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Early Computer VS Modern Computer: A Comparitive Study and an Approach to Advance Computer

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Abstract - In this paper, emphasis has been given on the gradual and continuous advancement of computer from on and before 300BC to 2012 and beyond. During this very long period of time, a simple device like computer has witnessed many significant changes in its manufacturing and development. By and large, the changes are conceptual, manufacturing and in ever increasing applications.

Keywords : *computer, abacus, napier bones, punched cards, analytic engine, vacuum tubes, mainframe computer, transistors, integrated circuits, ram, microprocessor, hard disk, printed circuit board, motherboard, artificial intelligence, voice recognition, quantum computing, nanotechnology, natural language.*

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Early Computer VS Modern Computer: A Comparitive Study and an Approach to Advance Computer

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I. Introduction

Since time immemorial and still today man has been feeling the need to compute, count, store and get accurate results all the time and always. It is quite apparent and significant that in our daily life, we need to keep written records what we have done in the past, basically in the form of numerals to increase productivity, growth and efficiency. In the past, man had felt the need to prepare navigational table, logarithmic table and trigonometric table for which the man himself was not efficient. From the history of computational work done in the past, man has observed the following shortcomings/limitations/demerit in the manual computational work. The demerits include: a) man/woman cannot work continuously for a longer period of time. b) Problem of short memory (memory loss) c) repetitive task is boredom d) results are prone to error (problem of inaccuracy) e) not efficient for scientific calculation.

In order to find the solution of the above problems, man has been continuously searching and inventing machine to replace man with machines to get the desired and accurate result. So in this paper, some of the early but significant achievements of man in the field of computing have been enumerated as under.

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II. Definition

a) Computer in the past

The term 'computer' is derived from the Latin word "computare" meaning to calculate. In the past, computer is restricted only to arithmetic calculations.

b) Computer in modern form

Computer is defined as an advanced electronic device that takes raw data as input from the user and process these data under the control of set of instructions called program and gives the result called output and saves output for the future use.

III. Early Computers

a) Computers before 300BC

Men/Women: --- During this period, the word computer was used to describe human beings (basically women).Their primary job was to perform the repetitive calculations like navigational tables, tide charts and planetary positions for astronomical almanacs. Therefore, we can say that a group of intelligent women were first computers.

i. *Disadvantages of human computer*

- Repetitive job is boring
- Carelessness leads to error
- Not good and efficient for longer period of time
- Accuracy problem
- Team work
- A lot of space needed to set up laboratory/office
- Time consuming

These problems forced man to search for a new method, device, technique or a mechanism to solve real world problems quickly, accurately and efficiently.

b) Computers at 300BC

To get rid of human errors, man had developed a calculating machine called ABACUS. It was first developed, invented and used by the Babylonians.

i. *Salient features of Abacus*

- Abacus aids the memory of the human performing the calculation.
- Addition and subtraction can be done efficiently but multiplication and division are slower.

- Accurate results can be obtained

The Abacus is still in use today, principally in the far East.

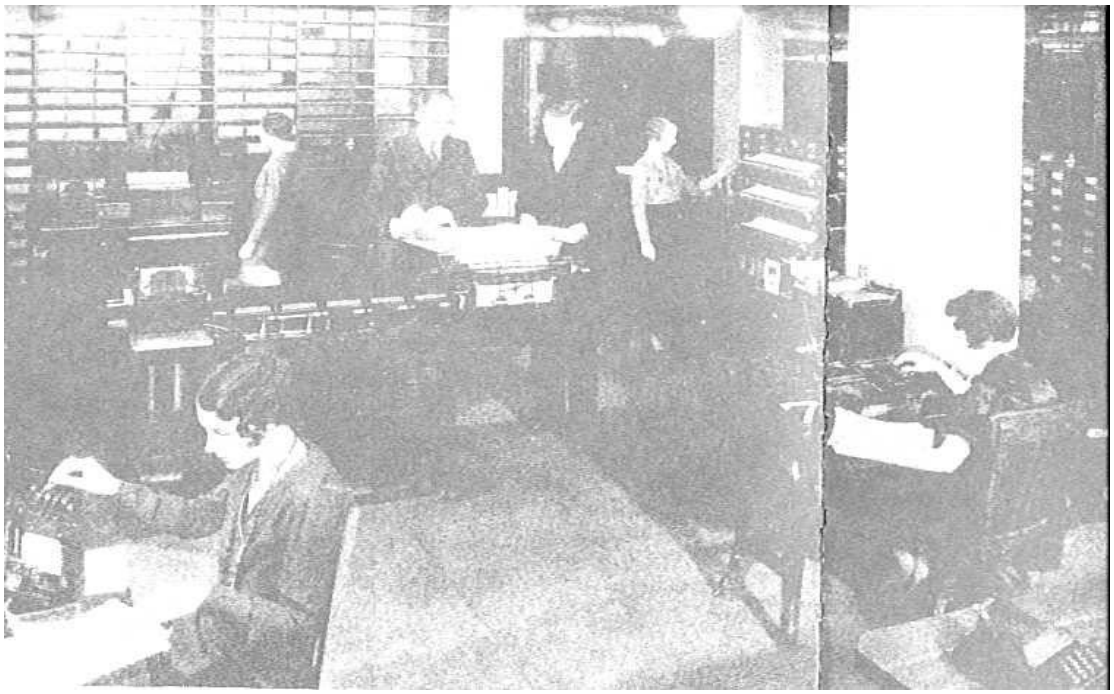

Fig. 1 : A typical operation back when computers were people

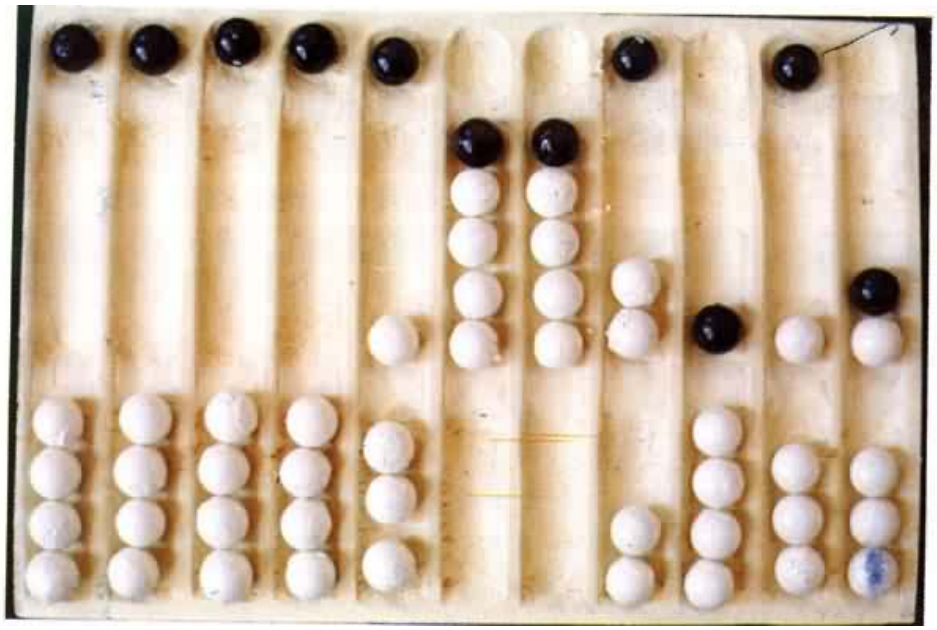

Fig. 2 : A very old Abacus

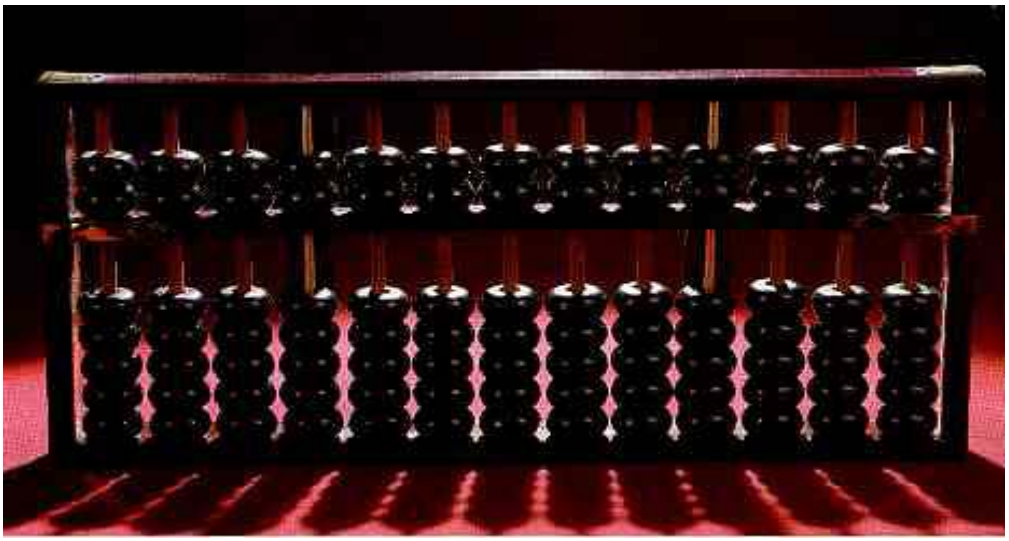

Fig. 3 : Modern Abacus

c) 1617

After a long period, in 1617 a new scientist Scotsman named John Napier came up with new ideas. He invented logarithms, which is a technology that allows multiplication to be performed via addition. Napier also invented an alternative to tables, where the logarithmic values were carved on ivory sticks which are now called Napier's bones.

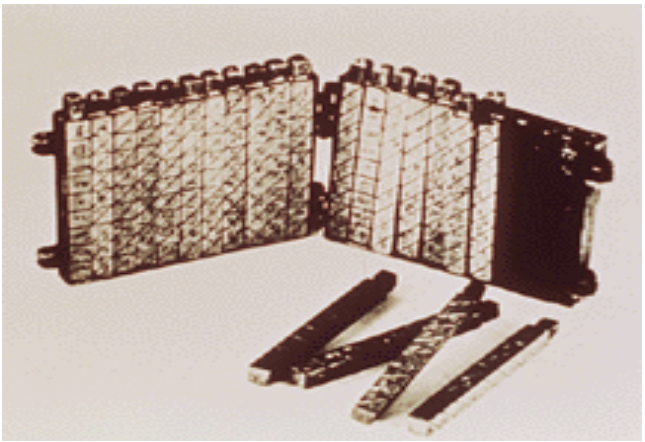

Fig. 4 : An original set of Napier's Bones [Photo courtesy IBM]

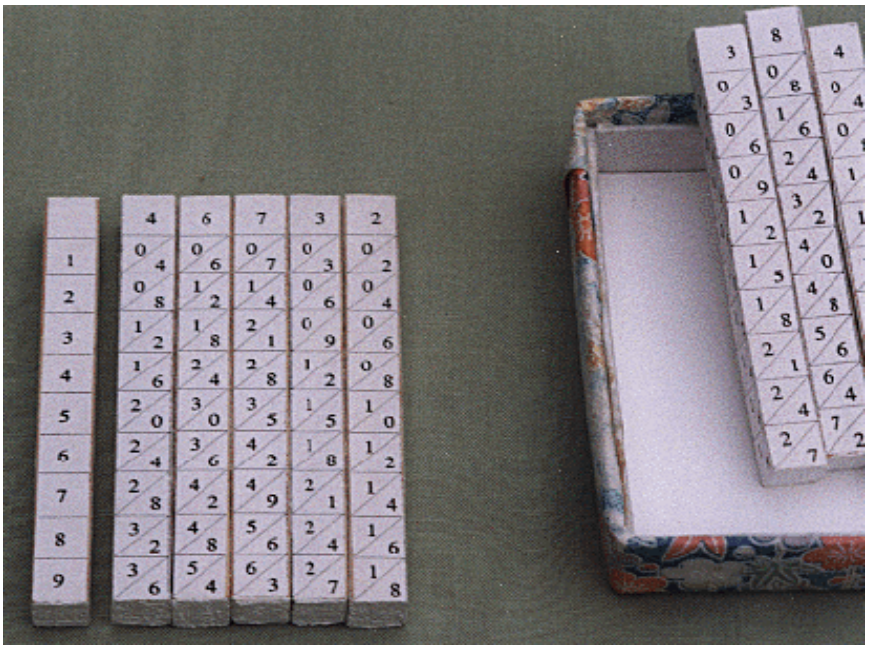

Fig. 5 : A more modern set of Napier's Bones

d) 1623

Calculating clock: It is the first gear-driven calculating machine. It is invented by the German professor Wilhelm Schickard.

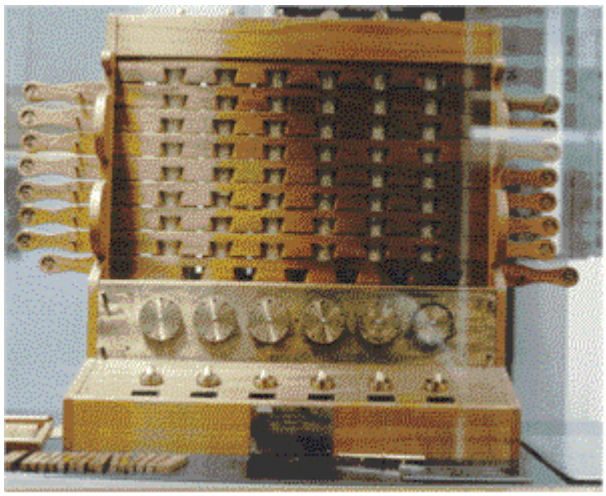

Fig. 6 : Schickard's calculating clock

e) 1642

In 1642 Blaise Pascal invented the gear driven Pascaline to add numbers.

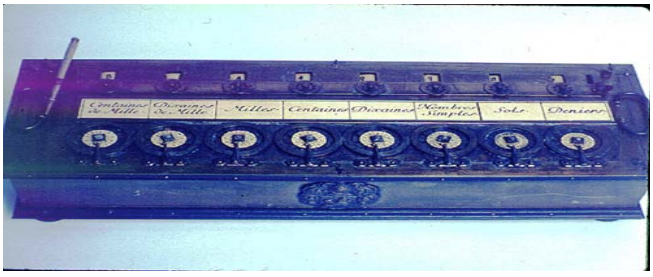

Fig. 7 : Pascal's Pascaline[photo IEEE 2002]

i. *Gottfried Wilhelm Leibniz*

He built a four function (addition, subtraction, multiplication and division) calculator called the stepped reckoner because instead of gears, it employed fluted drums having ten flutes arranged around their circumference in a stair step fashion.

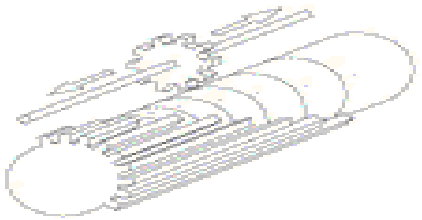

Fig. 8 : Leibniz's stepped Reckoner

f) 1801

Joseph Marie Jacquard: A Frenchman who invented a power loom. This invention paved the path for inventing punched card. The invention of punched is considered as the major contribution and development in the development of advanced computer.

Fig. 9 : Jacquard's power Loom with punched card

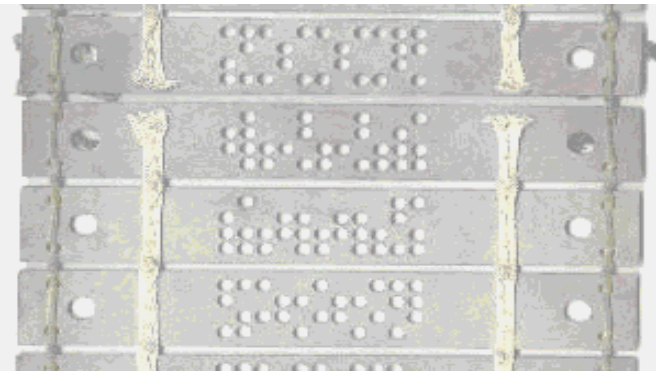

Fig. 10 : View of Jacquard card

g) 1822

Charles Babbage: The English mathematician proposed a stream driven calculating machine called the Difference engine. The machine would be able to compute tables of numbers, such as logarithmic table. But unfortunately the project of Difference Engine failed due to over expense. Soon after Babbage had introduced a new machine called Analytic Engine powered by six steam engines. In this project Babbage had used punched card to store numbers for future use and a mechanism to get result. Charles Babbage had divided Analytic Engine into two parts the "store" and the "Mill". The term "store" indicates the place where numbers are held and the "Mill" indicate the place where numbers are processed to give new results.

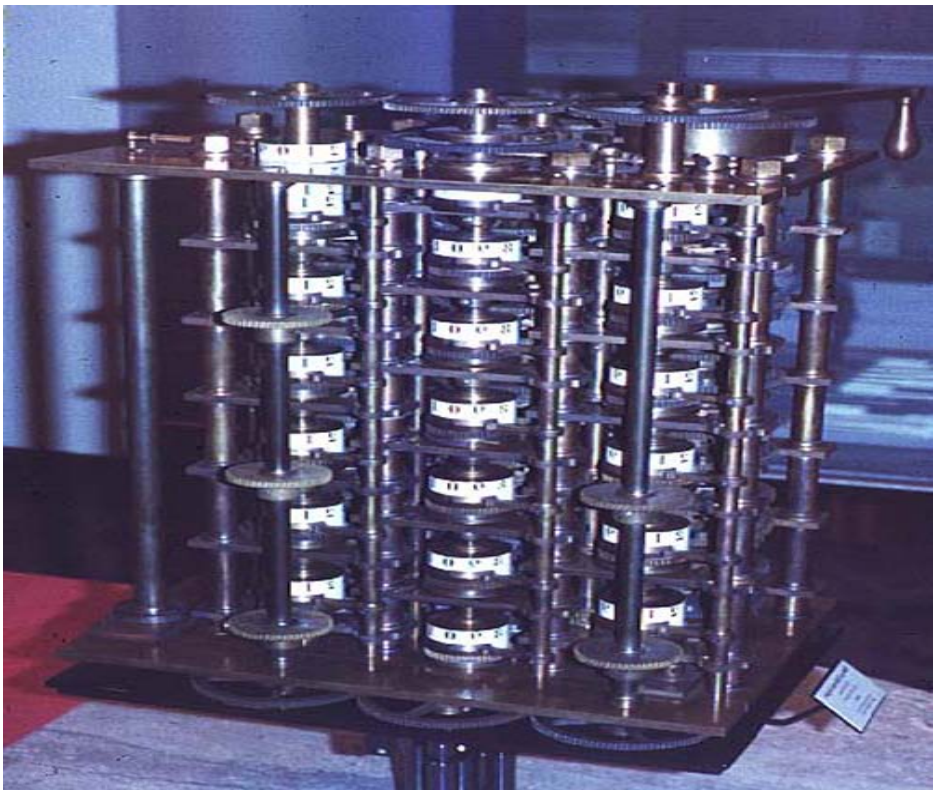

Fig. 11 : Babbage's Difference Engine [photo 2002 IEEE]

The development of the Analytic engine with the idea of "store" and "Mill" is considered as the major breakthrough in computer history because in a modern computer the same kind of parts are called the memory unit and the central processing unit (CPU).Due to this reason only, he is called the father of modern computer.

h) 1890

Hollerith: He had the insight to convert punched card to what is today called a read/write technology. Hollerith built a company, the tabulating machine company which after a few buyouts eventually became International Business machines, known today as IBM.

Fig. 12 : Hollerith Desk

i. *Some application of manual/mechanical computer*

- Efficient in arithmetic calculations like addition, subtraction, multiplication and division.
- Using these computer man has succeeded in preparing logarithmic table and trigonometric table.
- The computers were restricted only to scientific use.

ii. *Parts of Early computer*

- Human Brain---(Human Intelligence) ---- Before 300BC
- Abacus-------- Rings, Rods, Pebbles
- Napier Bones ----- Ivory sticks carved with numbers
- Calculating Clock ----- iron gear driven calculating machine
- Pascaline ---- gears and cylinders
- Leibniz stepped reckoner ------- ten flutes drum
- Jacquard power loom (punched card)----- punched wooden cards
- Difference engine/Analytic engine ----steam engines and punched cards
- Hollerith desk ---- holes cards, a gear driven mechanism
- Mark 1---- switches, relays, rotating shaft and clutches and electric motor
- Vacuum tubes----- three legged arrangement to amplify current
- Transistors----- Germanium, paper clips and razor blades
- IC (Integrated Circuit) ---- transistors
- DRAM ---- capacitor (To store data in the form of electric charge)
- ENIAC ------ vacuum tubes, card readers, patch cords
- UNIVAC ------- magnetic tapes
- Drum memory------ metal cylinder coated with recordable ferromagnetic material
- Magnetic core memory ----- ferrite core memory, magnetic ceramic rings

IV. Development and Invention of Electronic Device/Computer

a) 1943

ENIAC--- (Electronic Numerical Integrator and Calculator).It was the first electronic digital computer, built at the university of Pennsylvania between 1943 and 1945 by two professors John Mauchly and J.Presper Eckert. ENIAC requires 20 by 40 foot room, weighed 30 tons, and used more than 18000 vacuum tubes.

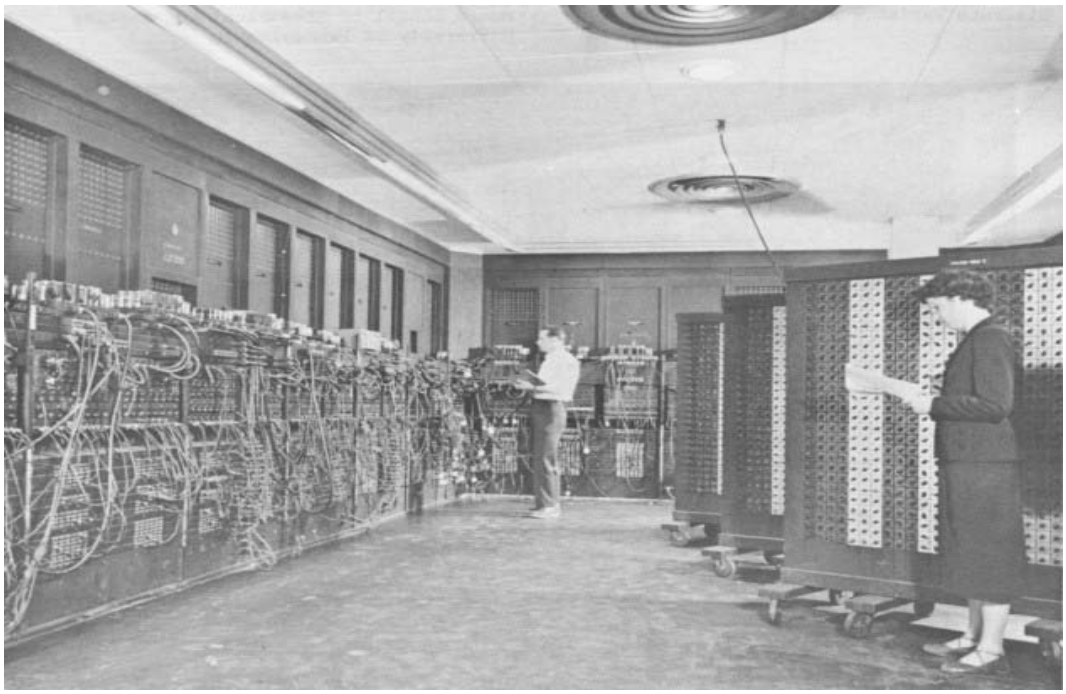

Fig. 13 : ENIAC [U.S Army photo]

b) 1944

Harvard's Mark1: He built partnership with IBM and developed the first programmable digital computer in USA. But it was not a purely electronic computer. He had used switches, relays, rotating shafts and clutches. The Mark1 was capable to operate on numbers that were 23 digits wide.

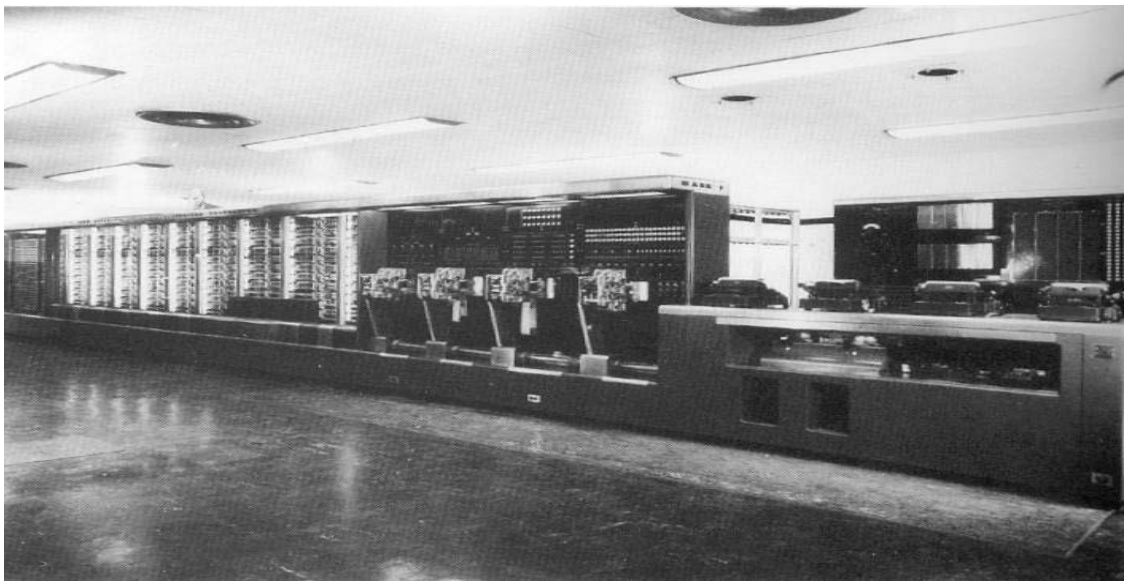

Fig. 14 : The Harvard Mark1: An electro mechanical computer

i. *Mainframe computer*

The development of mainframe computer before 1947. Before the invention of microprocessor, computers were built in mainframes, with components which were connected by a backplane that had countless slots for connecting wires. With the invention of PCB (Printed circuit Board) wires needed to connect card connector pins in mainframes have been replaced with PCB. The CPU, memory and other peripherals are all installed on PCB and the size is reduced to a large extent.

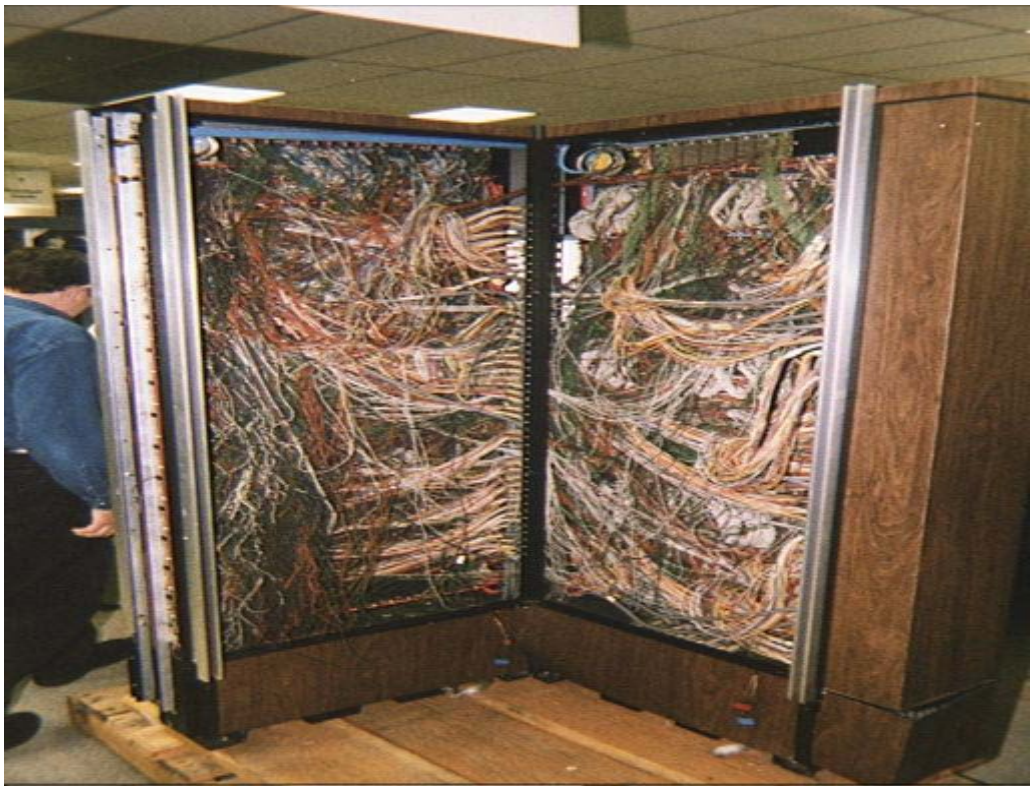

Fig.15 : Typical wiring of an early mainframe computer [photo courtesy: The computer museum]

c) 1947

William Shockley, John Bardeen and Walter Brattain: They successfully build the first transistor at Bell Labs. In 1950 William Shockley develops the bipolar junction transistor, the device most commonly referred to as a transistor by today's standard. The invention of transistor in 1947 is considered as a revolution because in digital computer like ENIAC it quickly replaced the

traditional vacuum tubes. Strong reasons for the replacement are as under:

- Transistors amplify current much more quickly than vacuum tubes.
- Transistors do not generate lot of heat whereas vacuum tubes generate lot of heat.
- Transistors size is very small and light weight in comparison to vacuum tubes. So transistors helped a lot in making small size computer.
- Transistors do not generally burn whereas vacuum tube has a tendency to burn. So vacuum tubes are not cost effective, reliable and safe. For instance, the first digital computer ENIAC used around 18000 vacuum tubes that constantly burned out, making it very unreliable, problematic, unsafe and erroneous.

Fig. 16 : Vacuum tubes [A three terminal devices called triodes]/Transistor

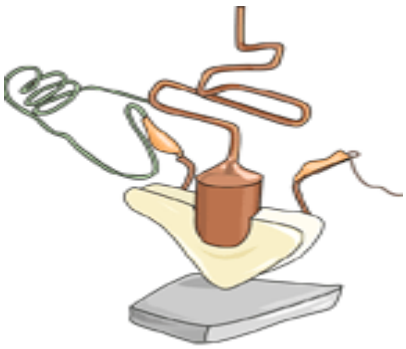

Fig. 17 : The first point contact transistor

i. *Function of transistors*

The transistor acts like a switch. It can turn electricity on or off, or it can amplify current. In modern computers it is used to store information and in stereo amplifiers to make the sound signal strong.

d) 1958

The development and invention of IC (Integrated circuit) took place in the year 1958 by two great engineers Jack Kilby and Robert Noyce. The development was the result of the microelectronics revolution started in 1947. In an IC millions of transistors can be created and interconnected. All the elements on the IC are fabricated simultaneously via a small number (may be 12) of optical masks that define the geometry of each layer. The development of IC speeds up the process of fabricating the computer and equally responsible for reducing the size and its cost.

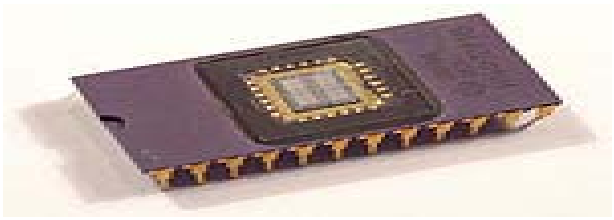

Fig. 18 : An integrated circuit (silicon chip) [photo courtesy of IBM]

i. *Importance of IC in modern computer development*

The impact of this tiny chip has been far reaching. The chip virtually created the modern computer industry, transforming past room size machines into today's array of mainframes, minicomputers and personal computers.

V. Development of Modern/Fourth Generation Computers

a) 1970—1972

Invention of RAM: Between 1970 and 1972 computer memory on an IC or chip was developed. This memory was named as random Access Memory (RAM). It allowed data to be accessed randomly, not just in the sequence it was recorded. DRAM (Dynamic Random Access Memory) is the most common kind of RAM for personal computers. Intel released the 1103 chip, the first generally available DRAM memory chip. The introduction of 1103 DRAM was considered as a turning point in the history of IC. For the first time, significant amount of information could be stored on a single chip.

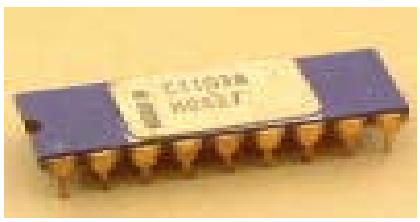

Fig. 19 : 1103 chip

b) 1971

Invention of microprocessor: In 1971 Intel introduced Intel 4004, the first commercially available single chip microprocessor. This was considered as the first single chip microprocessor in mankind history. It was a 4-bit CPU designed for usage in calculators.

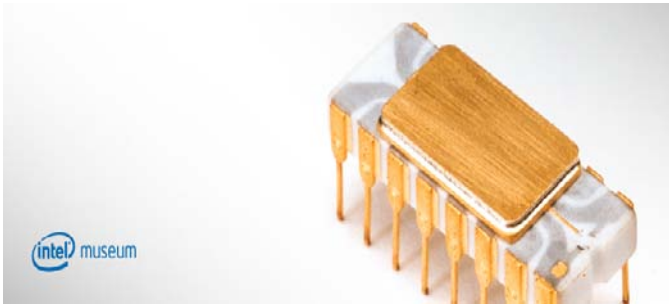

Fig. 20 : Intel 4004 microprocessor

This development marked the new era of Integrated circuit.

i. *Some Advanced Intel Pentium processors are*

Fig. 21 : Pentium 60MHZ microprocessor for desktop

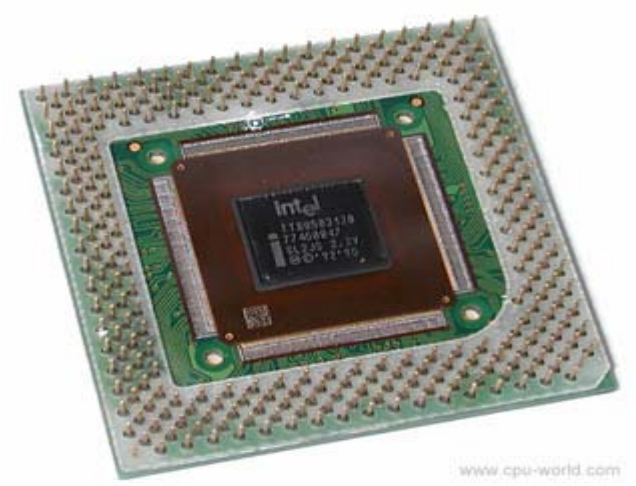

Fig. 22 : Mobile Pentium MMX processor

Modern processors are designed by two distinct companies: Intel and Advanced Micro Devices (AMD).

c) 1973

Invention of Hard Disk Drives: In 1973 IBM introduced the model 3340 Winchester sealed hard disk drive, the predecessor of all current hard disk drives. Its storage capacity was 30 Mbytes. In 1980, Seagate technology introduced the first hard disk drive for microcomputers, the ST506.

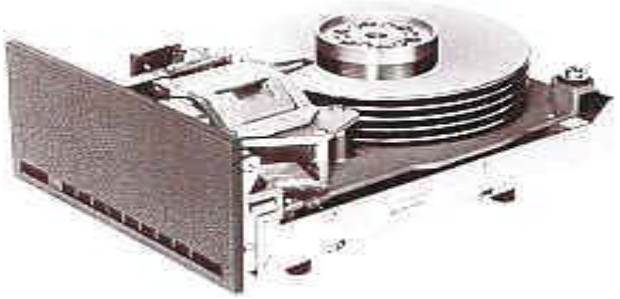

Fig. 23 : Seagate Hard Disk Drive [ST506]

In 1997 Seagate introduced the first 7200 RPM, ultra ATA hard disk drive for desktop computers.

Fig. 24 : Advanced Hard disk drives

d) PCB (Printed circuit board)

It is a device that provides electrical interconnections and a surface for mounting electronic components. In 1903 the first PCB was made by Dr Paul Eisler, an Austrian scientist working in England.

Fig. 25 : Modern printed circuit board

e) Motherboard

Motherboard is the most important part of modern computer. It is very difficult to think about modern computers without a motherboard. Motherboard is by and large responsible for smaller size computers. A motherboard is a PCB found in all modern computers. It holds many of the crucial components of the system such as the CPU, memory and connectors for other peripherals. It is also known as the main board, system board, planar board or logic board.

Fig. 26 : Modern Intel motherboard

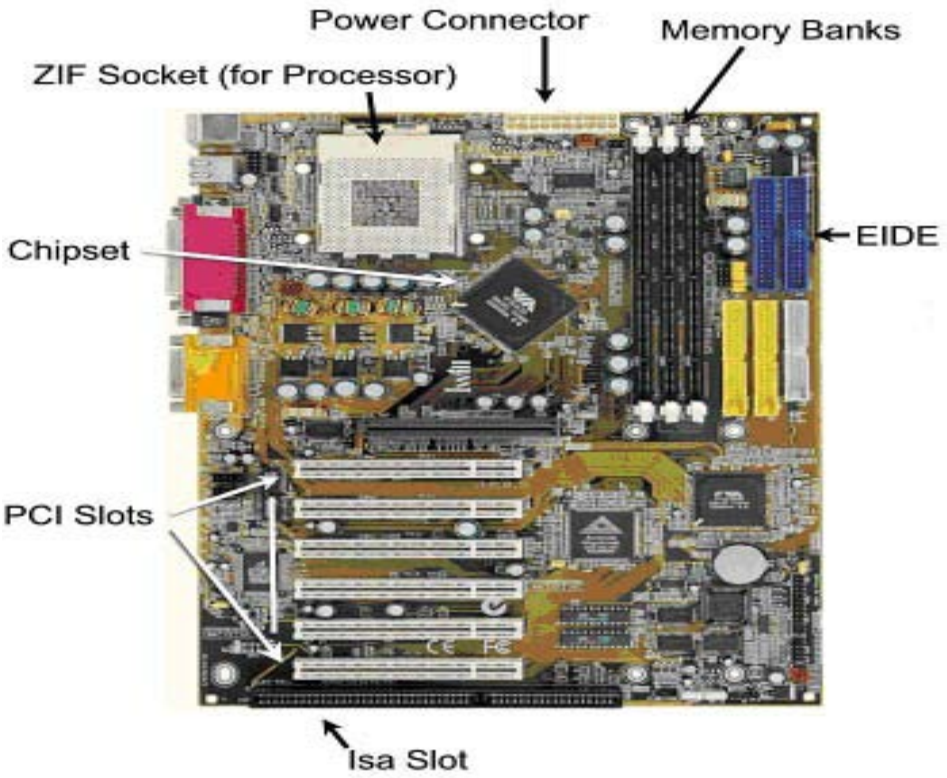

Fig. 27 : Facilities provided by modern motherboards

i. *Motherboard manufacturing companies of the world*

(1) Micronics 2) Mylex 3) AMI 4) DTX 5) Orchid Technology 6) Elitegroup 7) Apple 8) IBM

Now a day's Apple and IBM are producing sophisticated motherboards with upgraded features and superior performance.

f) Parts of Modern computer

- **PCB:** Bakelite, Masonite, layered card board
- **Motherboard:** Capacitor, inductor, resistor, diode, transistor
- **Microprocessor:** ceramic material, plastic
- **RAM:** IC, PCB, semiconductor material
- **Hard disk:** stepper motor, hydraulic actuators
- **Software:** System software, Application software, utility software

VI. Generations of Electronic Computer

Major technological changes in the development of modern electronic computer are referred to as generations of computer. The technological changes in the development of computer resulted in smaller, cheaper, more powerful, more energy efficient, low maintenance, good performance and fast computer. The development of electronic computer has witnessed the following five generations.

a) First Generation of computer (1940-1956)

- The first electronic computer used vacuum tubes for circuitry and magnetic drums for memory.
- Dependent on machine language.
- The first generation computers are UNIVAC and ENIAC.

b) Second Generation of Computer (1956-1963)

- Transistors replaced vacuum tubes. This allowed computers to become smaller, faster, cheaper, more energy efficient and reliable than first generation of computers.
- Second generations of computer used punched cards for input and printouts for output.
- Assembly language was used instead of machine language.
- Magnetic core technology was used for memory instead of magnetic drums.

c) Third Generation of Computer (1964-1971)

- Integrated circuit (IC) replaced transistors. Transistors were miniaturised and placed on silicon chips called semiconductors which drastically increased the speed and efficiency of computers.
- Keyboards, monitors and operating system were introduced in this generation.
- Computers become accessible to a mass audience.

d) Fourth Generation of Computer (1971-2005)

- Microprocessors replaced IC. Example Intel 4004 chip.

- IBM and Apple introduced computers for the home users.
- Desktop computers were introduced in this generation.
- Computers became more powerful. Computers could be linked together to form networks which eventually led to the development of the internet.
- GUI (Graphical User Interface), the mouse and handheld devices have been introduced.
- Extensive use of computer software based on the conversion of high level language into machine readable language called low level language.

Fig. 28 : Fourth generation desktop computer

Fig. 29 : Fourth generation laptop computer

Factors responsible in increasing computer speed

i. *High capacity of RAM (Random Access Memory)*

More RAM the computer has, the better will be its speed and performance. The speed of the RAM connection directly controls how fast the computer can access instructions and data. Therefore, it has a big effect on system performance. Much of the memory available today is dual data rate (DDR) memory. This means that the memory can transmit data twice per cycle instead of once, which makes the memory faster.

ii. *Design of advanced motherboards*

- Newer motherboards provide facility to connect to the north bridge via a dual bus instead of a single bus. This reduces the amount of time it takes for the processor to get information from the memory.
- Newer motherboards provide space or slots for multiple memory chips to increase computer speed.

iii. *Design of microprocessor*

As we increase the number of transistors, the processor become faster. The drastic increase in number of transistors resulted in tremendously fast processors. For instance, in 1971 the Intel 4004 chip contained 2300 transistors only and was considered as a very slow processor. But in 1993 the Intel had launched a very fast processor namely Pentium chip that contained 3,100,000 transistors. The following technologies have been employed to increase the number of transistors in ac IC or a chip. These are commonly referred to as generations of IC.

- Small scale Integration (SSI) (1960): It is an IC that contains 3 to 30 transistors on a single chip.
- Medium scale Integration (MSI) (1960): It is an IC that contains 30 to 300 transistors on a single chip.
- Large scale Integration (LSI) (1970): It is an IC that contains 300 to 3000 transistors on a single chip.
- Very large scale Integration (VLSI) (1980): It is an IC that contains more than 3000 transistors on a single chip.
- Ultra large scale Integration (ULSI) (1980): It is an IC that contains more than 1 million transistors on a single chip.

iv. *Some application of modern/ fourth generation computer*

- Can be used at home and office for data storage and fast data retrieval.
- Can be used for entertainment purpose like playing games, listening music and watching videos.
- Can be used to exchange information among different computers.
- Teleconferencing and remote access is made possible.
- By making application software electronic digital computer can be used anywhere. Therefore, it can be considered as a versatile machine.

e) Fifth Generation of Computers (2005 onwards) (still under development)

- Fifth generation computing devices are based on Artificial Intelligence.
- Voice recognition concept has been introduced.
- Parallel processing and superconductor techniques have been introduced.
- Quantum computation technique, molecular technique and also Nanotechnology has been introduced.
- Scientists are trying to develop devices that are capable of learning, respond to natural language and self organisation.
- Fifth generation computing is still under research and development.

i. *Advancement in fifth generation computing*

The fifth generation computing is totally a new concept of developing computers. It does not match with the past or early developments of computer. In this generation of computer man is trying to incorporate the human characteristics or features like outstanding problem solving ability, high level deliberative reasoning,

and pattern recognition. The approach definitely remove the demerits of fourth generation computer and will prove to be a more reliable and versatile machine ever made by mankind. The new techniques used to achieve the above target are Artificial Intelligence (AI), voice recognition, quantum computation and Nanotechnology. Here, we first try to understand the following terms one by one.

ii. *Artificial Intelligence (AI)*

It is a branch of science that believes in making computers or machines that can find solutions to complex problems in a more human like fashion. Research on AI has focussed chiefly on the following components of intelligence: learning, reasoning, problem solving, perception and human language understanding.

iii. *Applications of Artificial Intelligence (AI)*

- Advance computer game playing and robotics pets.
- Speech recognition by a computer
- Understanding natural language by a computer
- Identifying 3 dimensional objects by a computer
- Developing expert system in medical science by a computer

iv. *Voice recognition*

Voice recognition refers to the ability of a machine to receive and interpret dictation, words or phrases spoken by humans. It is the technology by which sounds, words, phrases and sentences spoken by humans are converted into electrical signals, and these signals are transformed into coding patterns to which meaning has been assigned. Efforts have been made to speak a word or phrase into a microphone, then the electrical signal from the microphone is digitized by an "analog to digital (A/D) converter" and is stored in memory. Here the spoken words are considered as an input to a computer program. This technology will definitely eliminate peripherals like keyboard and mouse from computer system.

v. *Quantum computing*

It is the area of study focussed on developing computer technology based on the principles of quantum theory, which explains the nature and behaviour of energy and matter on the quantum (atomic and subatomic) level. Development of a quantum computer would mark a leap forward in computing capability far greater than that from the Abacus to a modern day super computer, with performance gains in the billion fold realm and beyond. The quantum computer, following the laws of quantum physics, would gain enormous processing power through the ability to be in multiple states, and to perform tasks using all possible permutations simultaneously. The concept and an approach to quantum computing is still under research and development.

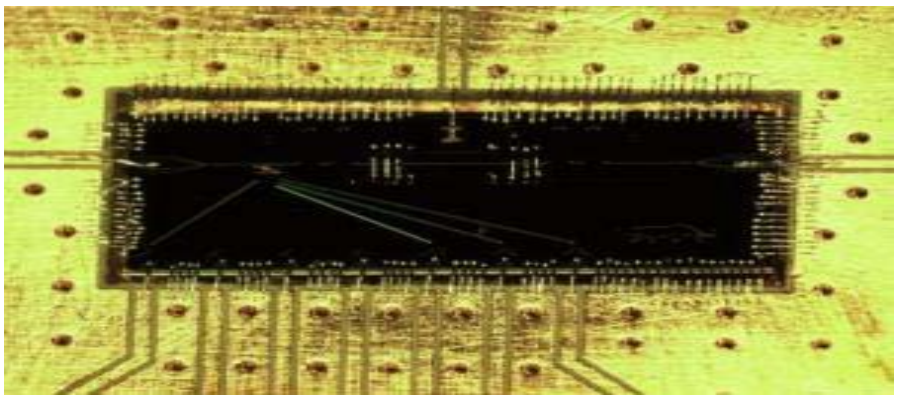

Fig. 30 : New route to large scale Quantum computing

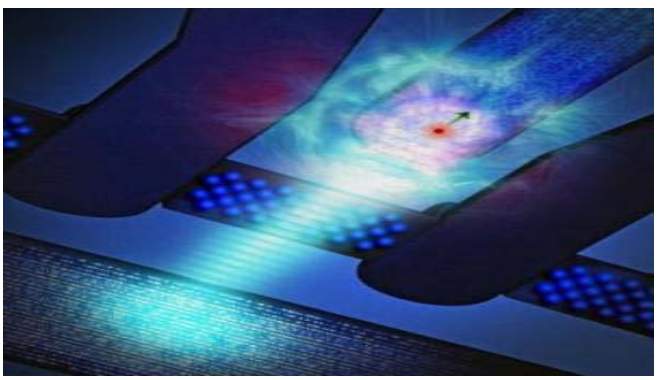

Fig. 31 : Single-Atom writer a landmark for quantum computing

vi. *Nanotechnology*

Nanotechnology refers to the engineering of functional systems at the molecular scale. It is the projected ability or technique to construct/make complete high performance very small products. The molecular scale nanotechnology is considered as the fourth generation of nanotechnology from 2010 to 2020. It is based on molecular devices by design and atomic design. The program is still under research and development.

vii. *Applications of Nanotechnology*

- Scientists are trying to build machines on the scale of molecules. For instance, a few nanometre wide

motors, robot arms and a complete computer far smaller than a cell.

- A computer using nanotechnology can make copies of data files – essentially as many copies as we want at little or no cost.

viii. *Natural language*

Natural language is defined as any human language. Example: English, French, Chinese, Hindi etc. Scientists are trying to replace programming languages like FORTRAN, BASIC, C, C++, Java with natural language.

VII. Conclusion

This paper describes the need and emergence of a machine like computer. Efforts have been made to describe the different stages of development of computer right from since time immemorial to 2012 and beyond. With the passage of time man has witnessed different forms of computer with much more improved capability. Development of computer has witnessed major technological changes and more sophisticated techniques have been employed to present a much better computer than the past. This paper also laid emphasis on the role played by the major contributors in the development of a more advanced, sophisticated and portable machine.

VIII. Acknowledgement

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