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1 HISTORY OF COMPUTERS

Computer generations are based on when major technological changes in computers occurred, like the use of vacuum tubes, transistors, and the microprocessor. As of 2020, there are five generations of the computer:

- First generation (1940– 1956)
- Second generation (1956 – 1963)
- Third generation (1964 – 1971)
- Fourth generation (1972 – 2010)
- Fifth generation (2010 – present)

First generation (1940 – 1956)

The first generation of computers used vacuum tubes as a major piece of technology. Vacuum tubes were widely used in computers from 1940 through 1956. Vacuum tubes were larger components and resulted in first generation computers being quite large in size, limited to basic calculations, taking up a lot of space in a room. Some of the first-generation computers took up an entire room. The input method of these computers was a machine language known as the 1GL or the first-generation language. The physical methods of using punch cards, paper tape, and magnetic tape were used to enter data into these computers.

The ENIAC is a great example of a first-generation computer. It consisted of nearly 20,000 vacuum tubes, as well as 10,000 capacitors and 70,000 resistors. It weighed over 30 tons and took up a lot of space, requiring a large room to house it. Other examples of first-generation computers include the EDSAC, IBM 701, and Manchester Mark 1.

Second generation (1956 – 1963)

The second generation of computers saw the use of transistors instead of vacuum tubes. These made them far more compact than the first-generation computers. Transistors were widely used in computers from 1956 to 1963. Transistors were

smaller than vacuum tubes and allowed computers to be smaller in size, faster in speed, and cheaper to build.

The first computer to use transistors was the TX-0 and was introduced in 1956. Other computers that used transistors include the IBM 7070, Philco Transac S-1000, and RCA 501. The inputs for these computers were higher level languages like COBOL, FORTRAN etc. In these computers, primary memory was stored on the magnetic cores and magnetic tape and they used magnetic disks as secondary storage devices. Examples of the second-generation computers include IBM 1620, IBM 7094, CDC 1604, CDC 3600, UNIVAC 1108. As a result, they worked on AC and therefore were faster than their predecessors.

Third generation (1964 1971)

The third generation of computers introduced the use of IC (integrated circuits) in computers. Using ICs in computers helped reduce the size of computers even more compared to second-generation computers, as well as make them faster.

An integrated circuit is a small device that can contain thousands and thousands of devices like transistors, resistances and other circuit elements that make up a computer. Jack Kilby is credited with the invention of the Integrated Circuit or the IC chips. With the invention of IC's, it became possible to fit thousands of circuit elements into a small region and hence the size of the computers eventually became smaller and smaller. Nearly all computers since the mid to late 1960s have utilized IC's. While the third generation is considered by many people to have spanned from 1964 to 1971, ICs are still used in computers today.

Another salient feature of these computers was that they were much more reliable and consumed far less power. The input languages for such computers were COBOL, FORTRAN-II up to FORTRAN-IV, PASCAL, ALGOL-68, BASIC, etc. These languages were much better and could represent more information. Consequently, more and more complex calculations are possible.

Fourth generation (1972 2010)

The fourth generation of computers took advantage of the invention of the microprocessor, more commonly known as a CPU. Microprocessors, along with

integrated circuits, helped make it possible for computers to fit easily on a desk and for the introduction of the laptop.

Some of the earliest computers to use a microprocessor include the Altair 8800, IBM 5100, and Micral. Today's computers still use a microprocessor, despite the fourth generation being considered to have ended in 2010.

Fourth Generation of computers was between 1971 and 1980. These computers used the VLSI technology or the Very Large Scale Integrated (VLSI) circuit technology. Intel was the first company to develop a microprocessor. The first “personal computer” or PC developed by IBM, belonged to this generation. VLSI circuits had almost about 5000 transistors on a very small chip and were capable of performing many high-level tasks and computations. These computers were thus very compact and thereby required a small amount of electricity to run.

This generation of computers had the first “supercomputers” that could perform many calculations accurately. They were also used in networking and also used higher and more complicated languages as their inputs. The computer languages like languages like C, C+, C++, DBASE etc. were the input for these computers.

Fifth generation (2010 to present)

This is the present generation of computers and is the most advanced one. The generation began somewhere around 1981 and is the present generation of computers. The methods of input include the modern high-level languages like Python, R, C#, Java etc. These are extremely reliable and employ the ULSI or the Ultra Large Scale Integration technology. These computers are at the frontiers of the modern scientific calculations and are used to develop the Artificial Intelligence or AI components that will have the ability to think for themselves.

One of the more well-known examples of AI in computers is IBM's Watson, which was featured on the TV show Jeopardy as a contestant. Other better-known examples include Apple's Siri on the iPhone and Microsoft's Cortana on Windows 8 and Windows 10 computers. The Google search engine also utilizes AI to process user searches.

2 TYPES OF COMPUTERS AND THEIR USE

Mainframe computers

A mainframe is the most powerful type of computer. It can process and store large amounts of data. It supports multiple users at the same time and can support more simultaneous processes than a PC. The central system is a large server connected to hundreds of terminals over a network. Mainframes are used for large-scale computing purposes in banks, big companies and universities.

Supercomputers

Supercomputers are also very powerful, but unlike mainframes, people typically only use them for one, complex task. All of the computer's resources are thrown at that one task to help find a solution. To deserve all that work, that task is usually a big one: something researchers are using to simulate and model some big, hairy problem. Problems like these usually take multiple years to solve. We're talking about things like simulating flight and processing climate patterns.

Desktop PC

A desktop PC has its own processing unit, monitor and keyboard. It is used as a personal computer in the home or as a workstation for group work. It's designed to be placed on your desk.

Laptops

A laptop is a lightweight computer that you can transport easily. It can work as fast as a desktop PC, with similar processors, memory capacity and disk drives, but it is portable and has a smaller screen. Instead of a mouse, they have a touchpad built into the keyboard. They come with battery packs, which let you use the computer when there are no electrical outlets available.

Tablet

A tablet is an even more portable computer that has a touch screen instead of a keyboard.

Smartphone

Smartphone is a portable version of a table that also can receive calls.

Wearable computers

A wearable computer runs on batteries and is worn on the user's body. It is designed for mobile or hands-free operation.

3 CPU

3.1 Components of the CPU

The central processing unit (CPU), also called processor, is the electronic circuitry within a computer that executes instructions that make up a computer program and controls the operation of all parts of the computer.

The processor consists of three main parts:

- The control unit examines the instructions in the user's program, interprets each instruction and causes the circuits and the rest of the components – monitor, disk drives, etc. – to execute the functions specified.
- The arithmetic logic unit (ALU) performs mathematical calculations (addition, subtraction, division and multiplication) and logical operations (AND, OR, NOT).
- The registers are high-speed units of memory used to store and control data. One of the registers (the program counter, or PC) keeps track of the next instruction to be performed in the main memory. The other (the instruction register of IR) holds the instruction that is being executed.

3.2 What is clock speed?

The performance of the CPU has a major impact on the speed at which programs are loaded and how smoothly they run. There are a few different ways to measure processor performance, but clock speed is one of the most significant. The CPU processes many instructions from different programs every second and the clock speed determines the number of cycles the CPU executes per second. Clock speed of modern CPUs is measured in GHz (gigahertz). For example, a CPU with a clock speed of 3.2 GHz executes 3.2 billion cycles per second.

In general, a higher clock speed means a faster CPU, but other factors should be taken into consideration as well. Since different CPU designs handle instructions differently, it's best to compare clock speeds within the same CPU brand and generation.

For example, a CPU with a higher clock speed from five years ago might be outperformed by a new CPU with a lower clock speed, as the newer architecture deals with instructions more efficiently. An X-series Intel processor might outperform a K-series processor with a higher clock speed, because it splits tasks between more cores and features a larger CPU cache. But within the same generation of CPUs, a processor with a higher clock speed will generally outperform a processor with a lower clock speed.

4 HOW CAN DATA BE STORED?

4.1 Cache memory

Most PCs are held back not by the speed of their main processor, but by the time it takes to move data in and out of the memory. One of the most important techniques for getting around this bottleneck is the memory cache.

The idea is to use a small number of very fast memory chips as a buffer or cache between main memory and the processor. Whenever the processor needs to read data it looks in this cache area first. If it finds the data in the cache then this counts as a ‘cache hit’ and the processor need not go through the more laborious process of reading data from the main memory. Only if the data is not in the cache does it need to access main memory, but it copies in the process whatever it finds into the cache so that it is there ready for the next time it is needed. The whole process is controlled by a group of logic circuits called the cache controller.

One of the cache controller’s main jobs is to look after ‘cache coherency’ which means ensuring that any changes are reflected within the cache and vice versa. There are several techniques for achieving this, the most obvious being the processor to write directly to both the cache and the main memory at the same time. This is known as a ‘write-through’ cache and is the safest solution, but also is the slowest.

The main alternative is the ‘write-back’ cache which allows the processor to write changes only to the cache and not to main memory. Cache entries that have changed are flagged as a ‘dirty’ telling to the cache controller to write their contents back to the main memory before using the space to cache new data. A write back cache speeds up the write process, but does require a more intelligent cache controller.

Most cache controllers move a ‘line’ of data rather than just a single item each time they need to transfer data between main memory and the cache. This tends to improve the cache of cache hit as most programs spend their time stepping through instructions stored sequentially in memory, rather than jumping about from one area to another. The amount of data transferred each time is known as a ‘line size’.

4.2 RAM, ROM, HDD, SSD

RAM and ROM

The programs and data which pass through the processor must be loaded into the main memory in order to be processed Therefore, when the user runs a program, the

CPU looks for it on the hard disk and transfers a copy into the RAM chips. RAM (random access memory) is volatile — that is, its information is lost when the computer is turned off. However, ROM (read only memory) is non-volatile, containing instructions and routines for the basic operations of the CPU. The BIOS (basic input/output system) uses ROM to control communication with peripherals. RAM capacity can be expanded by adding extra chips, usually contained in small circuit boards called dual in-line memory modules (DIMMs).

Magnetic storage

Magnetic storage devices store data by magnetizing particles on a disk or tape.

A floppy disk is so called because it consists of a flexible sheet of plastic, coated with iron oxide – a magnetizable material. A floppy disk drive spins at 360 revolutions per minute (rpm), so it's relatively slow. However, a hard drive spins at over 7200 rpm and stores data on a stack of metal rotating disks called platters. This means you can store much more data and retrieve information much faster.

New disks need to be formatted before you can use them, unless they come preformatted from the manufacturer. When the disk is formatted, the operating system organizes the disk surface into circular tracks and divides each track into sectors. The OS creates a directory which will record the specific location of files. When you save a file, the OS moves the read/write head of the drive towards empty sectors, records the data and writes an entry for the directory. Later on, when you open that file, the OS looks for its entry in the directory, moves the read/write heads to the correct sector, and reads the file in the RAM area. However, formatting erases any existing files on a disk, so do not format disks on which data that you don't want to lose is stored.

The OS allows you to create one or more partitions on your hard drive, in effect dividing it into several logical parts. Partitions let you install more than one operating system (e.g. Windows and Linux) on your computer. You may also decide to split your hard drive because you want to store the OS and programs on one partition and your data files on another; this allows you to reinstall the OS when a problem occurs, without affecting the data partition.

The average time required for the read/write heads to move and find data is called seek time (or access time) and it is measured in milliseconds (ms); most hard drives have a seek time of 7 to 14 ms. Don't confuse this with transfer rate - the average speed required to transmit data from the disk to the CPU, measured in megabytes per second.

Optical storage

Optical discs can store data at much higher densities than magnetic disks. They are therefore ideal for multimedia applications where images, animation and sound occupy a lot of disc space. Furthermore, optical discs are not affected by magnetic fields, meaning that they are secure and stable, and can be transported through airport metal detectors without damaging the data. However, optical drives are slower than hard drives.

CDs and DVDs

At first sight, a DVD is similar to a CD. Both discs are 120 mm in diameter and 1.2 mm thick. They also both use a laser beam to read data. However, they are very different in internal structure and data capacity. In a DVD, the tracks are very close together, thus allowing more tracks. The pits in which data is stored are also smaller, so there are more pits per track. As a result, a CD can hold 650-700MB, whereas a basic DVD can hold 4.7GB. In addition, a DVD can be double-sided and dual layer, with a capacity of 17GB.

The DVD drive used in computers is also called a DVD burner it records information by burning via a laser to a blank DVD disc. However, a DVD recorder typically refers to a standalone unit which resembles a video cassette recorder. New DVD recorders can play all CD and DVD formats. There are also portable DVD players - handheld devices which let you watch movies or TV, play games and listen to music, wherever you are. They come with a built-in DVD drive and widescreen (rectangular 16:9 format) LCD display. They usually support multi-format playback - that is, they can play many file formats, including DVD-video, DivX, CD audio discs, MP3 music and JPEG images.

HD-DVD and Blu-ray discs

These two competing formats are expected to replace current DVD as the standard for watching movies at home. On one side are Toshiba, Microsoft and the DVD Forum, who support the High Definition-DVD (HD- DVD), Sony, Panasonic, Samsung, JVC and many movie studios are behind the Blu-ray format.

A Blu-ray disc has a capacity of 25GB (single layer), 50GB (dual layer) and 100GB (four layer). Unlike DVDs, which use a red laser to read and write data, Blu-ray uses a blue- violet laser, hence its name. Blu-ray discs can record and play back high-definition television and digital audio, as well as computer data.

Flash memory

Flash memory is a type of non-volatile memory that can be electronically erased and reprogrammed. Its name was invented by Toshiba to express how much faster it could be erased - 'in a flash', which means 'very quickly'.

Unlike RAM, which is volatile, flash memory retains the information stored in the chip when the power is turned off. This makes it ideal for use in digital cameras, laptops, network switches, video game cards, mobile phones and portable multimedia players. In addition, it offers fast read access times (although not as fast as RAM), with transfer rates of 12MB per second. Unlike ROM chips, flash memory chips are rewritable, so you can update programs via software.

Inside the chip, data is stored in several floating gate transistors, called cells. Each cell traditionally stores one bit of data (1 = erased and 0 = programmed). New devices have a multi-level cell structure so they can store more than one bit per cell. The chips are constructed with either NOR or NAND gates. NOR chips function like a computer's main memory, while NAND works like a hard drive. For example, in a camera, NOR flash contains the camera's internal software, while NAND flash is used to store the images.

SSD

A solid-state drive (SSD) is a solid-state storage device that uses integrated circuit assemblies to store data persistently, typically using flash memory, and functioning as secondary storage in the hierarchy of computer storage. It is also sometimes called a solid-state device or a solid-state disk, even though SSDs lack the

physical spinning disks and movable read–write heads used in hard disk drives (HDDs) and floppy disks.

Compared with electromechanical drives, SSDs are typically more resistant to physical shock, run silently, and have quicker access time and lower latency. SSDs store data in semiconductor cells. As of 2019, cells can contain between 1 and 4 bits of data. SSD storage devices vary in their properties according to the number of bits stored in each cell, with single bit cells ("SLC") being generally the most reliable, durable, fast, and expensive type, compared with 2 and 3-bit cells ("MLC" and "TLC"), and finally quad-bit cells ("QLC") being used for consumer devices that do not require such extreme properties and are the cheapest of the four. In addition, 3D XPoint memory (sold by Intel under the Optane brand), stores data by changing the electrical resistance of cells instead of storing electrical charges in cells, and SSDs made from RAM can be used for high speed, when data persistence after power loss is not required, or may use battery power to retain data when its usual power source is unavailable. Hybrid drives or solid-state hybrid drives (SSHDDs), such as Apple's Fusion Drive, combine features of SSDs and HDDs in the same unit using both flash memory and an HDD in order to improve the performance of frequently accessed data.

Key Differences Between Magnetic disk and Optical disk

The magnetic disk is a fixed storage device whereas optical disk is transportable storage media which is removable. Optical disk generates better signal-to-noise ratio as compared to magnetic disk. The sample rate used in the magnetic disk is lower than used in the optical disk. In the optical disk, the data is sequentially accessed. In contrast, the data in the magnetic disk is randomly accessed. Tracks in the magnetic disk are generally circular while in optical disk the tracks are constructed spirally. Optical disk allows mass replication. On the contrary, in the magnetic disk, only one disk is accessed at a time. The access time of the magnetic disk is lesser than the optical disk.

6 OPERATING SYSTEM

6.1 Operating system

The OS (operating system) is the set of computer programs that allow the user to perform basic tasks like copying, moving, saving and printing files. It also provides an interface between (i.e. provides communication between) applications programs (e.g. word processors or spreadsheets) and the computer hardware. As a user interacts with an applications program on the screen, the applications program communicates with the operating system and the operating system communicates with the computer hardware. The work of the operating system takes place in the background and is not always obvious to the user.

The most important program in an OS is the supervisor program. It remains in memory all the time that the computer is operating, and manages the OS. It loads other parts of the OS into memory when they are needed. Programs that remain in memory while the computer is in use are known as resident programs. Programs that only stay in memory while they are being used are known as non-resident programs.

Some operating systems are command driven (i.e. the user runs a program by typing a command). The screen is usually blank except for a symbol (e.g. \$) which acts as a command prompt. When the command is typed at the prompt and the Enter key is pressed, the command is processed and the output is displayed on the screen. OS commands are usually short words or abbreviations (e.g., date, logout, passwd, ls).

Unix is a command driven operating system used on all sizes of computers, but mostly large multi-user, multi-tasking mainframe computers. It is available in many versions, such as Linux, Minix, HP-UX, Xenix, Venix, Ultrix, A/UX, AIX, Solaris, and PowerOpen. Other command driven operating systems mentioned in this unit include: VAX/VMS, MVS VM OS/390, NetWare, MS. DOS and PC-DOS.

Some operating systems have a GUI (pronounced like 'goo-ey' — graphical user interface) that allows the user to use a mouse to click on icons on the screen or choose commands from a list of choices known as a menu. Operating systems with graphical interfaces mentioned in this unit include: MacOS, OS/2, Penpoint, Windows NT, Windows 3.x, Windows 9X and Windows 2000.

* An operating system has three main functions: (1) manage the computer's resources, such as the central processing unit, memory, disk drives, and printers, (2) establish a user interface, and (3) execute and provide services for applications software.

6.2 Open-source software

With open-source software, what do people think first? Money, usually because open-source software is cheaper or free. But this is not the only reason. First there is freedom from the software vendors. Organizations say that freedom is the number one reason to choose open-source software. With open-source software, an organization doesn't have to follow the software vendor's decisions. Anyone can study and modify the open-source code. With proprietary software the vendor controls software updates and users can't add features to proprietary software themselves.

Sometimes people worry about open-source operating systems. They think that some software they use won't run on open-source operating system. However, this isn't true because there is a lot of office software, such as word processors and spreadsheets for open-source operating systems. In fact, there are many kinds of this software and they work well. It is only special areas, such as graphics design, where proprietary software is clearly better.

7 APPLICATION PROGRAM

Software is the word used to refer to programs (sets of computer instructions written in a computer language) and data that is input, processed and output by a computer system. Applications programs are programs that allow the user to do various types of work on a computer e.g. word processors, databases. A set of related applications programs is referred to as a package (or suite). Common applications programs include:

- word processors for creating and editing texts;
- spreadsheets for performing calculations using formulas;
- databases for storing data so that it can be easily searched and sorted;
- graphics for drawing;
- games for playing fast action games;
- accounts for keeping business accounts;
- payroll for calculating salaries;
- presentations program for creating multimedia slide shows;
- email for sending electronic mail messages;
- PIM (personal information manager) for keeping track of appointments, address book, task etc.;
- DTP (desktop publishing program) for creating publications to be printed by a professional printer;
- small business tools for performing various business tasks;
- website editor for creating and editing webpages;
- image editor for editing graphic images;
- developer tools for writing programs to add features to existing applications and creating integrated program systems.

Some applications programs, such as word processors, spreadsheets and databases, are commonly referred to as office programs because they are commonly

used in a typical office. Office packages (or suites) such as Microsoft Office are sets of inter-related office programs. Different versions of office suites are usually available containing different combinations of programs. Mail merging is a useful feature found in most office suites that combines a database with a word processor document to automatically produce a copy of a standard letter for each record in the database.

8 NETWORKS

8.1 Network topologies

A network is a collection of computers, servers, mainframes, network devices, peripherals, or other devices connected to one another to allow the sharing of data. An example of a network is the Internet, which connects millions of people all over the world. Typical network configurations include the bus topology, mesh topology, ring topology, star topology, tree topology and hybrid topology. In general, the more interconnections there are, the more robust the network is; but the more expensive it is to install. Let's have a look at the distinct features of the network topologies mentioned above:

- **Bus network:** all nodes are connected to a single cable that acts as the backbone of the entire network. There is no limit to the number of nodes that can be connected to this network.
- **Star network:** all nodes are connected to a special central node. This is the typical layout found in a Wireless LAN, where each wireless client connects to the central wireless access point.
- **Ring topology:** each device/node is connected with its neighboring node forming the shape of a ring, hence its name. In ring topology, data circulates from one computer to another. The flow of data in ring topology can be unidirectional or bi-directional.

- Mesh topology: a network topology in which the infrastructure nodes (i.e. bridges, switches, and other infrastructure devices) connect directly and non-hierarchically to as many other nodes as possible.
- Tree topology: all the computers are connected like the branches of a tree. In computer networking, tree topology is known as a combination of a bus and star network topologies. The main advantages of this topology are better flexibility and scalability.
- Hybrid topology: this type includes a mix of bus topology, mesh topology, ring topology, star topology, and tree topology. The combination of topologies depends on the need of a company.

Wireless network topologies:

- Ad hoc topology: all devices connect directly to other devices in a peer-to-peer network.
- Wireless mesh: each wireless access point connects to other wireless access points to create a seamless internet connection.

Wireless networks by coverage:

- Satellites – for long distances;
- WiMAX – for connecting Wi-Fi hotspots;
- Wi-Fi – for medium-range distances;
- Bluetooth – for short distances;
- GSM – for mobile phones.

Networks by geographical area:

- PANs (personal area networks) – a laptop, a mobile phone and a PDA;
- LANs (local area networks) cover a building;
- MANs (metropolitan area networks) cover a campus or a city;
- WANs (wide area networks) cover a country or a continent.

Networks by architecture:

- Client-server network: a computer acts as a server and stores and distributes information to the other nodes, or clients.
- Peer-to-peer network: all the computers have the same capabilities – share files and peripherals without requiring a separate server computer.

8.2 Components of a network

1. A gateway is an interface enabling dissimilar networks to communicate.
2. A bridge is a hardware and software combination used to connect the same type of networks.
3. A backbone is a network transmission path handling major data traffic.
4. A router is a special computer directing messages when several networks are linked.
5. A network is a number of computers and peripherals linked together.
6. A LAN is a network connecting computers over a small distance such as within a company.
7. A server is a powerful computer storing data shared by all the clients in the network.
8. A client is a network computer used for accessing a service on a server.
9. A thin client is a simple computer comprising a processor and memory, display, keyboard, mouse and hard drives only.
10. A hub is an electronic device connecting all the data cabling in a network.

Hub vs switch vs router

A hub passes the signal to all of the connected computers inside a network. A switch passes the signal to a specific computer inside a network using MAC address. A router connects multiple networks and sends packets to computers outside of the local network.

9 THE INTERNET

9.1 Access to the internet

DSL

Digital Subscriber Line (DSL) is a high-speed Internet connection, which utilizes the standard telephone lines, but allows digital signals to be carried rather than analogue. It allows the full bandwidth of the copper twisted-pair telephone cabling to be utilized. The DSL signal is pulled out from the phone line as it enters the premises and is wired separately to a DSL modem. DSL service can be delivered simultaneously with wired telephone service through the same telephone line since DSL uses higher frequency bands for data transmission.

The most commonly installed DSL technology for Internet access is ADSL (Asymmetric Digital Subscriber Line). It is asymmetric because the download speed is faster than upload speed. DSL-based services are a low-cost option when compared to other solutions offering similar bandwidth, so they can be made available to customers at extremely competitive prices.

Although DSL makes use of telephone cabling, it should not be confused with the dial-up connection of yesteryear. A dial-up connection to the Internet is set up by dialing a phone number, hence the name. Since the same frequency is used to carry voice and data signals over the copper telephone wire, only one service can be provided at a time and it is impossible to use the phone to make calls and browse the Internet at the same time.

* SDSL (symmetric digital subscriber line) – upload and download speeds are the same

VDSL (very high bit rate digital subscriber line) – runs on copper wire and only made for short distances

Cable Internet

Cable Internet is a form of broadband Internet access that uses the infrastructure of cable TV networks to provide Internet services. It is integrated into the cable television infrastructure analogously to DSL, which uses the existing telephone network. Since TV itself takes up only a small portion of the cable's bandwidth, it leaves room for Internet access to be provided through the same network.

First, your Internet Service Provider sends a data signal through the coaxial cable into your home — specifically, to a cable modem. The cable modem then connects to your computer and other devices via an Ethernet cable or through Wi-Fi network using a Wi-Fi router.

A cable connection is highly reliable and is not subject to outages due to storms, like satellite Internet. However, since residential cable Internet access is provided through shared bandwidth, which everyone in the neighborhood uses, the speed can be slower during peak usage hours when a lot of Internet users are online. This does not happen with a DSL network, which keeps a consistent Internet signal because each subscriber has their own dedicated line.

Fiber-optic Internet

Fiber-optic Internet uses fiber-optic cables instead of copper wires and it is incredibly fast. Those cables send data to and from a computer by harnessing the power of light and can carry data over long distances with low attenuation and distortion of the light signal. That light signal uses binary system to communicate with computers. The presence of light indicates a binary one and the absence of light indicates a binary zero. Fiber-optic cables transfer data faster than copper wiring, which means faster load times and higher-quality streaming.

Wireless connection

The three wireless technologies widely used today are Wi-Fi, cellular and satellite Internet. Wi-Fi uses radio waves to wirelessly connect devices and is commonly applied for local area networking. To get access to the Internet, a device (a tablet or a smartphone) has to be connected over Wi-Fi to a wireless router.

Internet over Satellite usually allows a user to access the Net via a geostationary satellite that orbits the Earth. As signals must travel long distances from the Earth up to the satellite and back again, it may cause a delay between the request and the answer. However, modern technologies make it possible to minimize this latency. Thus, satellite Internet access can provide high-speed Internet where the conventional cable or DSL is either not available or not functioning well. To get access to the Internet, one needs a satellite dish for two-way (upload and download) data communications and a modem.

A cellular network is a communication network distributed over land areas called "cells". Each cell has at least one fixed-location transceiver, but more commonly, there are three cell sites. These base stations (cell towers) provide a cell with the network coverage, which can be used for transmission of voice and data. A cell typically uses a different set of frequencies from the neighboring cells to avoid interference and provide guaranteed service quality within each cell.

9.2 Packet switching

Switching – selecting a path that data must take out of the available options.

Switching types:

1. Circuit switching: a circuit is established between the two ends, which provides a path for data to travel from one end to another; intermediate switches are connected by the physical link; as soon as data reaches the destination, the circuit is disconnected. Data travels without delay at any switch, but channel is blocked for duration of transmission and time required for establishing the circuit is long.
2. Packet switching: message is divided into multiple packets (packetization); there are two types of packet switching:
 - a. Virtual circuit switching: first packet informs all intermediate switches about following packets and reserves resources for them.

- b. Datagram switching: each packet is treated as separate entity and routed independently through the network.

Packet switching is more cost effective and uses less bandwidth, but it is unsuitable for applications that require no delay in transmission of data.

9.3 How does the internet work

1. PC connects to the web through a modem or router
2. Web address from PC goes to internet provider
3. Browser looks for IP address of the target server through DNS (domain name server)
4. Browser sends an HTTP request to the target server to send a copy of the website
5. Server sends the requested web page
6. Web page loads from received packets

9.4 TCP/IP

At the heart of the Internet Protocol (IP) portion of TCP/IP is a concept called the Internet address. This 32-bit coding system assigns a number to every node on the network. There are various types of addresses designed for networks of different sizes, but you can write every address with a series of numbers that identify the major network and the sub-networks to which a node is attached. Besides identifying a node, the address provides a path that gateways can use to route information from one machine to another.

Although data-delivery systems like Ethernet or X.25 bring their packets to any machine electrically attached to the cable, the IP modules must know each other's

Internet addresses if they are to communicate. A machine acting as a gateway connecting different TCP/IP networks will have a different Internet address on each network. Internal look-up tables and software based on another standard - called Resolution Protocol - are used to route the data through a gateway between networks.

Another piece of software works with the IP-layer programs to move information to the right application on the receiving system. This software follows a standard called the User Datagram Protocol (UDP). You can think of the UDP software as creating a data address in the TCP/IP message that states exactly what application the data block is supposed to contact at the address the IP software has described. The UDP software provides the final routing for the data within the receiving system.

The Transmission Control Protocol (TCP) part of TCP/IP comes into operation once the packet is delivered to the correct Internet address and application port. Software packages that follow the TCP standard run on each machine, establish a connection to each other, and manage the communication exchanges. A data-delivery system like Ethernet doesn't promise to deliver a packet successfully. Neither IP nor UDP knows anything about recovering packets that aren't successfully delivered, but TCP structures and buffers the data flow, looks for responses and takes action to replace missing data blocks. This concept of data management is called reliable stream service.

After TCP brings the data packet into a so computer, other high-level programs handle it. Some are enshrined in official US government standards, like the File Transfer Protocol (FTP) and the Simple Mail Transfer Protocol (SMTP). If you use these standard protocols on different kinds of computers, you will at least have ways of easily transferring files and other kinds of data.

Conceptually, software that supports the TCP protocol stands alone. It can work with data received through a serial port, over a packet-switched network, or from a network system like Ethernet. TCP software doesn't need to use IP or UDP, it doesn't even have to know they exist. But in practice TCP is an integral part of the TCP/IP picture, and it is most frequently used with those two protocols.

10 COMPUTER LANGUAGES

Unfortunately for us, computers can't understand spoken English or any other natural language. The only language they can understand directly is machine code, which consists of 1s and 0s (binary code).

Machine code is too difficult to write. For this reason, we use symbolic languages to communicate instructions to the computer. For example, assembly languages use abbreviations such as ADD, SUB, MPY to represent instructions. The program is then translated into machine code by a piece of software called an assembler.

Machine code and assembly languages are called low-level languages because they are closer to the hardware. They are quite complex and restricted to particular machines. To make the programs easier to write, and to overcome the problem of intercommunication between different types of computers, software developers designed high-level languages which are closer to the English language.

Programs written in high-level languages must be translated into machine code by a compiler or an interpreter. A compiler translates the source code into object code - that is, it converts the entire program into machine code in one go. On the other hand, an interpreter translates the source code line by line as the program is running.

It is important not to confuse programming languages with markup languages, used to create web documents. Markup languages use instructions, known as markup tags, to format and link text files.

11 SEARCH ENGINES

A search engine allows users to extract requested information from the huge database of resources available on the Internet. Internet usage has increased tremendously in the recent years with the easy-to-use search engines like Google, Bing and Yahoo! Optimizing websites for Google and other search engines is essential for

any website owner if they want to reach a larger audience. Studies suggest that when using search engines, most people do not go beyond the listings mentioned on the first couple of pages of the search engine results list.

Search engines can be classified into the following three categories:

1. Crawler-based search engines
2. Human-powered search engines
3. Meta-search engines

Crawler-based search engines

There are three basic steps that every crawler-based search engine follows before displaying search results:

- Crawling
- Indexing
- Ranking

Crawling

Crawler-based search engines create their listings automatically by using a special program known as ‘a crawler’ or ‘a spider’ to find new and updated content. Content can vary – it could be a webpage, an image, a video – but regardless of the format, content is discovered by links. For example, Googlebot starts out by fetching a few webpages and then follows the links on those webpages to find new URLs. Various data mining techniques are used to define which pages should be crawled and the crawling frequency. Every time a web crawler finds a new website through a link, it scans and passes its content for further processing (called indexing).

Indexing

Search engines process and store information they find in an index - a massive database of discovered URLs – to be retrieved later when a user enters a query. Indexing is performed by identifying the words and expressions that best describe the page. The identified words are referred to as keywords and the page is assigned to the identified keywords.

Ranking

Search engines compare the search string with the indexed pages from the database to provide the content that will best answer the user's query. The results are ordered from most relevant to least relevant. This ordering of search results by relevance is known as ranking. There are various algorithms to calculate relevancy, which is why different search engines give different search results for the same search string. These algorithms are constantly evolving to provide users with most relevant search results.

Human-powered directories

Human-powered directories depend on human editors to compile their listings. This means that they only show results for content that is added manually. Here is the way the indexing in web directories works:

- A short description along with the URL of the website is submitted to the directory for approval.
- Submitted site is then manually reviewed and added in the appropriate category or rejected for listing.
- Keywords entered in the search box will be matched with the description of the site. This means that changes made to the content of a webpage are not taken into consideration as it is only the description that matters.

Meta-search engines

A meta-search engine does not have a database of indexed pages of its own. Instead, it sends users' queries to several other search engines and compiles top results from each into one overall list. After redundancy removal, these results are processed, ranked and presented to the user. Dogpile, MetaCrawler, and SavvySearch are a few examples of such meta-search engines.

12 WEB DESIGN

12.1 Websites

A set of related webpages (hyperlinked documents in a web network system) stored on a Web server (a server computer that stores and provides access to webpages) is known as a website. A Webmaster is a person who sets up and maintains a website. The design of websites varies greatly and some are more successful than others. Features of a good website include:

1. Good webpage design.
2. A good navigation system (a way of allowing visitors to move from webpage to webpage and find their way around your website).

12.2 Creating a professional website

The website needs to be planned carefully if it is to be a success. This involves a number of stages including analyzing the demand and other related websites, designing the webpages and the overall structure of the website, publishing and advertising the website including registering it on search engines and getting other websites to create links to it, and evaluating the website after it has been published by using user feedback and statistics on the use of the website.

12.3 Web page design

HTML and web editors

The code behind most web pages is HTML (hypertext markup language), which consists of commands called tags. Tags are placed around pieces of text to tell the web browser how to display text or pictures. You can view the source HTML code of a web page by choosing the Page Source option in your web browser. But you needn't learn HTML in order to build your own website. Instead, you can use a word processor with web design capabilities or a dedicated web editor like Macromedia Dreamweaver or Microsoft FrontPage. Web editors are user-friendly and WYSIWYG (What You See Is What You Get). Different buttons and menu items let you design a page without writing HTML.

Web page elements

There are a number of different elements that you can use on a web page:

- Text – displayed in a variety of fonts and sizes. Most text files are available in two formats: HTML or PDF.
- Background – the underlying colors and patterns of a web page.
- Tables – with columns and rows used to position images and text on a page.
- Frames – rectangular areas that allow the display of different pages in the same browser window.
- Cascading Style Sheets (CSS) – a mechanism for adding styles to web documents. You could use HTML code to specify the font, text styles and background color. Nowadays, however it is more common to use CSS. This makes it easy to apply presentation changes across a website.
- Graphics, clip art, icons, background templates, wallpaper, and transparent images - common formats I are .jpg (joint photographic experts group), ideal for pictures with many colors, .gif (graphics interchange format), ideal for pictures with fewer colors, and .png (portable network graphics), which supports 16 million colors.
- Hyperlinks - highlighted text or pictures (buttons, image maps, etc.) that act as links to other pages. If you want to share information with people,

you can use RSS feeds and provide readers with a link to the feed. RSS allows subscribers to receive updates of blogs, news, podcasts, etc. Before going live, you should check that all the links work.

Audio, video and animation

Many websites now incorporate audio files, and if you're designing a site, you may like to insert songs, podcasts, etc. The most common audio formats are: .wav (Windows wave audio format), .ra (RealAudio file) and .mp3 (MPEG-I Audio Layer-3). Full-motion video is stored in these formats: .avi (audio video interleave), .mov (QuickTime movie) and .mpg (moving picture experts group). If you want to inject something special into your web pages, you can use Adobe Flash to include interactive animations and streaming audio. Additionally, you can insert Java applets — small programs that enable the creation of interactive files. Animations are made up of a series of independent pictures put together in sequence to look like moving pictures. To see or hear all these files, you must have the right plug-in, an auxiliary program that expands the capabilities of your web browser.

13 COMPUTES VIRUSES AND CRIMES

13.1 Types of malware

Viruses

The fear that a virus may infect your computer is a familiar one for many. Even casual computer users know that unfamiliar files may host viruses.

While viruses are a well-known threat, many computer users do not know their enemy. There are many specific types of viruses that one needs to guard against.

One dangerous type of virus is an overwriting virus. These viruses not only spread malicious code; they also replace the information contained in other programs. They erase important information, sometimes rendering a computer entirely unusable.

Another common virus is a resident virus. They stay dormant until a particular event activates them. If your computer harbors resident viruses, you may not discover them until the damage is done.

A Trojan horse is another destructive type of program. It's not technically a virus because it doesn't replicate itself, but it's still dangerous. A Trojan horse looks like an ordinary, useful file or program. However, it has destructive programming embedded in it. This programming may also piggyback onto beneficial files. Lastly, unlike viruses and Trojan horses, a worm does not need to attach itself to another program.

Virus vs Worm

The main difference between a virus and a worm is that viruses must be triggered by the activation of their host, whereas worms are standalone malicious programs that can self-replicate and propagate independently as soon as they have breached the system. Worms do not require activation - or any human intervention - to execute or spread their code.

Viruses are often attached or concealed in downloaded files. When the host file is accepted by a system, the virus remains dormant until the infected host file is activated. Only after the host file is activated, the virus can run, executing malicious code and replicating itself to infect other files on the computer.

In contrast, worms don't require the activation of a host file. Once a worm has entered the system, usually via a network connection, it can run, self-replicate and propagate without a triggering event. A worm makes multiple copies of itself, which then spread across the network. These copies will infect any inadequately protected computers and servers that connect - via the network or internet - to the originally infected device.

13.2 What is a virus

There are a variety of different crimes that can be committed in computing, including:

- **Spreading viruses:** distributing programs that can reproduce themselves and are written with the purpose of causing damage or causing a computer to behave in an unusual way.
- **Hacking:** gaining unauthorized access to a network system.
- **Salami shaving:** manipulating programs or data so that small amounts of money are deducted from a large number of transactions or accounts and accumulated elsewhere. The victims are often unaware of the crime because the amount taken from any individual is so small.
- **Denial of service attack:** swamping a server with large numbers of requests.
- **Trojan horse:** a technique that involves adding concealed instructions to a computer program so that it will still work but will also perform prohibited duties. In other words, it appears to do something useful but actually does something destructive in the background.
- **Trapdoors:** a technique that involves leaving, within a completed program, an illicit program that allows unauthorized -- and unknown — entry.
- **Mail bombing:** inundating an email address with thousands of messages, slowing or even crashing the server.
- **Software piracy:** unauthorized copying of a program for sale or distributing to other users.
- **Piggybacking:** using another person's identification code or using that person's files before he or she has logged off (disconnected from a network account).
- **Spoofing:** tricking a user into revealing confidential information such as an access code or a credit- card number.
- **Defacing:** changing the information shown on another person's website.
- **Hijacking:** redirecting anyone trying to visit a certain site elsewhere.

A computer virus is a program that can reproduce itself and is written with the purpose of causing damage or causing a computer to behave in an unusual way. It infects other programs i.e. it attaches itself to other programs, known as host programs, and therefore reproduces itself. It operates by replacing the first instruction in the host program with a JUMP command. This is a command that changes the normal instruction sequence in a program, causing the virus instructions to be executed (processed by the processor) before the host program instructions. When the virus has been executed, the host program is executed in the normal way.

When it attaches to operating system programs to integrate itself with the operating system (the set of programs that control the basic functions of a computer and provide communication between the applications programs and the hardware), it is said to have patched the operating system. Viruses normally attach themselves to programs that have a COM extension (e.g. command.com) that are known as command files or COM files, or to programs that have an EXE extension (e.g. explorer.exe) that are known as executable files or EXE files. A virus is loaded into memory (copied from the storage media into memory) when a program it has attached itself to is run or executed (processed by the processor). It then becomes memory resident i.e. it stays in the memory until the computer is switched off. When the virus is triggered by a predetermined event, it operates the payload (the part of the virus that causes the damage). Although a virus is the term used to describe any program that can reproduce itself, viruses usually have four main parts:

- a. a misdirection routine that enables it to hide itself
- b. a reproduction routine that allows it to copy itself to other programs
- c. a trigger that causes the payload to be activated at a particular time or when a particular event takes place
- d. a payload that may be a fairly harmless joke or may be very destructive.

A program that has a payload but does not have a reproduction routine is known as a Trojan. Each virus is given a name e.g. Love Bug and can be classified as a particular type of virus. Virus types include: logic bombs that destroy data when

triggered; boot sector viruses that store themselves in the boot sector of a disk (the part of a disk containing the programs used to start up a computer); file viruses that attach themselves to COM files; macro viruses that are small macro programs that attach themselves to word processor files and use the macro programming facilities provided in some word processor programs.

14 HOW TO PROTECT A COMPUTER FROM CRIMES AND DISASTERS

There are a variety of security measures that can be used to protect hardware (the physical components of a computer system) and software (programs and data) including:

1. **Controlling physical access** to hardware and software.
2. **Backing up** data and programs (storing a copy of files on a storage device to keep them safe).
3. **Implementing network controls** such as:
 - a. using passwords (a secret code used to control access to a network system).
 - b. installing a firewall (a combination of hardware and software used to control the data going into and out of a network; It is used to prevent unauthorized access to the network by hackers)
 - c. encrypting data (protecting data by putting it in a form only authorized users can understand)
 - d. installing a callback system (a system that automatically disconnects a telephone line after receiving a call and then dials the telephone number of the system that made the call, to reconnect the line; it is used in remote access systems to make sure that connections can only be made from permitted telephone numbers)

- e. using signature verification or biometric security devices (security devices that measure some aspect of a living being e.g. a fingerprint reader or and eye scanner).
4. **Separating and rotating the computing functions** carried out by employees and carrying out periodic audits of the system i.e. observing and recording events on the network systematically.
 5. **Protecting against natural disasters** by installing uninterruptible power supplies (battery backup systems that automatically provide power to a computer when the normal electricity source fails and surge protectors.
 6. **Protecting against viruses** by using antivirus programs (computer programs or sets of programs used to detect, identify and remove viruses from a computer system) and ensuring that all software is free of viruses before it is installed. Particular care must be taken when using public domain software (free software) and shareware (software that is free to try out but must be paid for if it is used after the trial period).

A smart card is a plastic card containing a processor and memory chip . It can be used to store large amounts of confidential data including coded data that can be used as digital cash (electronic currency that is used for making electronic purchases over the Internet). It can also be used as a security device to prevent or allow access to a system and allow a user to withdraw cash from a bank ATM (automatic teller machine — a type of machine used by banks for enabling customers to withdraw money from their bank accounts). A smart card reader is a device used for reading smart cards by detecting radio signals emitted from a radio antenna (aerial) in the form of a small coil inside the smart card.

An anti-virus program is a program that checks files for virus coding instructions inside another program and can be used for removing any virus coding instructions detected.

A backup program is a program that stores a copy of data on a storage device to keep it safe. There are different kinds of backup, including:

1. **Incremental backup** which copies all the selected files that have been created or changed since the last full, differential or incremental backup. These files are identified by the fact that their archive bit would be on. The archive bit is a digital bit stored with a file indicating if the file has been backed up since it was last edited. The archive bit is switched off when the file is backed up using a full or incremental backup.
2. **Differential backup** which copies all the files created or modified since the last full backup. The archive bit is not set to 'off' by a differential backup.
3. **Full backup** which copies all the selected files on a system, whether or not they have been edited or backed up before.

A series of incremental backups and a full backup, or the most recent differential backup and a full backup, is known as a **backup set**.

15 PROFESSIONS IN IT

There is a wide range of jobs in computing and different titles are sometimes given to the same type of job. Jobs mentioned in this unit include:

- A Webmaster — a person who administers a Web server.
- A help-desk troubleshooter a person who works as part of a telephone service that helps users solve problems that occur on computer systems.
- An applications programmer — a person who writes applications programs (computer programs designed to be used for a particular purpose e.g. word processors, spreadsheets or database programs).
- A security specialist — a person who tests the security of networks systems and advises customers how to introduce and maintain security policies including:
 - setting up secure password systems (secret codes used to control access to a network system)

- installing firewalls (a combination of hardware and software used to control the data going into and out of a network)
- keeping out hackers (skilled programmers who attempt to gain unauthorized access to network systems)
- dealing with viruses (programs written with the purpose of causing damage or causing a computer to behave in an unusual way).
- A systems programmer - a person who specialises in writing systems software (a program or set of programs that are used to control the basic functions of a computer system e.g. operating system programs).

Being employed in any of these jobs requires the person to have particular formal qualifications, personal qualities and technical skills. Qualifications mentioned in this unit include:

- Standard grades in Maths. This is a basic level school qualification in mathematics.
- HNC in Computing. This is a Higher National Certificate in computing including the study of hardware (the physical components of a computer system) and software (programs and data). This is a college qualification that can usually be obtained by a period of part-time study.
- HND in Computing Support. This is a Higher National Diploma in installing, maintaining and troubleshooting (to find and fix faults in a system) computing systems and training users. This is a higher college qualification than an HNC but not as high as a university degree. It usually requires a period of full-time study.

An IT (Information Technology) engineer is a professional who provides help for computer users by designing, building and maintaining information technology systems (systems and equipment such as computers for dealing with information). A support engineer might start out in their career by working on a help-desk (a telephone service for helping users solve problems that occur on computer systems).

An IT manager manages projects, technology and people. An IT systems manager is responsible for developing and implementing computer software that supports the operations of the business. Off-the-shelf systems are ready-made systems that are purchased from systems suppliers. In-house systems are developed by the employees of the company. A university degree is usually required but not necessarily in computing science (the study of computers and their use). The best qualification for becoming a manager is experience.

A systems analyst studies system in an organization and decides how to computerize them (change the system into one controlled by computers). They analyze requirements and report on options for using information technology (the study and practice of techniques or use of equipment for dealing with information).

A software engineer/designer produces the programs which control the internal operations of computers. They use program libraries (sets of programmed functions that are made available for use by any program) to produce programs. They also design, test and improve programs for a variety of purposes including computer-aided design and manufacture (the production of technical designs and the production of goods using machines-controlled computers).

A computer services engineering technician is responsible for installation, maintenance and repair of computers and peripherals (associated equipment). They install, test, troubleshoot, upgrade (add components to improve the features or performance of a system) and carry out routine maintenance on hardware, ranging from personal computers (a computer designed to be used by one person at a time) to mainframes (the largest and most type Of computer, usually operated by a team of professionals).

A network support person or engineer maintains the link between PCs (personal computers) and workstations (powerful desktop computers used by power users for work that requires a lot of processing e.g. graphic design) connected in a network (a number of computers and peripheral devices connected together). They use telecommunications (technology concerned with communications over long distances), software, electronic skills and knowledge of networking software to

troubleshoot systems. This may involve work with the controlling software, on the wiring, printed circuit boards (the electronic boards that hold the components of a circuit and connect them together), software or microchips (small integrated electronic circuits) on a file server (a powerful network computer that stores computer files and makes them available to users on a network), or on cables either within or outside the building.

An applications programmer writes applications programs (computer programs designed to be used for a particular purpose e.g. word processors, spreadsheets or database programs).

A systems support person is an analyst programmer (a person whose job is a combination of systems analysis and computer programming) who is responsible for maintaining, updating (bring up to date i.e. change into the latest version) and modifying the software used by a company. Some specialize in systems software (software that handles the basic operation of the computers). This involves use of machine code (computer language that consists entirely of a combination of Is and Os) and specialized low-level computer languages (computer languages, such as machine code or assembly language, that is closer to the form that a computer understands than to that of a human language). They may sort out problems encountered by users including amending an area of code (text of a program or part of a program using a computer language) in the software, retrieving files and data lost when a system crashes (fails suddenly and completely, usually referring to the failure of a hard disk).

16 FUTURE IN IT

16.1 Smaller and faster

Nanotechnology, the science of creating and using materials or devices at molecular and atomic sizes, is going to represent a new technological revolution. These

devices will fall in the range of 1 nanometer, which is equal to one billionth of a meter, to 100 nanometers (nm).

Nanobots, robots formed from molecules or molecular components, will be used in medicine to control and diagnose diseases. For example, they will be injected and will move through blood vessels destroying cholesterol molecules or cancer.

Nanocomputers, molecule-sized computers, may have the power of 100 workstations but only be the size of a grain of sand. There will be two main types of molecular computers:

- Quantum computers, based on quantum mechanics, may be millions of times faster than current computers. They will be so fast because they will be able to examine all possible answers to a query at the same time. This capability is made possible by qbits, quantum bits, which can be 0 or 1, or something in between, simultaneously.
- DNA computers will use DNA biochips to perform the same functions as silicon microchips do today but at a much faster speed.

16.2 An artificial neural network

If you have spent any time reading about artificial intelligence, you should have heard about artificial neural networks. Artificial neural networks, usually simply called neural networks, are computing systems inspired by the biological neural networks that make up animal brains. Artificial neural networks are one of the main tools used in machine learning.

As the “neural” part of their name suggests, they are brain-inspired systems which are intended to replicate the way that humans learn. Artificial neural network is based on a collection of connected units, or nodes, called artificial neurons, which simulate the neurons in a biological brain. Each connection, like the synapses in a biological brain, can transmit a signal to other neurons. An artificial neuron that

receives a signal then processes it and can signal neurons connected to it. Such neurons are usually relatively simple, but being connected in a large network, they can perform quite complex tasks.

Neural network can accomplish many tasks: from face recognition and making cars drive autonomously on the roads, to generating shockingly realistic CGI (Computer-generated image) faces, to machine translation, to fraud detection, to reading our minds, to recognizing when a cat is in the garden and turning on the sprinklers; neural nets are behind many of the biggest advances in A.I. Broadly speaking, they are designed for spotting patterns in data. Specific tasks could include classification (classifying data sets into predefined classes), clustering (classifying data into different undefined categories), and prediction (using past events to guess future ones, like the stock market or movie box office).

Neural networks are excellent tools for finding patterns which are too complex or numerous for a human programmer to extract and teach the machine to recognize. Neural networks are not programmed in the usual meaning of the word, they are trained. Training or learning is one of the main advantages of neural networks over traditional algorithms.

In the same way that we learn from experience in our lives, neural networks require data to learn. In most cases, the more data can be thrown at a neural network, the more accurate it will become. Think of it like any task you do over and over. Over time, you gradually get more efficient and make fewer mistakes.

On a technical level, one of the main challenges is the amount of time it takes to train networks, which can require a considerable amount of computing power for more complex tasks. The biggest issue, however, is that neural networks are “black boxes,” in which the user feeds in data and receives answers. They can fine-tune the answers, but they don’t have access to the exact decision-making process.

This is the problem a number of researchers are working on today, but it will only become more important as artificial neural networks play a bigger and bigger role in our lives.

How does artificial neural network work

While neural networks (also called “perceptrons”) have been around since the 1940s, it is only in the last several decades where they have become a major part of artificial intelligence. This is due to the arrival of a technique called “backpropagation”. Neural networks consist of input and output layers, as well as (in most cases) a hidden layer consisting of units that transform the input into something that the output layer can use. Backpropagation allows networks to adjust their hidden layers of neurons in situations where the outcome does not match what the creator is hoping for — like a network designed to recognize dogs, which mistakenly identifies a cat, for example.

Another important advance has been the arrival of deep learning neural networks, in which different layers of a multilayer network extract different features until it can recognize what it is looking for. For a basic idea of how a deep learning neural network learns, imagine a factory line. After the raw materials (the data set) are input, then they are passed down the conveyer belt, with each subsequent stop or layer extracting a different set of high-level features. If the network is intended to recognize an object, the first layer might analyze the brightness of its pixels.

The next layer could then identify any edges in the image, based on lines of similar pixels. After this, another layer may recognize textures and shapes, and so on. By the time the fourth or fifth layer is reached, the deep learning net will have created complex feature detectors. It can figure out that certain image elements (such as a pair of eyes, a nose, and a mouth) are commonly found together.

Once this is done, the researchers who have trained the network can give labels to the output, and then use backpropagation to correct any mistakes which have been made. After a while, the network can carry out its own classification tasks without human help.

When researchers or computer scientists set out to train a neural network, they typically divide their data into three sets. First is a training set, which helps the network establish the various weights between its nodes. After this, they fine-tune it using a validation data set. Finally, they use a test set to see if it can successfully turn the input into the desired output.

16.3 Internet of things

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or artificial object that can be assigned with an Internet Protocol (IP) address and is able to transfer data over a network.

How IoT works

An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and operate on the data they acquire from different sources. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices — for instance, to set them up, give them instructions or access the data.

IoT can also use artificial intelligence (AI) and machine learning to make data collecting processes easier and more dynamic.

Why IoT is important

The internet of things helps people to gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a real-time look into how their systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations.

IoT enables companies to automate processes and reduce labor costs. It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods, as well as offering transparency into customer transactions.