UNIT-1

INTERNET OF THINGS

1.1 What is the Internet of Things? :

The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.

IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy, and economic benefit.

"Thing" in the Internet of Things

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 man-made object.

These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices.

Examples

- Smart refrigerators
- Smart watches,
- Smart fire alarm
- Smart door lock
- Smart bicycle
- Medical sensors
- Fitness trackers
- Smart security system etc.

1.1.1 IoT − Key Features

The most important features of IoT include artificial intelligence, connectivity, sensors, active engagement, and small device use. A brief review of these features is given below −

- **AI** − IoT essentially makes virtually anything "smart", meaning it enhances every aspect of life with the power of data collection, artificial intelligence algorithms, and networks. This can mean something as simple as enhancing your refrigerator and cabinets to detect when milk and your favourite cereal run low, and to then place an order with your preferred grocer.

- **Connectivity** − New enabling technologies for networking, and specifically IoT networking, mean networks are no longer exclusively tied to major providers. Networks can exist on a much smaller and cheaper scale while still being practical. IoT creates these small networks between its system devices.
- **Sensors** − IoT loses its distinction without sensors. They act as defining instruments which transform IoT from a standard passive network of devices into an active system capable of real-world integration.
- **Active Engagement** − Much of today's interaction with connected technology happens through passive engagement. IoT introduces a new paradigm for active content, product, or service engagement.
- **Small Devices** − Devices, as predicted, have become smaller, cheaper, and more powerful over time. IoT exploits purpose-built small devices to deliver its precision, scalability, and versatility.

1.1.2 Evolution of Internet of Things (IoT)/ History of IoT

Let us have a look at how the evolution of IoT as a concept happened over a period of time along with the timelines:

Year 1999: Kevin Ashton, co-founder of the Auto-ID (for Automatic Identification) Center at MIT coined the term “Internet of things “. His definition of IoT was based on reinventing RFID as a networking technology by linking objects to the internet using the RFID tag.

Year 1999: Device to Device (D2D) communication as a concept was coined by Bill Joy as part of his “Six Webs” framework at the World Economic Forum.

Year 2000: LG Internet Digital DIOS, the first Internet-connected refrigerator in the world was invented. The refrigerator used a LAN port for IP connectivity.

Year 2001: David Brock, co-director at the Auto-ID Centre, MIT, proposed a new object identification scheme, the Electronic Product Code (EPC), instead of the conventional Universal Product Code (UPC or ‘bar code’) for unique identification and tracking of objects throughout the product life cycle using the infrastructure/internet.”

Year 2003: The "Project JXTA-C: Enabling a Web of Things" is published by Bernard Traversat and team at the 36th Annual Hawaii International Conference.

According to them, the Project JXTA's aim is to specify a standard set of protocols for ad hoc, pervasive, peer-to-peer computing as a foundation of the upcoming Web of Things.

Year 2003: A special kind of network to connect many of the millions of tags that are already in the world was launched at the McCormick Place conference centre.

The launch of electronic product code (EPC) network was attended by numerous delegates from across the worlds of retail, technology and academia.

Year 2005: The faculty at the Interaction Design Institute Ivrea (IDII), Italy, invents a single-board microcontroller to be used in interactive projects being developed their students.

Year 2008: Different industry stakeholders come together to form the IPSO Alliance to promote connected devices. This was a big leap towards having the IoT implemented for large scale business in real production setups.

2016 and Beyond: We have connected home, connected cars, IoT enabled manufacturing plants, and IoT based solar trackers.

Year 2018: As of 2018, nearly half of all IoT (Internet of Things) devices were connected to WPAN (Wireless Personal Area Networks), including Zigbee, Bluetooth, and Z-wave.

Year 2019: By 2019, the global IoT market will generate a revenue of $1.7T.

Year 2020: Of the 21.7 billion active connected devices worldwide, 11.7 billion (or 54%) will be IoT device connections at the end of 2020.

"By 2025, it is expected that there will be more than 30 billion IoT connections, almost 4 IoT devices per person on average."

1.1.3 IoT − Advantages

The advantages of IoT span across every area of lifestyle and business. Here is a list of some of the advantages that IoT has to offer −

- **Improved Customer Engagement** − Current analytics suffer from blind-spots and significant flaws in accuracy; and as noted, engagement remains passive. IoT completely transforms this to achieve richer and more effective engagement with audiences.
- **Technology Optimization** − The same technologies and data which improve the customer experience also improve device use, and aid in more potent improvements to technology. IoT unlocks a world of critical functional and field data.

- **Reduced Waste** − IoT makes areas of improvement clear. Current analytics give us superficial insight, but IoT provides real-world information leading to more effective management of resources.
- **Enhanced Data Collection** − Modern data collection suffers from its limitations and its design for passive use. IoT breaks it out of those spaces, and places it exactly where humans really want to go to analyse our world. It allows an accurate picture of everything.
- **Efficient resource utilization:** If we know the functionality and the way that how each device work, we definitely increase the efficient resource utilization as well as monitor natural resources.
- **Minimize human effort:** As the devices of IoT interact and communicate with each other and do lot of task for us, then they minimize the human effort.
- **Save time:** As it reduces the human effort then it definitely saves out time. Time is the primary factor which can save through IoT platform.

1.1.4 IoT − Disadvantages

Though IoT delivers an impressive set of benefits, it also presents a significant set of challenges. Here is a list of some its major issues −

- **Security** − IoT creates an ecosystem of constantly connected devices communicating over networks. The system offers little control despite any security measures. This leaves users exposed to various kinds of attackers.
- **Privacy** − The sophistication of IoT provides substantial personal data in extreme detail without the user's active participation.
- **Complexity** − Some find IoT systems complicated in terms of design, deployment, and maintenance given their use of multiple technologies and a large set of new enabling technologies.
- **Flexibility** − Many are concerned about the flexibility of an IoT system to integrate easily with another. They worry about finding themselves with several conflicting or locked systems.
- **Compliance** − IoT, like any other technology in the realm of business, must comply with regulations. Its complexity makes the issue of compliance seem incredibly challenging when many consider standard software compliance a battle.

1.2 Sensors, their types and features

The most important hardware in IoT might be its sensors. These devices consist of energy modules, power management modules, RF modules, and sensing modules. RF modules manage communications through their signal processing, WiFi, ZigBee, Bluetooth, radio transceiver, duplexer, and BAW.

The sensing module manages sensing through assorted active and passive measurement devices. Here is a list of some of the measurement devices used in IoT –

Table 1.1 Types of Sensors

S. No	Devices	Type of Sensors
1.	accelerometers	temperature sensors
2.	magnetometers	proximity sensors
3.	gyroscopes	image sensors
4.	acoustic sensors	light sensors
5.	pressure sensors	gas RFID sensors
6.	humidity sensors	micro flow sensors

1.2.1 Types of Sensors used in IoT

Temperature sensors

By definition, "A device, used to measure amount of heat energy that allows to detect a physical change in temperature from a particular source and converts the data for a device or user, is known as a Temperature Sensor."

These sensors have been deployed for a long time in a variety of devices. However, with the emergence of IoT, they have found more room to be present in an even greater number of devices. Only a couple of years ago, their uses mostly included A/C control, refrigerators and similar devices used for environmental control. However, with the advent of the IoT world, they have found their role in manufacturing processes, agriculture and health industry.

In the manufacturing process, many machines require specific environment temperature, as well as device temperature. With this kind of measurement, the manufacturing process can always remain optimal.

On the other hand, in agriculture, the temperature of soil is crucial for crop growth. This helps with the production of plants, maximizing the output.

Proximity sensor

A device that detects the presence or absence of a nearby object, or properties of that object, and converts it into signal which can be easily read by user or a simple electronic instrument without getting in contact with them.

Proximity sensors are largely used in the retail industry, as they can detect motion and the correlation between the customer and product they might be interested in. A user is immediately notified of discounts and special offers of nearby products.

Another big and quite an old use-case is vehicles. You are reversing your car and are alrmed about an obstacle while taking reverse, that's the work of proximity sensor.

They are also used for parking availability in places such as malls, stadiums or airports.

Pressure sensor

A pressure sensor is a device that senses pressure and converts it into an electric signal. Here, the amount depends upon the level of pressure applied.

Deployment of these sensors is not only very useful in manufacturing, but also in the maintenance of whole water systems and heating systems, as it is easy to detect any fluctuation or drops in pressure.

Water quality sensor

Water quality sensors are used to detect the water quality and Ion monitoring primarily in water distribution systems.

Water is practically used everywhere. These sensors play an important role as they monitor the quality of water for different purposes. They are used in a variety of industries.

Chemical sensor

Chemical sensors are applied in a number of different industries. Their goal is to indicate changes in liquid or to find out air chemical changes. They play an important role in bigger cities, where it is necessary to track changes and protect the population.

Main use cases of chemical sensors can be found in Industrial environmental monitoring and process control, intentionally or accidentally released harmful chemical detection, explosive and radioactive detection, recycling processes on Space Station, pharma industries and laboratory etc.

Gas sensor

Gas sensors are similar to the chemical ones, but are specifically used to monitor changes of the air quality and detect the presence of various gases. Like chemical sensors, they are used in numerous industries such as manufacturing, agriculture and health and used for air quality monitoring, detection of toxic or combustible gas, hazardous gas monitoring in coal mines, oil & gas industries, chemical laboratory research, manufacturing – paints, plastics, rubber, pharmaceutical & petrochemical etc.

Following are some common Gas sensors:

- Carbon dioxide sensor
- Breathalyzer
- Carbon monoxide detector
- Catalytic bead sensor
- Hydrogen sensor
- Air pollution sensor
- Nitrogen oxide sensor
- Oxygen sensor
- Ozone monitor
- Electrochemical gas sensor
- Gas detector
- Hygrometer

Smoke sensor

A smoke sensor is a device that senses smoke (airborne particulates & gases), and it's level.

Smoke sensors are extensively used by manufacturing industry, HVAC, buildings and accommodation infra to detect fire and gas incidences. This serves to protect people working in dangerous environments, as the whole system is much more effective in comparison to the older ones.

Common Type of Smoke Sensors

Smoke sensors detect the presence of Smoke, Gases and Flame surrounding their field. It can be detected either optically or by the physical process or by the use of both the methods.

- Optical smoke sensor (Photoelectric): Optical smoke sensor used the light scatter principle trigger to occupants.

- Ionization smoke sensor: Ionization smoke sensor works on the principle of ionization, kind of chemistry to detect molecules causing a trigger alarm.

IR sensors

An infrared sensor is a sensor which is used to sense certain characteristics of its surroundings by either emitting or detecting infrared radiation. It is also capable of measuring the heat being emitted by the objects.

Other common use includes home appliances & remote control, breath analysis, Infrared vision (i.e. visualize heat leaks in electronics, monitor blood flow, art historians to see under layers of paint), wearable electronics, optical communication, non-contact based temperature measurements, automotive blind-angle detection.

Their usage does not end there, they are also a great tool for ensuring high-level security in your home. Also, their application includes environment checks, as they can detect a variety of chemicals and heat leaks. They are going to play an important role in the smart home industry, as they have a wide-range of applications.

Level sensors

A sensor which is used to determine the level or amount of fluids, liquids or other substances that flow in an open or closed system is called Level sensor.

Best use cases of level sensor is, fuel gauging & liquid levels in open or closed containers, sea level monitoring & Tsunami warning, water reservoirs, medical equipment, compressors, hydraulic reservoirs, machine tools, beverage and pharmaceutical processing, high or low-level detection etc.

This helps better streamline their businesses, as sensors collect all the important data at all times. With the use of these sensors, any product manager can precisely see how much liquid is ready to be distributed and whether the manufacturing should be stepped up.

Image sensors

Image sensors are instruments which are used to convert optical images into electronic signals for displaying or storing files electronically.

The major use of image sensor is found in digital camera & modules, medical imaging and night vision equipment,thermal imaging devices, radar, sonar, media house, Biometric & IRIS devices.

Motion detection sensors

A motion detector is an electronic device which is used to detect the physical movement (motion) in a given area and it transforms motion into an electric signal; motion of any object or motion of human beings

Motion detection plays an important role in the security industry. Businesses utilize these sensors in areas where no movement should be always detected, and it is easy to notice anybody's presence with these sensors installed.

These are primarily used for intrusion detection systems, automatics door control, boom barrier, smart camera (i.e motion based capture/video recording), toll plaza, automatic parking systems, automated sinks/toilet flusher, hand dryers, energy management systems(i.e. Automated Lighting, AC, Fan, Appliances Control) etc.

Accelerometer sensors

Accelerometer is a transducer that is used to measure the physical or measurable acceleration experienced by an object due to inertial forces and converts the mechanical motion into an electrical output. It is defined as rate of change of velocity with respect to time

These sensors are now present in millions of devices, such as smartphones. Their uses involve detection of vibrations, tilting and acceleration in general. This is great for monitoring your driving fleet, or using a smart pedometer.

Gyroscope sensors

A sensor or device which is used to measure the angular rate or angular velocity is known as Gyro sensors, Angular velocity is simply defined as a measurement of speed of rotation around an axis. It is a device used primarily for navigation and measurement of angular and rotational velocity in 3-axis directions. The most important application is monitoring the orientation of an object.

Their main applications are in car navigation systems, game controllers, cellular & camera devices, consumer electronics, robotics control, drone & RC control helicopter or UAV control, vehicle control/ADAS and many more.

There are several different kinds of gyro sensors which are selected by their working mechanism, output type, power, sensing range and environmental conditions.

- Rotary (classical) gyroscopes
- Vibrating Structure Gyroscope
- Optical Gyroscopes
- MEMS(micro-electro-mechanical systems) Gyroscopes

These sensors are always combined with accelerometers. The use of these two sensors simply provides more feedback to the system. With gyroscopic sensors installed, many devices can help athletes improve the efficiency of their movements, as they gain access to the athletes movement during sports activities.

This is only one example of its application, however, as the role of this sensor is to detect rotation or twist, its application is crucial for the automation of some manufacturing processes.

Humidity sensors

Humidity is defined as the amount of water vapour in an atmosphere of air or other gases. The most commonly used terms are “Relative Humidity (RH)

These sensors usually follow the use of temperature sensors, as many manufacturing processes require perfect working conditions. Through measuring humidity, you can ensure that the whole process runs smoothly, and when there is any sudden change, action can be taken immediately, as sensors detect the change almost instantaneously.

Their applications and use can be found in Industrial & residential domain for heating, ventilating, and air conditioning systems control. They can also be found in Automotive, museums, industrial spaces and greenhouses , meteorology stations,Paint and coatings industries, hospitals & pharma industries to protect medicines

Optical sensors

A sensor which measures the physical quantity of light rays and convert it into electrical signal which can be easily readable by user or an electronic instrument/device is called optical sensor.

Optical sensors are loved by IoT experts, as they are practical for measuring different things simultaneously. The technology behind this sensor allows it to monitor electromagnetic energy, which includes, electricity, light and so on.

Due to this fact, these sensors have found use in healthcare, environment monitoring, energy, aerospace and many more industries. With their presence oil companies, pharmaceutical companies and mining companies are in a much better position to track environmental changes while keeping their employees safe.T

Their main use can be found in ambient light detection, digital optical switches, optical fibres communications,due to electrical isolation best suited for oil and gas applications, civil and transportation fields, high speed network systems, elevator door control, assembly line part counters and safety systems.

1.3 IoT components: layers

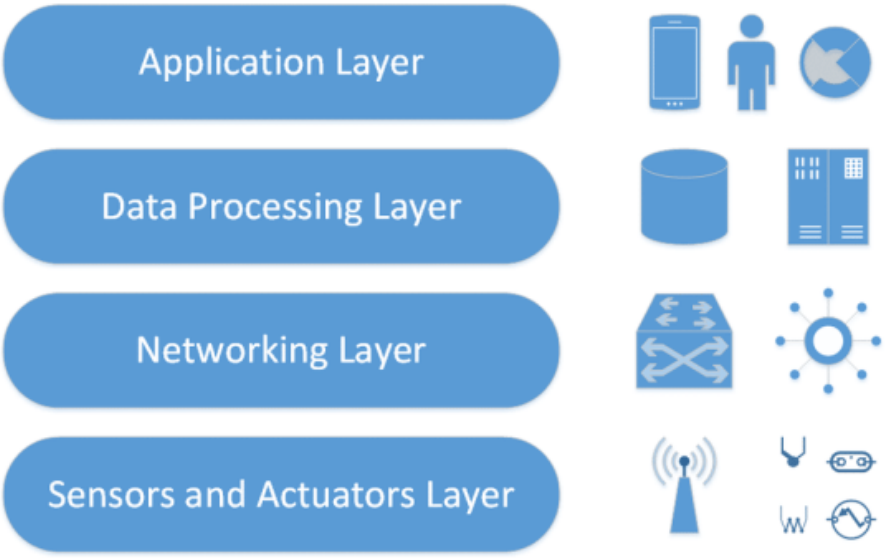


Fig 1.1 IoT Components

Application Layer

The application layer defines all applications in which IoT has deployed. It is the interface between the end IoT devices and the network. IoT Applications such as smart homes, smart health, smart cities, etc. It has the authority to provide services to the applications. The services may be different for each application because of services based on the information collected by sensors.

It is applied through a dedicated application at the device end. Such as for a computer, the application layer is applied by the browser. It is the browser that executes application layer protocols like HTTP, HTTPS, SMTP, and FTP. There are many concerns in the application layer out of which security is the key issue.

Common issues and threats of application layers are:

Cross-site scripting:

It is a type of computer security infirmities that typically found in web applications. It enables attackers to inject client-side scripts such as JavaScript into web pages viewed by other users. By doing so, an attacker can completely change the contents of the application as per his needs and use original information in an illegal way.

Malicious Code Attack:

It is a particular code in any part of the software system or script that is considered to cause undesired effects, security threats or damage to the system. It is that threat that may not be blocked or controlled by the use of anti-virus software.

Data Processing Layer

In three-layer architecture, the data were directly sent to the network layer. Due to sending data directly the chances of getting damages increase. In four-layer architecture, data is sent to this layer

that is obtained from a perception layer. Data Processing Layer has two responsibilities it confirms that data is forwarded by the authentic users and prevented from threats.

Authentication is the most commonly used method to verify the users and the data. It is applied by using pre-shared, keys and passwords to the concerned user. The second responsibility of the layer is to send information to the network layer. The medium through which data is transferred from the Data Processing Layer to the network layer can be wireless and wire-based.

Common issues and threats of the Data Processing layer are:

DoS Attack:

An attacker sends a huge amount of data to make network traffic overloaded. Thus, the huge consumption of system resources exhausts the IoT and makes the user unable to access the system.

Malicious Insider Attack:

It comes from the inside of an IoT environment to access private information. It is conducted by an authorized user to access the information of another user.

Network Layer

This layer is also known as a transmission layer. It acts like a bridge that carries and transmits data gathered from physical objects through sensors. The medium can be wireless or wire-based. It also connects the network devices and networks to each other. Hence, it is extremely sensitive to attacks from the attackers. It has important security issues regarding integrity and authentication of data that is being transmitted to the network.

Common issues and threats of the Network layer are:

Main-in-The-Middle Attack:

MiTM attack is an attack where the attacker privately intercepts and modifies the communication between the sender and receiver who assume they are directly communicating with each other. It leads to a serious threat to online security because they give the attacker the pathway to capture and control data in real-time

Storage Attack:

The crucial information of users is saved on storage devices or on the cloud. Both the storage devices and the cloud can be attacked by the attacker and the user's information may be modified to incorrect details.

By making regular backups of files, by running anti-virus software and using a system with strong passwords so that data access is restricted are the ways by which we can protect data from the attacker.

Exploit Attack:

An exploit is any unethical or illegal attack in a form of software, blocks of data or a sequence of commands. It takes benefit of security infirmities in an application, system or hardware. It usually occurs with the goal of getting control of the system and steals information stored on the network. By installing all software patches, security releases and all updates for your software are few preventive measures against attack.

Perception layer/Sensor layer

The sensor layer has the responsibility to recognize things and gather the data from them. There are many types of sensors connected to the objects to gather information such as RFID, sensors and 2-D barcode. The sensors are selected as per the requirement of applications. The data that is collected by these sensors can be about location, changes in the air, environment, etc. However, they are the main aim of attackers who wish to use them to replace the sensor with their own.

Hence, most of the threats are related to sensors are

Eavesdropping:

It is an unauthorized real-time attack where personal communications, such as phone calls, fax transmissions, text messages are intercepted by an attacker. It tries to take crucial information that is transferred over a network. Preventive measures such as Access control, continuous supervision/observation of all devices, thorough inspection by a qualified technical countermeasures specialist of all components need to be ensured.

Replay Attack:

It is also known as a playback attack. It is an attack in which an attacker intrudes on the conversation between the sender and receiver and extracts authentic information from the sender. The added risk of replay attacks is that a hacker doesn't even need improved skills to decrypt a message after seizing it from the network.

Timing Attack:

It is usually utilized in devices that have weak computing abilities. It allows an attacker to find vulnerabilities and withdraw secrets maintained in the security of a system by observing how long it takes the system to respond to various queries, input or other algorithms.

1.4 Smart City:

A **smart city** is an urban area that uses different types of electronic methods and sensors to collect data. It is a framework, predominantly composed of Information and Communication Technologies

(ICT), to develop, deploy, and promote sustainable development practices to address growing urbanization challenges. A big part of this ICT framework is essentially an intelligent network of connected objects and machines that transmit data using wireless technology and the cloud.

Cloud-based IoT applications receive, analyze, and manage data in real-time to help municipalities, enterprises, and citizens make better decisions that improve quality of life. Citizens engage with smart city ecosystems in various ways using smartphones and mobile devices and connected cars and homes. Pairing devices and data with a city's physical infrastructure and services can cut costs and improve sustainability.

The first question is what is meant by a 'smart city'. The answer is, there is no universally accepted definition of a smart city. It means different things to different people. The conceptualization of Smart City, therefore, varies from city to city and country to country, depending on the level of development, willingness to change and reform, resources and aspirations of the city residents. A smart city would have a different connotation in India than, say, Europe. Even in India, there is no one way of defining a smart city.

Some definitional boundaries are required to guide cities in the Mission. In the imagination of any city dweller in India, the picture of a smart city contains a wish list of infrastructure and services that describes his or her level of aspiration. To provide for the aspirations and needs of the citizens, urban planners ideally aim at developing the entire urban eco-system, which is represented by the four pillars of comprehensive development-institutional, physical, social and economic infrastructure. This can be a long term goal and cities can work towards developing such comprehensive infrastructure incrementally, adding on layers of 'smartness'.

In the approach of the Smart Cities Mission, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a light house to other aspiring cities. The Smart Cities Mission of the Government is a bold, new initiative. It is meant to set examples that can be replicated both within and outside the Smart City, catalyzing the creation of similar Smart Cities in various regions and parts of the country.

The core infrastructure elements in a smart city would include:

- adequate water supply,
- assured electricity supply,
- sanitation, including solid waste management,
- efficient urban mobility and public transport,
- affordable housing, especially for the poor,

- robust IT connectivity and digitalization,
- good governance, especially e-Governance and citizen participation,
- sustainable environment,
- safety and security of citizens, particularly women, children and the elderly, and
- health and education.

As far as Smart Solutions are concerned, an illustrative list is given below. This is not, however, an exhaustive list, and cities are free to add more applications.

Fig 1.2 Smart solutions within smart cities

Accordingly, the purpose of the Smart Cities Mission is to drive economic growth and improve the quality of life of people by enabling local area development and harnessing technology, especially technology that leads to Smart outcomes. Areabased development will transform existing areas (retrofit and redevelop), including slums, into better planned ones, thereby improving liveability of the whole City. New areas (greenfield) will be developed around cities in order to accommodate the expanding population in urban areas. Application of Smart Solutions will enable cities to use technology, information and data to improve infrastructure and services. Comprehensive development in this way will improve quality of life, create employment and enhance incomes for all, especially the poor and the disadvantaged, leading to inclusive Cities.

1.5 Industrial Internet of Things (IIoT)

IIoT stands for the Industrial Internet of Things or Industrial IoT that initially mainly referred to an industrial framework whereby many devices or machines are connected and synchronized through the use of software tools and third platform technologies in a machine-to-machine and Internet of Things context, later an Industry 4.0 or Industrial Internet context.

The industrial internet of things (IIoT) is the use of smart sensors and actuators to enhance manufacturing and industrial processes. Also known as the industrial internet or Industry 4.0, IIoT leverages the power of smart machines and real-time analytics to take advantage of the data that 'dumb machines' have produced in industrial settings for years. The driving philosophy behind IIoT is that smart machines are not only better than humans at capturing and analyzing data in real time, they are better at communicating important information that can be used to drive business decisions faster and more accurately.

Connected sensors and actuators enable companies to pick up on inefficiencies and problems sooner, and save time and money in addition to supporting business intelligence (BI) efforts. In manufacturing specifically, IIoT holds great potential for quality control, sustainable and green practices, supply chain traceability and overall supply chain efficiency. In an industrial setting, IIoT is key to processes such as predictive maintenance (PdM), enhanced field service, energy management and asset tracking.

1.5.1 IIoT versus IoT

Although the internet of things and the industrial internet of things have many technologies in common, including cloud platforms, sensors, connectivity, machine-to-machine communications and data analytics, they are used for different purposes.

IoT applications connect devices across multiple verticals, including agriculture, healthcare, enterprise, consumer and utilities, as well as government and cities. IoT devices include smart appliances, fitness bands and other applications that generally don't create emergency situations if something goes amiss.

IIoT applications, on the other hand, connect machines and devices in such industries as oil and gas, utilities and manufacturing. System failures and downtime in IIoT deployments can result in high-risk situations or even life-threatening situations. IIoT applications are also more concerned with improving efficiency and improving health or safety, versus the user-centric nature of IoT applications.

1.5.2 IIoT applications and examples

In a real-world IIoT deployment of smart robotics, ABB, a power and robotics firm, is using connected sensors to monitor the maintenance needs of its robots to prompt repairs before parts break.

Likewise, commercial jetliner maker Airbus has launched what it calls the "factory of the future," a digital manufacturing initiative to streamline operations and boost production. Airbus has integrated sensors into machines and tools on the shop floor and outfitted employees with wearable tech, e.g., industrial smart glasses, aimed at cutting down on errors and enhancing workplace safety.

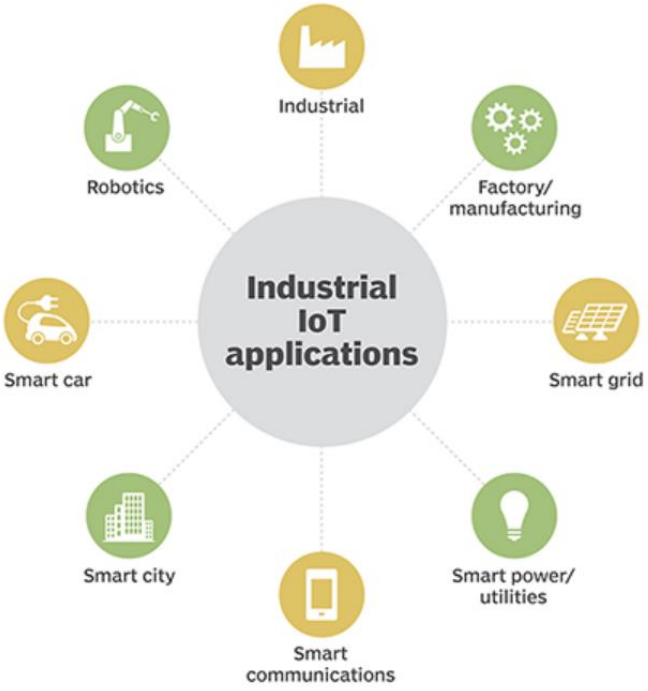


Fig 1.3 IIoT Applications and examples

Questions:

1. What is the Internet of Things (IoT)? Give some examples
2. What are the fundamental components of IoT?
3. What is the difference between IoT and IIoT?
4. List layers of IoT protocol stack
5. What are the advantages and disadvantages of IoT?
6. Define Smart City with some real-life examples.
7. What do you understand by sensors in w.r.t. IoT? Give the various types of sensors.
8. List 10 real life examples where IoT technology is being used.

UNIT-2

CLOUD COMPUTING

2.1 Cloud-Computing:

Cloud computing is the delivery of different services through the Internet, including data storage, servers, databases, networking, and software. Cloud-based storage makes it possible to save files to a remote database and retrieve them on demand.

The word "cloud" often refers to the Internet, which more precisely means a datacentre full of servers connected to the Internet performing a service.

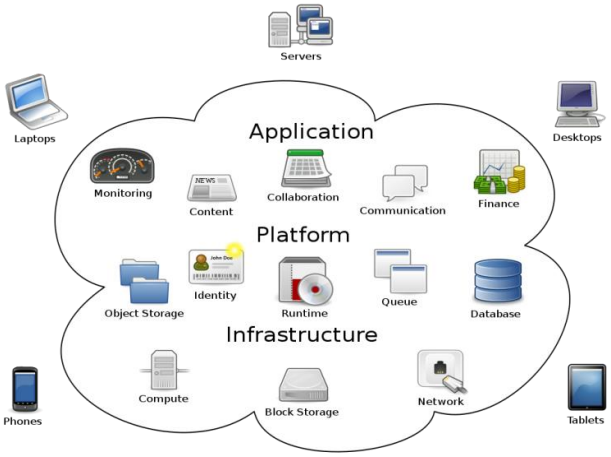


Fig 2.1 Cloud Computing Application

Cloud computing offers platform independency, as the software is not required to be installed locally on the PC. Hence, the Cloud Computing is making our business Applications mobile and collaborative.

2.1.1 Deployment Models of Cloud-Computing

Deployment models define the type of access to the cloud, i.e., how the cloud is located? Cloud can have any of the four types of access: Public, Private, Hybrid, and Community.

Public Cloud

The **public cloud** allows systems and services to be easily accessible to the general public. Public cloud may be less secure because of its openness.

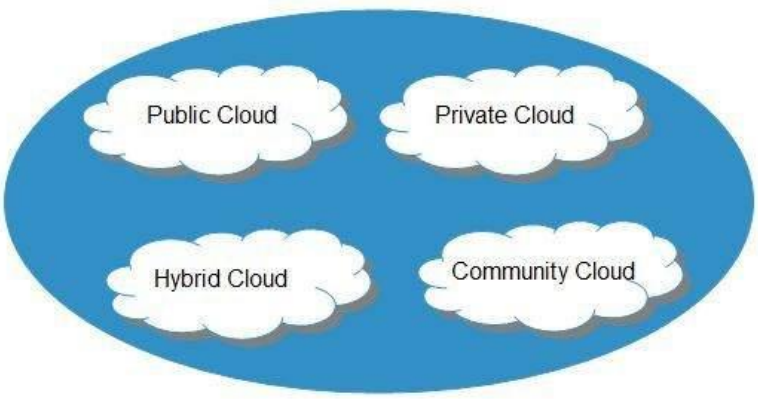


Fig 2.2 Deployment Models of Cloud Computing

Private Cloud

The **private cloud** allows systems and services to be accessible within an organization. It is more secured because of its private nature.

Community Cloud

The **community cloud** allows systems and services to be accessible by a group of organizations.

Hybrid Cloud

The **hybrid cloud** is a mixture of public and private cloud, in which the critical activities are performed using private cloud while the non-critical activities are performed using public cloud.

2.1.2 Service Models of Cloud-Computing

i. SaaS (Software as a Service)

SaaS or Software as a Service is a model that gives quick access to cloud-based web applications. The vendor controls the entire computing stack, which you can access using a web browser. These applications run on the cloud and you can use them by a paid licensed subscription or for free with limited access.

SaaS does not require any installations or downloads in your existing computing infrastructure. This eliminates the need for installing applications on each of your computers with the maintenance and support taken over by the vendor. Some known examples of SaaS include Google G Suite, Microsoft Office 365, Dropbox, etc.

Some of the core benefits of using SAAS model are:

- Easier administration.
- automatic updates and patch management.
- compatibility: all users will have the same version of software.
- easier collaboration, for the same reason.
- global accessibility.

ii. PaaS (Platform as a Service)

Platform as a Service or PaaS is essentially a cloud base where you can develop, test, and organize the different applications for your business. Implementing PaaS simplifies the process of enterprise software development. The virtual runtime environment provided by PaaS gives a favourable space for developing and testing applications.

The entire resources offered in the form of servers, storage, and networking are manageable either by the company or a platform provider. Google App Engine and AWS Elastic Beanstalk are two typical

examples of PaaS. PaaS is also subscription-based and gives you flexible pricing options depending on your business requirements.

Some of the main characteristics of PAAS are:

- Scalability and auto-provisioning of the underlying infrastructure.
- Security and redundancy.
- Build and deployment tools for rapid application management and deployment.
- Integration with other infrastructure components such as web services, databases, and LDAP.
- Multi-tenancy, platform service that can be used by many concurrent users.
- Logging, reporting, and code instrumentation.
- Management interfaces and/or API.

iii. IaaS (Infrastructure as a Service)

IaaS or Infrastructure as a Service is basically a virtual provision of computing resources over the cloud. An IaaS cloud provider can give you the entire range of computing infrastructures such as storage, servers, networking hardware alongside maintenance and support.

Businesses can opt for computing resources of their requirement without the need to install hardware on their premises. Amazon Web Services, Microsoft Azure, and Google Compute Engine are some of the leading IaaS cloud service providers.

iv. Storage as a Service (SAAS)

Storage as a Service is a business model in which a large company rents space in their storage infrastructure to a smaller company or individual. The economy of scale in the service provider's infrastructure theoretically allows them to provide storage much more cost-effectively than most individuals or corporations can provide their own storage when the total cost of ownership is considered. Storage as a Service is generally seen as a good alternative for a small or mid-sized business that lacks the capital budget and/or technical personnel to implement and maintain their own storage infrastructure.

v. Communications as a Service (CAAS)

Communications as a Service (CAAS) is an outsourced enterprise communications solution that can be leased from a single vendor. Such communications can include voice over IP (VoIP or Internet telephony), instant messaging (IM), collaboration and video conference applications using fixed and mobile devices. The CAAS vendor is responsible for all hardware and software management and

offers guaranteed Quality of Service (QoS). CAAS allows businesses to selectively deploy communications devices and modes on a pay-as-you-go, as-needed basis.

vi. Network as a Service (NAAS)

Network as a Service (NAAS), a framework that integrates current cloud computing offerings with direct, yet secure, client access to the network infrastructure. NAAS is a new cloud computing model in which the clients have access to additional computing resources collocated with switches and routers. NAAS can include flexible and extended Virtual Private Network (VPN), bandwidth on demand, custom routing, multicast protocols, security firewall, intrusion detection and prevention, Wide Area Network (WAN), content monitoring and filtering, and antivirus.

vii. Monitoring as a Service (MAAS)

Monitoring-as-a-service (MAAS) is a framework that facilitates the deployment of monitoring functionalities for various other services and applications within the cloud. The most common application for MAAS is online state monitoring, which continuously tracks certain states of applications, networks, systems, instances or any element that may be deployable within the cloud. MAAS makes it easier for users to deploy state monitoring at different levels of Cloud services.

Vendors providing Cloud Services:

1. Amazon Web Services.
2. Microsoft Azure.
3. Google Cloud Platform.
4. Alibaba Cloud.
5. IBM. Etc.

2.2 AWS (Amazon Web Services (AWS):

In 2006, **Amazon Web Services (AWS)** started to offer IT services to the market in the form of web services, which is nowadays known as **cloud computing**. With this cloud, we need not plan for servers and other IT infrastructure which takes up much of time in advance. Instead, these services can instantly spin up hundreds or thousands of servers in minutes and deliver results faster. We pay only for what we use with no up-front expenses and no long-term commitments, which makes AWS cost efficient.

How AWS works: AWS is separated into different services; each can be configured in different ways based on the user's needs. Users should be able to see configuration options and individual server maps for an AWS service.

More than 100 services comprise the Amazon Web Services portfolio, including those for compute, databases, infrastructure management, application development and security. These services, by category, include:

- Compute
- Storage databases
- Data management
- Migration
- Hybrid cloud
- Networking
- Development tools
- Management
- Monitoring
- Security
- Governance
- Big data management
- Analytics
- Artificial intelligence (AI)
- Mobile development
- Messages and notification

2.2.1 Services provided by AWS

Availability

Amazon Web Services provides services from dozens of data centers spread across availability zones (AZs) in regions across the world. An AZ is a location that contains multiple physical data centers. A region is a collection of AZs in geographic proximity connected by low-latency network links.

A business will choose one or multiple availability zones for a variety of reasons, such as compliance and proximity to end customers. For example, an AWS customer can spin up virtual machines (VMs) and replicate data in different AZs to achieve a highly reliable infrastructure that is resistant to failures of individual servers or an entire data center.

Amazon Elastic Compute Cloud (EC2) is a service that provides virtual servers -- called EC2 instances -- for compute capacity. The EC2 service offers dozens of instance types with varying capacities and sizes, tailored to specific workload types and applications, such as memory-intensive and accelerated-computing jobs. AWS also provides an Auto Scaling tool to dynamically scale capacity to maintain instance health and performance.

Storage

Amazon Simple Storage Service (S3) provides scalable object storage for data backup, collection and analytics. An IT professional stores data and files as S3 objects -- which can range up to 5 gigabytes (GB) -- inside S3 buckets to keep them organized. A business can save money with S3 through its Infrequent Access storage tier or by using Amazon Glacier for long-term cold storage.

Amazon Elastic Block Store provides block-level storage volumes for persistent data storage when using EC2 instances. Amazon Elastic File System offers managed cloud-based file storage.

A business can also migrate data to the cloud via storage transport devices, such as AWS Snowball and Snowmobile, or use AWS Storage Gateway to enable on-premises apps to access cloud data.

Databases, data management

The Amazon Relational Database Service -- which includes options for Oracle, SQL Server, PostgreSQL, MySQL, MariaDB and a proprietary high-performance database called Amazon Aurora -- provides a relational database management system for AWS users. AWS also offers managed NoSQL databases through Amazon DynamoDB.

An AWS customer can use Amazon ElastiCache and DynamoDB Accelerator as in-memory and real-time data caches for applications. Amazon Redshift offers a data warehouse, which makes it easier for data analysts to perform business intelligence (BI) tasks.

Migration, hybrid cloud

AWS includes various tools and services designed to help users migrate applications, databases, servers and data onto its public cloud. The AWS Migration Hub provides a location to monitor and

manage migrations from on premises to the cloud. Once in the cloud, EC2 Systems Manager helps an IT team configure on-premises servers and AWS instances.

Amazon also has partnerships with several technology vendors that ease hybrid cloud deployments. VMware Cloud on AWS brings software-defined data center technology from VMware to the AWS cloud. Red Hat Enterprise Linux for Amazon EC2 is the product of another partnership, extending Red Hat's operating system to the AWS cloud.

Networking

An Amazon Virtual Private Cloud (Amazon VPC) gives an administrator control over a virtual network to use an isolated section of the AWS cloud. AWS automatically provisions new resources within a VPC for extra protection.

Admins can balance network traffic with the Elastic Load Balancing (ELB) service, which includes the Application Load Balancer and Network Load Balancer. AWS also provides a domain name system called Amazon Route 53 that routes end users to applications.

An IT professional can establish a dedicated connection from an on-premises data center to the AWS cloud via AWS Direct Connect.

Developer tools

A developer can take advantage of AWS command-line tools and software development kits (SDKs) to deploy and manage applications and services. This includes:

- The AWS Command Line Interface, which is Amazon's proprietary code interface.
- A developer can use AWS Tools for Powershell to manage cloud services from Windows environments.
- Developers can use AWS Serverless Application Model to simulate an AWS environment to test Lambda functions.

AWS SDKs are available for a variety of platforms and programming languages, including Java, PHP, Python, Node.js, Ruby, C++, Android and iOS.

Amazon API Gateway enables a development team to create, manage and monitor custom application program interfaces (APIs) that let applications access data or functionality from back-end services. API Gateway manages thousands of concurrent API calls at once.

AWS also provides a packaged media transcoding service -- Amazon Elastic Transcoder -- and a service that visualizes workflows for microservices-based applications -- AWS Step Functions.

A development team can also create continuous integration and continuous delivery pipelines with services like:

- AWS CodePipeline
- AWS CodeBuild
- AWS CodeDeploy
- AWS CodeStar

A developer can also store code in Git repositories with AWS CodeCommit and evaluate the performance of microservices-based applications with AWS X-Ray.

Management and monitoring

An admin can manage and track cloud resource configuration via AWS Config and AWS Config Rules. Those tools, along with AWS Trusted Advisor, can help an IT team avoid improperly configured and needlessly expensive cloud resource deployments.

AWS provides several automation tools in its portfolio. An admin can automate infrastructure provisioning via AWS CloudFormation templates, and also use AWS OpsWorks and Chef to automate infrastructure and system configurations.

An AWS customer can monitor resource and application health with Amazon CloudWatch and the AWS Personal Health Dashboard, as well as use AWS CloudTrail to retain user activity and API calls for auditing.

Security and governance

AWS provides a range of services for cloud security, including AWS Identity and Access Management, which allows admins to define and manage user access to resources. An admin can also create a user directory with Amazon Cloud Directory, or connect cloud resources to an existing Microsoft Active Directory with the AWS Directory Service. Additionally, the AWS Organizations service enables a business to establish and manage policies for multiple AWS accounts.

Amazon Web Services has also introduced tools that automatically assess potential security risks. Amazon Inspector analyzes an AWS environment for vulnerabilities that might impact security and compliance. Amazon Macie uses machine learning (ML) technology to protect sensitive cloud data.

AWS also includes tools and services that provide software- and hardware-based encryption, protect against DDoS attacks, provision Secure Sockets Layer (SSL) and Transport Layer Security (TLS) certificates and filter potentially harmful traffic to web applications.

The AWS Management Console is a browser-based graphical user interface (GUI) for AWS. The Management Console can be used to manage resources in cloud computing, cloud storage and security credentials. The AWS Console interfaces with all AWS resources.

Big data management and analytics

AWS includes a variety of big data analytics and application services. This includes:

- Amazon Elastic MapReduce, which offers a Hadoop framework to process large amounts of data.
- Amazon Kinesis, which provides several tools to process and analyze streaming data.
- AWS Glue, which is a service that handles extract, transform and load jobs.
- Amazon Elasticsearch Serviceenables a team to perform application monitoring, log analysis and other tasks with the open source Elasticsearch tool.
- Amazon Athena for S3, which allows analysts to query data.
- Amazon QuickSight, which help analysts visualize data.

Artificial intelligence

AWS offers a range of AI model development and delivery platforms, as well as packaged AI-based applications. The Amazon AI suite of tools includes:

- Amazon Lex for voice and text chatbot technology;
- Amazon Polly for text-to-speech translation; and
- Amazon Rekognition for image and facial analysis.

AWS also provides technology for developers to build smart apps that rely on machine learning technology and complex algorithms.

With AWS Deep Learning Amazon Machine Images (AMIs), developers can create and train custom AI models with clusters of graphics processing units (GPUs) or compute-optimized instances. AWS also includes deep learning development frameworks for MXNet and TensorFlow.

On the consumer side, AWS technologies power the Alexa Voice Services, and a developer can use the Alexa Skills Kit to build voice-based apps for Echo devices.

Mobile development

The AWS Mobile Hub offers a collection of tools and services for mobile app developers, including the AWS Mobile SDK, which provides code samples and libraries.

A mobile app developer can also use Amazon Cognito to manage user access to mobile apps, as well as Amazon Pinpoint to send push notifications to application end users and then analyze the effectiveness of those communications.

Messages and notifications

AWS messaging services provide core communication for users and applications. Amazon Simple Queue Service (SQS) is a managed message queue that sends, stores and receives messages between components of distributed applications to ensure that the parts of an application work as intended.

Amazon Simple Notification Service (SNS) enables a business to send publish/subscribe messages to endpoints, such as end users or services. SNS includes a mobile messaging feature that enables push messaging to mobile devices. Amazon Simple Email Service (SES) provides a platform for IT professionals and marketers to send and receive emails.

AR & VR (Augmented reality and virtual reality)

AWS offers augmented reality (AR) and virtual reality (VR) development tools through the Amazon Sumerian service. Amazon Sumerian allows users to create AR and VR applications without needing to know programming or create 3D graphics. The service also enables users to test and publish applications in-browser. Amazon Sumerian can be used in:

- 3D web applications
- E-commerce & sales applications
- Marketing

- Online education
- Manufacturing
- Training simulations
- Gaming

Game development

AWS can also be used for game development. Large game developing companies, such as Ubisoft, will use AWS services for their games, like For Honor. AWS can provide services for each part of a game's lifecycle.

For example, AWS will provide a developer back-end services, analytics and developer tools. Developer tools should help aid developers in making their game, while back-end services might be able to help with building, deploying or scaling a developer's platform. Analytics might help developers better know their customers and how they play the game. Developers can also store data, or host game data on AWS servers.

Internet of Things

AWS also has a variety of services that enable the internet of things (IoT) deployments. The AWS IoT service provides a back-end platform to manage IoT devices and data ingestion to other AWS storage and database services. The AWS IoT Button provides hardware for limited IoT functionality and AWS Greengrass brings AWS compute capabilities to IoT devices.

Other services

Amazon Web Services has a range of business productivity SaaS options, including:

- The Amazon Chime service enables online video meetings, calls and text-based chats across devices.
- Amazon WorkDocs, which is a file storage and sharing service
- Amazon WorkMail, which is a business email service with calendaring features.

Desktop and streaming application services include Amazon WorkSpaces, a remote desktop-as-a-service platform (DaaS), and Amazon AppStream, a service that lets a developer stream a desktop application from AWS to an end user's web browser.

2.3 Google Cloud:

Google Cloud consists of a set of physical assets, such as computers and hard disk drives, and virtual resources, such as virtual machines (VMs), that are contained in Google's data centers around the globe. Each data center location is in a region. Regions are available in Asia, Australia, Europe, North America, and South America. Each region is a collection of zones, which are isolated from each other within the region. Each zone is identified by a name that combines a letter identifier with the name of the region. For example, zone a in the East Asia region is named asia-east1-a.

This distribution of resources provides several benefits, including redundancy in case of failure and reduced latency by locating resources closer to clients. This distribution also introduces some rules about how resources can be used together.

2.3.1 Google Cloud Functions

Google Cloud Functions is a serverless, event-driven computing service within Google Cloud Platform. Developers can use it to create and implement programmatic functions within Google's public cloud, without having to provision the underlying cloud infrastructure -- such as servers, storage and other resources.

Google Cloud Functions allows small code segments to perform specific, limited tasks, which are typically related to triggering responses to real-world and software-driven events. When an event triggers an associated function, the function is loaded into a provisioned cloud environment and executed. All infrastructure resources are provisioned and recovered automatically by Google Cloud Platform (GCP).

Google Cloud vs AWS

Google Cloud is a suite of Google's public cloud computing resources & services whereas AWS is a secure cloud service developed and managed by Amazon. Google Cloud offers Google Cloud Storage, while AWS offers Amazon Simple Storage Services.

2.3.2 Advantages of Google Cloud

- **Higher Productivity owing to Quick Access to Innovation:** Google's systems can deliver updates efficiently and on a weekly basis.
- **Less Disruption When Users Adopt New Functionality:** Rather than large disruptive batches of change, Google delivers manageable improvements in a continuous stream.

- **Employees Can Work from Anywhere:** They can gain full access to information across devices from anywhere in the world through web-based apps powered by Google cloud.
- **Google Cloud Allows Quick Collaboration:** Many users can contribute to and access projects at the same time as data is stored in the cloud instead of their computers.
- **Google's Investments in Security Protect Customers:** Customers benefit from process-based and physical security investments made by Google. Google hires leading security experts.
- **Fewer Data stored on Vulnerable Devices:** Minimal data is stored on computers that may get compromised after a user stops using web-based apps on the cloud.
- **Customers get Higher Uptime and Reliability:** If a data center is not available for some reason, the system immediately falls back on the secondary center without any service interruption being visible to users.
- **Control and Flexibility Available to Users:** They have control over technology and have ownership over their data in Google apps. If they decide to not use the service anymore, they can get their data out of Google cloud.
- **Google's Economies of Scale Let Customers Spend Less:** Google minimizes overheads and consolidates a small number of server configurations. It manages these through an efficient ratio of people to computers.

2.3.3 Google Cloud Categories

Products offered by Google Cloud are categorized into four categories: Compute, Storage, Big Data, and Services.

Compute: It further consists of two sub-categories:

i. **Compute Engine**

It is Google's infrastructure-as-a-service (IaaS). Through this, Google's infrastructure can be used to run workloads on a large scale on virtual machines. You can select a virtual computer to fit your needs and enjoy the consistency and performance of Google's network worldwide. You have to pay only for what you use since the billing is per minute.

Features

- Security and Compliance
- Easy and Fast Provisioning
- Balancing of Loads
- High-Performance Virtual Computers

ii. App Engine

It is a platform-as-a-service (PaaS). You can ensure productivity by using in-built services to develop your apps. You must download the software development kit (SDK) and can start development work immediately and for free.

Features

- Google Scale Deployment
- Known Development Tools
- Strong In-Built Services
- Many Options for Storage
- Code Focus
- Popular Frameworks and Languages

Storage

It further consists of three sub-categories:

i. Cloud SQL

Cloud SQL is a relational MySQL database that helps manage and store data. To ensure performance and availability, Google takes care of database management, patch management, and replication.

Features

- Completely Managed
- Easy to Control

- Simpler Migration Without Lock-In
- Robustness, Accessibility, Security
- Pay Per Use and Package Charging
- Standard Infrastructure

ii. Cloud Storage

It is an object storage service that is highly available and durable. Users can quickly access data from their app from anywhere, on account of edge-caching on a global scale. Google presents a simple application programming interface (API), provides a robust service-level agreement, and runs versioning to let you handle data programmatically.

Features

- Variable Access
- Storage of Objects with Feature-Rich API
- Adjustable and Viable Pricing
- Safe and Secure

iii. Cloud Datastore

It provides a database, which is schemaless, NoSQL, and managed, for storage of non-relational data. SQL-like queries are supported well, in addition to transactions, and the data store also scales as required.

Features

- Access to Data Anywhere
- Local Tools for Development
- In-built Redundancy
- ACID Transactions
- Scaling Automatically with Users
- Database Management
- SQL-Like Querying and Schemaless Access

Big Data

BigQuery analyzes big data in the cloud. It can process datasets containing several terabytes in a few seconds and run quick SQL-like queries. It even provides insights in real-time and is scalable and straightforward to use.

Features

- Suitable Interface
- Economical Big Data
- Easy Import of Data

- Queries Executed in Background

Google also provides developer tools such as Google Plugin for Eclipse, Google Cloud SDK, Android Studio, Cloud Playground, and Push-to-Deploy, along with the cloud platform.

Services

Javascript, Android, and iOS clients can access your code through RESTful services from your system with Cloud Endpoints. The front-end wiring can become smooth, and the generation of client libraries can generate automatically. Client key management, OAuth 2.0 support, and protection against denial of service are part of the significant in-built infrastructure.

Features

- Integration of client-side becomes flexible
- Client-server maintenance is low
- App engine infrastructure can be extended
- Multiple clients handling with a single tool

2.4 Microsoft Azure

Azure is Microsoft's cloud platform, just like Google has it's Google Cloud and Amazon has it's Amazon Web Service or AWS.000. Generally, it is a platform through which we can use Microsoft's resource. For example, to set up a huge server, we will require huge investment, effort, physical space and so on. In such situations, Microsoft Azure comes to our rescue. It will provide us with virtual machines, fast processing of data, analytical and monitoring tools and so on to make our work simpler. The pricing of Azure is also simpler and cost-effective. Popularly termed as "Pay As You Go", which means how much you use, pay only for that.

Azure History

Microsoft unveiled Windows Azure in early October 2008 but it went to live after February 2010. Later in 2014, Microsoft changed its name from Windows Azure to Microsoft Azure. Azure provided a service platform for .NET services, SQL Services, and many Live Services. Many people were still very skeptical about "the cloud". As an industry, we were entering a brave new world with many possibilities. Microsoft Azure is getting bigger and better in coming days. More tools and more functionalities are getting added. It has two releases as of now. It's famous version **Micorosft Azure v1** and later **Microsoft Azure v2**. Microsoft Azure v1 was more like JSON script driven then the new version v2, which has interactive UI for simplification and easy learning. Microsoft Azure v2 is still in the preview version.

Azure can help in our business in the following ways-

- **Capitaless:** We don't have to worry about the capital as Azure cuts out the high cost of hardware. You simply pay as you go and enjoy a subscription-based model that's kind to your cash flow. Also, to set up an Azure account is very easy. You simply register in Azure Portal and select your required subscription and get going.
- **Less Operational Cost:** Azure has low operational cost because it runs on its own servers whose only job is to make the cloud functional and bug-free, it's usually a whole lot more reliable than your own, on-location server.
- **Cost Effective:** If we set up a server on our own, we need to hire a tech support team to monitor them and make sure things are working fine. Also, there might be a situation where the tech support team is taking too much time to solve the issue incurred in the server. So, in this regard is way too pocket-friendly.
- **Easy Back Up and Recovery options:** Azure keep backups of all your valuable data. In disaster situations, you can recover all your data in a single click without your business getting affected. Cloud-based backup and recovery solutions save time, avoid large up-front investment and roll up third-party expertise as part of the deal.
- **Easy to implement:** It is very easy to implement your business models in Azure. With a couple of on-click activities, you are good to go. Even there are several tutorials to make you learn and deploy faster.
- **Better Security:** Azure provides more security than local servers. Be carefree about your critical data and business applications. As it stays safe in the Azure Cloud. Even, in natural disasters, where the resources can be harmed, Azure is a rescue. The cloud is always on.
- **Work from anywhere:** Azure gives you the freedom to work from anywhere and everywhere. It just requires a network connection and credentials. And with most serious Azure cloud services offering mobile apps, you're not restricted to which device you've got to hand.
- **Increased collaboration:** With Azure, teams can access, edit and share documents anytime, from anywhere. They can work and achieve future goals hand in hand. Another advantage of the Azure is that it preserves records of activity and data. Timestamps are one example of the Azure's record keeping. Timestamps improve team collaboration by establishing transparency and increasing accountability.

2.4.1 Microsoft Azure Services

Some following are the services of Microsoft Azure offers:

1. **Compute:** Includes Virtual Machines, Virtual Machine Scale Sets, Functions for serverless computing, Batch for containerized batch workloads, Service Fabric for microservices and container orchestration, and Cloud Services for building cloud-based apps and APIs.
2. **Networking:** With Azure you can use variety of networking tools, like the Virtual Network, which can connect to on-premise data centers; Load Balancer; Application Gateway; VPN Gateway; Azure DNS for domain hosting, Content Delivery Network, Traffic Manager, ExpressRoute dedicated private network fiber connections; and Network Watcher monitoring and diagnostics
3. **Storage:** Includes Blob, Queue, File and Disk Storage, as well as a Data Lake Store, Backup and Site Recovery, among others.
4. **Web + Mobile:** Creating Web + Mobile applications is very easy as it includes several services for building and deploying applications.
5. **Containers:** Azure has a property which includes Container Service, which supports Kubernetes, DC/OS or Docker Swarm, and Container Registry, as well as tools for microservices.
6. **Databases:** Azure has also includes several SQL-based databases and related tools.
7. **Data + Analytics:** Azure has some big data tools like HDInsight for Hadoop Spark, R Server, HBase and Storm clusters
8. **AI + Cognitive Services:** With Azure developing applications with artificial intelligence capabilities, like the Computer Vision API, Face API, Bing Web Search, Video Indexer, Language Understanding Intelligent.
9. **Internet of Things:** Includes IoT Hub and IoT Edge services that can be combined with a variety of machine learning, analytics, and communications services.
10. **Security + Identity:** Includes Security Center, Azure Active Directory, Key Vault and Multi-Factor Authentication Services.

2.4.2 Difference between AWS (Amazon Web Services), Google Cloud and Azure

Table 2.1 AWS vs Google Cloud vs Azure

	AWS	Google Cloud	Azure
Technology	EC2 (Elastic Compute Cloud)	Google Compute Engine (GCE)	VHD (Virtual Hard Disk)
Databases Supported	AWS fully supports relational and NoSQL databases and Big Data.	Technologies pioneered by Google, like Big Query, Big Table, and Hadoop, are naturally fully supported.	Azure supports both relational and NoSQL databases, and Big Data, through Windows Azure Table and HDInsight.
Pricing	Per hour – rounded up	Per minute – rounded up (minimum 10 minutes)	Per minute – rounded up commitments (pre-paid or monthly)
Models	On demand, reserved, spot	On demand – sustained use	On demand – short term commitments (pre-paid or monthly)
Difficulties	Many enterprises find it difficult to understand the company's cost structure	Fewer features and services.	Less "enterprise-ready"
Storage Services	• Simple Storage Service (S3) • Elastic Block Storage (EBS) • Elastic Block Storage (EBS)	• Blob Storage • Queue Storage • File Storage • Disk Storage • Data Lake Store	• Cloud Storage • Persistent Disk • Transfer Appliance
Machine Learning	• Sage Maker • Lex • Polly • And many more	• Machine Learning • Azure Bot Service • Cognitive Service	• Cloud Speech API • Cloud Video Intelligence • Cloud Machine Learning Engine • And many more.

2.5 Vendor **Offering – IBM**

IBM Cloud is a suite of cloud computing services from IBM that offers both platform as a service (PaaS) and infrastructure as a service (IaaS). With IBM Cloud IaaS, organizations can deploy and access virtualized IT resources -- such as compute power, storage and networking -- over the internet. For compute, organizations can choose between bare-metal or virtual servers.

With IBM Cloud PaaS -- which is based on the open source cloud platform Cloud Foundry -- developers can use IBM services to create, manage, run and deploy various types of applications for the public cloud, as well as for local or on-premises environments. IBM Cloud supports various programming languages, such as Java, Node.js, PHP and Python and extends to support other languages. IBM Cloud products and services IBM Cloud platform supports access to other IBM tools and services -- including IBM Watson and IBM Cloud Functions for serverless computing -- as well as those from third-party vendors.

The IBM Cloud Catalog lists over 170 services across categories, including:

- Compute -- Offers various compute resources, including bare-metal servers, virtual servers, serverless computing and containers, on which enterprises can host their workloads;

- Network -- Provides cloud networking services, such as a load balancer, a content delivery network (CDN), virtual private network (VPN) tunnels and firewalls;
- Storage -- Offers object, block and file storage for cloud data;
- Management -- Provides tools to manage and monitor cloud deployments, such as those for log analysis, automation and Infrastructure as Code (IaC);
- Security -- Includes services for activity tracking, identity and access management and authentication;
- Data management -- Provides SQL and NoSQL databases, as well as data querying and migration tools;
- Analytics -- Offers data science tools such as Apache Spark, Apache Hadoop and IBM Watson Machine Learning, as well as analytics services for streaming data;
- Artificial Intelligence (AI) -- Uses IBM Watson to deliver services such as machine learning, natural language processing and visual recognition;
- Internet of things (IoT) -- Includes the IBM IoT Platform, which provides services that connect and manage IoT devices, and analyzes the data they produce;
- Mobile -- Enables a development team to build and monitor mobile applications and their back-end components;
- Developer tools -- Includes a command-line interface (CLI), as well as a set of tools for continuous delivery, continuous release and application pipelines;
- Blockchain -- Provides IBM's Blockchain Platform, a software-as-a-service offering to develop apps, enforce governance and monitor a Blockchain network;
- Integration -- Offers services to integrate cloud and on-premises systems, or various applications, such as API Connect, App Connect and IBM Secure Gateway;
- Migration -- Provides tools to migrate apps to the cloud, such as IBM Lift CLI and Cloud Mass Data Migration;
- VMware -- Enables the migration of VMware workloads into the cloud.

2.5.1 IBM Cloud deployment models:

Public: A public cloud that provides access to virtual servers in a Multi-tenant environment. An enterprise can choose to deploy its applications in one or multiple geographical regions.

Dedicated: A single tenant private cloud that IBM hosts in one of its data centers. An enterprise can connect to the environment using a direct network connection or virtual private network (VPN), and IBM manages the platform.

IBM Cloud Private: A version of the IBM platform that an organization deploys as a private cloud in its own data center behind a firewall.

Questions:

1. What is cloud computing?
2. What are the benefits of cloud computing?
3. What are the different layers in cloud computing? Explain working of them.
4. What do you mean by software as a service (SaaS)?
5. What is the platform as a service (PaaS)?
6. Explain Infrastructure as s Service (IaaS)?
7. Write short notes on following
   a) AWS
   b) Google
   c) Microsoft
8. List the name of vendors offering Cloud Services.
9. Enlist the real-life scenarios where Cloud- Computing services are being used.

UNIT-3

BLOCKCHAIN

3.1 What is Blockchain? Fundamentals:

A blockchain is a growing list of records, called blocks, which are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data.

Blockchain is the backbone Technology of Digital Cryptocurrency BitCoin. The blockchain is a distributed database of records of all transactions or digital event that have been executed and shared among participating parties. Each transaction verified by the majority of participants of the system. It contains every single record of each transaction. BitCoin is the most popular cryptocurrency an example of the blockchain. Blockchain Technology first came to light when a person or Group of individuals name 'Satoshi Nakamoto' published a white paper on "BitCoin: A peer to peer electronic cash system" in 2008. Blockchain Technology Records Transaction in Digital Ledger which is distributed over the Network thus making it incorruptible. Anything of value like Land Assets, Cars, etc. can be recorded on Blockchain as a Transaction.

Blockchain technology has been garnering great hype recently. It gained popularity after the introduction of Bitcoin in 2009 by the person or group of people by the pseudonym Satoshi

Nakamoto. Many people confuse and believe blockchain to be bitcoin. But, bitcoin is one application of the blockchain technology. There are many other applications and use cases that can be solved using blockchain other than just payment systems.

A blockchain is defined as a peer-to-peer distributed ledger forged by consensus, combined with a system for smart contracts. -Hyperledger, Linux Foundation

3.2 Block-Chain Principles and Technologies

Blockchain is built on four main concepts:

1. It is a distributed ledger, so every participant in the network has simultaneous access to a view of the information.
2. Cryptographic functions ensure the integrity and security of the information.
3. Participants confirm changes directly with one another. This replaces the need for a third party to authorize transactions.
4. It can run additional business logic (set by computer code) that allows the agreement on and automatic enforcement of the expected behaviour of a transaction or asset embedded in the blockchain. These are known as smart contracts.

3.2.1 What Can Blockchain Technology do?

The network can connect to users and make direct transactions between them. The time stamps and ledgers are maintained automatically by the system. This means you won't need any third party official figures in the system.

However, all the users of the blockchain technology are the administrators. You can also use smart contracts on the blockchain technology. As the network uses consensus algorithms, you can quickly create a project with certain conditions. So, after all of them are fulfilled accordingly, every member of the project will get a fair distribution of their payment. This eliminates the prioritizing or favouring in case of any teamwork.

A great example would be the real estate market. If certain conditions aren't met in deals, then the transaction never happens. Usually, in the blockchain, the users use the networks very own specified currency to pay up as the token money.

3.2.2 How Block-Chain Technology works

Now, let's talk about how it works. But first, let's see some important features of the whole system.

1. Blockchain will keep score of all type of data exchanges. This is called a ledger system, and the data exchanges are called ‘transactions.’ After verification, every transaction gets to add up to the ledger as a block.
2. It uses a different kind of distributed network to ensure that every transaction is on the point between P2P nodes.
3. After a block gets added and verified, no one can alter its information.

The Process

Blockchain ensures security in this network by using the concept of ‘Key.’ If you use a set of encrypted keys, you’ll get a unique identification that no one can break. You’ll get a private and public key, using this combination you’ll get a unique identity. Others will use your public key to find you on the network. With the help of your private key, you’ll be able to sign any action or authorize transactions associated with your public key.

If you think about cryptocurrencies, then the public key will get used as your wallet address, and you’ll use the private key to withdraw, send or buy digital money. That’s why it’s essential for you to keep this key safe. If someone gets their hands on your private key, then he/she could access all your digital assets and misuse it.

So, every time you send something over the network, you’ll authorize it. It might be something like “Todd is sending Jamie 2 BTC”, this will include the public key of Jamie to locate him and Todd’s public and private key to encrypt the transaction.

After the transaction, the system nodes will verify it, and it’ll get added to the ledger with the help of a unique id and time frame. In short, every transaction will have the same features, a public key, digital signature, unique ID and the timestamp.

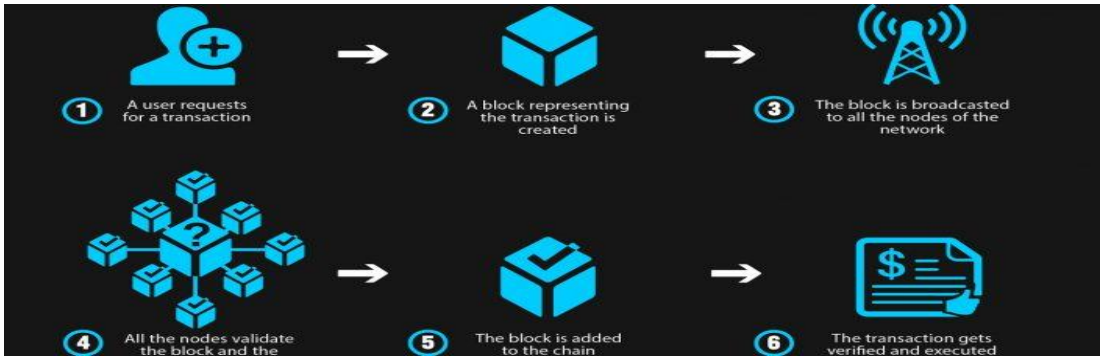


Fig 3.1 Block-Chain Process

Advantages of Block-Chain Technology

- Greater transparency. Transaction histories are becoming more transparent through the use of **blockchain technology**

- Enhanced security. There are several ways **blockchain** is more secure than other record-keeping systems.
- Improved traceability.
- Increased efficiency and speed.
- Reduced costs.

Disadvantages of Block-Chain Technology

- Blockchain use excessive energy.
- Blockchain is not a huge, distributed computing system.
- Mining does not provide network security.
- Blockchain entries do not last forever or are not immutable.
- Scalability remains blockchain's weakness.
- Blockchain is not indestructible.

3.3 Cryptocurrency:

A **cryptocurrency** (or crypto currency) is a digital asset designed to work as a medium of exchange wherein individual coin ownership records are stored in a ledger existing in a form of computerized database using strong cryptography to secure transaction records, to control the creation of additional coins, and to verify the transfer of coin ownership.

How Secure Is Cryptocurrency?

Cryptocurrencies are usually built using blockchain technology. Blockchain describes the way transactions are recorded into "blocks" and time stamped. It's a fairly complex, technical process, but the result is a digital ledger of cryptocurrency transactions that's hard for hackers to tamper with.

In addition, transactions require a two-factor authentication process. For instance, you might be asked to enter a username and password to start a transaction. Then, you might have to enter an authentication code that's sent via text to your personal cell phone.

While securities are in place, that doesn't mean cryptocurrencies are un-hackable. In fact, several high-dollar hacks have cost cryptocurrency startups heavily. Hackers hit Coincheck to the tune of $534 million and BitGrail for $195 million in 2018. That made them two of the biggest cryptocurrency hacks of 2018, according to Investopedia.

Tips to Invest in Cryptocurrency Safely

Investments are always risky, but some experts say cryptocurrency is one of the riskier investment choices out there, according to Consumer Reports. However, digital currencies are also some of the hottest commodities. Earlier this year, CNBC forecasted that the cryptocurrency market is expected to reach a value of $1 trillion by the end of 2018. If you're planning to invest in cryptocurrencies, these tips can help you make educated choices.

1. **Research Exchanges**

Before you invest one dollar, learn about cryptocurrency exchanges. These platforms provide the means to buy and sell digital currencies, but there are 500 exchanges to choose from, according to Bitcoin.com. Do your research, read reviews and talk with more experienced investors before moving forward.

2. **Know How to Store Your Digital Currency**

If you buy cryptocurrency, you have to store it. You can store it on an exchange or in a digital "wallet," for example one of the crypto wallets described in our Blog post Which cryptocurrency wallet to choose. While there are many different kinds of wallets, each has its own benefits, technical requirements and security. As with exchanges, you should investigate your storage choices before investing.

3. **Diversify Your Investments**

Diversification is a key to any good investment strategy, and it holds true when you're investing in cryptocurrency too. Don't put all of your money in Bitcoin, for example, just because that's the name you know. There are thousands of options, and it's best to spread your investment around to several currencies.

4. **Prepare for Volatility**

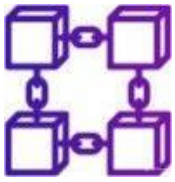
The cryptocurrency market is a volatile one, so be prepared for ups and downs. You'll see dramatic swings in prices. If your investment portfolio or mental wellbeing can't handle that, cryptocurrency might not be a wise choice for you.

Cryptocurrency is all the rage right now, but remember, it's still in its infancy. Investing in something that's new comes with challenges, so be prepared. If you plan to participate, do your research and invest conservatively to start.

3.4 Smart- Contracts:

Smart contracts are lines of code that are stored on a blockchain and automatically execute when predetermined terms and conditions are met. At the most basic level, they are programs that run as they've been set up to run by the people who developed them.

A smart contract is **an agreement between two people in the form of computer code**. They run on the blockchain, so they are stored on a public database and cannot be changed.



The transactions that happen in a smart contract are **processed by the blockchain**, which means they can be sent automatically without a third party. This means there is no one to rely on!

The transactions only happen **when the conditions in the agreement are met** — there is no third party, so there are no issues with trust.

The key features of smart contracts are-

1. Once the smart contract is released, no one including the creator (owner) can modify its terms.
2. Physical documents are not required to initiate and complete the transaction.
3. Although users can remain anonymous, the smart contract records the transaction details.
4. Moderators can track market activity but cannot regulate the transactions.
5. Smart contract transactions are irreversible.

3.4.1 How Smart Contracts work:

Step 1. Transfer contract terms into code

First, the contractual parties should determine the terms of the contract. After the contractual terms are finalized, they are translated into programming code. Basically, the code represents a number of different conditional statements that describe the possible scenarios of a future transaction.

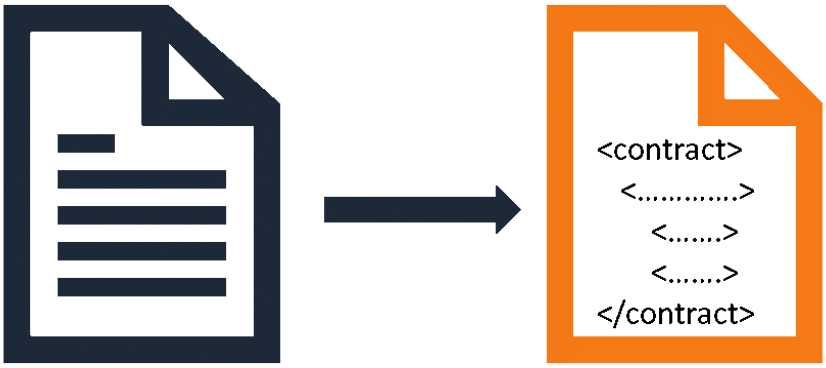


Fig 3.2 Transfer contract terms into code

Step 2. The code is stored in a blockchain and replicated between participants

When the code is created, it is stored in the blockchain network and is replicated among the participants in the blockchain.

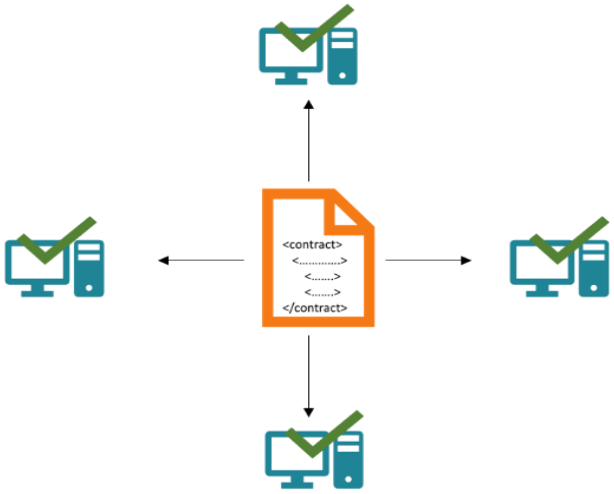


Fig 3.3 replication of code between participants

Step 3. When a term is satisfied, computers in the network verify its correctness.

Then, the code is run and executed by all computers in the network. If a term of the contract is satisfied and it is verified by all participants of the blockchain network, then the relevant transaction is executed.

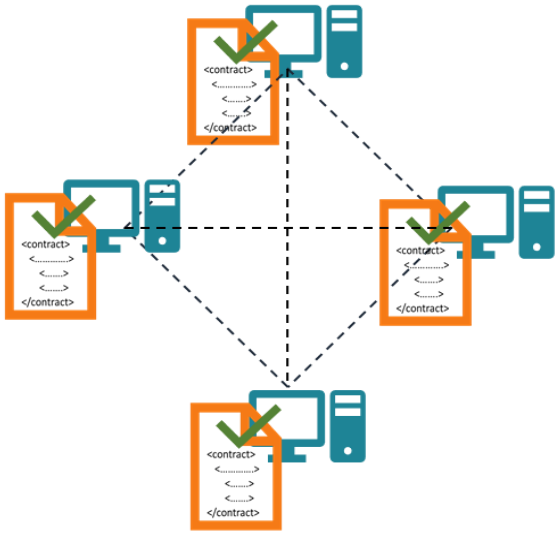


Fig 3.4 verification of correctness

3.4.2 What are the benefits of smart contracts?

The benefits of smart contracts go hand-in-hand with blockchain.

1. **Speed and accuracy**: Smart contracts are digital and automated, so you won't have to spend time processing paperwork or reconciling and correcting the errors that are often written into documents that have been filled manually. Computer code is also more exact than the legalese that traditional contracts are written in.
2. **Trust**: Smart contracts automatically execute transactions following predetermined rules, and the encrypted records of those transactions are shared across participants. Thus, nobody has to question whether information has been altered for personal benefit.
3. **Security**: Blockchain transaction records are encrypted, and that makes them very hard to hack. Because each individual record is connected to previous and subsequent records on a distributed ledger, the whole chain would need to be altered to change a single record.
4. **Savings**: Smart contracts remove the need for intermediaries because participants can trust the visible data and the technology to properly execute the transaction. There is no need for an extra person to validate and verify the terms of an agreement because it is built into the code.

3.5 Blockchain Applications and use cases

1. **Internet of Things (IoT)**

The word is widespread in the crypto niche – Internet of Things (IoT). But what is it? Think of all the devices that have the ability to connect to the internet. It could be your refrigerator, your home assistant, even maybe your smart TV. The basic concept is – no matter whatever the "thing" is, if it can connect to the internet, it's in the IoT club.

Generally, the smart home appliances get considered as the entities of the Internet of Things. Every dot that connects to the web is a great asset to the technology network. What's the best part of this technology, it's energy efficient? Cryptocurrencies generally consume insane amount to generate. The IoT can do a lot save a massive amount of electrical power.

Blockchain Healthcare

One of the unique features of the blockchain technology is all the data is encrypted. It never violates personal privacy. It's a great weapon against data breach and other virtual crimes. So, we think this technology can highly benefit the healthcare sector. Blockchain could encrypt all the user data and keep it safe for specific eyes only. All the documentation like surgery data could be encoded and kept private.

So, undoubtedly, healthcare could be a vast field that can get the utmost benefit from the tech.

2. Cross-Broder Payments Made Easy: Say Goodbye to Settlement Disputes

Sending and receiving money from abroad has always been an issue of hassle. First of all, not every payment method is available in every country. Almost every state has a governing eye that maintains the overall process. Second of all, it takes about 4-5 days to transact money from a state to another.

Something had to be done! We are talking about a lot of money. About 150 trillion dollars have transacted from country to country only in the years 2015. Still, the process is very complicated, opaque and questionable. Blockchain can be a lifesaver in this case.

You could just say goodbye to annoying waiting time. What's the best part? No one would look at your money like vultures lurking over its feasts! Cross-border payments is now a matter of a click with this tech. Moreover, there is scope for laundering money and other related crimes. There will undoubtedly be fewer disputes and life will be much easier for people supporting families from abroad.

3. E-Voting: Not Just a Myth!

Voting is one of the fundamental civil rights of all the citizens. But the evilness has made things harsh or honesty and clarity. The process could get immense of help from the blockchain technology. There are two primary reasons to support the e-voting system – anonymous and secured. People always doubt such a system. And it is quite reasonable. The competing parties could feel that an election is getting rigged. But 2016 US election and 2014 election of Denmark gave a definite reply to the doubters.

4. **Enhanced Digital Security**

Cybercriminals are now a massive threat to governments and big companies. The cybersecurity industry is worth at least $18 billion annually according to various reports. Distil Networks has published a statement regarding the matter, and it made a lot of tech gurus rethink the issue. When we see popular, and tech giants like Facebook got tricked by cybercriminals, our faith starts to crumble. Who knows if advertising agencies buy your personal data or not. There is a dire need for transparency. Otherwise, you are nothing but products to the corporate world.

5. **Your Car is Getting Smarter**

Car stealing is a common crime in most of the countries in the world. Losing such a great asset to the thieves is a matter of great grief. But the good thing is that your car is getting smarter! Now a lot of new model cars can be unlocked using a smartphone. But what if hackers could hack the passwords and steal your car even easier. This is where blockchain comes to the scene. Blockchain provides a more secured and cryptographic way to manage and handle the data. So, we could easily assume that smart cars would be even more secured with the magical touch of the technology. All hail the mighty blockchain ledger!

3.5.1 Block-Chain use Cases

1. **Money Transfer use Cases**

Pioneered by Bitcoin, cryptocurrency transfer apps are exploding in popularity right now. Blockchain is especially popular in finance for the money and time it can save financial companies of all sizes.

By eliminating bureaucratic red tape, making ledger systems real-time and reducing third-party fees, blockchain can save the largest banks $8-$12 billion a year, according to a recent article by ComputerWorld. We'll take a deeper dive into four companies using blockchain to efficiently transfer money.

2. **Smart Contracts use Cases**

Smart contracts are like regular contracts except the rules of the contract are enforced in real-time on a blockchain, which eliminates the middleman and adds levels of accountability for all parties involved in a way not possible with traditional agreements. This saves businesses time and money, while also ensuring compliance from everyone involved.

Blockchain-based contracts are becoming more and more popular as sectors like government, healthcare and the real estate industry discover the benefits. Below are a few examples of how companies are using blockchain to make contracts smarter.

3. **Internet of Things use Cases**

The Internet of Things (IoT) is the next logical boom in blockchain applications. IoT has millions of applications and many safety concerns, and an increase in IoT products means better chances for hackers to steal your data on everything from an Amazon Alexa to a smart thermostat.

Blockchain-infused IoT adds a higher level of security to prevent data breaches by utilizing transparency and virtual incorruptibility of the technology to keep things "smart." Below are a few US companies using blockchain to make the Internet of Things safer and smarter.

Questions:

1. What is Block-Chain. Define the fundamentals of Block-Chain technology.
2. Give the principle and technologies used in Block-Chain.
3. Define smart contract and cryptocurrencies with examples.
4. Give the various applications of Block-Chain.
5. Write the Use-cases of Block Chain Technology
6. When was blockchain first created?
7. How does blockchain support bitcoin?
8. What does a decentralised blockchain mean?
9. Does the decentralised nature of the blockchain make it more secure?
10. But there have been many reports of bitcoins being stolen, so it is possible to hack the blockchain, right?

UNIT-4

DIGITAL MANUFACTURING: 3D PRINTING & DRONES

4.1 The history and survey of 3D Printing:

- 3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file.
- The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced cross-section of the object.
- 3D printing is the opposite of subtractive manufacturing which is cutting out / hollowing out a piece of metal or plastic with for instance a milling machine.
- 3D printing enables you to produce complex shapes using less material than traditional manufacturing methods.

4.1.1 History of 3D Printing

1981: Hideo Kodama of the Nagoya Municipal Industrial Research Institute develops a rapid-prototyping system that uses photopolymers and a layer-by-layer approach to build a physical model.

1987: Charles (Chuck) Hall invents and patents stereolithography, also known as SLA. Stereolithography "is a resin 3D printing or additive manufacturing process that uses a vat of

photopolymer resin that can be cured." He co-founds the 3D printing company 3D Systems the same year

1987: 3D Systems commercializes the first 3D printer, the SLA-1.

1988: Carl Deckard of the University of Texas patents selective laser sintering (SLS). Selective laser sintering is an additive manufacturing process that uses a laser to fuse and build powders into a 3D model.

1989: S. Scott Crump and Lisa Crump invent and patent Fused Deposition Modeling (FDM). They also founded the 3D printing company Stratasys the same year.

1992 : DTM creates the first selective laser sintering (SLS) machine.

1999: Scientists at the Wake Forest Institute for Regenerative Medicine 3D print the structure of a human bladder.

2004: The RepRap Project launches. The RepRap Project is an open-source 3D printing project, while the RepRap is a free desktop 3D printer that can self-replicate by printing its own parts. Both initiatives made 3D printing more readily available.

2009: FDM patents expire and entered the public domain, driving the cost of FDM printers down.

2010: Bioprinting company Organovo creates the first 3D printed blood vessel.

2014: The first 3D printed car, the Strati, is created.

2016: The Chinese National High-Tech Research and Development Program creates 3D printed vein-tissue.

2018: MIT discovers a way to 3D print glass.

4.1.2 How Does 3D Printing Work?

A typical 3D printer is very much like an inkjet printer operated from a computer. It builds up a 3D model one layer at a time, from the bottom upward, by repeatedly printing over the same area in a method known as fused depositional modeling (FDM).

Working entirely automatically, the printer creates a model over a period of hours by turning a 3D CAD drawing into lots of two-dimensional, cross-sectional layers—effectively separate 2D prints that sit one on top of another, but without the paper in between. Instead of using ink, which would never build up to much volume, the printer deposits layers of molten plastic or powder and fuses them together (and to the existing structure) with adhesive or ultraviolet light.

4.1.3 Types of 3D printer technologies

Now that you know about the process of printing and materials used, it's time for an overview of the different types of 3D printer technologies and ways in which they differ. The methods they all use are of an ever-evolving nature and as newer techniques are perfected, they're bound to undergo change. For now, 3D printers are broadly based on four operational methods.

1. Traditional 3D Printers: Traditional 3D printers employ the simplest method of them all. The addictive's are layered in a basic two-dimensional way across an X-Y axis, similar to an inkjet printer's functioning. This basic style is typically known as '3D printing', with more specialised names for other versions of this technique. An advanced version of this technique is known as 'PolyJet photopolymer' 3D printing which employs the traditional inkjet method of applying ink but uses a photopolymer liquid that solidifies when struck by UV light. The use of photopolymer allows for a variety of materials to be used in an assortment of colours and very high resolution prints.

2. Stereolithography (SLA): The next method is known as stereolithography. It is chemical based and relies on the combination of light sensitive chemicals and lasers. These chemicals are oriented in such a manner that when they're exposed to UV laser light they turn from liquid to solid. The 3D printers that use this method are designed to maneuver the UV laser across a thin surface of the chemical liquid in the design of the required object. As each layer solidifies, it is lowered and thinly submerged in the chemical liquid. The UV laser then creates another solid layer by moving across the liquid and so on until the final product is solidified and complete.

The stereolithography method has proven to provide a very high level of detailing and finishing on the surface of the objects created. The entire printing process takes places in the chemical liquid and the finishing involves separating the solidified 3D object from the pool of chemicals in a single flow. This was the first ever method of 3D printing that was invented in 1983 by Charles Hull.

3. Fused Deposition Modeling (FDM): The third technique, known as 'Fused Deposition Modelling', is based on the use of molten material that becomes solid as it's layered on to the print surface. As the molten material is injected from the printer head, it creates the successive layers of the 3D design. This process continues until the product is fully created. This technique also uses food-based molten material such as cheese and chocolate to create complex-shaped food items. This is one of the most affordable types of 3D printers available in the market.

These types of printers use ABS and PLA plastics as well as biodegradable polymers which are organic in nature. The plastic additives used can also be dispensed as filaments from spools in a

slightly augmented type of this printer. This technique is called 'Fused Filament Fabrication' since the additive source is in the form of spooled filaments of plastic.

Printers of this design are capable of employing nearly any material that has a creamy viscosity, including materials such as clay, silicone, chocolate, cheese, frosting, cement and certain metals. The heating necessary for different additives is either done through the ejection nozzle or the additive storage unit based on the required melting point.

4. Selective Laser Sintering (SLS): The fourth method uses powdered materials that are fused together using either heat or adhesives between layers to achieve the desired 3D shape. This method is called 'Selective Laser Sintering' (SLS) and is a combination of traditional 3D printing and powered lasers, (instead of UV light). By augmenting the stereolithographic method, SLS replaces the chemical pool with powdered base material and the UV light with a powered laser.

Combining both the methods makes it possible for SLS printers to use not only all plastics but also ceramics and metals to fabricate objects. It has proven to be a cost-effective alternative to other 3D printers in specialised cases which call for the use of materials such as polystyrene, nylon, glass, metals, and other exotic additives. The powdered material from these sources is easy to fuse using a laser and once the 3D printing project is completed, the surplus material is left available for reuse. It also removes the need for the use of supports and makes the overall process much more efficient.

4.1.4 Examples of 3D Printing

3D printing encompasses many forms of technologies and materials as 3D printing is being used in almost all industries you could think of. It's important to see it as a cluster of diverse industries with a myriad of different applications.

A few examples:

- – consumer products (eyewear, footwear, design, furniture)
- – industrial products (manufacturing tools, prototypes, functional end-use parts)
- – dental products
- – prosthetics
- – architectural scale models & maquettes
- – reconstructing fossils
- – replicating ancient artefacts
- – reconstructing evidence in forensic pathology

- – movie props

4.2 Design Principles and Tools

Flexible Design: 3D printing allows for the design and print of more complex designs than traditional manufacturing processes. More traditional processes have design restrictions which no longer apply with the use of 3D printing.

Rapid Prototyping: 3D printing can manufacture parts within hours, which speeds up the prototyping process. This allows for each stage to complete faster. When compared to machining prototypes, 3D printing is inexpensive and quicker at creating parts as the part can be finished in hours, allowing for each design modification to be completed at a much more efficient rate.

Print on Demand: Print on demand is another advantage as it doesn't need a lot of space to stock inventory, unlike traditional manufacturing processes. This saves space and costs as there is no need to print in bulk unless required.

The 3D design files are all stored in a virtual library as they are printed using a 3D model as either a CAD or STL file, this means they can be located and printed when needed. Edits to designs can be made at very low costs by editing individual files without wastage of out of date inventory and investing in tools.

Strong and Lightweight Parts: The main 3D printing material used is plastic, although some metals can also be used for 3D printing. However, plastics offer advantages as they are lighter than their metal equivalents. This is particularly important in industries such as automotive and aerospace where light-weighting is an issue and can deliver greater fuel efficiency.

Also, parts can be created from tailored materials to provide specific properties such as heat resistance, higher strength or water repellency.

Fast Design and Production: Depending on a part's design and complexity, 3D printing can print objects within hours, which is much faster than moulded or machined parts. It is not only the manufacture of the part that can offer time savings through 3D printing but also the design process can be very quick by creating STL or CAD files ready to be printed.

Minimising Waste: The production of parts only requires the materials needed for the part itself, with little or no wastage as compared to alternative methods which are cut from large chunks of non-recyclable materials. Not only does the process save on resources but it also reduces the cost of the materials being used

Cost Effective: As a single step manufacturing process, 3D printing saves time and therefore costs associated with using different machines for manufacture. 3D printers can also be set up and left to get on with the job, meaning that there is no need for operators to be present the entire time. As

mentioned above, this manufacturing process can also reduce costs on materials as it only uses the amount of material required for the part itself, with little or no wastage. While 3D printing equipment can be expensive to buy, you can even avoid this cost by outsourcing your project to a 3D printing service company.

Ease of Access: 3D printers are becoming more and more accessible with more local service providers offering outsourcing services for manufacturing work. This saves time and doesn't require expensive transport costs compared to more traditional manufacturing processes produced abroad in countries such as China.

Environmentally Friendly: As this technology reduces the amount of material wastage used this process is inherently environmentally friendly. However, the environmental benefits are extended when you consider factors such as improved fuel efficiency from using lightweight 3D printed parts.

Advanced Healthcare: 3D printing is being used in the medical sector to help save lives by printing organs for the human body such as livers, kidneys and hearts. Further advances and uses are being developed in the healthcare sector providing some of the biggest advances from using the technology.

4.2.1 3D Printing Tools

If you are new to 3D printing the below list should give you a good starting point in case you want to compile an accessories kit. While you don't need to go and buy all of these tools at once, I am convinced that over time you'll amass a tool set that will look very similar to the below.

1. Masking Tape

Masking tape is the most basic and most widely used surface covering for print beds. Adding masking tape to the print bed is a simple way to help the 3D printed objects to adhere better. Additionally, the tape also makes removing the finished print easier and it protects your print bed from scratches.

Fig 4.1 Masking Tape

2. Kapton Tape

Kapton tape is a polyimide adhesive tape that is used an alternative material to cover print beds. Contrary to masking tape however, Kapton tape has been specifically designed to withstand high temperatures (up to 400°C).

Kapton tape is used to improve 3D print adhesion and to prevent warping but mostly in combination with ABS filament. When printing with PLA, it is cheaper to stick with masking tape as a roll of Kapton is about twice as expensive.

Due to its heat-resistant properties Kapton tape is also commonly used to secure 3D printer components in the area of the hot end. I always keep a roll at hand, be it for ABS prints or for attaching something to the heated print bed or hot end.

Fig 4.2 Kapton Tape

3. Glue Stick

Glue sticks come in handy when you are trying to improve 3D print adhesion: just cover your print bed in water soluble glue stick and the adhesion of the 3D prints will improve instantly. The glue stick can be applied on top of blue/Kapton tape or even directly to glass in case your 3D printer uses a glass print bed.

I personally prefer the glue stick over hair spray (an alternative often used to combat adhesion issues) since it can be applied precisely without having to worry about covering the gantry or moving parts in residual spray.

Fig 4.3 Glue Stick

4. Digital Caliper

In the context of 3D printing, a caliper will have many applications: you can use it to check the precision of your prints as well as you can use it to dimension parts that you want to replicate in CAD software.

3D printer filament, though advertised as being 3mm or 1.75 mm, rarely turns out to be manufactured to these exact measurements. Here the caliper comes in handy again: measure the filament at a few different positions, average your readings and if necessary adjust the filament diameter in your slicing software.

Fig 4.4 Digital Caliper

5. A Set of Tweezers

I always have my tweezers handy when I launch a 3D print. I use them frequently to plug any oozing filament from the extruder nozzle just before the printer starts printing (without burning my fingers). The tweezers also come in handy when cleaning up a 3D print. I'd recommend buying a set of tweezers that includes various shapes and sizes such that you are covered for all jobs.

Fig 4.5 A Set of Tweezers

6. Palette Knives

Sometimes you are faced with a 3D print that sticks so well to your print bed that you can't remove it by hand. In those cases I use a palette knife to try and get under the print and to carefully pry it loose from the print bed.

Over time, I have build up quite a collection of palette knives. In case you are just starting out, I'd recommend that you get at least a flexible and a stiffer one. I particularly like the stainless steel scrapers by **Titan** as they have a tapered tip that really helps to get under the base of a 3D print. Titan offers a set of 3 blades ranging from rigid to flexible, that should be enough to get you started.

Fig 4.6 Palette Knives

7. Knife & Cutting Mat

You'll need knives to post process your prints: 3D prints rarely turn out perfect and you may have to remove plastic blobs or filament strings that have appeared during the printing process. A knife with an array of exchangeable blades, such as an **X-Acto knife**, will serve you well. And while you are at it, make sure to get a cutting mat as well, you won't regret it.

Fig 4.7 Knife & Cutting Mat

8. Sandpaper

A good selection of sandpaper in various grits will come in handy when post processing your 3D prints. I keep a selection from coarse (220 grit) to fine (1000 grit). The grid of quality sandpaper tends to wear off slower, so stick with one of the well-known brands such as 3M or similar.

Fig 4.8 Sandpaper

9. Pliers

A set of pliers will have various uses, be it to remove hard sticking prints or to fix something on your 3D printer. I recommend that you get quality pliers with rubberized slip-resistant grips. No matter what brand you end up buying, the absolute must-haves are **needle nose pliers** and **wire cutting pliers**. The wire cutting pliers are particularly useful to snip away support material or when trimming filament.

Fig 4.9 Pliers

10. Screw Drivers & Hex Key Screw Drivers

In all likelihood, you already own some screwdrivers and hex keys. If you don't, make sure to buy some as you will need to periodically re-tighten the screws of the gantry and stepper motors of your 3D printer. Hex nuts and bolts are widely used in the assembly of 3D printers so it pays to have a good set of hex key screwdrivers and hex key wrenches.

Fig 4.10 Screw Drivers & Hex Key Screw Drivers

11. Desiccant

Most 3D printer filament absorbs water over time, resulting in filament degradation that will eventually lead to complications during printing. Therefore, I do highly recommend that you store your filament in a sealed container.

Fig 4.11 Desiccant

12. Permanent Marker

I keep a set of permanent markers/sharpies that I use to mark 3D prints, especially when running multiple prints of the same model but with different slicer settings. I note down the sequence and settings for each print and mark the finished objects accordingly, otherwise it becomes difficult tell them apart later on.

Fig 4.12 Permanent Marker

4.3 Emerging trends and Use-Cases in 3D Printing:

- **The 3D printing landscape will become even more diverse :** The 3D printing industry is growing in diversity, as the number of players entering the market increases. One evidence of this trend is the 2019 edition of Formnext, the event attracting almost the entire industry. In 2019, it was by far the biggest ever: 852 exhibitors representing 35 per cent growth over the previous year. The growing number of exhibitors is encouraging, as it means that the industry is on a steady growth path. But at the same time, this growth is signalling the increasing number of companies entering the market as start-ups and spinoffs, with new technologies or their own take on existing ones.
- **A wider range of application-specific materials are on the horizon:** According to a recent survey by Jabil, material cost and availability are two of the key challenges when it comes to adopting 3D printing for production. While material costs are unlikely to decrease substantially in 2020, we'll definitely see more materials developed with industrial applications in mind. Manufacturing giant, Jabil, for example, opened its Materials Innovation Center at the start of 2019 to do just that. The Materials Innovation Center is an end-to-end facility for developing, testing and manufacturing polymer powders and filaments for 3D printing. Its goal is to be able to take application requirements – from Jabil or external customers – and convert them into materials that can be printed. There are still not enough options in polymer 3D printing materials on the market, compared to the range of materials for injection moulding. It means that the developments, like the one from Jabil, will help to fill the gaps in materials, driving a new generation of 3D printing applications.
- **Expect more options for high-temperature polymer 3D printers and materials:** In 2019, we saw a surge in high-temperature polymer 3D printers entering the market from companies like Roboze, Zortrax and Essentium. This surge has been largely driven by the growing demand for high-performance thermoplastics like PEEK. These thermoplastics have many compelling properties, like heat and chemical resistance, as well as high strength and durability, which makes them sought-after in many industrial applications. But due to such properties, they can be challenging to print. 3D printer manufacturers are overcoming this challenge, by equipping their printers with a heated bed and a high-temperature nozzle. That said, the number of solutions available for printing high-performance polymers remains small. As the demand for high-performance plastics is growing, 2020 will see more high-temperature 3D printer launches, furthering the adoption of polymer 3D printing across industries.

- **The evolution of 3D printing software will accelerate significantly:** Until recently, focus on 3D printing software has been lacking, when compared with the hardware and materials segments. With 3D printing, designers have had to deal with a cumbersome design preparation process, where a lot of disparate design tools create an inefficient and complex workflow. Furthermore, simulation software also needs to evolve to enable more accurate simulation results. Finally, the tools for designing for additive also need to become more intuitive and easier to use. We anticipate 2020 to be the year when we see many of the software challenges being solved. Software innovations, particularly in the design space, will come into greater focus, unlocking a faster and easier 3D printing design process.
- **MES software will become essential for scalability:** We see 2020 as the year when more companies will realise that achieving scalable production with 3D printing is virtually impossible without an end-to-end management system in place. This will create a greater need for workflow management solutions – also known as Manufacturing Execution System (MES) software. Developed with AM needs in mind, MES software solutions can help to establish an ecosystem, where different stages of the AM workflow are linked together to achieve a streamlined and digitalised AM process management.

  Integrating MES software into a 3D printing facility or department is a crucial step on a 3D printing journey, and its importance will be growing apace with the technology industrialisation.

4.4 Introduction of Drones, Engineering Disciplines

Drones are more formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UASes). Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously through software-controlled flight plans in their embedded systems, working in conjunction with onboard sensors and GPS.

Fig 4.13 Drone

4.4.1 Types of Drones:

"**Drones**" can be classified on a different basis – say based on '**usage** 'like Drones for Photography, Drones for aerial Mapping, Drones for Surveillance etc. However, the best classification of 'Drones' can be made on the basis of aerial platforms. Based on the type of aerial platform used, there are 4 major types of drones.

1. **Multi Rotor Drones**
2. **Fixed Wing Drones**
3. **Single Rotor Helicopter**
4. **Fixed Wing Hybrid VTOL**

Multi Rotor Drones

Multi Rotor drones are the most common types of drones which are used by professionals and hobbyists alike. They are used for most common applications like aerial photography, aerial video surveillance etc.

Fig 4.14 Multi Rotor Drones

Multi-rotor drones can be further classified based on the number of rotors on the platform. They are **Tricopter** (3 rotors), **Quadcopter** (4 rotors), **Hexacopter** (6 rotors) and **Octocopter** (8 rotors). Out of these, Quadcopters are the most popular and widely used variant.

Fixed Wing Drones

Fixed Wing drones are entirely different in design and build to multi-rotor type drones. They use a 'wing' like the normal airplanes out there. Unlike multi-rotor drones, fixed wing type models never

utilize energy to stay afloat on air (fixed wing types can't stand still on the air) fighting gravity. Instead, they move forward on their set course or as set by the guide control (possibly a remote unit operated by a human) as long as their energy source permits.

Fig 4.15 Fixed Wing Drones

Most fixed wing drones have an average flying time of a couple of hours. Gas engine powered drones can fly up to 16 hours or higher. Owing to their higher flying time and fuel efficiency, fixed wing drones are ideal for long distance operations (be it mapping or surveillance). But they can not be used for aerial photography where the drone needs to be kept still on the air for a period of time.

Single Rotor Drones

Single rotor drones look very similar in design & structure to actual helicopters. Unlike a multi rotor drone, a single rotor model has just one big sized rotor plus a small sized one on the tail of the drone to control its heading. Single rotor drones are much efficient than multi rotor versions. They have higher flying times and can even be powered by gas engines. In aerodynamics, the lower the count of rotors the lesser will be the spin of the object. And that's the big reason why quadcopters are more stable than octocopters. In that sense, single rotor drones are much efficient than multi-rotor drones.

Fig 4.16 Single Rotor Drones

Hybrid VTOL:

These are hybrid versions combining the benefits of Fixed wing models (higher flying time) with that of rotor based models (hover). This concept has been tested from around 1960's without much success. However, with the advent of new generation sensors (gyros and accelerometers), this concept has got some new life and direction.

Fig 4.17 Hybrid VTOL

Hybrid VTOL's are a play of automation and manual gliding. A vertical lift is used to lift the drone up into the air from the ground. Gyros and accelerometers work in automated mode (autopilot concept) to keep the drone stabilized in the air. Remote based (or even programmed) manual control is used to guide the drone on the desired course.

Roles of Drones in Engineering:

Drones can reach places where humans cannot. Plus, they can be more accurate than people and capture significant amounts of data at once. **UAVs** are widely used for different works connected either with hard-to-reach places or dangerous working conditions.

4.5 Multirotor Drone Assembly

The tools you need will largely depend on the type of drone you want to build, however, there are some key components that all drones require. These include:

- Motors
- Electronic speed control

- Flight controller
- The drone frames
- Propellers
- Batteries
- Connectors
- Camera (if you want to build your own camera drone)
- Gimbal
- A mounting pad
- A micro-SD card
- An RC receiver

If you're having trouble finding parts for your drone, websites such as RoboShop and Hobby King stock all the components for drone building, as well as DIY kits with all the right equipment included.

4.5.1 Making your drone

Now you've got the parts, it's time to put them all together! Read on to discover how to build a quadcopter drone:

1. **Construct a frame**

You can use whichever materials you like to construct the drone frame, just make sure to pick materials which can hold structure and shape, such as wood, plastic or metal. For a quadcopter, you'll need to make your frame into an X shape, and each propeller will go on each point of the 'X'.

2. **Assemble your drone's motors**

For this step, you'll need to make holes in your frame for the motors. Then, fix the motor to the frame with screws and a screwdriver.

If you're building a drone from a kit, you may find that the motors come with mounts that make it easier for you to affix them to the frame.

3. Mount your electronic speed controllers (escs)

After attaching the motors, you'll need to attach your ESCs to the bottom of your drone's frame. This will free up more space for other components to be added to the top.

4. Attach the landing gear

You'll need to attach landing gear to your drone to absorb the shock when it lands on solid ground. This will help you to avoid any costly repairs and accidents with your drone!

Be sure to opt for a material that's both flexible and strong, such as plastic, so that it absorbs the shock and doesn't break.

5. Add your flight controller

A flight controller is an essential for any drone. This allows your drone to stay stable whilst in flight, and make sense of all the shifts and changes in the wind. You can make these yourself, however, it's easier to get a ready-made controller if it's your first time building a drone from scratch.

Once you've found the right controller, you need to mount it to your drone. Make sure to attach a piece of sponge underneath the controller to reduce the vibrations coming from the drone.

6. Connect librepilot to your drone

The software 'LibrePilot' allows you to control and test UAVs, however, you'll need to connect your ESCs to your flight controller and also connect your drone to the remote control first. You'll need to find a tutorial online for your specific flight controller for this step.

Once you've done this, you can connect LibrePilot to your drone and check that everything is working via the software.

7. Take your drone for a spin!

Now that all the hard work is done, it's time to take your drone for a spin! Don't forget to choose an open space free from buildings, crowds of people, and aircrafts to avoid any unfortunate incidents.

Questions:

1. Give the evolution of 3 D printing.
2. Write down the design principles used in 3D printing.
3. Give the various emerging trends in 3D printing.
4. Define Drone technology. Why it is used in Engineering Deciplines.
5. Define multirotor drone.
6. Write the procedure for becoming a drone pilot.
7. Write the procedure for multirotor drone assembly.
8. Give the various advantages of 3D printing.
9. Write down the various applications of 3D printing

UNIT-5

FUTURE TRENDS

5.1 Augmented Reality (AR) and Virtual Reality (VR)

Augmented reality (**AR**):

It is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.

Augmented reality uses existing reality and physical objects to trigger computer-generated enhancements over the top of reality, in real time. Essentially, AR is a technology that lays computer-generated images over a user's view of the real world. These images typically take shape as 3D models, videos and information.

Best Current Examples of Augmented Reality

- **IKEA** Mobile App.
- Nintendo's Pokémon Go App.

- Google Pixel's Star Wars Stickers.
- Disney Coloring Book.
- L'Oréal Makeup App.
- Weather Channel Studio Effects.
- U.S. Army.

Virtual Reality (**VR**):

It is the use of computer technology to create a simulated environment. Unlike traditional user interfaces, **VR** places the user inside an experience. Instead of viewing a screen in front of them, users are immersed and able to interact with 3D worlds.

Virtual Reality's most immediately recognizable component is the head-mounted display (HMD). Human beings are visual creatures, and display technology is often the single biggest difference between immersive Virtual Reality systems and traditional user interfaces. For instance, CAVE automatic virtual environments actively display virtual content onto room-sized screens. While they are fun for people in universities and big labs, consumer and industrial wearables are the wild west.

With a multiplicity of emerging hardware and software options, the future of wearables is unfolding but yet unknown. Concepts such as the HTC Vive Pro Eye, Oculus Quest and Playstation VR are leading the way, but there are also players like Google, Apple, Samsung, Lenovo and others who may surprise the industry with new levels of immersion and usability. Whomever comes out ahead, the simplicity of buying a helmet-sized device that can work in a living-room, office, or factory floor has made HMDs center stage when it comes to Virtual Reality technologies.

Virtual Reality and the importance of audio:

Convincing Virtual Reality applications require more than just graphics. Both hearing and vision are central to a person's sense of space. In fact, human beings react more quickly to audio cues than to visual cues. In order to create truly immersive Virtual Reality experiences, accurate environmental sounds and spatial characteristics are a must. These lend a powerful sense of presence to a virtual world. To experience the binaural audio details that go into a Virtual Reality experience, put on some headphones and tinker with this audio infographic published by The Verge.

5.1.1 Virtual Reality Vs Augmented Reality

Table 5.1 Virtual Reality Vs Augmented Reality

AR	VR

The system augments the real-world scene	Completely immersive virtual environment
In AR User always have a sense of presence in the real world	In VR, visual senses are under control of the system
AR is 25% virtual and 75% real	VR is 75% virtual and 25% real
This technology partially immerses the user into the action	This technology fully immerses the user into the action
AR requires upwards of 100 Mbps bandwidth	VR requires at least a 50 Mbps connection
No AR headset is needed.	Some VR headset device is needed.
With AR, end-users are still in touch with the real world while interacting with virtual objects nearer to them.	By using VR technology, VR user is isolated from the real world and immerses himself in a completely fictional world.
It is used to enhance both real and virtual worlds.	It is used to enhance fictional reality for the gaming world.

5.2 History, objective & global scenario of 5G Telecom

5G Wireless Technology is the 5th generation of mobile networks and an evolution from the current 4G LTE networks. It is specially designed to fulfill the demands of current technological trends, which includes a large growth in data and almost global connectivity along with the increasing interest in the Internet of Things. In its initial stages, 5G Technology will work in conjugation with the existing 4G Technology and then move on as a fully independent entity in subsequent releases**.**

5G Wireless Technology is now the latest cellular technology that will greatly increase the speed of wireless networks among other things(And who doesn't want that?!!). So the data speed for wireless broadband connections using 5G would be at a maximum of around 20 Gbps. Contrasting that with the peak speed of 4G which is 60 Mbps, that's a lot! Moreover, 5G will also provide more bandwidth and advanced antenna technology which will result in much more data transmitted over wireless systems.

And that's just a small sampling of the capabilities of 5G technology! It will also provide various network management features such as Network Slicing using which mobile operators will be able to create multiple virtual networks using a single physical 5G network. So in this futuristic scenario, if you are inside a self-driving car, then a virtual network with an extremely fast, low-latency connections would be required because obviously the car needs to navigate in real-time. On the other hand, if you are using any smart appliance in your home, then a virtual network with lower power and a slower connection would be fine because it's not a life or death situation!!!

History

- 1G: Where it all began

The first generation of mobile networks – or 1G as they were retroactively dubbed when the next generation was introduced – was launched by Nippon Telegraph and Telephone (NTT) in Tokyo in 1979. By 1984, NTT had rolled out 1G to cover the whole of Japan.

In 1983, the US approved the first 1G operations and the Motorola's DynaTAC became one of the first 'mobile' phones to see widespread use stateside. Other countries such as Canada and the UK rolled out their own 1G networks a few years later.

Despite these shortcomings and a hefty $3,995 price tag ($9,660 in today's money), the DynaTAC still managed to rack up an astonishing 20 million global subscribers by 1990. There was no turning back; the success of 1G paved the way for the second generation, appropriately called 2G.

- 2G: The Cultural Revolution

The second generation of mobile networks, or 2G, was launched under the GSM standard in Finland in 1991. For the first time, calls could be encrypted and digital voice calls were significantly clearer with less static and background crackling. But 2G was about much more than telecommunications; it helped lay the groundwork for nothing short of a cultural revolution. For the first time, people could send text messages (SMS), picture messages, and multimedia messages (MMS) on their phones. The analog past of 1G gave way to the digital future presented by 2G. This led to mass-adoption by consumers and businesses alike on a scale never before seen.

- 3G: The 'Packet-Switching' Revolution

3G was launched by NTT DoCoMo in 2001 and aimed to standardize the network protocol used by vendors. This meant that users could access data from any location in the world as the 'data packets' that drive web connectivity were standardized. This made international roaming services a real possibility for the first time.

3G's increased data transfer capabilities (4 times faster than 2G) also led to the rise of new services such as video conferencing, video streaming and voice over IP (such as Skype). In 2002, the Blackberry was launched, and many of its powerful features were made possible by 3G connectivity. The twilight era of 3G saw the launch of the iPhone in 2007, meaning that its network capability was about to be stretched like never before.

- 4G: The Streaming Era

4G was first deployed in Stockholm, Sweden and Oslo, Norway in 2009 as the Long Term Evolution (LTE) 4G standard. It was subsequently introduced throughout the world and made high-quality video streaming a reality for millions of consumers. 4G offers fast mobile web access (up to 1 gigabit per second for stationary users) which facilitates gaming services, HD videos and HQ video conferencing. The catch was that while transitioning from 2G to 3G was as simple as switching SIM cards, mobile devices needed to be specifically designed to support 4G. This helped device manufacturers scale their profits dramatically by introducing new 4G-ready handsets and was one factor behind Apple's rise to become the world's first trillion dollar company.

While 4G is the current standard around the globe, some regions are plagued by network patchiness and have low 4G LTE penetration. According to Ogury, a mobile data platform, UK residents can only access 4G networks 53 percent of the time, for example.

- 5G: The Internet of Things Era

With 4G coverage so low in some areas, why has the focus shifted to 5G already? 5G has actually been years in the making. During an interview with Tech Republic, Kevin Ashton described how he coined the term "the Internet of Things" – or IoT for short – during a PowerPoint presentation he gave in the 1990s to convince Procter & Gamble to start using RFID tag technology.

The phrase caught on and IoT was soon touted as the next big digital revolution that would see billions of connected devices seamlessly share data across the globe. According to Ashton, a mobile phone isn't a phone, it's the IoT in your pocket; a number of network-connected sensors that help you accomplish everything from navigation to photography to communication and more. The IoT will see data move out of server centers and into what are known as 'edge devices' such as Wi-Fi-enabled appliances like fridges, washing machines, and cars.

By the early 2000s, developers knew that 3G and even 4G networks wouldn't be able to support such a network. As 4G's latency of between 40ms and 60ms is too slow for real-time responses, a number of researchers started developing the next generation of mobile networks.

In 2008, NASA helped launch the Machine-to-Machine Intelligence (M2Mi) Corp to develop IoT and M2M technology, as well as the 5G technology needed to support it. In the same year, South

Korea developed a 5G R&D program, while New York University founded the 5G-focused NYU WIRELESS in 2012.

5.3 5G in India, Application and Use Cases

5.3.1 5G in India

The Government of India, through the DoT and Digital India initiatives, is leading the charge towards 5G. It has declared that India must not only be among the first countries to implement 5G, but also be a leader amongst nations that design 5G systems for worldwide use.

For this purpose, it has set up a high-powered committee to seed R&D as a public-private effort. It has nominated 6 IITs and created a new entity called CeWIT (Centre of Excellence in Wireless Technology) that would split up the research among themselves, create standards-based products and software that would be saleable across the world, making India a pioneer in 5G.

The labs are racing to complete the targets that run till late 2019. A major test bed is being created in which all new products can be tested. All private firms, especially startups, are invited to participate and accelerate the development.

Current progress: Different companies are also creating their own Proof-of-Concept systems, and early this year, Airtel succeeded in sending 5G signals for a short distance in its own test platform. Siemens and Ericsson are also active in the design and collaborate with DoT, IITs, etc.

However, the world leader in 5G design – Huawei – is stuck in controversies created by the US government, saying the company is a security risk and no one should associate with it. Huawei had a lot of investment and R&D planned for India in 5G but it is now in a limbo, with the Indian government still not accepting the company into the 5G community.

DoT has still not allotted the test frequencies, free on trial basis, for test bed-based tests, already due to commence. Even if they allot frequencies today, it will take 6 months to adapt these and get the system ready for real-world testing. This means we are already one year behind other countries

Issues and problems

The TRAI has gone ahead and announced spectrum licensing fees that are minimum 5 times that levied by the lowest-price country. And 54 times what Germany levies for 5G spectrum. Singapore has waived all fees (licensing, spectrum, etc) in order to encourage fast development and deployment. The Telcos have to, in addition, substantially enhance and make uniform their current networks and make them uniformly broadband and fully IP-based. This involves substantial investment in money,

time and technology. Only the new Telco Jio has got a very good 4G network that needs little work and investment to become 5G.

The finances of the Telcos are in bad shape and it is doubtful if they can gather the resources for spectrum fees and network rollout. It looks doubtful if they can at all rollout anything before end 2020 or 2021.

Operational issues: A lot of 5G spectrum would cater to video-fast, interactive. However, customers are now used to free video or very low-priced video on demand. India has both the highest data consumption (mostly video on cheap smartphones by young people looking for cheap entertainment) and the lowest tariff in the world. These two are an oxymoron. Companies are unable to monetise their investment in technology to provide faster, better and cheaper technology. 5G will take this to a higher level, but with no commensurate benefits.

5.3.2 Applications and Use-Cases of 5G Technology:

Harnessing the Power of IoT : When the term "Internet of Things" was coined in 1999, it was largely conceptual. Two decades later, everything from home thermostats to smart city sensors depend on IoT technology. Now, 5G and IoT stand ready to enable applications that would have seemed impossible just a few years ago.

Broadband-Like Mobile Service: Upgraded mobile service is among the most noticeable of the initial impacts of the 5G network rollout. All major US wireless carriers, as well as many smaller communications service providers, intend to deploy 5G mobile networks that will deliver broadband-like services, such as high-definition streaming video without dreaded buffering. With a vastly increased network capacity, 5G is also predicted to reduce slowdowns during usage spikes—for example, sports fans can still stream during the big game.

Connectivity for Edge Computing: With the move to cloud-native 5G networks, enterprises can take advantage of strategically distributed computational power, allowing more data to be processed and stored in the right place based on the needs of the application. Intelligent edge computing operates at the convergence of 5G's ultra-low latency, IoT, and AI technologies. Devices and applications can tap into edge cloud computing resources without needing to access a centralized data center potentially thousands of miles away.

Unleashing AI: Applying AI to an immense amount of data at scale will be accelerated with fast, efficient connectivity. For example, smart city AI could correlate traffic light data automatically and implement new patterns after an apartment complex nearby is opened. Smart security and machine

vision can keep secure facilities safe with automatic recognition of potential security breaches or unauthorized visitors.

Immersive Gaming and Virtual Reality: For gamers, 5G promises a more immersive future. High-definition live streaming will get a big boost from 5G speeds, and thanks to ultra-low latency, 5G gaming won't be tied down to devices with high computing power. Processing, storage, and retrieval can be done in the cloud, while the game itself is displayed and controlled by a mobile device.

Industry Applications: Whether their goal is to increase revenue opportunities, reduce total cost of ownership (TCO), or improve customer experiences, today's enterprises are expected to see major benefits from the 5G upgrade.

Healthcare: 5G healthcare use cases will enable doctors and patients to stay more connected than ever. Wearable devices could alert healthcare providers when a patient is experiencing symptoms—like an internal defibrillator that automatically alerts a team of ER cardiologists to be ready for an incoming patient, with a complete record of data collected by the device.

Retail: For 5G retail applications, the customer experience will be everything. Stores of tomorrow may no longer look like today's aisles of stocked shelves. Imagine a store that's more like a showroom—one that lets you add items to a virtual cart rather than shopping with a physical one.

Agriculture: Farms of the future will use more data and fewer chemicals. Taking data from sensors located directly in fields, farmers can identify with pinpoint precision which areas need water, have

Manufacturing: Factory floors will be totally transformed by the convergence of 5G, AI, and IoT. Beyond predictive maintenance that helps control costs and minimize downtime, factories will also use 5G to control and analyze industrial processes with an unprecedented degree of precision.

Logistics: In shipping and logistics, keeping track of inventory is expensive, slow, and difficult. 5G offers the potential for greater communication among vehicles, as well as between vehicles and infrastructure itself. Fleet monitoring and navigation will become significantly easier at scale with 5G. Driver navigation could potentially be powered with an augmented reality system that identifies and flags potential hazards without diverting a driver's attention away from the road.

5.4 Brain Computer Interface, Application, Modal and Global Market

A brain–computer interface (BCI), sometimes called a direct neural interface or a brain–machine interface, is a direct communication pathway between a brain and an external device. BCIs are often aimed at assisting, augmenting or repairing human cognitive or sensory-otorfunctions.

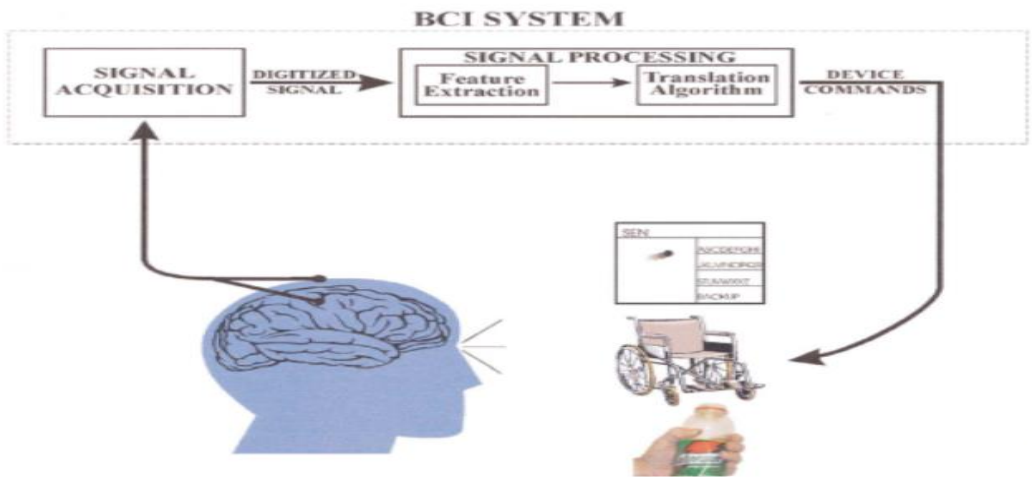


Fig 5.1 BCI system

Goal of Brain Computer Interface:

- The major goal of BCI is to replace or restore useful function to people disabled by neuromuscular disorders such as amyotrophic lateral sclerosis, cerebral palsy, stroke, or spinal cord injury.
- Brain-computer interfaces may also prove useful for rehabilitation after stroke and for other disorders. In the future, they might augment the performance of surgeons or other medical professionals.

Applications:

The main applications of the Brain–Computer Interface (BCI) have been in the domain of rehabilitation, control of prosthetics, and in neuro-feedback.

Global Market of BCI:

According to application, the healthcare segment accounted for the highest share in the global brain computer interface market in 2019, owing to the prime objective of BCI technology to provide basic communication capabilities to paralyzed patients.

Top impacting factors

Rising Incidences of brain disorders affecting the movements of body

According to a report from the National Institute of Mental Health, 1 in 4 adults in the U.S. suffer from brain disorders every year and approximately 6% of the population in the region suffers from serious disabilities. The global rise in brain disorders results in stiff competition amongst the key BCI

players and facilitates swift technological advances. These players primarily focus on technological advancements that address such disabilities and simultaneously invest in R&D studies to be competitively ahead in the brain computer interface market. For instance, in 2015, Mind Solutions, Inc. launched the world's smallest BCI device, "Synapse". Such innovations improve the efficiency of existing BCI technologies and help paralyzed patients control prosthetic limbs using thought-enabled processes. It also allows speech impaired patients to display their thoughts by the computer. Due to these benefits, healthcare holds a major application of BCI technologies and contributes to the growth of the overall market.

Miniaturization of components is propelling the growth of BCI technology

The technology whereby miniaturization of several electronic components is made possible on a single chip is referred to as flexible circuit technology. The flexible circuit technology eliminates the need to build a separate chip to support individual electronic components. In BCI technology, flexible electronics, due to their versatility, have enabled implementing pressure sensors in blood vessels and electrodes on the heart. They are also biocompatible with the brain as compared to silicon chips. The data is then transferred to external devices. Such miniaturization enables the ease of wearable BCI technology, which is driving the growth of this brain computer interface market.

Emerging opportunities in the healthcare sector

The growing healthcare infrastructure in the developing economies such as India, is expected to provide huge opportunities for the growth of BCI technology in the region. As the healthcare infrastructure improves, innovative systems that improve the lives of the disabled are encouraged. Also, the government in such regions is expected to contribute funds for the welfare of the population that creates immense opportunities for the R&D of BCI technology. Moreover, as per a WHO report, around 82 million people will be affected by dementia by year 2030, which directs the potential demand for BCI in the upcoming years. Growing occurrence of neurodegenerative conditions such as Alzheimer's, Parkinson's disease and epilepsy are anticipated to fuel the demand for brain computer interface during the forecast period.

5.5 Brain Computer Interface (BCI): BCI and Human Brain

BCI (Brain computer interface) also called as Neural controller interface (NCI) ,Human machine interface(HMI) and Brain machine interface(BMI) all are used as synonyms. Human body is one of most complex machine and brain is one of most complex structure and function .Brain computer interface has been the buzzword in this decade after elon musk introduced his company Neuralink he bought in 2017 that was found in 2016 by Nudo and Mohensi funded by U.S Army and paralysed

veterans of America. There are also other leading companies that work on brain computer interface like Kernel, Emotiv, Bio Augmentation systems, Neurable and some other as well. It was believed as pure science fiction to create such kind of systems or devices and can only be featured in sci-fi movies.

History of Brain computer interface

In 1929 human brain recieved attention when a German scientist named Hans berger recorded brain signals or electrical activity from human scalp using a device.But there were inadequecies of devices to measure and process those brain signals .During that period there was inadecquacy of knowledge and understanding human brain and computer compared to this day.The days have changed now the field of neuroscience has way better understanding of human brain than before and the computer scientist have developed devices that can record,measure and process the electrical activity of the brain.The collusion of Neuroscience and computer/software tech is yielding to better results.

The first BCI was introduced by Dr.Grey Walter in 1964.He connected electrodes to a patient's motor areas of brain and he was asked to press the button that advances slides on the display.Every time he did, Dr.Grey walter recorded his brain activity and introduced a delay in advancing slides so that whenever patient likes to press the button to advance the slide the brain region would activate that is associated with motor actions and would advance slide before pressing the button.The control happens before physical action .It is control without movement.This is the first BCI known.Research over last decades has enabled better understanding of brain and led to development of signal processing algorithms and computing power that doesn't require expensive or bulky devices.There are very few laboratories in the world working effortlessly on this cutting edge technology.

Questions:

1. Define Augmented Reality (AR).
2. Define Virtual Reality (VR).

3. Give the Evolution of 5G technology.
4. Write down the various objective and global scenario of 5 G Technology.
5. Describe the scenario of 5G technology in India.
6. Explain Brain Computer Interface.
7. Give the various applications of Brain Computer Interface (BCI).
8. Explain correlation between BCI and human brain.
9. Give the global scenario of BCI.
10. Give the various advantages of 5G Technology.