Chapter 01

Computing

Computing is any goal-oriented activity requiring, benefiting from, or creating [computing machinery](https://en.wikipedia.org/wiki/Computer). It includes the study and experimentation of [algorithmic](https://en.wikipedia.org/wiki/Algorithm) processes, and development of both [hardware](https://en.wikipedia.org/wiki/Computer_hardware) and [software](https://en.wikipedia.org/wiki/Software). Computing has scientific, engineering, mathematical, technological and social aspects. Major computing disciplines include [computer engineering](https://en.wikipedia.org/wiki/Computer_engineering), [computer science](https://en.wikipedia.org/wiki/Computer_science), [cybersecurity](https://en.wikipedia.org/wiki/Cybersecurity), [data science](https://en.wikipedia.org/wiki/Data_science), [information systems](https://en.wikipedia.org/wiki/Information_systems), [information technology](https://en.wikipedia.org/wiki/Information_technology) and [software engineering](https://en.wikipedia.org/wiki/Software_engineering).[[2]](https://en.wikipedia.org/wiki/Computing#cite_note-2)

The term computing is also [synonymous](https://en.wikipedia.org/wiki/Synonymous) with counting and calculating. In earlier times, it was used in reference to the action performed by [mechanical computing machines](https://en.wikipedia.org/wiki/Mechanical_computer), and before that, to human computers.[[3]](https://en.wikipedia.org/wiki/Computing#cite_note-3)

A computer is a [machine](https://en.wikipedia.org/wiki/Machine) that manipulates [data](https://en.wikipedia.org/wiki/Data_%28computing%29) according to a set of instructions called a [computer program](https://en.wikipedia.org/wiki/Computer_program). The program has an executable form that the computer can use directly to execute the instructions. The same program in its human-readable source code form, enables a programmer to study and develop a sequence of steps known as an [algorithm](https://en.wikipedia.org/wiki/Algorithm). Because the instructions can be carried out in different types of computers, a single set of source instructions converts to machine instructions according to the [CPU](https://en.wikipedia.org/wiki/Central_processing_unit) type.

The execution [process](https://en.wikipedia.org/wiki/Process_%28computing%29) carries out the instructions in a computer program. Instructions express the computations performed by the computer. They trigger sequences of simple actions on the executing machine. Those actions produce effects according to the [semantics](https://en.wikipedia.org/wiki/Formal_semantics_of_programming_languages) of the instructions.

### Computer hardware

Computer hardware includes the physical parts of a computer, including [central processing unit](https://en.wikipedia.org/wiki/Central_processing_unit), [memory](https://en.wikipedia.org/wiki/Computer_memory) and [input/output](https://en.wikipedia.org/wiki/Input/output). [Computational logic](https://en.wikipedia.org/wiki/Computational_logic) and [computer architecture](https://en.wikipedia.org/wiki/Computer_architecture) are key topics in the field of computer hardware.

### Computer software

Computer software, or just *software*, is a collection of computer programs and related [data](https://en.wikipedia.org/wiki/Data), which provides instructions to a [computer](https://en.wikipedia.org/wiki/Computer). Software refers to one or more computer programs and data held in the storage of the computer. It is a set of *programs, procedures, algorithms,* as well as its *documentation* concerned with the operation of a data processing system. Program software performs the [function](https://en.wikipedia.org/wiki/Function_%28engineering%29) of the [program](https://en.wikipedia.org/wiki/Computer_program) it implements, either by directly providing [instructions](https://en.wikipedia.org/wiki/Instruction_%28computer_science%29) to the computer hardware or by serving as input to another piece of software. The [term](https://en.wikipedia.org/wiki/Terminology) was coined to contrast with the old term [*hardware*](https://en.wikipedia.org/wiki/Computer_hardware) (meaning physical devices). In contrast to hardware, software is intangible.[[15]](https://en.wikipedia.org/wiki/Computing#cite_note-15)

Software is also sometimes used in a more narrow sense, meaning application software only.

#### System software

System software, or systems software, is computer software designed to operate and control computer hardware, and to provide a platform for running application software. System software includes [operating systems](https://en.wikipedia.org/wiki/Operating_system), [utility software](https://en.wikipedia.org/wiki/Utility_software), [device drivers](https://en.wikipedia.org/wiki/Device_driver), [window systems](https://en.wikipedia.org/wiki/Window_system), and [firmware](https://en.wikipedia.org/wiki/Firmware). Frequently used development tools such as [compilers](https://en.wikipedia.org/wiki/Compiler), [linkers](https://en.wikipedia.org/wiki/Linker_%28computing%29), and [debuggers](https://en.wikipedia.org/wiki/Debugging) are classified as system software.[[16]](https://en.wikipedia.org/wiki/Computing#cite_note-16) [System software](https://en.wikipedia.org/wiki/System_software) and [middleware](https://en.wikipedia.org/wiki/Middleware) manage and integrate a computer's capabilities, but typically do not directly apply them in the performance of tasks that benefit the user, unlike application software.

[*Application software*](https://en.wikipedia.org/wiki/Application_software)

Application software, also known as an *application* or an *app*, is [computer software](https://en.wikipedia.org/wiki/Computer_software) designed to help the user perform specific tasks. Examples include [enterprise software](https://en.wikipedia.org/wiki/Enterprise_software), [accounting software](https://en.wikipedia.org/wiki/Accounting_software), [office suites](https://en.wikipedia.org/wiki/Office_suite), [graphics software](https://en.wikipedia.org/wiki/Graphics_software) and [media players](https://en.wikipedia.org/wiki/Media_player_%28application_software%29). Many application programs deal principally with [documents](https://en.wikipedia.org/wiki/Document_file_format).[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)] Apps may be [bundled](https://en.wikipedia.org/wiki/Product_bundling) with the computer and its system software, or may be published separately. Some users are satisfied with the bundled apps and need never install additional applications. The system software manages the hardware and serves the application, which in turn serves the user.

Application software applies the power of a particular [computing platform](https://en.wikipedia.org/wiki/Computing_platform) or system software to a particular purpose. Some apps, such as [Microsoft Office](https://en.wikipedia.org/wiki/Microsoft_Office), are developed in multiple versions for several different platforms; others have narrower requirements and are generally referred to by the platform they run on. For example, a [*geography*](https://en.wikipedia.org/wiki/Geographic_information_system)*application for*[*Windows*](https://en.wikipedia.org/wiki/Microsoft_Windows) or an [*Android*](https://en.wikipedia.org/wiki/Android_%28operating_system%29)*application for*[*education*](https://en.wikipedia.org/wiki/Educational_software) or [*Linux gaming*](https://en.wikipedia.org/wiki/Linux_gaming). Applications that run only on one platform and increase the desirability of that platform due to the popularity of the application, known as [killer applications](https://en.wikipedia.org/wiki/Killer_application).[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]

Computers in Society

Computers are fast becoming a primary need in society. Twenty years ago, very few people in Sri Lanka had the opportunity to have even seen a computer. Today, computers are used by individuals as well as organizations on a day-to-day basis.

Some of the common uses of computers are

Word processing

Typing of letters

Typing of reports

Spreadsheet applications

Accounts applications

Presentations

Preparation of lectures

Databases

Accounts systems

To store data about payments

To store data about receipts

Registration systems

University student information systems

Advantages of using Computers

High speed

Can process large amounts of data

Easy to find data

"Who invented the computer?" is not a question with a simple answer. The real answer is that many inventors contributed to the history of computers and that a computer is a complex piece of machinery made up of many parts, each of which can be considered a separate invention.

In 1936, Conrad Zeus invented the first freely programmable computer. Then, in 1944 Howard Aiken and Grace Hopper invented the ‘Harvard Mark I’ computer. After that, the number of new inventions that contributed to the present day computer are innumerable

Chapter 02

Computer Architecture

In computer engineering, computer architecture is a description of the structure of a computer system made from component parts.[1] It can sometimes be a high-level description that ignores details of the implementation.[2] At a more detailed level, the description may include the instruction set architecture design, microarchitecture design, logic design, and implementation.[3]

Instruction set architecture

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An instruction set architecture (ISA) is the interface between the computer's software and hardware and also can be viewed as the programmer's view of the machine. Computers do not understand high-level programming languages such as Java, C++, or most programming languages used. A processor only understands instructions encoded in some numerical fashion, usually as binary numbers. Software tools, such as compilers, translate those high level languages into instructions that the processor can understand.

Besides instructions, the ISA defines items in the computer that are available to a program—e.g., data types, registers, addressing modes, and memory. Instructions locate these available items with register indexes (or names) and memory addressing modes.

The ISA of a computer is usually described in a small instruction manual, which describes how the instructions are encoded. Also, it may define short (vaguely) mnemonic names for the instructions. The names can be recognized by a software development tool called an assembler. An assembler is a computer program that translates a human-readable form of the ISA into a computer-readable form. Disassemblers are also widely available, usually in debuggers and software programs to isolate and correct malfunctions in binary computer programs.

ISAs vary in quality and completeness. A good ISA compromises between programmer convenience (how easy the code is to understand), size of the code (how much code is required to do a specific action), cost of the computer to interpret the instructions (more complexity means more hardware needed to decode and execute the instructions), and speed of the computer (with more complex decoding hardware comes longer decode time). Memory organization defines how instructions interact with the memory, and how memory interacts with itself.

During design emulation, emulators can run programs written in a proposed instruction set. Modern emulators can measure size, cost, and speed to determine whether a particular ISA is meeting its goals.

Computer organization

Microarchitecture

Computer organization helps optimize performance-based products. For example, software engineers need to know the processing power of processors. They may need to optimize software in order to gain the most performance for the lowest price. This can require quite a detailed analysis of the computer's organization. For example, in an SD card, the designers might need to arrange the card so that the most data can be processed in the fastest possible way.

Computer organization also helps plan the selection of a processor for a particular project. Multimedia projects may need very rapid data access, while virtual machines may need fast interrupts. Sometimes certain tasks need additional components as well. For example, a computer capable of running a virtual machine needs virtual memory hardware so that the memory of different virtual computers can be kept separated. Computer organization and features also affect power consumption and processor cost.

Implementation

Once an instruction set and micro-architecture have been designed, a practical machine must be developed. This design process is called the implementation. Implementation is usually not considered architectural design, but rather hardware design engineering. Implementation can be further broken down into several steps:

Logic implementation designs the circuits required at a logic-gate level.

Circuit implementation does transistor-level designs of basic elements (e.g., gates, multiplexers, latches) as well as of some larger blocks (ALUs, caches etc.) that may be implemented at the logic-gate level, or even at the physical level if the design calls for it.

Physical implementation draws physical circuits. The different circuit components are placed in a chip floor plan or on a board and the wires connecting them are created.

Design validation tests the computer as a whole to see if it works in all situations and all timings. Once the design validation process starts, the design at the logic level are tested using logic emulators. However, this is usually too slow to run a realistic test. So, after making corrections based on the first test, prototypes are constructed using Field-Programmable Gate-Arrays (FPGAs). Most hobby projects stop at this stage. The final step is to test prototype integrated circuits, which may require several redesigns.

For CPUs, the entire implementation process is organized differently and is often referred to as CPU design.

Computer Network

A computer network is a set of computers sharing resources located on or provided by network nodes. The computers use common communication protocols over digital interconnections to communicate with each other. These interconnections are made up of telecommunication network technologies, based on physically wired, optical, and wireless radio-frequency methods that may be arranged in a variety of network topologies.

The nodes of a computer network can include personal computers, servers, networking hardware, or other specialized or general-purpose hosts. They are identified by network addresses, and may have hostnames. Hostnames serve as memorable labels for the nodes, rarely changed after initial assignment. Network addresses serve for locating and identifying the nodes by communication protocols such as the Internet Protocol.

Computer networks may be classified by many criteria, including the transmission medium used to carry signals, bandwidth, communications protocols to organize network traffic, the network size, the topology, traffic control mechanism, and organizational intent[citation needed].

Computer networks support many applications and services, such as access to the World Wide Web, digital video, digital audio, shared use of application and storage servers, printers, and fax machines, and use of email and instant messaging applications.

Network topology

Common network topologies

The physical or geographic locations of network nodes and links generally have relatively little effect on a network, but the topology of interconnections of a network can significantly affect its throughput and reliability. With many technologies, such as bus or star networks, a single failure can cause the network to fail entirely. In general, the more interconnections there are, the more robust the network is; but the more expensive it is to install. Therefore, most network diagrams are arranged by their network topology which is the map of logical interconnections of network hosts.

Common layouts are:

Bus network: all nodes are connected to a common medium along this medium. This was the layout used in the original Ethernet, called 10BASE5 and 10BASE2. This is still a common topology on the data link layer, although modern physical layer variants use point-to-point links instead, forming a star or a tree.

Star network: all nodes are connected to a special central node. This is the typical layout found in a small switched Ethernet LAN, where each client connects to a central network switch, and logically in a wireless LAN, where each wireless client associates with the central wireless access point.

Ring network: each node is connected to its left and right neighbor node, such that all nodes are connected and that each node can reach each other node by traversing nodes left- or rightwards. Token ring networks, and the Fiber Distributed Data Interface (FDDI), made use of such a topology.

Mesh network: each node is connected to an arbitrary number of neighbors in such a way that there is at least one traversal from any node to any other.

Fully connected network: each node is connected to every other node in the network.

Tree network: nodes are arranged hierarchically. This is the natural topology for a larger Ethernet network with multiple switches and without redundant meshing.

The physical layout of the nodes in a network may not necessarily reflect the network topology. As an example, with FDDI, the network topology is a ring, but the physical topology is often a star, because all neighboring connections can be routed via a central physical location. Physical layout is not completely irrelevant, however, as common ducting and equipment locations can represent single points of failure due to issues like fires, power failures and flooding.

Overlay network

A sample overlay network

An overlay network is a virtual network that is built on top of another network. Nodes in the overlay network are connected by virtual or logical links. Each link corresponds to a path, perhaps through many physical links, in the underlying network. The topology of the overlay network may (and often does) differ from that of the underlying one. For example, many peer-to-peer networks are overlay networks. They are organized as nodes of a virtual system of links that run on top of the Internet.

Overlay networks have been around since the invention of networking when computer systems were connected over telephone lines using modems before any data network existed.

The most striking example of an overlay network is the Internet itself. The Internet itself was initially built as an overlay on the telephone network. Even today, each Internet node can communicate with virtually any other through an underlying mesh of sub-networks of wildly different topologies and technologies. Address resolution and routing are the means that allow mapping of a fully connected IP overlay network to its underlying network.

Another example of an overlay network is a distributed hash table, which maps keys to nodes in the network. In this case, the underlying network is an IP network, and the overlay network is a table (actually a map) indexed by keys.

Overlay networks have also been proposed as a way to improve Internet routing, such as through quality of service guarantees achieve higher-quality streaming media. Previous proposals such as IntServ, DiffServ, and IP multicast have not seen wide acceptance largely because they require modification of all routers in the network. On the other hand, an overlay network can be incrementally deployed on end-hosts running the overlay protocol software, without cooperation from Internet service providers. The overlay network has no control over how packets are routed in the underlying network between two overlay nodes, but it can control, for example, the sequence of overlay nodes that a message traverses before it reaches its destination[citation needed].

For example, Akamai Technologies manages an overlay network that provides reliable, efficient content delivery (a kind of multicast). Academic research includes end system multicast,[29] resilient routing and quality of service studies, among others.