History of computing

Specific/special purpose machines are machines that have a limited set of instruction which can not be changed, for example, a desk calculator.

General purpose machines: Machines that can carry out a wide range of tasks and are not limited to specific purposes.

A programmable computer can be re-programmed to improve previous or to solve completely different problems.

In addition to being programmable and general purpose modern computers are also digital and electronic.

They are digital because they use discrete values for their calculations. Analog or continuous signals can have an infinite number of values in a given range, Digital signals take on a limited number of values.

Modern digital computers use 1 or 0 – these are binary digital computers. However, in theory, you could build a computer with any number of discrete digits, for example, base 10.

Electronic computers operate using electricity. They use DC as it is easier to produce using batteries, it has a constant voltage that is either on or off. This is ideal for modern electronics which are built around transistors and act as switches with on or off states. These allow us to model Boolean algebra using electronics.

Conductors are materials that allow electricity to flow freely through them. Example: copper.

Insulators are materials that don’t allow electricity to flow freely through them. Example: glass.

Semiconductors are designed so they can act as a conductor or insulator or both. This special property allows them to control the flow of electricity making modern computers possible.

Vacuum tube – electrical devices that control the flow of electricity. They were used in the first computers until they were replaced by transistors.

Transistor – Silicon under certain conditions can act as a con doctor or insulator – it is a semi-conductor. By adding impurities, in a process called doping, scientists can control the flow of electrons and so make an electronic switch,

1st Generation Computers: Vacuum tubes

2nd Generation Computers: Transistors

3rd Generation Computers: Integrated circuits

4th Generation Computers: Micro-Processors

Early Counting Devices

Pile of stones – adding or removing stones from a pile would provide a way of calculating and storing the results.

Abacus – A frame with wires on it. Beads were treaded onto the wire which could slide back and forth to calculate values. Abacus’s are still used today but are not computers because they only act as an aid to the person doing the computation.

First Computers

The original meaning of the term computer was a person who performed mathematical calculations. For Example:

Calculating the position of stars and movement of the planets

Compiling mathematical tables and trajectories of missiles

Early computing machines

1600s

Slide Rule – a mechanical, analog computing device used until the 1970s when they were replaced by pocket calculators.

1800s

1822:

Charles Babbage difference engine – a mechanical calculator that could solve polynomial equations. It was a special purpose machine

1830:

Charles Babbage designs the Analytical engine.

Designed for general purpose computations, with data stored on punch cards (thick paper with holes punched in them). The computations were specified by programs also stored on punch cards. Though never completed, the design included mechanical memory and the equivalent of a CPU.

Programmable and general purpose it was arguably the worlds first non-human computer.

It had the four key features of all modern computers: Input, Storage, Processing and Output.

1815-1852

Ada Lovelace – first computer programmer.

Took an interest in the analytical engine, she designed and published the first algorithm designed to be executed by a machine. She is considered the first computer programmer.

While many other mechanical computers were devised they were all very complex, large and heavy. This made them expensive and difficult to produce in large quantities.

1900s

1936

Alan Turing described a mathematical model of computation called the a-machine (automatic machine which later on became known as the Turing machine. A Turing Machine can be constructed to solve any given computer algorithm. It is in this sense, the first concept of a universal, all-purpose, computing machine. This laid the foundation for AI and machine learning.

The Turing machine

The Turing machine was invented in 1936 by Alan Turing. It is a basic abstract symbol-manipulating device that can be used to simulate the logic of any computer that could possibly be constructed.

Although it was not actually constructed by Turing, its theory yielded many insights.

Anything that can be mathematically computed could be programmed on a Turing machine.

A Turing machine consist of three components as follows:

1. An infinity long tape made up of individual cells. Each cell can contain a single character – typically 1, 0, or blank.
2. A read/write head pointed at an individual cell.
3. A controller which instructs the read/write head what to do.

Initially the tape is inscribed with a sequence of characters – called the input.

The operation of the Turing Machine is controlled by the controller. The operation takes place as a sequence of steps known as transitions. The controller decides for a given (input character, state) pair, the (output character state) pair – known as a transition.

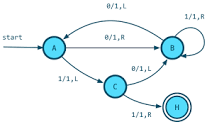
Each transition involves:

-Reading

-Writing

-Moving

-Updating (state)



AT any given time, a TM is said to be in a particular state. States are usually denoted by the letter S followed by a number e.g. S2 is taken to mean state two.

S0 is conventionally used to denote the initial state. This is the state TM is in before it starts to operate.

A double circle is used to denote the final or halting state. This is the state TM is in when it finishes.

A task is computable if it can be carried out by a Turing Machine.

1940

Alan Turing developed the Bombe machine to break the encryption of the enigma machine. Both machines were specific purpose.

1943

Colossus

World’s first programmable electronic digital computer. Created 1943 Bletchley park UK to break codes during WW2. Could not store programs in memory just data. Had to be rebuilt using cables and switches every time a new program was needed. Not considered general purpose as it was solely used for code breaking.

ENIAC (Electronic Numerical Integrator and Computer)

American programmable computer. Considered the first general purpose digital computer. Similar to Colossus, had to be rebuilt for each different program. Kay McNulty was one of the first programmers of the ENIAC. Betty Jean Jennings and Fran Bilas were also women programmers of the ENIAC.

Both the Colossus and ENIAC used punch cards and vacuum tubes and did not store the programs in memory.

The Colossus was a Binary {0,1} computer but the ENIAC was a decimal {0,1,2,3,4,5,6,7,8, 9} computer

1947

The digital revolution, began with the invention of the solid state transistor at Bell Labs in the USA. The device which can act as a switch, turning tiny electric currents on or off, and also as an amplifier of the electric current.

Logic gates which allow us to build circuits for Boolean Algebra are made, primarily, of transistors, as are memory components and CPUs.

1953

Invention of high-level programming languages.

In the early days of computing electronic computer could only be programmed by numbers, tape, punch cards or even manually manipulate the thermionic valves (vacuum tubes) to certain settings.

After WW2 Grace Hopper worked on the first commercial computer called the UNIVAC (Universal Automatic Computer). A stored program computer, it used magnetic tape instead of punch cards. It was a decimal computer that used vacuum tubes.

In 1953 she invented the first higher level programming language, A-0, that used words and expressions to program the UNIVAC. She also created the first modern day compiler and coined the

1954

The first computer without vacuum tubes. Known as TRADIC (for TRAnsistor Digital Computer)

IBM invented the FORTRAN programming language

1956

MIT was working on the keyboard for input and output

1957

The Soviet Union launched Sputnik, the first unmanned satellite in space.

1958

Integrated Circuits (IC) were invented in 1958, independently, by electrical engineers Jack Kilby (Texas Instruments) and Robert Noyce (Fairchild Semiconductors).

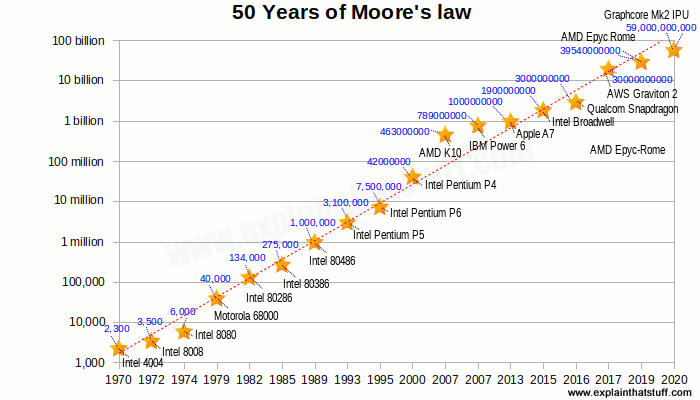
They consist of a number of electronic circuits on a single chip

The motivation was how can we squeeze more components into a smaller space, at reduced cost and operating faster speeds?

Integrated circuits are made of transistors which make use of the properties of semi-conducting elements such as Germanium and Silicon.

Noyce founded the Intel Corporation with Gordon Moore in 1968. They released the first microchip computer or microprocessor in 1974, paving the way for the first modern Personal Computers

Moore’s law is one of the most famous laws in the world of computer science. Moore’s Law says that the number of transistors on an IC will approximately double approximately every 2 years. Thus the processing power of computers will also double approximately every 2 years. Moore’s Law is more of an observation/prediction than a scientific law. As can be seen by the graphic below, it has been extremely accurate.



The latest innovations are the 5nm process. This has often been considered the limit for Moore’s law because it is a 25 atoms

1973

The Ethernet was developed at Xerox labs. It was a system for connecting computers within a building using hardware running from machine to machine.

Martin Cooper, a Motorola researcher, made the first ever call on a mobile phone.

ARPA’s Transmission Control Protocol / Internet Protocol (TCP/IP) was invented by Vint Cerf and Bob Khan

In 1977 APRA demonstrated that it could connect several different networks. This became known as the internet.

Note: ARPA was the pre-cursor to DARPA

The first Apple was completed in 1976 – users had to build their own casing for it and software had to be custom written for the hardware.

The second Apple was completed in 1977. Inspired by modern electronic commodities such as TV and stereos, the modern PC has truly arrived.

1989

The world wide web, was invented by Tim Berners-Lee while working at the CERN laboratories in Switzerland.

The internet is a global network that connects computer networks. The linking of computer networks is called internetworking, from which we get the name internet.

2000-2020

Cloud computing and the smartphone

Mainframe computers have existed since modern computing evolved, where end users hook up their terminal to a larger system with greater speed and processing power

Limited bandwidth and connectivity meant companies could not provide cloud computing on a commercial scale. That all changed in the 1990s as internet bandwidth developed. One of the first companies to capitalise was Amazon. The Amazon Web Service (AWS), grew out the realisation that their data centres had more computing power than the company could use. So they began to rent their computers as virtual servers to clients who wanted to avail of online storage and computing power.

Cloud computing allowed for virtualisation – the simulation of a device or a resource. It creates an environment for a user that is independent of physical infrastructure. For example, Office 365 or Photoshop online are software programs that run on the cloud.

Web 2.0

The original internet developed in 1989 had very static html pages where users could view or download content – it was Web 1.0. As the internet developed, in the mid-2000s Web 2.0 was coined to capture the change to a dynamic World Wide Web.

JavaScript, for example was developed in 1995 to give the browser more choice and responsiveness. By the early 2000s JS could do more and more through web browsers. As the web became more and more of a business and social tool, technologies such as AJAX (Asynchronous JavaScript and eXtensible markup language) allowed pages to update seamlessly without the need for http requests. Google Maps uses an AJAX engine to allow users work on data in real time in their browser.

2021 – present

Web 3.0

Building on web 2.0, web 3.0 places a strong emphasis on decentralized applications and will probably make extensive use of blockchain-based technologies. It will also use machine learning and AI to empower a more intelligent and adaptive web.

November 2022

Release of ChatGPT

1936: The Turing Machine

1942-1946: First Electronic Computer: Colossus and ENIAC

1947: Solid State Transistors

1953: Invention of High Level Programming Languages

1958: Integrated Circuits

1973: Mobile Phones and Interconnected Computers

1977: First Modern PC – Apple II

1989: The World Wide Web

2000-2020: Cloud Computing and the Smart Phone

LCCS Algorithms Searching and Sorting

Searching

Linear Search

Search each item in the list from start to finish.

If you find the item return its index.

If not, return the length of the list or -1, whichever you wish.

A list L and a search argument of 14

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 15 | 4 | 41 | 13 | 24 | 14 | 12 | 21 |

L[0] == 14? No

L[1] == 14? No

L[2] == 14? No

L[3] == 14? No

L[4] == 14? No

L[5] == 14? Yes

Return 5<- Index

Linear Search Flowchart

Binary Search is a search algorithm used in a sort array by repeatedly dividing the search interval in half.

Because we repeatedly divide the search space, it is said to follow the divide and conquer approach.

Algorithm in pseudo code

1. Set the list
2. Set low = first item in list
3. Set high = last item in list
4. Set mid = (high + low)//2
5. If Item at mid location return item, else it must be to the left or right of the middle value
6. If the value at mid position is less than the target value

Set low = mid + 1

1. If the value at mid position is greater than the target value

Set high = mid - 1

Make sure that low is never greater than high

A list L and a search argument (target value) of 28

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 2 | 4 | 5 | 7 | 8 | 9 | 12 | 14 | 17 | 19 | 22 | 25 | 27 | 28 | 33 | 37 |

Low mid high

Pseudo-code: (target value is 28)

1. Set low = 0

2. Set high = length of list – 1

3. Set mid = low + high / 2, rounded down to an integer

4. If the value at the mid position is the same as the target value

Else if the value at the mid position is less than the target value

Set low = mid + 1

Else If the value at the mid position is greater than the target value

Set high = mid – 1

5. As long as low doesn’t cross over high, go back to set 3

Algorithm in pseudo code

1. Initialise an unsorted list
2. Initialise an empty sorted list
3. Repeat as long as there are items in the unsorted list
4. Find the smallest item
5. Move the smallest item to the sorted list
6. Remove the item from the original list
7. Stop

A simple Sort Algorithm

Algorithm in pseudo-code

1. Initialise an unsorted list
2. Initialise a marker
3. Loop across every list name
4. Find the minimum item item to the right of the marker
5. Swap this item to the right of the marker
6. Advance the marker to the right one position
7. Stop

The Bubble Sort

The steps in the bubble sort algorithm are as follows:

1. Initialise an unsorted list
2. Traverse across every element in the list
3. Compare all adjacent elements starting from the beginning
4. If the elements are out of order, then swap then
5. NOTE: As the largest element always goes to the top of the list you can make one less comparison each time.
6. NOTE: If you make one pass and there is no swap you do not need to make any further passes i.e. if the list is already sorted you don’t need to make more than one pass through the list

Insertion Sort Algorithm

The steps in the insertion sort algorithm are as followed:

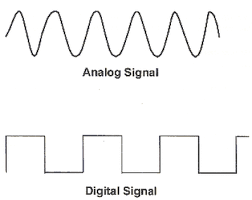
1. The first item considered to be sorted with respect to itself
2. Select the first item from the unsorted list
3. Insert the selected item into the correct position within the sorted list (this is done by swapping this item to the left until it arrives at the correct position)
4. Advance the marker to the right by one position

Quicksort

Pseudo-code

1. Choose the rightmost elementin the list as the *pivot*.
2. Create three empty lists called *left\_list*, *middle\_list* and *right\_list*
3. For each *element* (key) in the list:
   1. If *element* is < *pivot* add it to *left\_list*
   2. If *element* is == *pivot* add it to *middle\_list*
   3. If *element* is > *pivot* add it to *right\_list*
4. The result is a list made up by applying step 1-3 to *left\_list*, followed by the elements in *middle\_list*, followed by applying steps 1-3 to *right\_list*

Basic Electronics



Binary code and digital signals

Modern computers use binary digital inputs (usually binary) to represent all information

Binary code has two values 1 represents on/high and 0 represents off/low

On is usually 3 to 5 volts while off is usually 0 volts

Analog devices allow for any value within a given range but are susceptible to noise, binary systems are not greatly affected by noise

Analog signals

Analog signals have a continuously changing value and are used to represent continuous data

Examples of analog/continuous signals would be:

Temperature, acceleration, humidity, light intensity, sound level

Examples of digital/discrete signals would be:

Switch, keyboard button

Sensors

Analog sensors measure analog data, digital sensors measure digital data

Analog sensors give analog voltage as an output. The output voltage may be anywhere in the range of 0 to 5V.

Thermometer, pressure sensors, light sensors are all analog sensors

Digital sensors would include:

Proximity sensors, IR sensors, digital temperature sensors, and digital humidity sensors

A digital sensor consists of three components: sensor, cable, and transmitter.

In digital sensors, the signal measured is directly converted into digital signal output inside the digital sensor itself. And this digital signal is transmitted through cable digitally.

The signal measured may be analog but the output from the sensor is digital.

Electricity and electrons

The CPU, Memory, Bus and other components are all electrical devices that control the flow of electricity

An electric circuit is a loop of conductive material that allows current to flow when there is a potential difference between two points in the path

If the circuit is not closed it is said to be open-electricity cannot flow. A switch is used to break an electric circuit.

Electric current

The flow of electrons from one place to another is called current

The greater the number of electrons that pass through a given point in a given unit of time the stronger the current is said to be

The unit of current is the Ampere. It is measured using an Am-meter or a multi-meter set to measure Amps

Voltage

Voltage is the difference in electric potential between two parts of an electric circuit

This potential difference causes electrons to move around the circuit

The unit of voltage is the volt

Voltage is measured using a voltmeter or a multi-meter set to measure voltage

Resistance

Resistance is a measure of how much a material resists the flow of electric current. The excess current is generally lost as heat.

When the resistor consumes energy it causes a drop in electric potential or a voltage drop in the circuit.

Gold and copper have very low resistance

Glass has very high resistance.

If the material has a very high resistance to the flow of electrons it is called an insulator

If a material has very low resistance it is called a conductor

An electric kettle makes use of this to heat water

The unit of resistance is the Ohm

Resistance is measured using an Ohmmeter or a multi-meter set to measure Ohms

|  |  |  |  |
| --- | --- | --- | --- |
| Quantity | Symbol | Unit of measurement | Unit Abbreviation |
| Current | I |  | A |
| Voltage | E or V | Volt | V |
| Resistance | R | Ohm | Ω |

Ohms Law

An equation which represents the relationship between current, voltage, and resistance for a DC circuit

Discovered by Georg Simon Ohm and published in his 1827 paper, The Galvanic Circuit Investigated Mathematically

V = IR

V = Voltage

I = Current

R = Resistance

Given any two we can find the missing value

Capacitors

Stores electricity in the form of electric charge

Not used for long periods of storage like batteries

Capacitance is a measure of the amount of charge that a capacitor can store

The unit of capacitance is the farad (F)

Used in volatile memory (RAM) in computers

Used in touch screen devices

Power off indicators – when you turn off an electrical device and the light stays on for a few seconds before going out

Transistors – second generation of computers

A tiny electronic switch which allows a small current to “switch on” a much larger current. They are generally used as switches and amplifiers

Replace vacuum tubes – 1st generation of computers

Revolutionised computing:

More reliable

Energy efficient

Cost effective

Easier to manufacture

Could do the same job as a vacuum tube

Allowed supercomputers to be developed

CPU

Made up of lots of combinations of logic gates

Logic gates allow the CPU to carry out Boolean operations on binary code

Each logic gate has one or more inputs and only one output

Each logic gate consists of a particular circuit of transistors

There are billions of transistors in a CPU