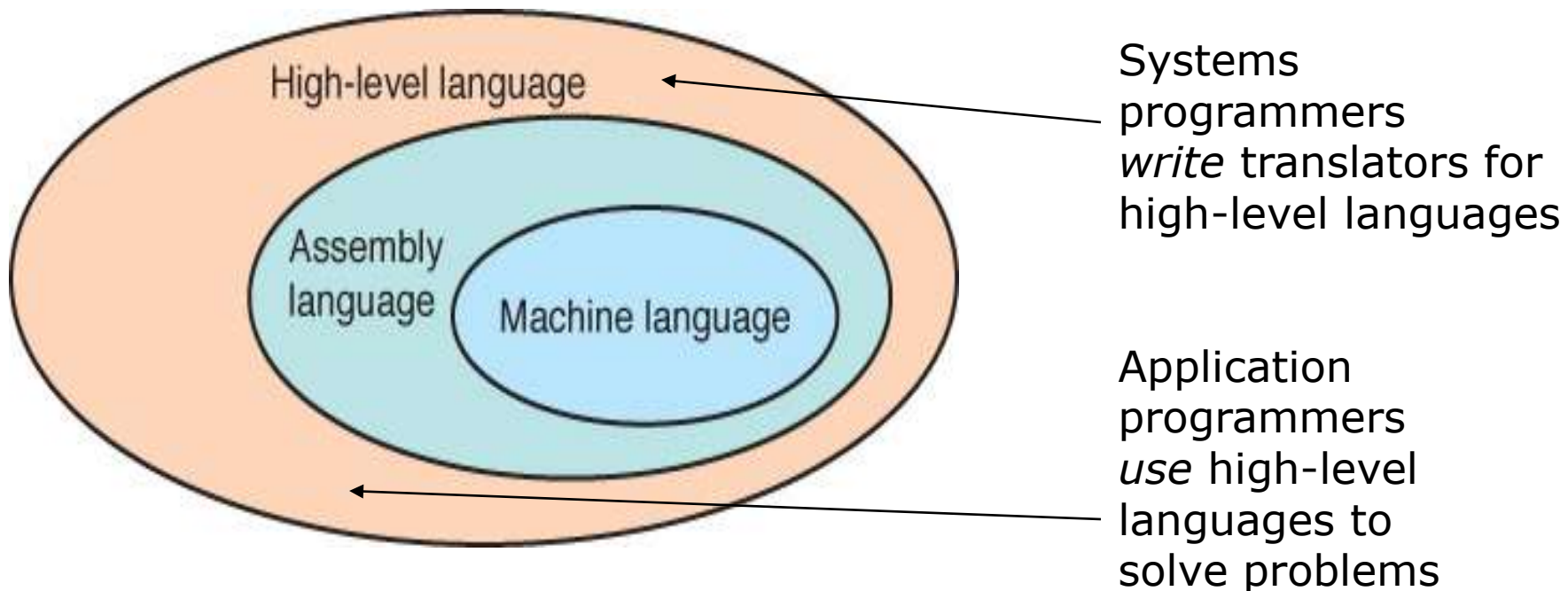
Application programmers
use assembly language to
solve problems

- Batch orientation
- Limited distribution
- Custom (tailor-made) software
- Proprietary software ultimately used by the same person or organization
- Implementation but not engineering (no well established set of rules followed)

Second Generation Software (1959-1965)

High-level Languages

English-like statements made programming easier:
Fortran, COBOL, Lisp



Third Generation Software (1965-1971)

Systems Software

Utility programs

Language translators

Operating systems; Decides which programs to run and when

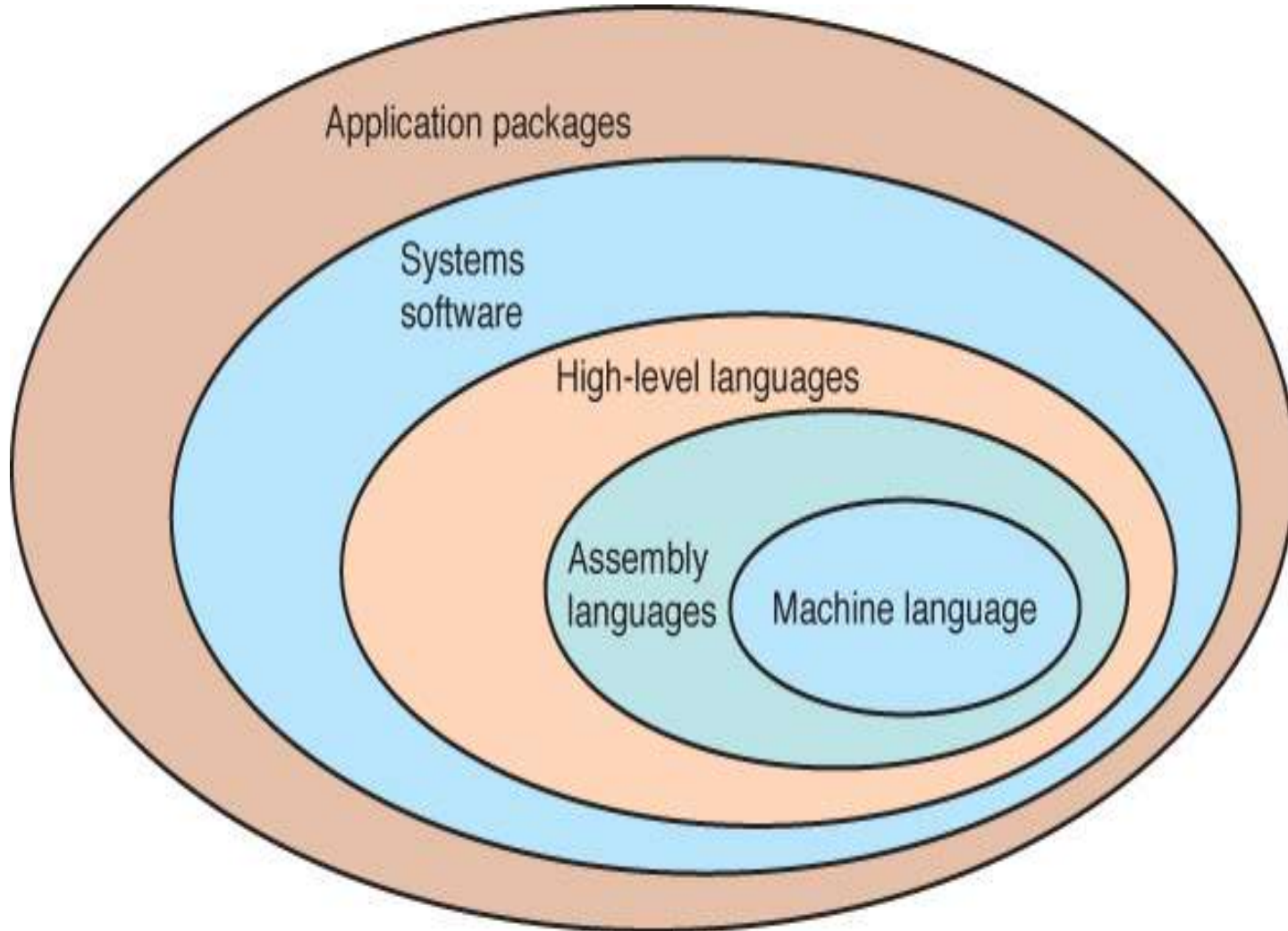
Separation between Users and Hardware

- Computer programmers write programs to be used by the general public (i.e., nonprogrammers);
- Computer programmers began to write programs to be used by people who did not know how to program

Third Generation Software Cont...

- Multi-user and multi-programming
- Real-time
- Database
- Product software
- HCI (DOS, WINDOWS)
- Control process (Software Engineering)
- Introduction of software houses

Third Generation Software (1965-1971)



Fourth Generation Software (1971-1989)

Structured and OOP Programming

Pascal

C++

Java (Some functionalities overlap with fifth generation)

New Application Software for Users

Spreadsheets

Word processors

Database management systems

❑ Convenience, affordability, usability, portability

Fourth Generation Software

- Distributed systems (networked systems)
- Embedded “intelligence”
- Low cost hardware (mass production)
- Customer impact
- Concurrency
- Global and local area network
- High bandwidth
- **Heavy demand for software developers**

Fifth Generation Software (1990- present)

Microsoft

Windows operating system and other Microsoft application programs dominate the market

Object-Oriented Design

Based on a hierarchy of data objects (i.e. Java and C#)

World Wide Web

Allows easy global communication through the Internet

New Users

Today's user needs no computer knowledge
Computer is like commodity

Fifth Generation Software

- Powerful desktop systems
- Object Oriented Technology
- Expert systems
- Artificial Neural Networks (implanted in beings)
- Parallel computing
- Pattern recognition and human like information processing capability
- Knowledge engineering
- Replacing conventional Software Development approaches
- CBSE