Computer Hardware and Software

Lesson 7

KEY CONCEPTS

■ Computer System ■ Primary Storage ■ Secondary Storage ■ Computer Peripherals – Inputs, Output, and Storage Devices ■ Computer Software ■ Software Trends ■ Multi-Programming ■ Multi-Processing ■ Time Sharing ■ Batch Processing ■ On-Line and Real-Time Processing ■ Application Software

Learning Objectives

To understand:

- The basic functions of hardware parts of the computer
- Identify the names and distinguishing features of different kinds of devices
- Identify the names, and distinguishing features, of memory and storage devices
- Identifies BIOS and System software
- Lists jobs of the operating system
- Features of different operating systems

Lesson Outline

AN INTRODUCTION

A computer is an electronic device that receives information and data, automatically stores it and retrieves it at any time, and uses it in a useful manner. The computer converts different types of numbers and solves intractable mathematical equations very quickly and with high accuracy.

The computer was invented in the second half of the twentieth century and now it has become the backbone of life. Some operations before the invention of the computer were very difficult, including searches and doing some arithmetic activities. In 1642 AD, the calculator was invented to facilitate arithmetic operations such as addition, subtraction, and other arithmetic operations.

Presently, in the world of digital economies, computers play an important role. Further, computer is vital in people's day to day life. It will be apt to state that computer is indispensable, and its presence has become very important and necessary in our daily life, and it has become easier for us to do many operations and activities.

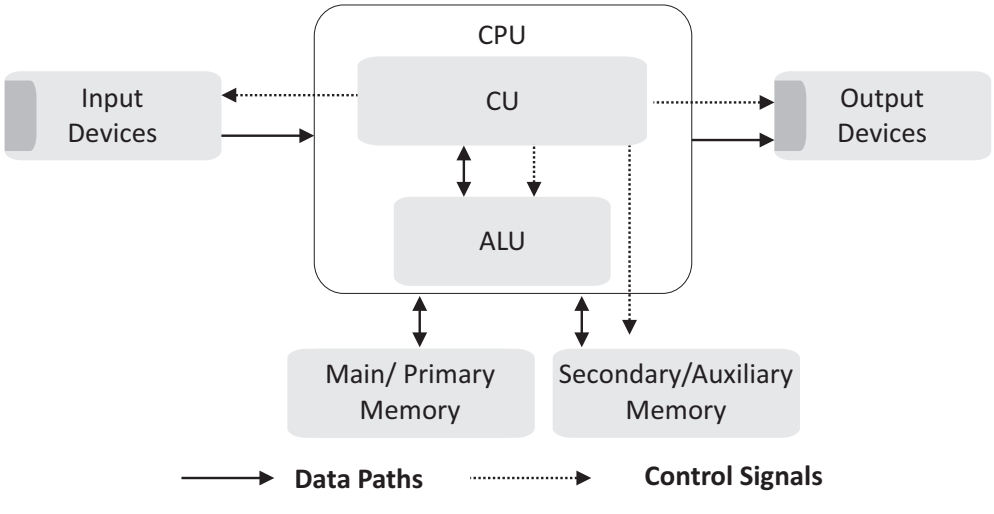
The computer has been able to invade the lives of individuals in a large way, and it is used in all areas of their lives. Computer use is common in homes, institutions, businesses, and education, it is also an integral part of the services, entertainment, and other sectors.

Based on this great position that it has enjoyed, the manufacturers have been interested in producing many shapes and types for it in line with the user's need, including the mobile device, office devices, and others.

The more advanced the device is, the more benefits will be gained from it. Hence the hardware and software are getting updated in the market time and again. One cannot understand the functioning of the computer without understanding the role of hardware and software in it. Hence this chapters dedicates to provide a clear understanding of Hardware and Software.

COMPUTER SYSTEM: CONCEPT

A computer is an electronic device that can be programmed to accept data (input), process it, and generate results (output). A computer along with additional hardware and software together is called a computer system. A computer system primarily comprises a Central Processing Unit (CPU), memory, input/output devices, and storage devices. All these components function together as a single unit to deliver the desired output. A computer system comes in various forms and sizes. It can vary from a high-end server to a personal desktop, laptop, tablet computer, or smartphone. The directed lines represent the flow of data and signal between the components.[1]



Source: https://ncerthelp.com/

1. Reproduced from https://ncert.nic.in/textbook/pdf/kecs101.pdf

Characteristics of a Computer[2]

High Speed

- Computer is a very fast device.
- It is capable of performing calculations of very large amounts of data.
- The computer has units of speed in microseconds, nanoseconds, and even the picosecond.
- It can perform millions of calculations in a few seconds as compared to a man who will spend many months performing the same task.

Accuracy

- In addition to being very fast, computers are very accurate.
- The calculations are 100% error free.
- Computers perform all jobs with 100% accuracy provided that the input is correct.

Storage Capability

- Memory is a very important characteristic of computers.
- A computer has much more storage capacity than human beings.
- It can store a large amount of data.
- It can store any type of data such as images, videos, text, audio, etc.

Diligence

- Unlike human beings, a computer is free from monotony, tiredness, and lack of concentration.
- It can work continuously without any error and boredom.
- It can perform repeated tasks with the same speed and accuracy.

Versatility

- A computer is a very versatile machine.
- A computer is very flexible in performing the jobs to be done.
- This machine can be used to solve problems related to various fields.
- At one instance, it may be solving a complex scientific problem, and the very next moment it may be playing a card game.

Reliability

- A computer is a reliable machine.
- Modern electronic components have long lives.
- Computers are designed to make maintenance easy.

Automation

- Computer is an automatic machine.
- Automation is the ability to perform a given task automatically. Once the computer receives a program

2. Reproduced from Introduction to Computer Hardware, Sathyabama Institute of Science and Technology

i.e., the program is stored in the computer memory, then the program and instruction can control the program execution without human interaction.

Reduction in Paper Work and Cost

- The use of computers for data processing in an organization leads to reduction in paper work and results in speeding up the process.
- As data in electronic files can be retrieved as and when required, the problem of maintenance of large number of paper files gets reduced.
- Though the initial investment for installing a computer is high, it substantially reduces the cost of each of its transactions.

CATEGORIES: TYPES OF COMPUTER SYSTEM[3]

There are various types of computer system. Major categories are discussed below:

1. Supercomputer

Supercomputers are the fastest and the most expensive computers. These huge computers are used to solve very complex science and engineering problems. Supercomputers get their processing power by taking advantage of parallel processing; they use lots of CPUs at the same time on one problem. A typical supercomputer can do up to ten trillion individual calculations every second. Example Supercomputers:

Categories of Computers

Category	*Physical Size*	*Number of Simultaneously Connected Users*
Personal computers (desktop)	Fits on a desk	Usually one (can be more if networked
Mobile computers and mobile devices	Fits on your lap or in your hand	Usually one
Game consoles	Small box or handheld device	One to several
Servers	Small cabinet	Two to thousands
Mainframes	Partial room to a full room of equipment	Hundred to thousands
Supercomputers	Full room of equipment	Hundreds to thousands
Embedded computers	Miniature	Usually one

Source: https://portal.abuad.edu.ng/

There are two types of supercomputers: General Purpose and Special Purpose.[4]

General Purpose: This form of a supercomputer can be divided into three subtypes.

- Vector processing supercomputers rely on array processors. These are similar to the central processing unit (CPU) of a standard computer. However, they perform rapid mathematical operations on a large

3. Reproduced from https://en.wikiversity.org/wiki/Types_of_computers

4. https://blog.udemy.com/categories-of-computer/

number of data elements. These were the basis of the supercomputer industry in the 1980s and 90s, and today's devices still have some form of vector processing instruction.

- Clusters refer to groups of connected computers that work together as a supercomputing unit. An example is a group that runs high-powered database programs that help produce results from the compilation of Big Data.
- Commodity clusters are large numbers of standard-issued personal computers (PCs). They're connected through high-bandwidth and low-latency local area networks (LANs).

Special Purpose: Special purpose computers are supercomputers designed with an explicit purpose to achieve a particular task or goal. They normally use application-specific integrated circuits (ASICs) for better performance. IBM's Deep Blue is an example of one of these devices.

2. Quantum Computer

The industry is replacing supercomputers with Quantum Computers. A quantum computer is a computer that exploits quantum mechanical phenomena. It measures in "Qubits".

3. Mainframe

Mainframe (colloquially, "big iron") computers are similar to supercomputers in many aspects, the main difference between them is the fact that a supercomputer uses all its raw power to focus on very few tasks, while a mainframe performs thousands or millions of operations concurrently. As discussed, mainframes are not supercomputers. Here are a few differences.

- They serve a large number of users.
- They're used as storage space for the collection, compilation, and release of multiple database arguments.
- Mainframe computations are recorded in MIPS instead of quadrillions of instructions.
- They cost less to purchase and maintain.
- They can run multiple operating systems at the same time.

Due to their nature, mainframes are often employed by large organizations for bulk data processing, such as census, industry and consumer statistics, enterprise resource planning, and transaction processing.

4. Server Computer

A server is a central computer that contains collections of data and programs. Also called a network server, this system allows all connected users to share and store electronic data and applications. Two important types of servers are file servers and application servers.

Servers are a step below supercomputers because they don't focus on trying to solve one very complex problem but try to solve many similar smaller ones. An example of servers would be the computers that Wikipedia stores its encyclopedia. Those computers have to go and find the page you're looking for and send it to you. In itself, it's not a big task, but it becomes a job for a server when the computers have to go and find lots of pages for a lot of people and send them to the right place. Some servers, like the ones Google uses for something like Google Documents, have applications on them instead of just files, like Wikipedia.

5. Midrange Computers

The midrange is a step down from a mainframe. About the size of a regular refrigerator, this multiprocessing machine supports a maximum of 200 users at the same time. Despite its name, a midrange computer isn't considered a PC.

This category of machine, originally named minicomputer, was developed in the 1960s as an affordable alternative to mainframes. However, it had higher processing power. The main reason is that midrange computers are capable of running on higher-level programming languages. For example, in the 70s and 80s, they processed data through Fortran or BASIC.

While midrange computers still exist, they are nearly obsolete. The processing power they possessed is now found in desktops, laptops, and even smart devices.

6. Microcomputers

A microcomputer is a smaller machine that runs on a microprocessor. This category costs far less than larger computers with immense power. Such "minicomputers" are used for regular and practical use.

The age of the microcomputer began in 1970 when the microprocessor was released. Rather than a series of circuit boards or vacuum tubes, a single central processing unit was established. Since the size of a computer could be greatly reduced, the company MITS was able to release the first personal microcomputer, the ALTAIR 8800, in 1974.

7. Workstation Computer

Workstations are high-end, expensive computers that are made for more complex procedures and are intended for one user at a time. Some of the complex procedures consist of science, math, and engineering calculations and are useful for computer design and manufacturing. Workstations are sometimes improperly named for marketing reasons. Real workstations are not usually sold in retail, but this is starting to change; Apple's Mac Pro would be considered a workstation.

8. Personal Computer or PC

PC is an abbreviation for a Personal Computer, it is also known as a Microcomputer. It's physical characteristics and low cost are appealing and useful for its users. The capabilities of a personal computer have changed greatly since the introduction of electronic computers. By the early 1970s, people in academic or research institutions had the opportunity for single-person use of a computer system in interactive mode for extended durations, although these systems would still have been too expensive to be owned by a single individual. The introduction of the microprocessor, a single chip with all the circuitry that formerly occupied large cabinets, led to the proliferation of personal computers after about 1975. Early personal computers, generally called microcomputers, were sold often in kit form and in limited volumes and were of interest mostly to hobbyists and technicians. By the late 1970s, mass-market pre-assembled computers allowed a wider range of people to use computers, focusing more on software applications and less on the development of processor hardware. Throughout the 1970s and 1980s, home computers were developed for household use, offering some personal productivity, programming, and games, while somewhat larger and more expensive systems (although still low-cost compared with minicomputers and mainframes) were aimed for office and small business use.

Today a personal computer is an all-around device that can be used as a productivity tool, a media server, and a gaming machine. The modular construction of the personal computer allows components to be easily swapped out when broken or upgraded.

9. Microcontroller

Microcontrollers are mini-computers that enable the user to store data and execute simple commands and tasks. Many such systems are known as embedded systems. The computer in your car, for example, is an embedded system. A common microcontroller that one might come across is called Arduino.

10. Mobile Computers

Mobile computers are small and meant to be taken from place to place. Today, many mobile devices have the same power, if not more, as a desktop computer. Furthermore, because they are destined for use in different locations, they are more versatile.

There have been waves of mobile computing over the years. Each of them has seen advancements that made the devices smaller. Yet, they still had the same performance abilities.

- *Portability*: This concept began with the introduction of the Dynabook in 1968. Though it was originally considered for children, developers realized a portable computer could be used for everyday needs. The first official portable computer, the GRiD Compass, came out in 1981 and was the size of half a briefcase.
- *Miniaturization*: By the 1990s, the size of computer hardware had reached a stage where small mobile computers could be introduced into the market. Thus, the concept of the personal digital assistant (PDA) was created. The PDA wasn't considered a substitute for a desktop. Rather, it was a supplement for those who spent long periods away from their PCs.
- *Connectivity*: This wave is connected to wireless communications. In 1973, a team at Motorola patented a mobile phone concept. A decade later, it produced the DynaTAC 8000X, the first commercial mobile phone small enough to carry. As technology improved, items like a short message service (SMS), calendars, and internet browsing were introduced to extend connectivity.
- *Convergence*: The next wave took place when manufacturers decided to combine specialized mobile devices into hybrids. The first phase was the smartphone. This combined a PDA's functionality with mobile phone operations. This created a large series of innovations that included mini-QWERTY keyboards and touchscreens.
- *Divergence*: Meanwhile, other manufacturers suggested an "information appliance" approach. Here, a mobile computer was designed to perform a specific activity. This is where machines such as the iPod and the Sony PlayStation Portable (PSP) appeared on the market.

  The concepts created during these waves are still active today. Those that aren't, like PDAs, are incorporated into other devices. Below is a list of contemporary mobile computers.

11. Laptops

Laptops are designed to be used in different locations. Components are contained within a single panel that has the functions of a keyboard, mouse, and power switch. An attached screen folds over, so the laptop is easily carried. As their size and weight decreased over the years, laptops have become more popular. When attached to a docking station, they have the same abilities as a desktop. For instance, multiple monitors can be attached to the station for a larger display.

12. Netbook

The netbook is a smaller version of a laptop. It's intentionally designed to be lighter and less expensive. For instance, it might have a screen that's six or seven inches wide, compared to the 11-inch to 13-inch screen of a standard laptop.

Everything in a netbook is miniaturized. Low-voltage, low-power CPUs are installed due to size restraints. To maintain its lightness, a netbook has smaller hard drives.

While popular in the late 2000s and early 2010s, the netbook market has eroded in place of smart tablets.

13. Tablet

A tablet, also called a smart tablet, is a flat mobile computer. Rather than having a keyboard and mouse, it uses touch-screen functionality for navigation. Tablets tend to be more versatile due to the wide range of third-party applications they can leverage.

Several types of tablets exist. Specialized models like the Amazon Kindle are primarily used for items like reading eBooks. However, they also allow users to watch videos and play games.

Hybrid tablets, like Microsoft Surface, have a similar style to this mobile computer. However, they come with a desktop-style OS and keyboard extensions to act like a microcomputer.

14. Handheld game console

Before the popularity of smart devices, handheld game consoles ruled the market. Some of the most popular of these were Nintendo's Game Boy & DS and the Sony PSP. Currently, the Nintendo Switch is the market leader as other consumers turn to their smartphones and tablets to play games.

15. Smartphone

A smartphone is a mobile device that combines cellular and mobile computing functions into one unit. They are distinguished from feature phones by their stronger hardware capabilities and extensive mobile operating systems, which facilitate wider software, internet (including web browsing over mobile broadband), and multimedia functionality (including music, video, cameras, and gaming), alongside core phone functions such as voice calls and text messaging. Smartphones typically contain a number of metals–oxide–semiconductor (MOS) integrated circuit (IC) chips, including various sensors that can be leveraged by their software (such as a magnetometer, proximity sensors, barometer, gyroscope, or accelerometer), and support wireless communications protocols (such as Bluetooth, Wi-Fi, or satellite navigation).

16. Microcontrollers

Microcontrollers, also known as embedded systems, are minicomputers that store data. Additionally, they execute simple commands and tasks. These are located in places that form the world called the "Internet of Things" (IoT).

IoT comprises those computing devices that operate out of other systems. Your vehicle's onboard computer is an example. Not only does it maintain the regular operations of your car, but it also sends information to the manufacturer or, in the case of trouble, a third party that alerts emergency services.

Microcontrollers are also part of appliances, including smart refrigerators and manufacturing machines. If it can reach the internet through an app or a wireless connection, the microcontroller is part of the IoT.

EMERGING TECHNOLOGIES

Emerging technologies are technologies whose development, practical applications, or both are still largely unrealized. These technologies are generally new but also include older technologies finding new applications. Emerging technologies are often perceived as capable of changing the status quo.[5]

Emerging technologies are characterized by radical novelty (in the application even if not in origins), relatively fast growth, coherence, prominent impact, and uncertainty and ambiguity. In other words, an emerging technology can be defined as "a radically novel and relatively fast-growing technology characterized by a certain degree of coherence persisting over time and with the potential to exert a considerable impact on the socio-economic domain(s) which is observed in terms of the composition of actors, institutions, and patterns

5. Rotolo, Daniele; Hicks, Diana; Martin, Ben R. (December 2015). "What is an emerging technology?" (PDF). Research Policy. 44 (10): 1827–1843.

of interactions among those, along with the associated knowledge production processes. Its most prominent impact, however, lies in the future and so in the emergence phase is still somewhat uncertain and ambiguous."[6]

Technologies[7]	*Key Benefits*	*Use Cases*
Artificial Intelligence (AI) and Machine Learning (ML)	Automate and optimize processes, provide insights	Chatbots, fraud detection, image recognition, predictive maintenance, personalization, recommendation engines, etc.
Robotic Process Automation (RPA)	Automation of repetitive and rule-based tasks	Data entry, invoicing, HR onboarding, financial reporting, etc.
Edge Computing	Reduced latency, improved performance	Autonomous vehicles, real-time analytics, video streaming, IoT, etc.
Quantum Computing	Solve complex problems traditional computers cannot	Cryptography, drug discovery, optimization, machine learning, etc.
Virtual Reality (VR) and Augmented Reality (AR)	Immersive experiences, user interaction with digital environments	Gaming, education, training, marketing, tourism, etc.
Blockchain	Secure and transparent transactions	Supply chain tracking, digital identity, voting, payment processing, etc.
Internet of Things (IoT)	Improved efficiency, automation, and monitoring	Smart homes, industrial automation, healthcare monitoring, energy management, etc.
5G	Increased speed, reduced latency	Enhanced mobile broadband, autonomous vehicles, smart cities, etc.
Cybersecurity	Protection of data, networks, and systems	Network security, threat intelligence, identity management, encryption, etc.
Full Stack Development	End-to-end development of software applications	Web development, mobile app development, e-commerce, etc.
Computing Power	Increased computing power for complex calculations	Scientific research, weather forecasting, financial modelling, artificial intelligence, etc.
Datafication	Collection, analysis, and use of data	Marketing analytics, customer insights, operational efficiency, personalized experiences, etc.
Digital Trust	Building trust in digital interactions	Online banking, e-commerce, social media, digital identity, etc.
Internet of Behaviours	Analysis and use of data from human behaviour	Retail analytics, healthcare monitoring, smart cities, etc.

6. Ibid

7. Reproduced from Koenig India – Step Forward

Predictive analytics	Analysis and use of data to predict outcomes	Customer retention, fraud detection, supply chain optimization, risk management, etc.
DevOps	Integration of development and operations processes	Continuous integration/continuous deployment (CI/CD), software testing, infrastructure as code, etc.
3D Printing	Printing of physical objects from digital designs	Prototyping, product design, medical implants, customized manufacturing, etc.
AI-as-a-Service	Access to AI technology through cloud computing	Chatbots, predictive analytics, natural language processing, image recognition, etc.
Genomics	Study of genes and their functions	Precision medicine, genetic engineering, disease diagnosis, personalized

Following are the emerging technologies related to computer systems and information and communication technologies:[8]

1. ***Computing Power***

   Computing power has already established its place in the digital era, with almost every device and appliance being computerized. And it's here for even more as data science experts have predicted that the computing infrastructure we are building right now will only evolve for the better in the coming years. At the same time, we have 5G already; gear up for an era of 6G with more power in our hands and devices surrounding us.

2. ***Smarter Devices***

   Artificial intelligence has played an essential role in making our world smarter and smoother. It is not just simulating humans but going the extra mile to make our life hassle-free and simpler. These smarter devices are here to stay in 2023 and even further, as data scientists are working on AI home robots, appliances, work devices, wearables, and so much more! Almost every job needs smart software applications to make our work life more manageable. Smarter devices are another addition to the IT industry that is of high requirement and demand as more companies transform into digital spaces.

3. ***Datafication***

   Datafication is simply transforming everything in our life into devices or software powered by data. So, in short, Datafication is the modification of human chores and tasks into data-driven technology. From our smartphones, industrial machines, and office applications to AI-powered appliances and everything else, data is here to stay for longer than we can ever remember! So, to keep our data stored the right way and secure and safe, it has become an in-demand specialization in our economy.

4. ***Artificial Intelligence (AI) and Machine Learning***

   Artificial Intelligence, or AI, has already received a lot of buzz in the past decade, but it continues to be one of the new technology trends because its notable effects on how we live, work, and play are only in the early stages. AI is already known for its superiority in image and speech recognition, navigation apps, smartphone personal assistants, ride-sharing apps and so much more.

8. Reproduced by Nikita Duggal (2023) Top 18 New Technology Trends for 2023, Simplilearn.com. Available at https://www.simplilearn.com/top-technology-trends-and-jobs-article

Other than that AI will be used further to analyze interactions to determine underlying connections and insights, to help predict demand for services like hospitals enabling authorities to make better decisions about resource utilization, and to detect the changing patterns of customer behavior by analyzing data in near real-time, driving revenues and enhancing personalized experiences. Machine Learning is the subset of AI.

5. Extended Reality

Extended reality comprises all the technologies that simulate reality, from Virtual Reality, Augmented Reality to Mixed Reality, and everything else in between. It is a significant technology trend presently as all of us are craving to break away from the so-called real boundaries of the world. By creating a reality without any tangible presence, this technology is massively popular amongst gamers, medical specialists, and retail and modeling.

6. Digital Trust

With people being accommodated and tangled with devices and technologies, confidence and trust have been built towards digital technologies. This familiar digital trust is another vital trend leading to more innovations. With digital conviction, people believe that technology can create a secure, safe, and reliable digital world and help companies invent and innovate without worrying about securing the public's confidence.

7. 3D Printing

A key trend in innovation and technology is 3D printing which is used to formulate prototypes. 3D printing is another innovation that's here to stay. Companies in the data and healthcare sector require a lot of 3D printing for their products. All you need is a sound knowledge of AI, Machine Learning, Modeling, and 3D printing.

8. Genomics

Imagine a technology that can study your DNA and use it to improve your health, helping you fight diseases and whatnot. Genomics is precisely that technology that peruses upon the make-up of genes, DNAs, their mapping, structure, etc. Further, this can help quantify your genes and result in finding diseases or any possible problems that can later be a health issues.

9. New Energy Solutions

The world has agreed to be greener for the sake of its landscapes and the energy we use. This results in cars running on electricity or battery and houses using greener choices like solar and renewable energy. What's even better is that people are conscious of their carbon footprints and waste; thus, minimizing it or turning those into renewable energy is even more helpful.

10. Robotic Process Automation (RPA)

Like AI and Machine Learning, Robotic Process Automation, or RPA, is another innovative technology. RPA is the use of software to automate business processes such as interpreting applications, processing transactions, dealing with data, and even replying to emails. RPA automates repetitive tasks that people used to do.

11. Edge Computing

Formerly a new technology trend to watch, cloud computing has become mainstream, with major players AWS (Amazon Web Services), Microsoft Azure, and Google Cloud Platform dominating the market.

12. Quantum Computing

The next remarkable technology trend is quantum computing, which is a form of computing that takes advantage of quantum phenomena like superposition and quantum entanglement. This amazing technology trend is also involved in preventing the spread of the coronavirus, and to develop potential vaccines, thanks to its ability to easily query, monitor, analyze, and act on data, regardless of the source. Another field where quantum computing is finding applications is banking and finance, to manage credit risk, for high-frequency trading and fraud detection.

13. Virtual Reality and Augmented Reality

The next exceptional technology trend - Virtual Reality (VR) and Augmented Reality (AR), and Extended Reality (ER). VR immerses the user in an environment while AR enhances their environment.

14. Blockchain

Although most people think of blockchain technology in relation to cryptocurrencies such as Bitcoin, we have to understand that blockchain offers security that is useful in many other ways. In the simplest of terms, blockchain can be described as data you can only add to, not take away from, or change. Hence the term "chain" because you're making a chain of data. Not being able to change the previous blocks is what makes it so secure. In addition, blockchains are consensus-driven, so no one entity can take control of the data. With blockchain, you don't need a trusted third-party to oversee or validate transactions.

15. Internet of Things (IoT)

Another promising new technology trend is IoT. Many "things" are now being built with WiFi connectivity, meaning they can be connected to the Internet—and to each other. Hence, the Internet of Things, or IoT. The Internet of Things is the future and has already enabled devices, home appliances, cars, and much more to be connected to and exchange data over the Internet.

16. 5G

The next technology trend that follows the IoT is 5G. Where 3G and 4G technologies have enabled us to browse the internet, use data driven services, increased bandwidths for streaming on Spotify or YouTube and so much more, 5G services are expected to revolutionize our lives. by enabling services that rely on advanced technologies like AR and VR, alongside cloud-based gaming services like Google Stadia, NVidia GeForce Now, and much more. It is expected to be used in factories, HD cameras that help improve safety and traffic management, smart grid control, and smart retail too.

17. Cybersecurity

Cybersecurity might not seem like an emerging technology, given that it has been around for a while, but it is evolving just as other technologies are. That's in part because threats are constantly new. The malevolent hackers who are trying to illegally access data are not going to give up any time soon, and they will continue to find ways to get through even the toughest security measures. It's also in part because new technology is being adapted to enhance security. As long as we have hackers, cybersecurity will remain a trending technology because it will constantly evolve to defend against those hackers.

COMPONENTS OF COMPUTER SYSTEM

From the computer system perspective, the computer can be defined as a collection of entities (hardware, software, and liveware) that are designed to receive, process, manage, and present information in a meaningful format.

(A) Computer hardware – They are physical parts/ intangible parts of a computer. For example Input devices, output devices, central processing unit, and storage devices.[9]

9. Students to note that Input Device, Output Device and Storage Device is being discussed in below mentioned sub-section of this Chapter.

(B) Computer software[10] – They also known as programs or applications. They are classified into two classes namely - system software and application software.

(C) Liveware – It is the computer user. Also, known as orgware or the humanware. The user commands the computer system to execute instructions.

PRIMARY AND SECONDARY STORAGE[11]

Primary Memory

Primary memory is the internal memory of a computer system. It stores and retrieves data, instructions, and information. The CPU directly and randomly accesses primary memory; hence primary memory is also referred to as Random Access Memory or RAM. It is a volatile memory and loses data and instructions when the power turns off.

Primary Memory: Types

1. ***RAM (Random Access Memory)***

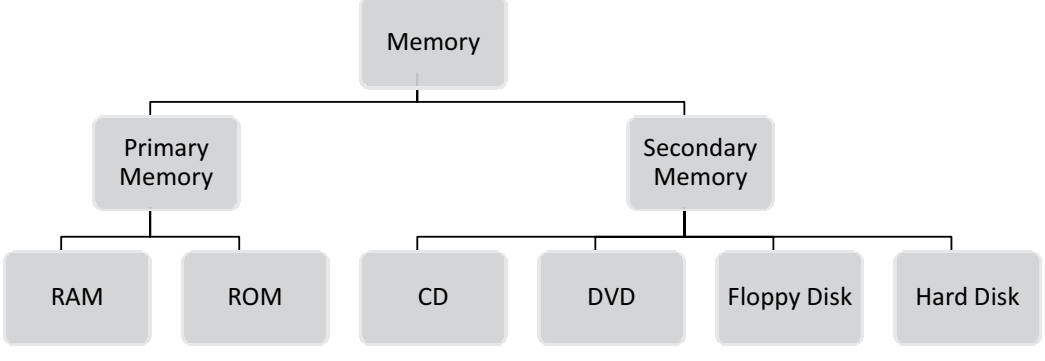
   Random Access Memory or RAM is usually provided as the computer system's main memory. It is also regarded as temporary or cache memory constantly being written to and read. You will lose information saved in primary memory when the power supply of the computer or laptop turns off. Simply put, RAM is a primary memory from which information can only be read.

2. ***ROM (Read-Only Memory)***

   ROM is a non-volatile memory containing data that we cannot change. In this case, information is not lost when the power supply is turned off. ROM information is determined by the computer manufacturer and is permanently stored at the time of manufacture so that the user cannot overwrite it.

Primary Memory: Characteristics

- The computer cannot function without primary memory.
- It is known as the main memory.
- You may lose data in case the power is off.
- Also known as volatile memory.
- It is the working memory of the computer.
- It is faster as compared to secondary memory.
- Examples: RAM, ROM, cache, PROM, EPROM, registers, etc.



Source: https://www.shiksha.com/

10. Students to note that Software is discussed in detail in the other sub-sections of this chapter.

11. Reproduced from https://www.shiksha.com/online-courses/articles/difference-between-primary-memory-and-secondary-memory/

Secondary Memory: Meaning

Secondary memory is a storage device that the CPU cannot access directly. It is used as a permanent storage device.

The CPU accesses these devices through an input/output channel, and data is first transferred to primary from secondary storage before being accessed. Modern computers often use hard drives and optical storage devices (CDs, DVDs) as secondary storage devices.

A secondary storage device organizes data into files and directories based on a file system. It also allows the user to access or use additional information like access permissions, owner, last access time, etc. Also, secondary memory is used temporarily to keep less used data when primary memory gets full.

Secondary memory devices are less expensive and can store vast amounts of data, audio, video, and multimedia files. Organizations can store the equivalent of a roomful of data on disks that consume dramatically and significantly less physical space.

Secondary Memory: Types

- Solid-state storage devices, such as USB memory sticks.
- Optical storage devices, such as CDs, DVDs, and Blu-ray discs.
- Magnetic storage devices include zip, floppy, and hard disk drives.

Secondary Memory: Characteristics

- These are magnetic and optical memories.
- It is a type of non-volatile memory.
- Data is permanently stored even when the computer is turned off
- It helps store data on a computer
- The computer can function without secondary memory
- Slower than primary memory
- Examples: magnetic tapes, optical discs, floppy disks, flash memory [USB drives], paper tape, punched cards, etc.

COMPUTER STORAGE CAPACITIES

Storage capacity is an important factor when deploying infrastructure in the data center. Storage capacity refers to the disk space one or more storage devices provide. It measures how much data a computer system may contain. For example, a computer with a 500GB hard drive has a storage capacity of 500 gigabytes A network server with four 1TB drives, has a storage capacity of 4 terabytes. Storage capacity is often used synonymously with “disk space.” However, it refers to overall disk space, rather than free disk space. For example, a hard drive with a storage capacity of 500GB may only have 150MB available if the rest of the disk space is already used up. Storage vendors describe capacity in different ways, and it’s essential that you know how to interpret them properly for sizing the infrastructure that your organization really needs, and for comparing the cost of capacity (cost divided by gigabytes) between different storage systems. However, interpreting the capacity of modern storage systems can be surprisingly tricky. Different vendors use wildly different metrics to advertise the capacity of their systems, including:

Raw Capacity

This is the total capacity of the storage media in the system. For example, if your system contains 20 drives at 5TB each, the raw capacity is 100 TB. Vendors sometimes mistakenly price their systems based on raw

capacity, but users should focus on usable capacity instead because usable capacity can be significantly lower than raw capacity. That is why raw capacity is generally reported in decimal terabytes.

Usable Capacity

This is how much data can be stored in the system in the absence of any data reduction, meaning before data reduction. The use of the term usable capacity to mean capacity before data reduction. Usable capacity is lower than raw capacity because of overheads such as RAID (redundant array of independent disks) and flash over-provisioning. The ratio of the usable capacity to the raw capacity is referred to as the "usable ratio", which by definition is usable capacity divided by raw capacity is greater or equal to one.

Usable Capacity / Raw Capacity = Usable Ratio

COMPUTER PERIPHERALS – INPUTS, OUTPUT, AND STORAGE DEVICES

1. ***Input Unit:***

   The input unit consists of input devices that are attached to the computer. These devices take input and convert it into binary language that the computer understands. Some of the common input devices are keyboard, mouse, joystick, scanner etc.

   The Input Unit is formed by attaching one or more input devices to a computer.

   A user input data and instructions through input devices such as a keyboard, mouse, etc. The input unit is used to provide data to the processor for further processing.

2. ***Central Processing Unit/Storage[12]:***

   Once the information is entered into the computer by the input device, the processor processes it. The CPU is called the brain of the computer because it is the control Centre of the computer. It first fetches instructions from memory and then interprets them so as to know what is to be done. If required, data is fetched from memory or input device. Thereafter CPU executes or performs the required computation, and then either stores the output or displays it on the output device. The CPU has three main components, which are responsible for different functions: Arithmetic Logic Unit (ALU), Control Unit (CU) and Memory registers.

   a. *Arithmetic and Logic Unit (ALU):* The ALU, as its name suggests performs mathematical calculations and takes logical decisions. Arithmetic calculations include addition, subtraction, multiplication and division. Logical decisions involve the comparison of two data items to see which one is larger or smaller or equal. Arithmetic Logical Unit is the main component of the CPU. It is the fundamental building block of the CPU. Arithmetic and Logical Unit is a digital circuit that is used to perform arithmetic and logical operations.

   b. *Control Unit:* The Control unit coordinates and controls the data flow in and out of the CPU, and also controls all the operations of ALU, memory registers and also input/output units. It is also responsible for carrying out all the instructions stored in the program. It decodes the fetched instruction, interprets it and sends control signals to input/output devices until the required operation is done properly by ALU and memory.

      - The Control Unit is a component of the central processing unit of a computer that directs the operation of the processor.
      - It instructs the computer's memory, arithmetic and logic unit, and input and output devices on how to respond to the processor's instructions.
      - In order to execute the instructions, the components of a computer receive signals from the control unit.

      It is also called the central nervous system or brain of the computer.

12. Students to note - Primary and Secondary Storage is already discussed in the above mentioned sub-sections of the Chapter.

c. *Memory Registers:* A register is a temporary unit of memory in the CPU. These are used to store the data, which is directly used by the processor. Registers can be of different sizes (16-bit, 32-bit, 64 bit and so on) and each register inside the CPU has a specific function, like storing data, storing an instruction, storing address of a location in memory etc. The user registers can be used by an assembly language programmer for storing operands, intermediate results etc. Accumulator (ACC) is the main register in the ALU and contains one of the operands of an operation to be performed in the ALU.

- Memory Unit is the primary storage of the computer.
- It stores both data and instructions.
- Data and instructions are stored permanently in this unit so that they are available whenever required.

3. Output Unit:

The output unit consists of output devices that are attached to the computer. It converts the binary data coming from the CPU to human understandable form. The common output devices are monitor, printer, plotter, etc.

- The output unit displays or prints the processed data in a user-friendly format.
- The output unit is formed by attaching the output devices of a computer.
- The output unit accepts the information from the CPU and displays it in a user-readable form.

COMPUTER SOFTWARE[13] : AN INTRODUCTION

Software is a set of computer programs and associated documentation and data. This is in contrast to hardware, from which the system is built and which actually performs the work. In the previous sections of this chapter, we have read in detail about the hardware of the computer system. But the hardware is of no use on its own. Hardware needs to be operated by a set of instructions. These sets of instructions are referred to as software. It is that component of a computer system, which we cannot touch or view physically. It comprises of the instructions and data to be processed using the computer hardware.

The computer software and hardware complete any task together. The software comprises of set of instructions which on execution deliver the desired outcome. In other words, each software is written for some computational purpose. Some examples of software include operating systems like Ubuntu or Windows 7/10, word processing tools like LibreOffice Writer or Microsoft Word, video player like VLC Player, photo editors like Paint and LibreOffice Draw. A document or image stored on the hard disk or pen drive is referred to as a softcopy. Once printed, the document or an image is called a hardcopy.

Software is a set of instructions, data or programs used to operate computers and execute specific tasks. It is the opposite of hardware, which describes the physical aspects of a computer. Software is a generic term used to refer to applications, scripts and programs that run on a device. It can be thought of as the variable part of a computer, while hardware is the invariable part.

The two main categories of software are:

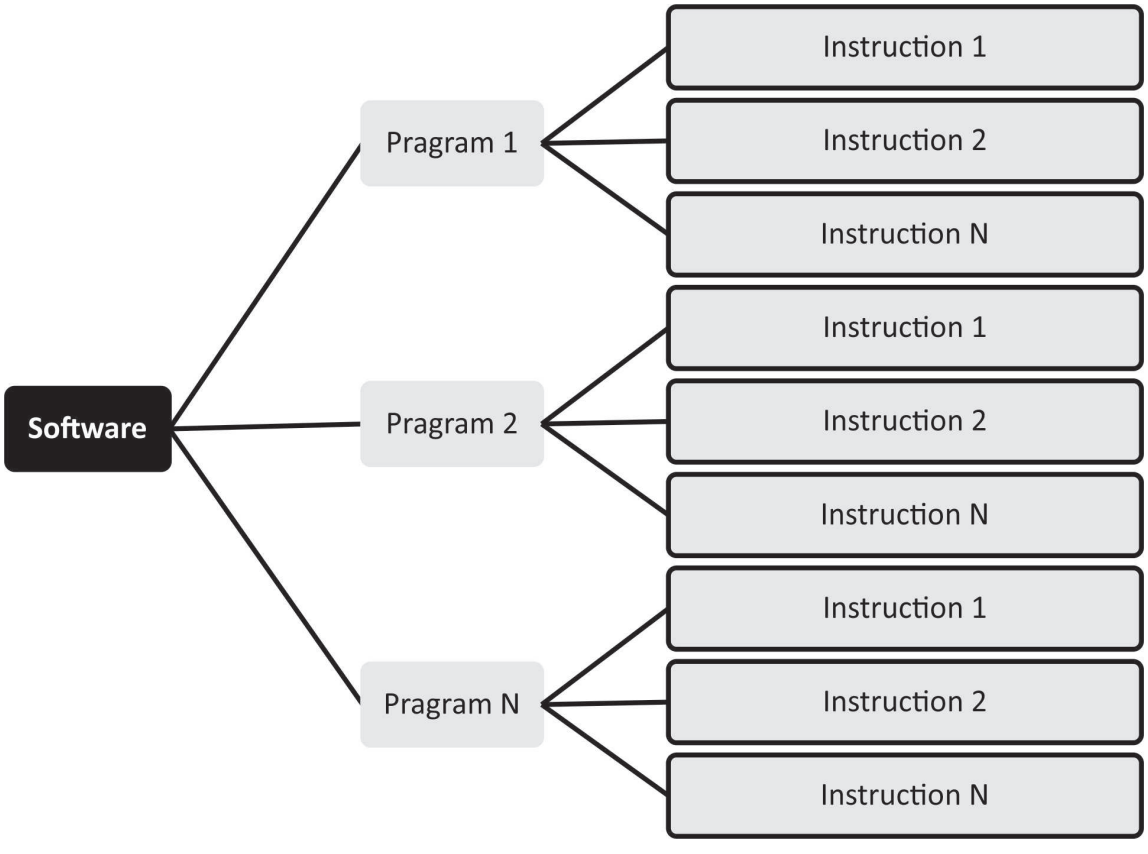
- Application software, and
- System software.

An application is software that fulfills a specific need or performs tasks. System software is designed to run a computer's hardware and provides a platform for applications to run on top of.

13. Source: https://www.techtarget.com/searchapparchitecture/definition/software

Other types of software include programming software, which provides the programming tools software developers need; middleware, which sits between system software and applications; and driver software, which operates computer devices and peripherals.

Set of instructions that tells the computer hardware what to do is known as computer program. This program or collection of such programs is known as computer software. Concept of software is illustrated in following figure:



Source: https://www.codesansar.com/

Among the various categories of software, the most common types include the following:

- **Application software:** The most common type of software, application software is a computer software package that performs a specific function for a user, or in some cases, for another application. An application can be self-contained, or it can be a group of programs that run the application for the user. Examples of modern applications include office suites, graphics software, databases and database management programs, web browsers, word processors, software development tools, image editors and communication platforms.
- **System software:** These software programs are designed to run a computer's application programs and hardware. System software coordinates the activities and functions of the hardware and software. In addition, it controls the operations of the computer hardware and provides an environment or platform for all the other types of software to work in. The OS is the best example of system software; it manages all the other computer programs. Other examples of system software include the firmware, computer language translators and system utilities.
- **Driver software:** Also known as device drivers, this software is often considered a type of system software. Device drivers control the devices and peripherals connected to a computer, enabling them

to perform their specific tasks. Every device that is connected to a computer needs at least one device driver to function. Examples include software that comes with any nonstandard hardware, including special game controllers, as well as the software that enables standard hardware, such as USB storage devices, keyboards, headphones and printers.

- **Middleware:** The term middleware describes software that mediates between application and system software or between two different kinds of application software. For example, middleware enables Microsoft Windows to talk to Excel and Word. It is also used to send a remote work request from an application in a computer that has one kind of OS, to an application in a computer with a different OS. It also enables newer applications to work with legacy ones.
- **Programming software:** Computer programmers use programming software to write code. Programming software and programming tools enable developers to develop, write, test and debug other software programs. Examples of programming software include assemblers, compilers, debuggers and interpreters.

SOFTWARE TRENDS

An article published in DevTeam.Space[14] highlighted the key trends in software development are as follows:

1. ***Mixed Reality (MR): High potential in enterprise solutions***

   Mixed Reality (MR), i.e., a combination of Augmented Reality (AR) and Virtual Reality (VR) has significant potential in enterprise applications. AR integrates digital content with the physical environment of users, whereas VR creates an immersive experience for users. Organizations in many sectors like defense, tourism, architecture, construction, gaming, healthcare, etc. are realizing key business value with the help of this technology.

2. ***Blockchain: Augmenting enterprise solutions with transparency, efficiency and security***

   While cryptocurrencies like Bitcoin and Ether have made us sit up and notice blockchain, the technology has wide implications for enterprise systems. Blockchain is a Peer-To-Peer (P2P) network, and it offers decentralization, a distributed ledger, security features, and transparency.

   Smart contracts running on blockchain networks are tamper-proof and transparent, therefore, they improve trust. Their execution is irreversible, which can make contract administration easier. Businesses and governments are keenly exploring blockchain, therefore, its global market is growing rapidly.

3. ***Artificial Intelligence (AI): Ushering in intelligent enterprise systems***

   Artificial Intelligence (AI) is a multi-disciplinary branch of computer science, which intends to make machines perform tasks that only human beings could do earlier. It is a vast field, and while parts of it have been commercialized, research & development continue on its other dimensions.

   AI includes various capabilities like machine learning (ML), deep learning, vision, natural language processing, speech, etc.

4. ***The Internet of Things (IoT)***

   As technology trends go, the Internet of Things (IoT) is one that could have far-reaching impacts on our world, and not just on businesses. IoT is a network of physical objects like gadgets, devices, vehicles, appliances, etc., and these devices use sensors. Devices on these networks use application programming interfaces (APIs) to exchange data over the Internet.

14. Source: https://www.devteam.space/blog/10-trends-in-software-development/

IoT is a result of the integration of various technologies like sensors, Big Data, AI, ML, Radio-Frequency Identification (RFID), and APIs. Read more about it in "What is the Internet of Things (IoT)?".

5. Language and framework trends for developing enterprise apps

Both Kotlin and Swift, the popular languages for native development on Android and iOS respectively, figure prominently in the list of "most preferred languages".

6. Cybersecurity: A Key consideration when building enterprise solutions

Experts consistently point out how cybercrimes cause trillions of dollars in losses, therefore, it is no surprise that cybersecurity is a prominent consideration when developing an enterprise app. Cybercriminals are organized, moreover, they are continuously upgrading their capabilities.

One ought to proactively mitigate the key application security risks. More often than not, mitigating application security risks boils down to managing the project well, adhering to IT architecture and coding guidelines, etc.

Key applications security risks are as follows:

- Injection;
- Ineffective Authentication;
- Exposure of Sensitive Data;
- XML External Entities (XXE);
- Incorrect Implementation of Identity and Access Management;
- Inadequate Security Configurations;
- Cross-Site Scripting (XSS);
- Deserialization without Adequate Security;
- Using Outdated Software with Known Vulnerabilities;
- Sub-Optimal Logging and Monitoring Processes.

7. ***"Progressive Web Applications" (PWAs)***

"Progressive Web Apps" (PWAs) are web apps; however, they deliver a user experience partly similar to native mobile apps. They are responsive, speedy, and secure, moreover, they can work offline. While PWAs fall short of the native app user experience, developing them can be a good option if the development budget is your priority. There is only one codebase to develop and maintain, therefore, PWAs are less costly. In recent years, several businesses have seen improved customer engagement with the help of PWAs, as you can read in "Progressive Web Apps (PWA): Source materials".

8. Low-Code Development

A key trend that has emerged in recent years is low-code development. Businesses using this approach have the objective of improving software development efficiency, and they seek to minimize hand-coding for this.

Low-code development platforms offer GUIs, and developers use them to draw flowcharts depicting the business logic. The platform then generates code for implementing that business logic.

If you plan to take advantage of such platforms then you should look for enterprise-grade platforms with industry-standard security features. Appian and Mendix are good examples of low-code development platforms.

9. Code quality

Some things never change. And that's why the importance of code quality in software development will never decrease. Since many projects involve continuous integration of code from multiple contributors, this process can throw up many code issues. Software development teams that maintain a high quality of code enable their organizations to maintain the code easily.

10. Outsourcing

As the global business environment grows more and more complex, businesses are striving to make the best use of the capabilities they have. Businesses have found out the importance of focusing on their core competencies and offloading the peripheral tasks to partners that have core competencies there. This realization continues to drive the trend of IT outsourcing.

One might need to outsource software development for its business too, however, focus on the right priorities. E.g., in the longer term, delivering a quality product to your customers matters more than reducing cost.

MULTI-PROGRAMMING

Multi-programming is the allocation of more than one concurrent program on a computer system and its resources. Multiprogramming allows using the CPU effectively by allowing various users to use the CPU and I/O devices effectively. Multiprogramming makes sure that the CPU always has something to execute, thus increases the CPU utilization.

MULTI-PROCESSING

Multi-processing is the use of two or more central processing units (CPUs) within a single computer system. The term also refers to the ability of a system to support more than one processor or the ability to allocate tasks between them. There are many variations on this basic theme, and the definition of multiprocessing can vary with context, mostly as a function of how CPUs are defined (multiple cores on one die, multiple dies in one package, multiple packages in one system unit, etc.). According to some on-line dictionaries, a multiprocessor is a computer system having two or more processing units (multiple processors) each sharing main memory and peripherals, in order to simultaneously process programs

TIME SHARING

Time sharing is the sharing of computing resources among several users simultaneously. Since this will allow many users to work in a single computer system simultaneously, it would lower the cost of providing computing capabilities.

BATCH PROCESSING

Batch processing is the method computers use to periodically complete high-volume, repetitive data jobs. Certain data processing tasks, such as backups, filtering, and sorting, can be compute intensive and inefficient to run on individual data transactions. Instead, data systems process such tasks in batches, often in off-peak times when computing resources are more commonly available, such as at the end of the day or overnight. For example, consider an ecommerce system that receives orders throughout the day. Instead of processing every order as it occurs, the system might collect all orders at the end of each day and share them in one batch with the order fulfillment team.

A good example of batch processing is how credit card companies do their billing. When customers get their credit card bills, it isn't a separate bill for each transaction; rather, there is one bill for the entire month.

ON-LINE AND REAL TIME PROCESSING[15]

Online Systems

Online systems are the type of systems that are logged in or connected to the internet, such systems include online gaming platforms, chatting through different social media platforms, etc. A number of applications are available which are online in nature.

Advantages of Online Systems:

- Online systems help in making communication possible in the whole world at a faster speed.
- Online systems are less costly when compared to real-time systems, anyone can use them with the help of the internet.
- Response time is really good in the case of many online systems like booking systems or online shopping sites.
- These systems do not have heavy hardware requirements means they can be used with simple hardware resources.

Limitations of Online Systems:

- There are times when a large number of data is fetched or either sent to online systems and in such cases, these systems fail to handle that data.
- They are not providing in-time information means these systems lag when compared to real-time systems hence these systems cannot be used for high-priority tasks.

Real-Time Systems:

Real-time systems are those systems that do not lag and respond instantly. These are different from online systems in the sense that they transform their state with correspondence to real or physical time.

Advantages of Real-Time Systems:

- These are the fastest available systems and hence are used in top-priority operations like rocket launching systems, military communications, etc.
- The response time of these systems is instant, they don't lag and provide real-time information or services.
- Real-time systems are the foundation of advanced technology in various fields like communication, information retrieval, etc.
- These systems are able to handle a huge amount of data.

Limitations of Real-Time Systems:

- These systems are expensive so they are not available for use to everybody.
- Heavy system requirements to use these systems, these systems need special software and hardware resources.

Online and real-time systems are two different types of computer systems used in organizations.

- Online systems are computer systems that are connected to a network and are accessible to users from anywhere at any time. These systems typically allow users to interact with data stored in databases and perform operations such as data entry, data retrieval, and data modification. Examples of online systems include e-commerce websites, banking systems, and online booking systems.

15. Reproduced from https://www.geeksforgeeks.org/

- Real-time systems, on the other hand, are computer systems that are designed to process data in real-time, as soon as it is generated. These systems typically have strict timing constraints and must be able to respond to events in a timely manner. Examples of real-time systems include control systems for manufacturing plants, traffic control systems, and flight control systems.

Key differences between online and real-time systems include:

- **Timing**: Online systems allow users to access and interact with data at any time, while real-time systems are designed to respond to events in real time.
- **Latency**: Online systems may have higher latency as data is transmitted over a network, while real-time systems typically have very low latency.
- **Response time**: Online systems may have longer response times as they must wait for user input and may require additional processing time, while real-time systems must respond to events quickly and have very short response times.
- **Reliability**: Real-time systems must be highly reliable and ensure that data is processed accurately and on time, while online systems may not require the same level of reliability.

In summary, while online systems allow users to interact with data stored in databases and are accessible from anywhere at any time, real-time systems are designed to process data in real time and must respond to events quickly and accurately.

APPLICATION SOFTWARE[16]

The term "application software" refers to software that performs specific functions for a user. When a user interacts directly with a piece of software, it is called application software. The sole purpose of application software is to assist the user in doing specified tasks. Microsoft Word and Excel, as well as popular web browsers like Firefox and Google Chrome, are examples of application software. It also encompasses the category of mobile apps, which includes apps like WhatsApp for communication and games like Candy Crush Saga. There are also app versions of popular services, such as weather or transportation information, as well as apps that allow users to connect with businesses. Global Positioning System (GPS), Graphics, multimedia, presentation software, desktop publishing software, and so on are examples of such software.

Function of application software:

Application software programs are created to help with a wide range of tasks. Here are a few examples:

- Information and data management;
- Management of documents (document exchange systems);
- Development of visuals and video;
- Emails, text messaging, audio and video conferencing, and cooperation are all options;
- Management of accounting, finance, and payroll;
- Management of resources (ERP and CRM systems);
- Management of a project;
- Management of business processes;
- Software for education (LMS and e-learning systems);
- Software for healthcare applications.

16. Reproduced from https://www.geeksforgeeks.org/what-is-application-software/

Types of application software:

Application software can also be categorized based on its chargeability and accessibility. Here is some application software:

- **Freeware**: It is offered for free, as the name implies. You can utilize freeware application software that you can obtain from the Internet. This software, on the other hand, does not allow you to change it or charge a fee for sharing it. Examples include Adobe PDF, Mozilla Firefox, and Google Chrome.
- **Shareware**: This is given away to users for free as a trial, usually with a limited-time offer. If consumers want to keep using this application software, they will have to pay. WinZip, Anti-virus, and Adobe Reader are instances of shareware.
- **Open-source**: This type of application software comes with the source code, allowing you to edit and even add features to it. These could be offered for free or for a fee. Open-source application software includes Moodle and Apache Web Server.
- **Closed source**: This category includes the majority of the application software programs used nowadays. These are normally charged, and the source code is usually protected by intellectual property rights or patents. It usually comes with a set of restrictions. Microsoft Windows, Adobe Flash Player, WinRAR, macOS, and other operating systems are examples.

Examples of application software:

Some of the examples of application software are:

- **System for Hotel Management:** It relates to the hotel industry's management strategies. Hotel administration, accounting, billing, marketing, housekeeping, and front office or front desk.
- **System for Payroll Management:** It is a term used by all modern businesses to refer to every employee who receives a regular salary or another form of payment. The payroll software calculates all different payment options and generates the relevant paychecks. Employee salary slips can also be printed or sent using this software.
- **System for Human Resources Management:** It describes the systems and activities that exist at the nexus of Human Resource Management (HRM) and Information Technology (IT). The HR department's role is primarily administrative and is found in all businesses.
- **Attendance Recording System:** It's a piece of software that tracks and optimizes a person's or student's presence in an organization or school. Nowadays, customers' existing time/attendance recording devices, such as biometrics/access cards, can be connected with attendance systems. Attendance management can be accomplished in two ways: Integration of biometrics & Integration of manual attendance
- **System of Billing:** It is the billing software that is utilized to complete the billing process. It keeps track of marked products and services given to a single consumer or a group of customers.

LESSON ROUND-UP

- A computer is an electronic device that receives information and data, automatically stores it and retrieves it at any time, and uses it in a useful manner.
- One cannot understand the functioning of the computer without understanding the role of hardware and software in it.