Introduction to Computer Science and Engineering

CSN-101

Evolution of computer hardware and Moore's Law

Prof. Partha Pratim Roy
Associate professor, CSE Department
Indian Institute of Technology Roorkee

Overview

- What is a Computer?
- Generation of Computers
- The evolution of computer
- The Early stage of computer
- Turing Machine
- IBM computers
- Moore’s Law
- Chip Shrinking

What is a Computer?

- Computer is an electronic device which is capable of receiving information (data) and performing a sequence of logical operations in accordance with a predetermined but variable set of procedural instructions (program) to produce a result in the form of information and signal.
- Computer can be more formally described as a Stored Program Electronic Digital Computer
- The computer was born not for entertainment or email but out of a need to solve a serious number-crunching crisis.
- By 1880, the U.S. population had grown so large that it took more than seven years to tabulate the U.S. Census results.
- The government sought a faster way to get the job done, giving rise to punch-card-based computers that took up entire rooms.

What is a Computer?

- Until 1960s, There were two different types of computer
  - Analogue Computers
  - Digital Computers
- Digital computer:
  - Stores its data
  - Performs its operations using digital (numeric) representation (usually using binary numbers).
- Analog Computer:
  - The analogue computer does operation by analogy using quantities like electronic voltages, volumes of liquid or fractions of the turn of a wheel.

Generation of Computers

- First Generation – Vacuum Tubes (1940 – 1956)
- Second Generation – Transistors (1956 – 1963)
- Third Generation – Integrated Circuits (1964 – 1971)
- Fourth Generation – Microprocessors (1972 – 2010)
- Fifth Generation – Artificial Intelligence (2010 Onwards)

Generation of computers

First generation of computers

- Main electronic component – vacuum tube
- Main memory – magnetic drums and magnetic tapes
- Programming language – machine language
- Power – consume a lot of electricity and generate a lot of heat.

Second generation of Computers

- Main electronic component – transistor
- Memory – magnetic core and magnetic tape / disk
- Programming language – assembly language
- Power and size – low power consumption, generated less heat, and smaller in size (in comparison with the first generation computers)

Third Generation of Computers

- Main electronic component – integrated circuits (ICs)
- Memory – large magnetic core, magnetic tape / disk
- Programming language – high level language (FORTRAN, BASIC, Pascal, COBOL, C, etc.)
- Size – smaller, cheaper, and more efficient than second generation computers (they were called minicomputers).

Fourth Generation of Computers

- Main electronic component – very large-scale integration (VLSI) and microprocessor.
- VLSI– thousands of transistors on a single microchip.
- Memory – semiconductor memory (such as RAM, ROM, etc.)
- Programming language – high level language (Python, C#, Java, JavaScript, Rust, Kotlin, etc.).
  - A mix of both third- and fourth-generation languages

Fifth Generation of Computers

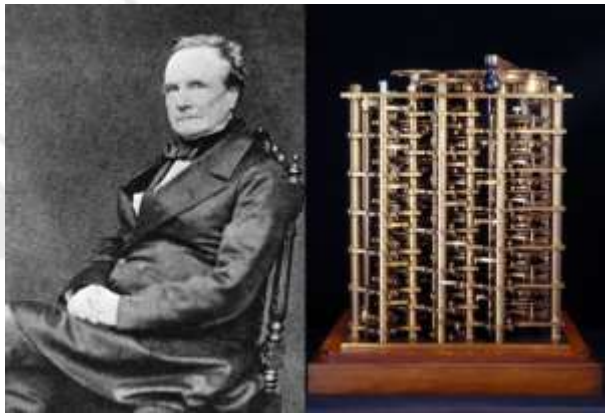
- Main electronic component: based on artificial intelligence, uses the Ultra Large-Scale Integration (ULSI) technology and parallel processing method.
- Language – understand natural language (human language).
- Power – consume less power and generate less heat.
- Speed – remarkable improvement of speed, accuracy and reliability (in comparison with the fourth generation computers).

The evolution of computer

- Today, we carry more computing power on our smartphones than was available in these early models.
- The following brief of computing is a timeline of how computers evolved from their humble beginnings to the machines of today.
  - Surf the INTERNET
  - Play games
  - Stream multimedia in addition to crunching numbers.

The Early stage

- In France, Joseph Marie Jacquard invents a loom that uses punched wooden cards to automatically weave fabric designs. Early computers would use similar punch cards.
- Charles Babbage was an English mathematician, philosopher, and inventor born on December 26, 1791, in London, England. Often called "The Father of Computing," **Babbage detailed plans for mechanical Calculating Engines, Difference Engines, and Analytical Engines**.
- English mathematician Charles Babbage conceives of a steam-driven calculating machine that would be able to compute tables of numbers.



The Early stage

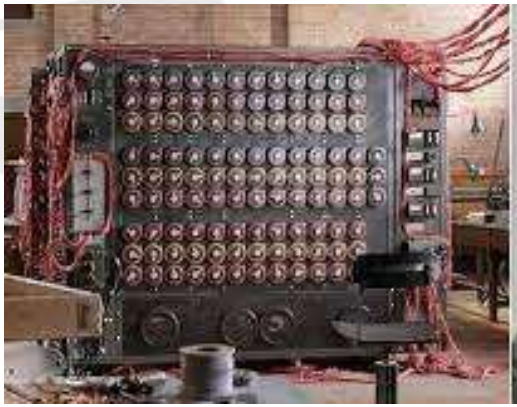
- Herman Hollerith designs a punch card system to calculate the 1880 census, accomplishing the task in just three years and saving the government $5 million. He establishes a company that would ultimately become IBM.

- Hollerith founded a company that was amalgamated in 1911 with several other companies to form the computer tabulating recording machine.

- In 1924, the company was renamed "International Business Machines" (IBM)and became one of the largest and most successful companies of the 20th century. Hollerith is regarded as one of the seminal figures in the development of data processing.

Turing Machine

- Alan Turing presents the notion of a universal machine, later called the Turing machine, capable of computing anything computable. The central concept of the modern computer was based on his ideas.
- A **Turing machine** is a mathematical machine of computation that defines an abstract machine that manipulates symbols on a strip of tape according to a table of rules. Despite the model's simplicity, given any computer algorithm, a Turing machine capable of simulating that algorithm's logic can be constructed.



The evolution of computer

- Hewlett-Packard is founded by David Packard and Bill Hewlett in a Palo Alto, California, garage, according to the computer history museum.
- J.V. Atanasoff, a professor of physics and mathematics at Iowa State University, attempts to build the first computer without gears, cams, belts or shafts.
- Atanasoff and his graduate student, Clifford Berry, design a computer that can solve 29 equations simultaneously. This marks the first time a computer is able to store information on its main memory.
- It was very less as compared to today's memory.

ENIAC

- ENIAC: **Electronic Numerical Integrator and Computer**
- The first programmable general-purpose electronic digital computer, built during World War 2 by the United States.
- American physicist John Mauchly, an American engineer, and their colleagues at the Moore School of Electrical Engineering at the University of Pennsylvania led a government-funded project to build an all-electronic computer.

The evolution of computer

- Two University of Pennsylvania professors, John Mauchly and J. Presper Eckert, build the Electronic Numerical Integrator and Calculator (ENIAC).
- Considered the grandfather of digital computers, it fills a 20-foot by 40-foot room and has 18,000 vacuum tubes.
- Mauchly and Presper leave the University of Pennsylvania and receive funding from the Census Bureau to build the UNIVAC, the first commercial computer for business and government applications.
- William Shockley, John Bardeen, and Walter Brattain of Bell Laboratories invented the transistor. They discovered how to make an electric switch with solid materials and no need for a vacuum.

The evolution of computer

- Grace Hopper develops the first computer language, which eventually becomes known as COBOL.
- Thomas Johnson Watson Jr., son of IBM CEO Thomas Johnson Watson Sr., conceives the IBM 701 EDPM to help the United Nations keep tabs on Korea during the war.
- The Fortran Programming Language, an acronym formula translation, is developed by a team of programmers at IBM led by John Backus, according to the University of Michigan.
- It is a popular language for high performance computing and is used for programs that benchmark and rank the world's fastest computers.

The evolution of computer

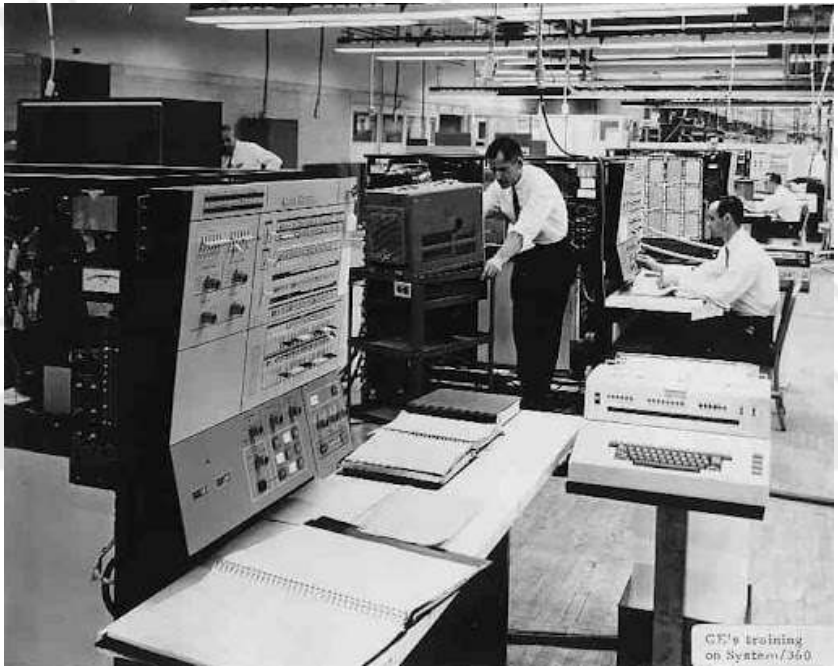
- Douglas Engelbart shows a prototype of the modern computer, with a mouse and a graphical user interface (GUI**)**.
- This marks the evolution of the computer from a specialized machine for scientists and mathematicians to technology that is more accessible to the general public.
- A group of developers at Bell Labs produce UNIX, an operating system that addressed compatibility issues.
- Written in the C programming language, UNIX was portable across multiple platforms and became the operating system of choice among mainframes at large companies and government entities.
- Due to the slow nature of the system, it never quite gained traction among home PC users.

IBM Computers

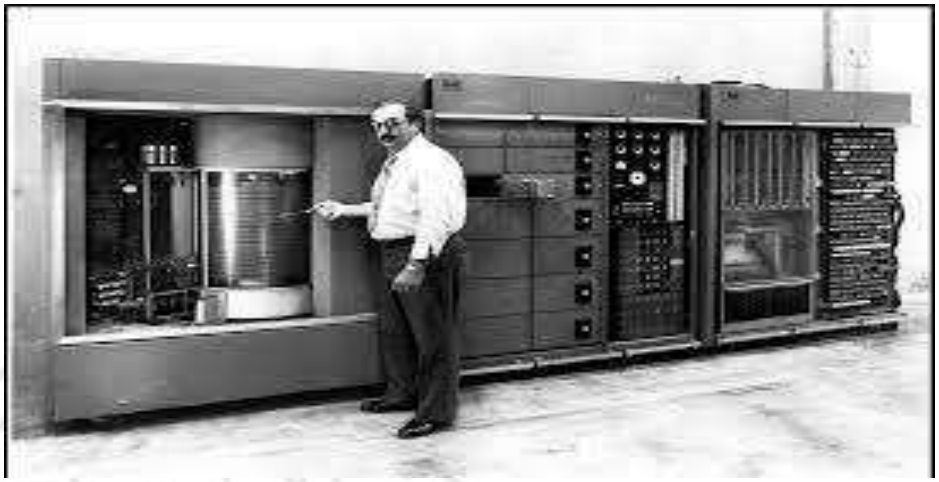
- The newly formed Intel unveils the Intel 1103, the first Dynamic Access Memory (DRAM) chip.
- Alan Shugart leads a team of IBM engineers who invent the "floppy disk," allowing data to be shared among computers.
- In **1967**, at an IBM facility in San Jose (CA), work began on a drive that led to the world's first floppy disk and disk drive. It was introduced into the market in an 8-inch (20 cm) format in 1972.

IBM Computers

- IBM's own Personal Computer (IBM 5150) was introduced in August 1981
- A number of personal computers hit the market, including Scelbi & Mark-8 Altair, IBM 5100, Radio Shack's TRS-80 — affectionately known as the "Trash 80" — and the Commodore PET.



IBM Computers



- In 1956 IBM launched there first supercomputer IBM 305 RAMAC .
- It was the first computer with hard drive
- It weighted over a ton and and can only hold 3.5 megabytes

Moore’s Law

- Moore's Law states that **the number of transistors on a microchip doubles about every two years**, though the cost of computers is halved.
- The reason why electronics have become cheaper much smaller and more powerful is because of the observation called Moore’s law.
- The continual cramming of most silicon transistors onto chips has been the feedstock of exuberant innovation in computing.
- In 1965, Gordon E. Moore, the co-founder of Intel, made this observation that became known as Moore's Law.

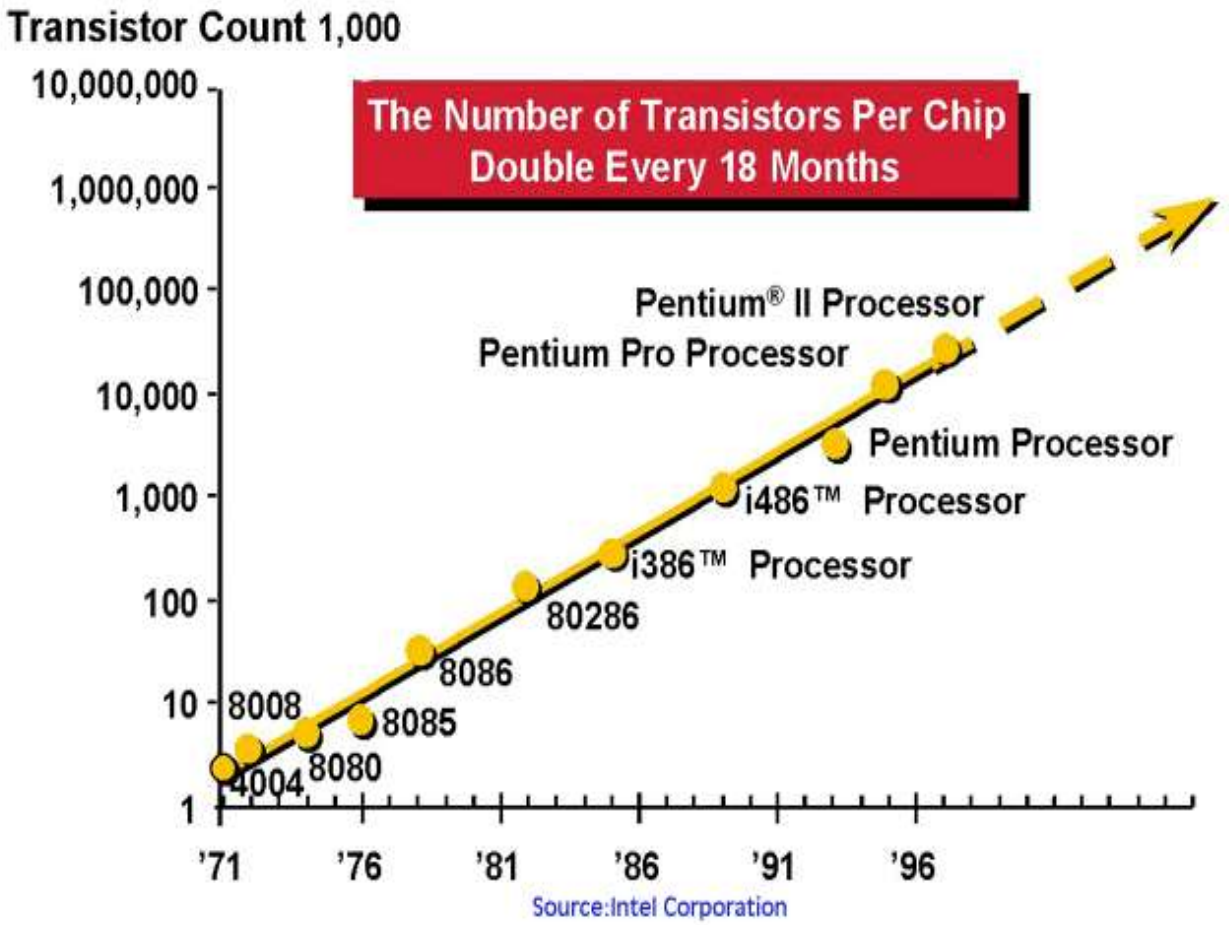
What is a Transistor?

- A transistor is a type of Semiconductor device that can be used to both conduct and insulate electric current or voltage
- A transistor acts as a switch and an amplifier.
- In simple words, we can say that a transistor is a miniature device that is used to control or regulate the flow of electronic signals.

Understanding Moore's Law

- In 1965, Gordon E. Moore—co-founder of INTEL postulated that the number of transistors that can be packed into a given unit of space will double about every two years.
- Gordon Moore did not call his observation "Moore's Law," nor did he set out to create a "law.“
- Moore made that statement based on noticing emerging trends in chip manufacturing at Intel.
- Eventually, Moore's insight became a prediction, which in turn became the golden rule known as Moore's Law.

Understanding Moore's Law



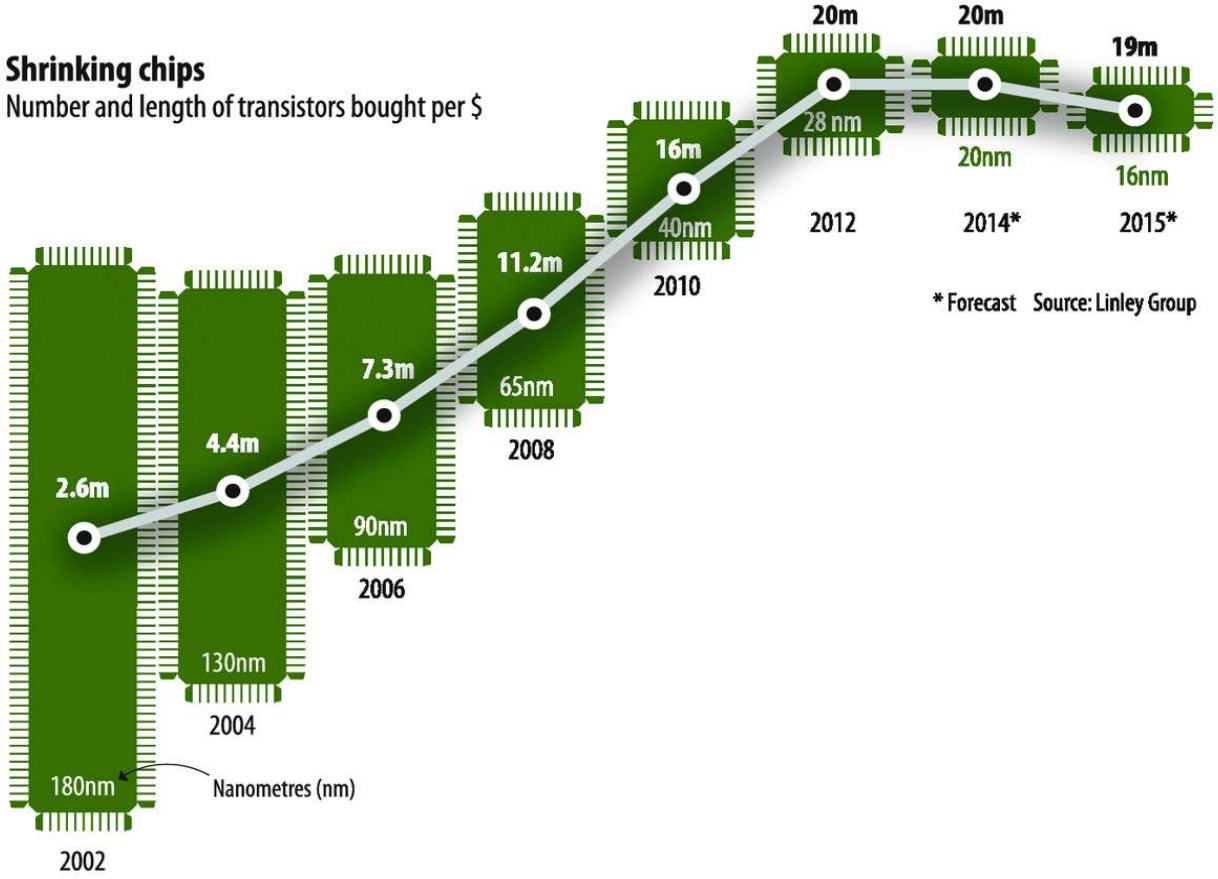
TODAY'S TECHNOLOGY

- In today's world the smartphones minimum storage is 64 GB
- That is around 17000X as big and weighted around 200 grams

Past Decade

- In the decades that followed Gordon Moore's original observation.
- Moore’s law guided the semiconductor industry in long-term planning and setting targets for research and development (R&D).
- Moore's Law has been a driving force of technological and social change, productivity, and economic growth that are hallmarks of the late-twentieth and early twenty-first centuries.
- Moore's Law implies that computers, machines that run on computers.
- Computing power all become smaller, faster, and cheaper with time, as transistors on integrated circuits become more efficient.
- More than 50 years later, we feel the lasting impact and benefits of Moore's Law in many ways.

Chip Shrinking



Computing

- As transistors in integrated circuits become more efficient, computers become smaller and faster.
- Chips and transistors are microscopic structures that contain carbon and silicon molecules, which are aligned perfectly to move electricity along the circuit faster.
- The faster a microchip processes electrical signals, the more efficient a computer becomes.
- The cost of higher-powered computers has been dropping annually, partly because of lower labor costs and reduced semiconductor prices.
- Practically every facet of a high-tech society benefits from Moore's Law in action.
- Mobile devices, such as smartphones and computer tablets would not work without tiny processors.
- Neither would video games, spreadsheets, accurate weather forecasts, and GPS(global positioning system).

All Sectors Benefit

- The importance of the law to semiconductor manufacturers is evident.

- Moreover, smaller and faster computers improve transportation, health care, education, and energy production—to name but a few of the industries that have progressed because of the increased power of computer chips.

- Computing devices continue to show exponential growth in complexity and computing power while effecting a comparable reduction in cost to the manufacturer and the consumer.

How Has Moore's Law Impacted Computing?

- Moore's Law has had a direct impact on the progress of computing power.
- What this means specifically is that transistors in integrated circuits have become faster.
- Transistors conduct electricity, which contains carbon and silicon molecules that can make the electricity run faster across the circuit.
- The faster the integrated circuit conducts electricity, the faster the computer operates.

Thanks…