Chapter 2: Computer Hardware and Software: Evolution and Architecture

- 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

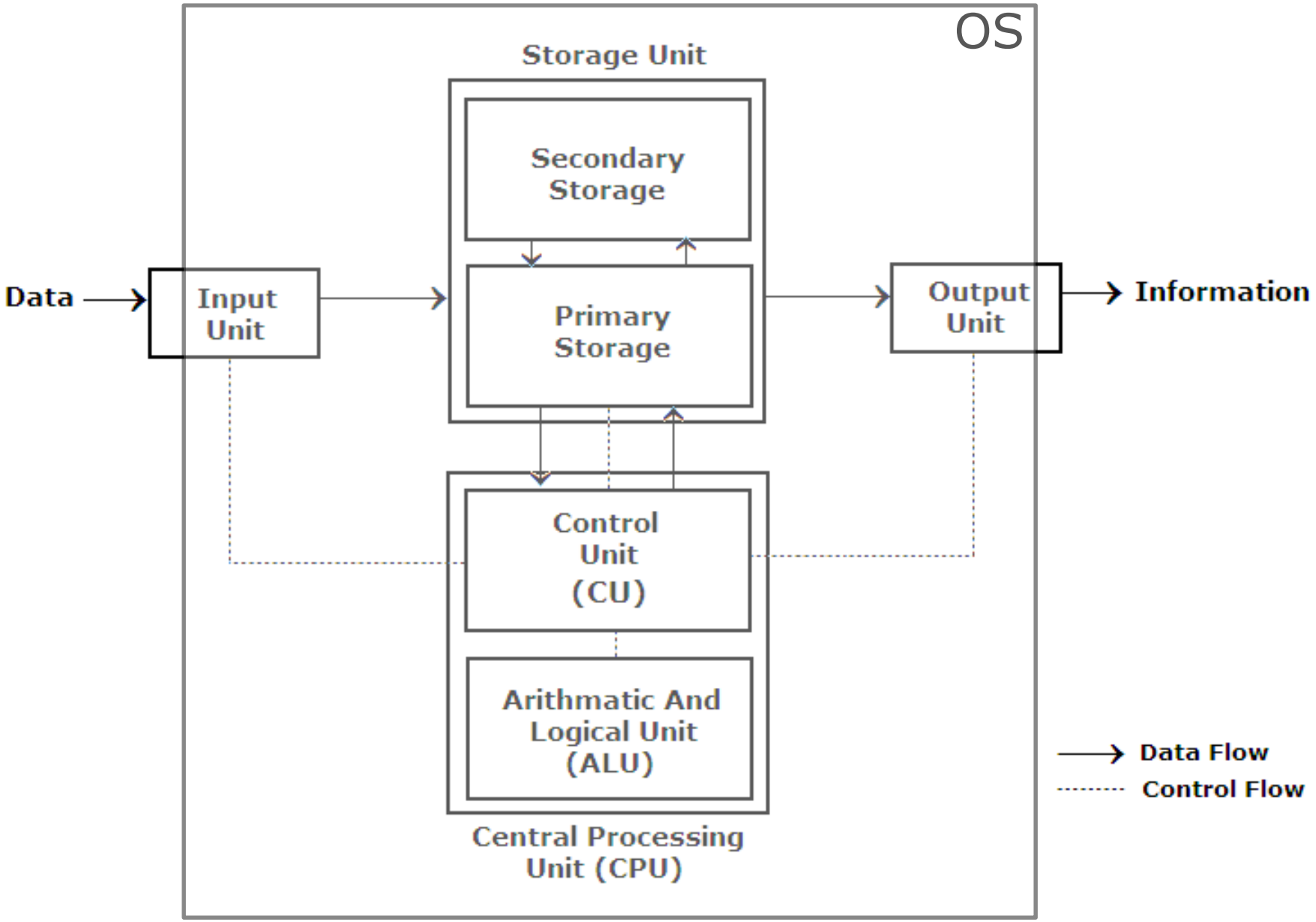
Learning Objectives

- Appreciate the evolution of computers (HW & SW) through five generations
- Identify the characteristics of computers
- Classification of computers*
- Understand functions of various components of a computer

Definition of a Computer

- a general purpose (stored program)
- Programmable (stored program)
- information processor
- with input and output

- Fixed Program Computer (embedded)
- Stored Program Computer

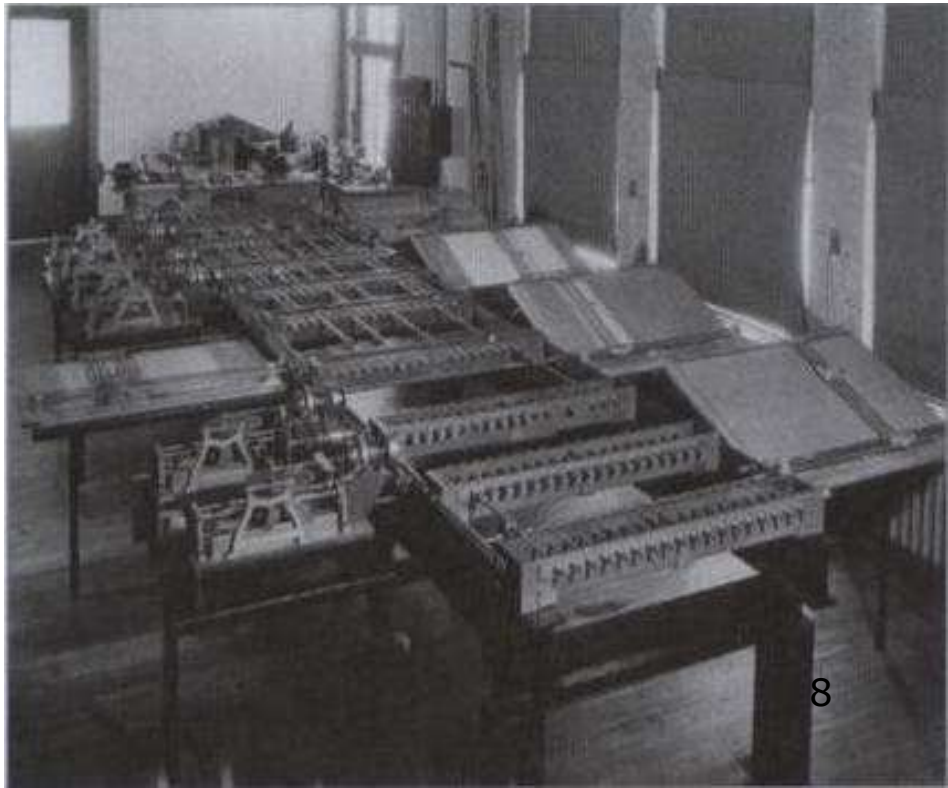


Basic computer Organization Block Diagram

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



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

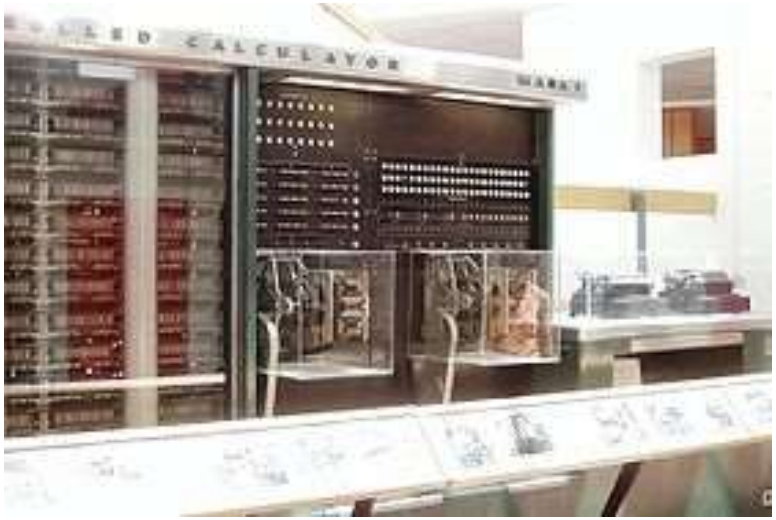
Generation of Computers

Generation	Dates	Characteristics
1st	1945-58	Use Valves (Vacuum tubes)
2nd	1959-64	Use transistors
3rd	1965-70	Integrated Circuits & Large Scale Integrated Circuits
4th	1971 - 89	Very Large Scale Integrated Circuits (Microprocessors)
5th	1990 - Under development	Advanced new HW technologies “Artificial Intelligence” based computers

Harvard Mark I (1944)

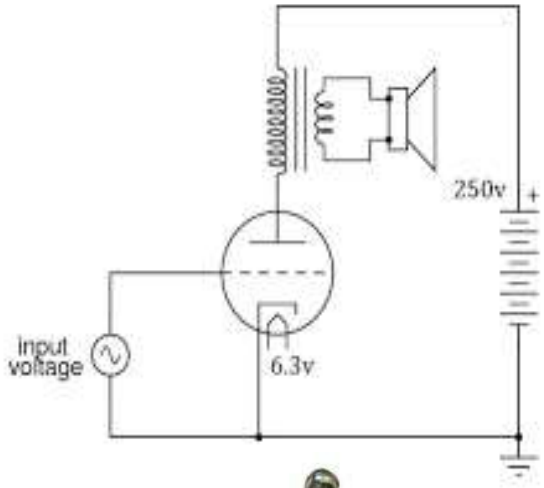
- Built from Switches, Relays, rotating shafts and clutches
- 765,000 components
- Hundreds of meters of wires
- Volume
  - Length (51ft) x Height (8 ft) x Depth (2 ft)
- Weight 4500 kg
- Used decimal number systems
- Called Automatic Sequence Controlled Calculator (ASCC)

Harvard Mark I, Generation 0



ENIAC (Generation 1)

- 1946 First general purpose (programmable, but need to reconfigure) 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

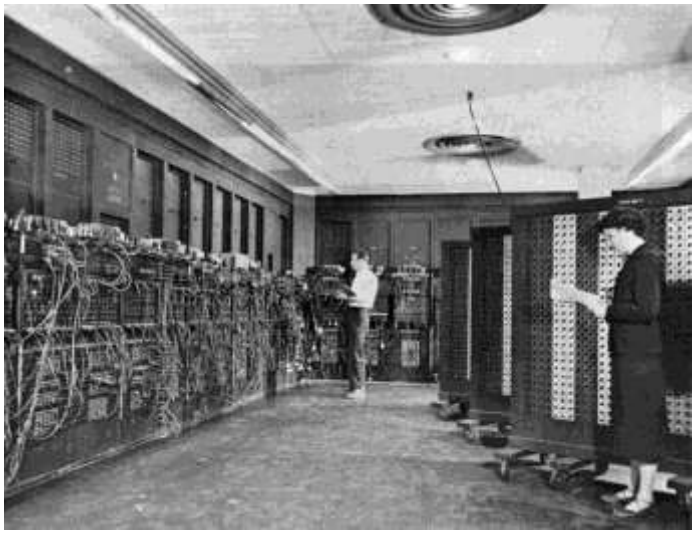


ENIAC

- 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

Generation 1 : ENIAC

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



Used machine languages and magnetic tapes

Also used assembly languages at end of generation 1 (transition period)

First Generation Hardware

Vacuum Tubes

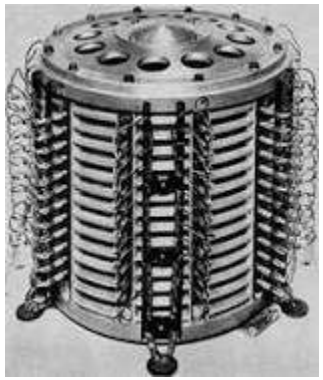
Large, not very reliable, generated a lot of heat

Magnetic Drum

Memory device that rotated under a read/write head

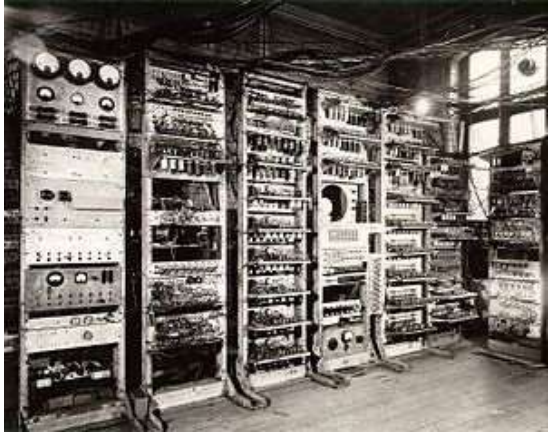
Card Readers → Magnetic Tape Drives

Sequential auxiliary storage devices



Magnetic drum

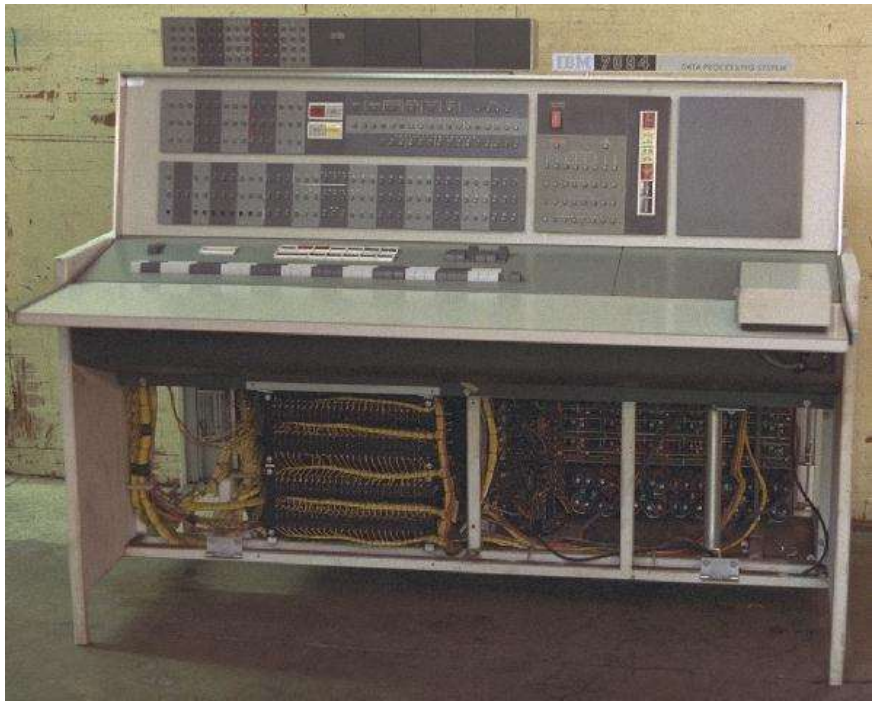
Manchester Mark I



- 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.

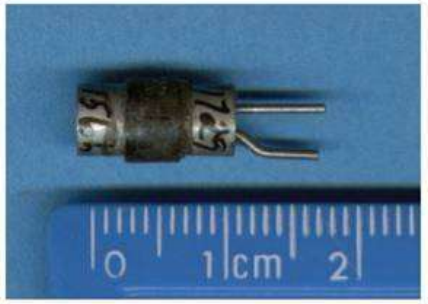
Generation 1

Generation 2: IBM7094



These machines used assembly language.

Second Generation Hardware



Transistors

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

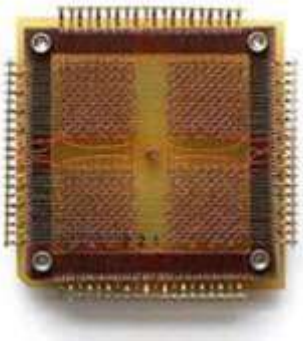
Magnetic Cores

Replaced magnetic drums, information available instantly. How?

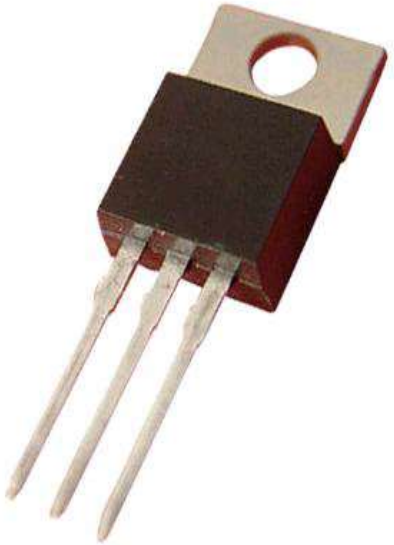
Magnetic Disks

Replaced magnetic tapes, data can be accessed directly (not sequentially).

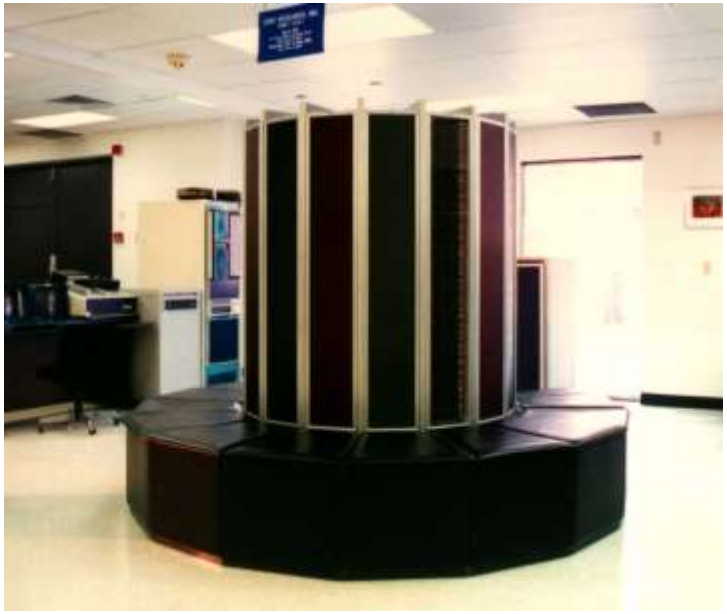
What does this mean?



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

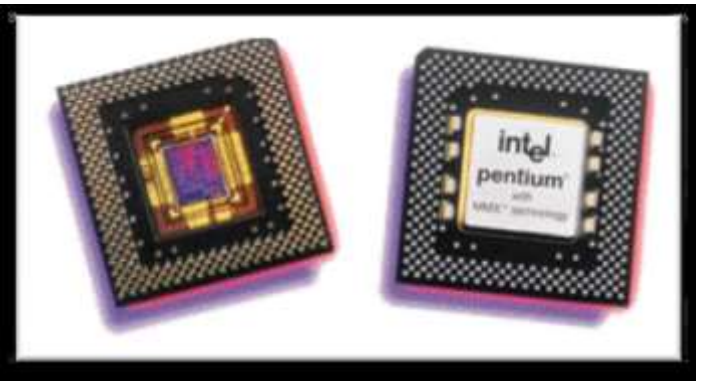
Terminal

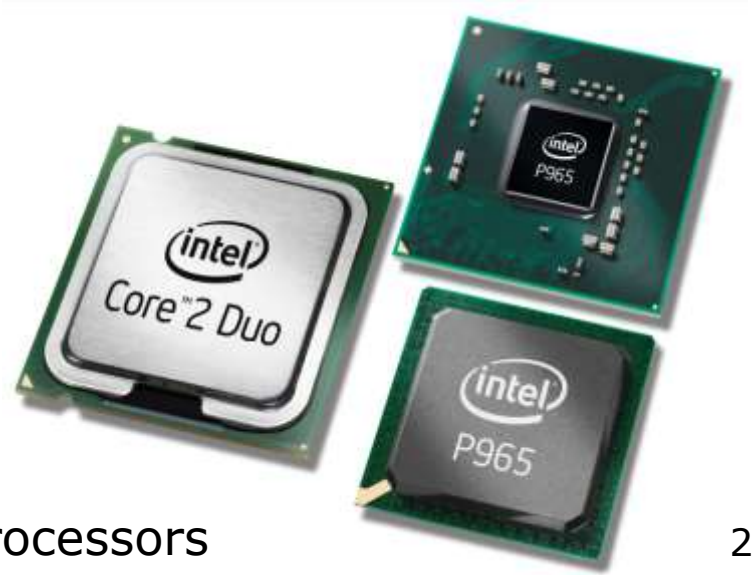
An input/output device with a keyboard and screen

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 - 1000
MSI (Medium Scale Integration): 1000 - 10,000
LSI (Large Scale Integration): 10,000 - 100,000
VLSI (Very Large Scale Integration): > 100,000





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 (Pervasive & Distributed Computing)

Types of computers

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

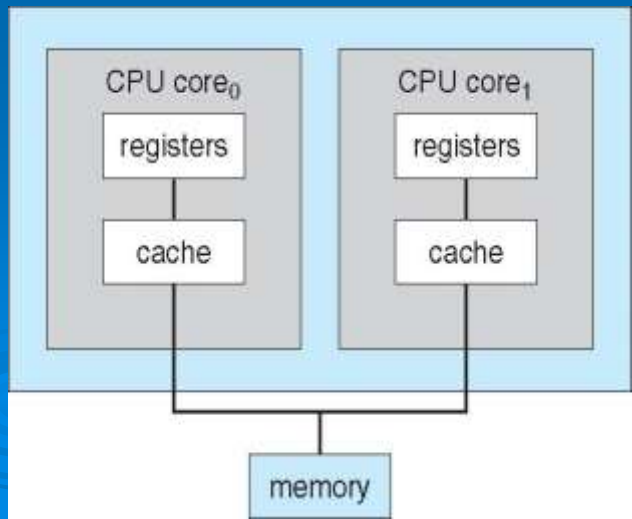
➢ In terms of size (and in terms of processing capacity)
  - ✓ ☐ small
  - ✓ ☐ medium
  - ✓ ☐ large

* The details are left as a Reading Assignment

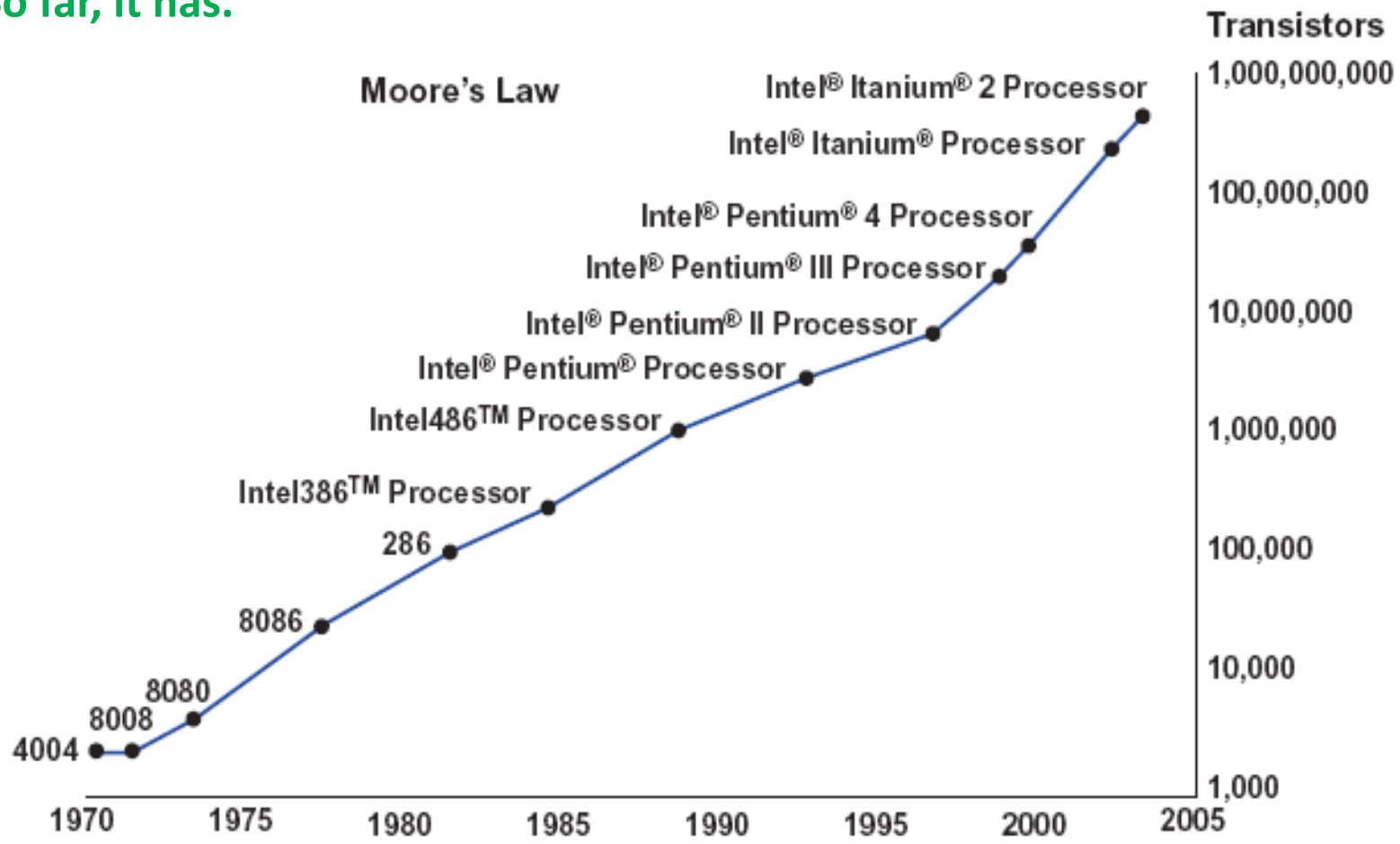
  - Microcontrollers (embedded systems)
  - Microcomputers
  - Minicomputers (Workstations)
  - Mainframe Computers
  - Super computers

- 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**
- **What are five developments growing out of the fusion of computers and communications? (refer to using information technology, 9th edition, Williams/Sawyer): *Reading assignment***



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

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

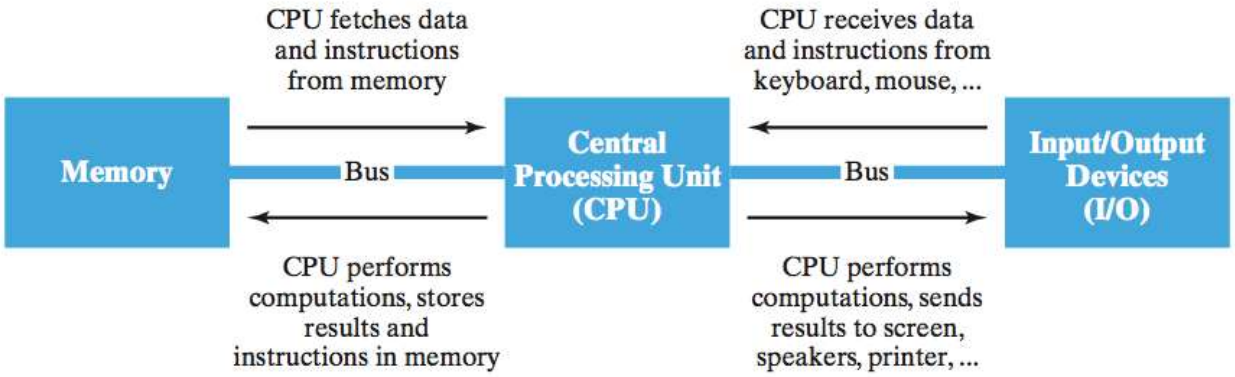
von Neumann Architecture

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

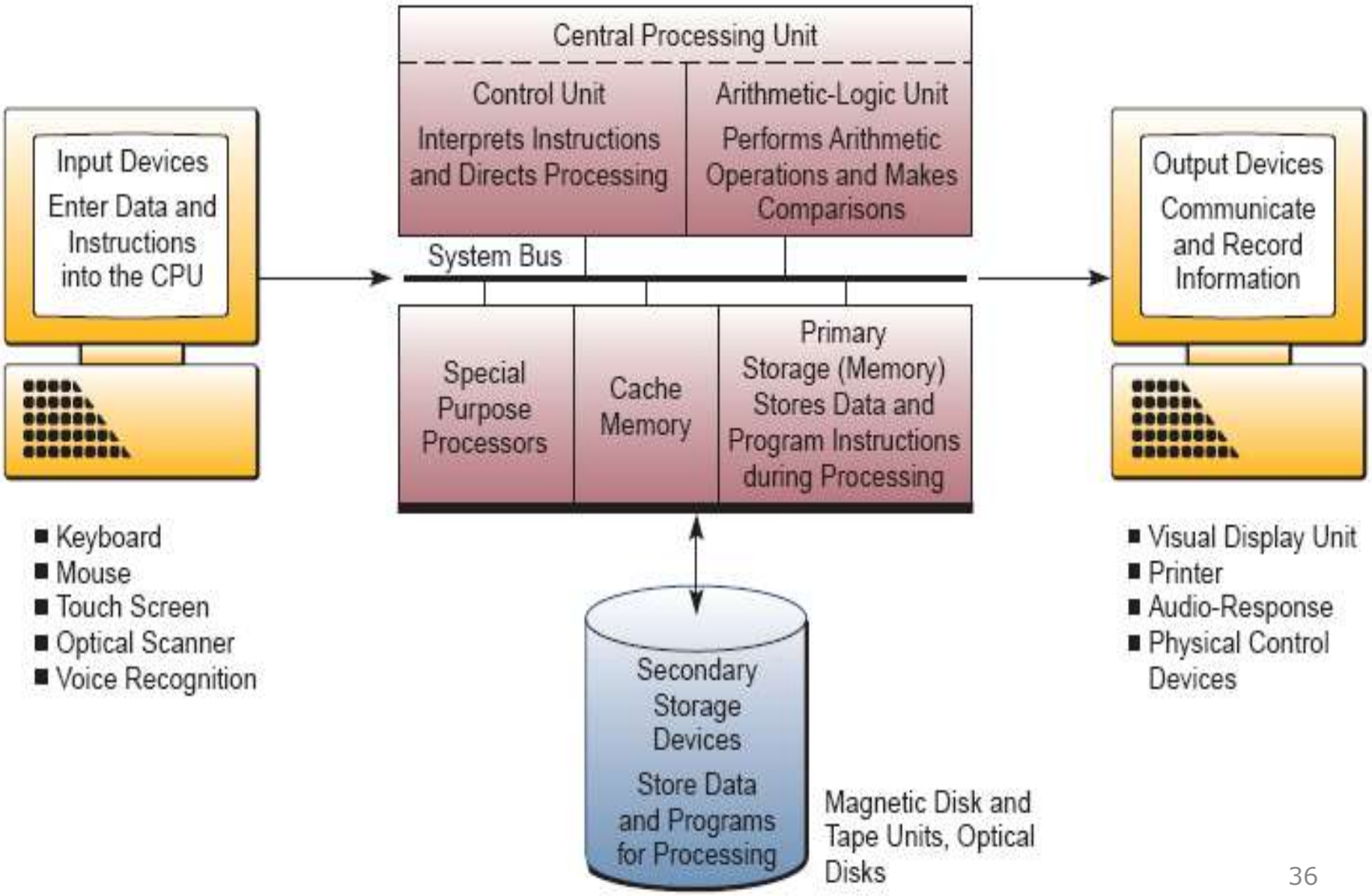
1. *Input/Output Devices (I/O)* allow the user to interact with the computer
2. *Memory* stores information to be processed as well as programs (instructions specifying the steps necessary to complete specific tasks)
3. Central Processing Unit (CPU) executes by loading program instructions from memory and processing them in sequence.



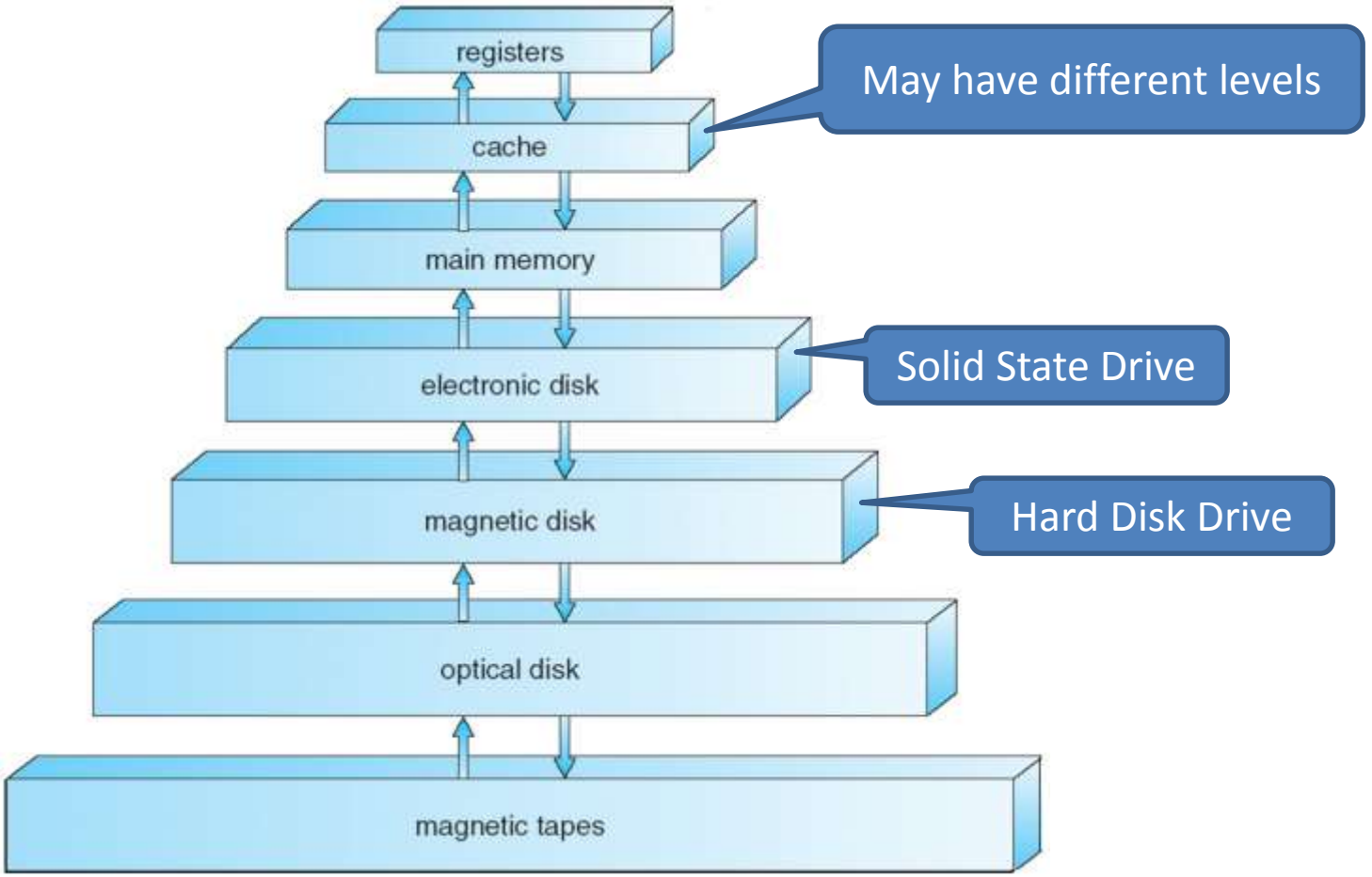
What Hardware Components Contribute to the Speed of a Computer?

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

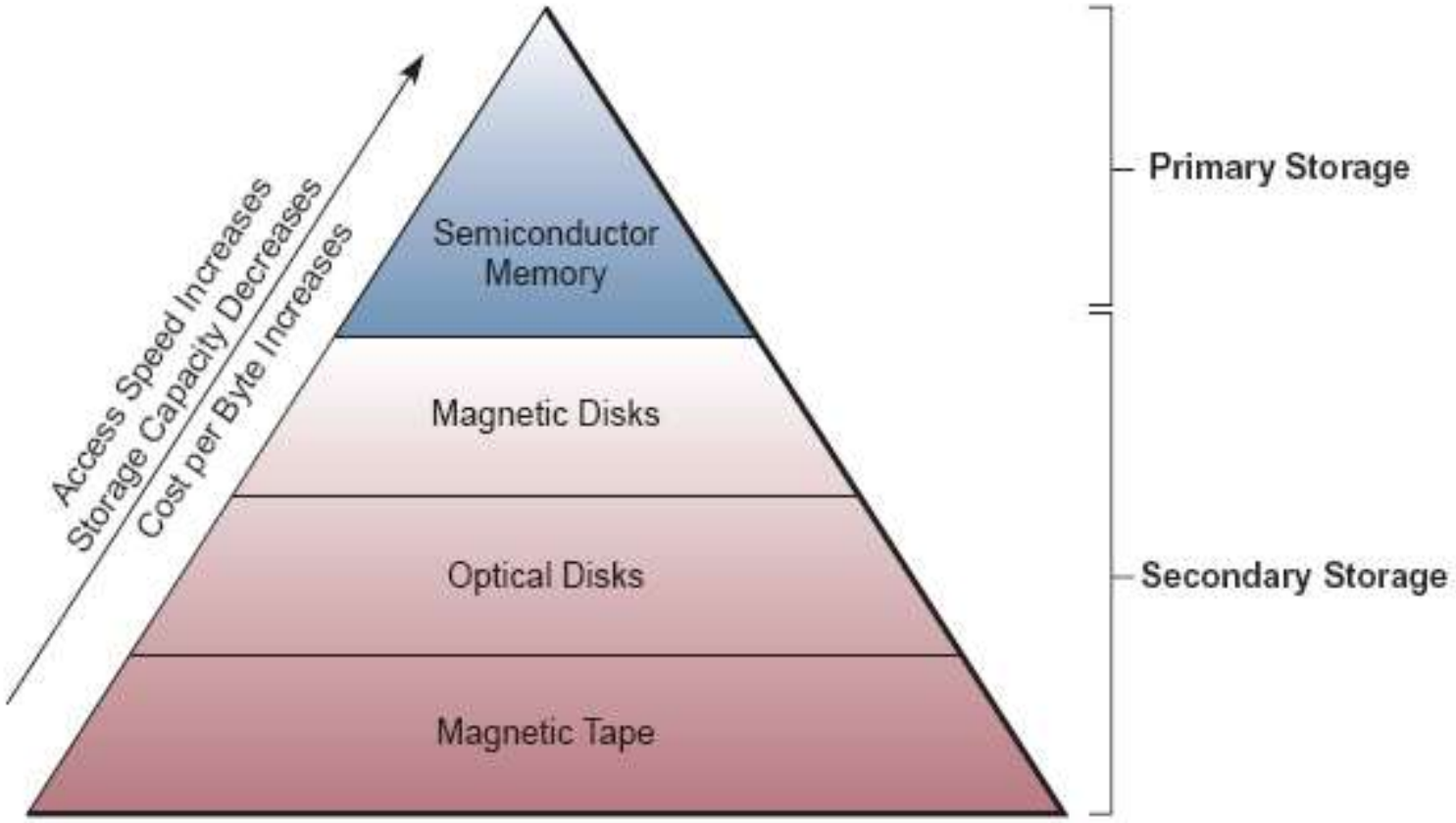


Storage (Memory)-Device Hierarchy



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

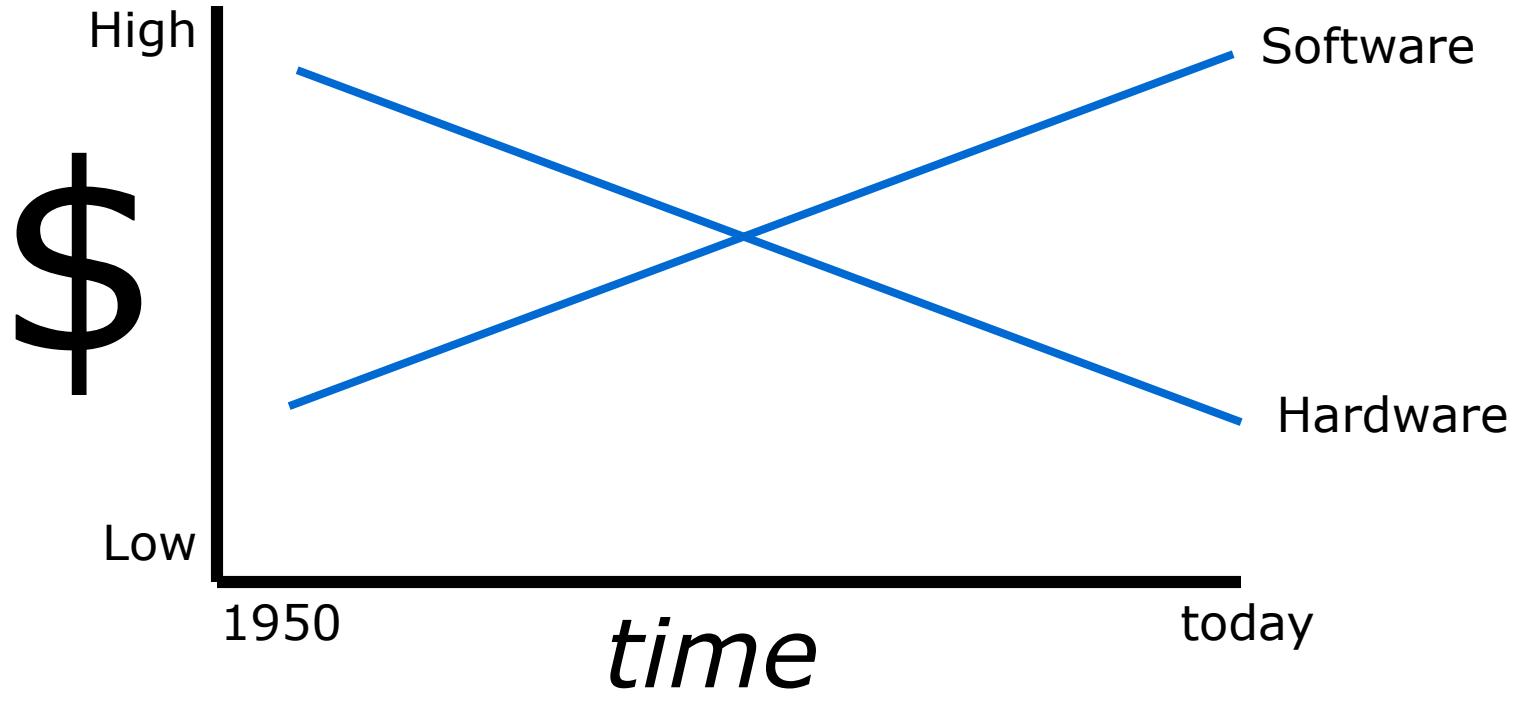
Note how cost increases with faster access speeds but decreases with the increased capacity of storage media.



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 (as the system is running, or due to stored program concept) 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

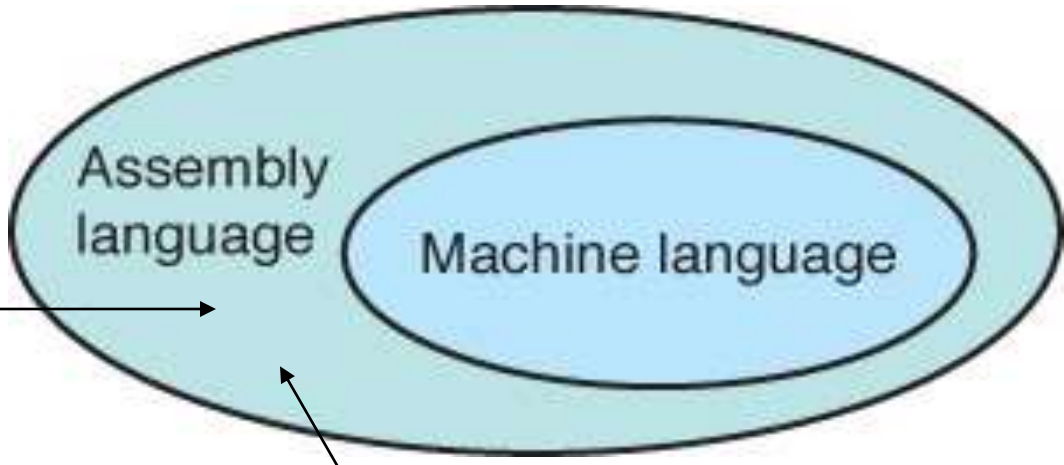
Programs written using mnemonics, which were translated into machine language

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 departments were using computers

First Generation Software Cont...



System programmers *write* the assembler (translator)

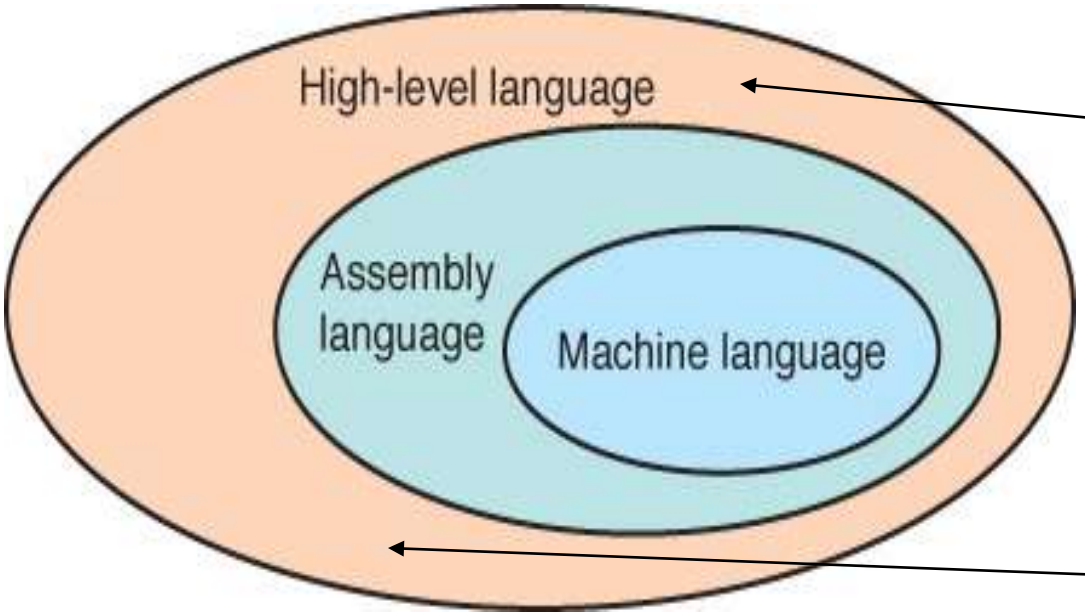
Application programmers *use* assembly language to solve problems

- 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



Systems programmers *write* translators for high-level languages

Application programmers *use* high-level languages to solve problems

Third Generation Software (1965-1971)

Systems Software

Utility programs

Language translators

Operating systems; Decides which programs to run and when, and what resources to be allocated for which programs

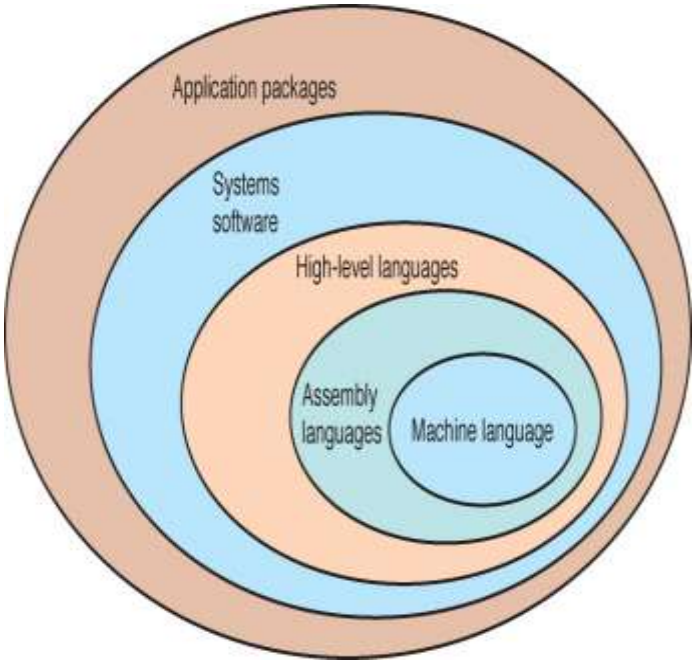
Separation between Users and Hardware

- 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...

(1965-1971)

- Multi-user and multi-programming
- Real-time
- Databases
- Product software
- HCI (DOS, WINDOWS)



The layers of software surrounding hardware continue to grow

- Control process (Software Engineering)
- Introduction of software houses

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

with VLSI came the rise of personal computing

SW & HW Companies like Microsoft, Apple, and IBM were founded

- **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