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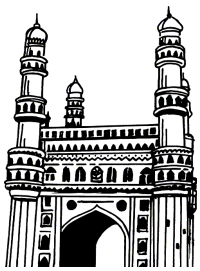

# M.C.A.

## II Year III Sem

## *(Osmania University)*

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# UNIT I

## INTRODUCTION TO INTERNET OF THINGS :

IOT vision, Strategic research and innnovation directions, Iot Applications, Related future technologies, Infrastructure, Networks and communications, Processes, Data Management, Security, Device level energy issues.

## 1.1 INTRODUCTION TO INTERNET OF THINGS

**Q1. What is IOT? Explain the components of IOT.**

*Ans :*

**Meaning**

The Internet of Things (IOT) refers to the network of physical objects or "things" embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet. In simple terms, it's about connecting everyday objects to the internet and enabling them to send and receive data.

**Components**

The components of the Internet of Things are:

**1. Devices/Things**

These are the physical objects that are equipped with sensors, actuators, and other technologies to collect and transmit data. Examples include smart home devices (thermostats, lights, cameras), wearable devices (smartwatches, fitness trackers), industrial sensors, and more.

**2. Sensors and Actuators**

Sensors gather data from the environment, such as temperature, humidity, motion, or light. Actuators, on the other hand, can perform actions based on the received data, like adjusting the temperature or turning on/off a device.

**3. Connectivity**

IOT devices rely on various communication technologies to transmit data to other devices or systems. This can include Wi-Fi, Bluetooth, Zigbee, cellular networks, and more.

**4. Data Processing**

The data collected by IOT devices is processed and analyzed to derive meaningful insights. This can happen on the device itself (edge computing) or be sent to a centralized cloud server for processing.

**5. Cloud Computing**

Many IOT applications leverage cloud computing for storing and processing large amounts of data. Cloud platforms provide the infrastructure and tools needed to manage and analyze IOT data on a large scale.

**6. Software and Applications**

IOT applications and software enable users to interact with and control connected devices. These applications can range from smart home apps to industrial automation software.

**7. Security**

Given the interconnected nature of IOT, security is a critical aspect. Measures such as encryption, authentication, and secure protocols are essential to protect IOT devices and the data they transmit.

**Q2. Explain the features of the Internet of Things.**

*Ans :*

**Features**

**(i) Interconnectivity**

With regard to the IOT, anything can be interconnected with the global information and communication infrastructure.

**(ii) Things-related services**

The IOT is capable of providing thing-related services within the constraints of things, such as privacy protection and semantic consistency

between physical things and their associated virtual things. In order to provide thing-related services within the constraints of things, both the technologies in physical world and information world will change.

**(iii) Heterogeneity**

The devices in the IOT are heterogeneous as based on different hardware platforms and networks. They can interact with other devices or service platforms through different networks.

**(iv) Dynamic changes**

The state of devices change dynamically, e.g., sleeping and waking up, connected and/or disconnected as well as the context of devices including location and speed. Moreover, the number of devices can change dynamically.

**(v) Enormous scale**

The number of devices that need to be managed and that communicate with each other will be at least an order of magnitude larger than the devices connected to the current Internet.

Even more critical will be the management of the data generated and their interpretation for application purposes. This relates to semantics of data, as well as efficient data handling.

**(vi) Safety**

As we gain benefits from the IOT, we must not forget about safety. As both the creators and recipients of the IOT, we must design for safety. This includes the safety of our personal data and the safety of our physical well-being.

**(vii) Connectivity**

Connectivity enables network accessibility and compatibility. Accessibility is getting on a network while compatibility provides the common ability to consume and produce data.

**Q3. Explain the advantages and disadvantages of IOT.**

*Ans :*

**Advantages**

**I. Communication**

IOT encourages the communication between devices, also famously known as Machine-to-Machine (M2M) communication. Because of this, the physical devices are able to stay connected and hence the total transparency is available with lesser inefficiencies and greater quality.

**(i) Automation and Control**

Due to physical objects getting connected and controlled digitally and centrally with wireless infrastructure, there is a large amount of automation and control in the workings. Without human intervention, the machines are able to communicate with each other leading to faster and timely output.

**(ii) Information**

It is obvious that having more information helps making better decisions. Whether it is mundane decisions as needing to know what to buy at the grocery store or if your company has enough widgets and supplies, knowledge is power and more knowledge is better.

**(iii) Monitor**

The second most obvious advantage of IoT is monitoring. Knowing the exact quantity of supplies or the air quality in your home, can further provide more information that could not have previously been collected easily. For instance, knowing that you are low on milk or printer ink could save you another trip to the store in the near future. Furthermore, monitoring the expiration of products can and will improve safety. Automation of daily tasks leads to better monitoring of devices.

**(iv) Efficient and Saves Time**

The machine-to-machine interaction provides better efficiency, hence; accurate results can be obtained fast. This results in saving valuable time. Instead of repeating the same tasks every day, it enables people to do other creative jobs.

**(v) Saves Money**

The biggest advantage of IOT is saving money. If the price of the tagging and monitoring equipment is less than the amount of money saved, then the Internet of Things will be very widely adopted. IOT fundamentally proves to be very helpful to people in their daily routines by making the appliances communicate to each other in an effective manner thereby saving and conserving energy and cost.

**(vi) Better Quality of Life**

All the applications of this technology culminate in increased comfort, convenience, and better management, thereby improving the quality of life.

**Disadvantages**

**(i) Compatibility**

Currently, there is no international standard of compatibility for the tagging and monitoring equipment. I believe this disadvantage is the most easy to overcome. The manufacturing companies of these equipment just need to agree to a standard, such as Bluetooth, USB, etc. This is nothing new or innovative needed.

**(ii) Complexity**

As with all complex systems, there are more opportunities of failure. With the Internet of Things, failures could sky rocket.

**(iii) Privacy/Security**

With all of this IOT data being transmitted, the risk of losing privacy increases. For instance, how well encrypted will the data be kept and transmitted with? Do you want your neighbors or employers to know what medications that you are taking or your financial situation?

**(iv) Safety**

Imagine if a notorious hacker changes your prescription. Or if a store automatically ships you an equivalent product that you are allergic to, or a flavor that you do not like, or a product that is already expired. As a result, safety is ultimately in the hands of the consumer to verify any and all automation.

**(v) Compatibility**

As devices from different manufacturers will be interconnected, the issue of compatibility in tagging and monitoring crops up. Although this disadvantage may drop off if all the manufacturers agree to a common standard, even after that, technical issues will persist. Today, we have Bluetooth-enabled devices and compatibility problems exist even in this technology! Compatibility issues may result in people buying appliances from a certain manufacturer, leading to its monopoly in the market.

**(vi) Complexity**

The IOT is a diverse and complex network. Any failure or bugs in the software or hardware will have serious consequences. Even power failure can cause a lot of inconvenience.

**(vii) Lesser Employment of Menial Staff**

The unskilled workers and helpers may end up losing their jobs in the effect of automation of daily activities. This can lead to unemployment issues in the society.

**(viii) Technology Takes Control of Life**

Our lives will be increasingly controlled by technology, and will be dependent on it. The younger generation is already addicted to technology for every little thing. We have to decide how much of our daily lives are we willing to mechanize and be controlled by technology.

**Q4. Explain the elements of Internet of Things.**

*Ans :*

**Following are the elements of Internet of Things**

**(i) Interconnected Devices**

The core of IOT is the interconnection of everyday objects and devices through the internet. This enables them to collect, exchange, and act on data, creating a network of intelligent and responsive entities.

**(ii) Data-driven Insights**

IOT devices generate vast amounts of data. The vision involves harnessing this data to gain valuable insights, make informed decisions, and optimize processes. This data-driven approach can lead to improved efficiency, cost savings, and enhanced user experiences.

**(iii) Automation and Control**

IOT envisions automation and control of devices and systems based on real-time data. This can range from smart home devices adjusting temperature and lighting to industrial processes optimizing production based on sensor inputs.

**(iv) Smart Cities**

IOT can contribute to the development of smart cities by integrating various systems, such as transportation, energy management, and public services. This integration aims to enhance urban living through increased efficiency, sustainability, and responsiveness to citizens' needs.

**(v) Enhanced Connectivity**

IOT relies on improved connectivity, including 5G networks, to enable seamless communication between devices. This high-speed, low-latency connectivity is crucial for the success of many IOT applications.

**(vi) Security and Privacy**

Ensuring the security and privacy of IOT data is a critical aspect of the vision. As more devices become interconnected, there is a need for robust security measures to protect against cyber threats and unauthorized access.

**(vii) Innovation and New Business Models**

The IOT vision involves fostering innovation and the development of new business models. Companies can create value by offering IOT-enabled products and services, and entire industries may undergo transformation as a result.

**(viii) Environmental Sustainability**

IOT can contribute to sustainability efforts by optimizing resource usage, reducing waste, and enabling more efficient energy management.

**(ix) Human-Centric Design**

The IOT vision emphasizes creating solutions that enhance the quality of life for individuals. Human-centric design principles ensure that IOT technologies are user-friendly, accessible, and contribute positively to people's daily lives.

**(x) Global Collaboration**

Achieving the full potential of IOT requires collaboration across industries, governments, and regions. Standardization, interoperability, and open ecosystems are essential for realizing a cohesive and interconnected IOT landscape.

In summary, the IOT vision revolves around creating a connected world where devices, systems, and data work together to provide valuable insights, automation, and improved experiences across various domains.

## 1.2 IOT VISION

**Q5. Explain briefly about IOT Vision From M2M to IoT.**

*Ans :*

**M2M to IOT _ The Vision From M2M to IoT**

**(i)** We attempt to describe the move from what is today referred to as Machine-to-Machine communication towards an emerging paradigm known as the Internet of Things.

**(ii)** The Internet has undoubtedly had a profound impact across society and industries over the past two decades. Starting off as ARPANET connecting remote computers together, the introduction of the TCP/IP protocol suite, and later the introduction of services like email and the World Wide Web (WWW), created a tremendous growth of usage and traffic.

**(iii)** In conjunction with innovations that dramatically reduced the cost of semiconductor technologies and the subsequent extension of the Internet at a reasonable cost via mobile networks, billions of people and businesses are now connected to the Internet.

**(iv)** Quite simply, no industry and no part of society have remained untouched by this technical revolution.

**(v)** At the same time that the Internet has been evolving, another technology revolution has been unfolding the use of sensors, electronic tags, and actuators to digitally identify, observe and control objects in the physical world.

**(vi)** Rapidly decreasing costs of sensors and actuators have meant that where such components previously cost several Euros each, they are now a few cents.

**(vii)** In addition, these devices, through increases in the computational capacity of the associated chipsets, are now able to communicate via fixed and mobile networks.

**(viii)** As a result, they are able to communicate information about the physical world in near real-time across networks with high bandwidth at low relative cost

**(ix)** So, while we have seen M2M solutions for quite some time, we are now entering a period of time where the uptake of both M2M and IoT solutions will increase dramatically. The reasons for this are three-fold:

1. An increased need for understanding the physical environment in its various forms, from industrial installations through to public spaces and consumer demands. These requirements are often driven by efficiency improvements, sustainability objectives, or improved health and safety (Singh 2012).
2. The improvement of technology and improved networking capabilities.
3. Reduced costs of components and the ability to more cheaply collect and analyze the data they produce.

## 1.3 Strategic Research and Innnovation Directons

**Q6. Explain the Strategic research and innovation directions.**

*Ans :* **(Imp.)**

Strategic research and innovation directions can vary across industries and organizations, but there are some general trends and areas of focus that are commonly considered important for driving progress. The following are the strategic research and innovation directions:

1. **Digital Transformation**

   Embracing digital technologies to improve processes, enhance customer experiences, and drive operational efficiency. This includes technologies like artificial intelligence, machine learning, Internet of Things (IOT), and blockchain.

2. **Sustainability and Green Technologies**

   Investing in research and innovation to develop sustainable solutions, reduce environmental impact, and promote the use of green technologies. This can include renewable energy, eco-friendly manufacturing processes, and circular economy initiatives.

3. **Healthcare and Biotechnology**

   Advancements in medical research, personalized medicine, and biotechnology are critical for improving healthcare outcomes. This may involve genomics, precision medicine, telemedicine, and the development of new pharmaceuticals.

4. **Cybersecurity**

   With the increasing reliance on digital systems, protecting data and information from cyber threats is a major priority. Innovation in cybersecurity technologies, encryption methods, and threat detection is crucial.

5. **Artificial Intelligence and Automation**

   Leveraging AI and automation to streamline processes, increase productivity, and create new business models. This includes autonomous systems, robotics, and the integration of AI in various industries.

6. **5G and Connectivity**

   The rollout and optimization of 5G networks, as well as the development of applications and services that leverage high-speed, low-latency connectivity. This is particularly relevant for the advancement of the Internet of Things (IOT) and Industry 4.0.

7. **Space Exploration and Technology**

   Investments in space research, satellite technology, and space exploration for both scientific and commercial purposes. This includes developments in satellite communication, space tourism, and mining asteroids.

8. **Human Augmentation**

   Research into technologies that enhance human capabilities, such as brain-machine interfaces, exoskeletons, and bio-hacking. This can have applications in healthcare, manufacturing, and other industries.

9. **AgTech and Food Security**

   Innovations in agriculture technology to increase efficiency, reduce environmental impact, and ensure food security. This includes precision farming, vertical farming, and the development of sustainable agricultural practices.

10. **Education Technology**

    Advancements in educational tools, platforms, and methodologies to support personalized and accessible learning experiences. This can include virtual reality, augmented reality, and online learning platforms.

    It's important for organizations to align their strategic research and innovation directions with their overall mission, goals, and the specific challenges and opportunities within their industry. Additionally, collaboration with external partners, academia, and research institutions often plays a crucial role in driving successful innovation initiatives.

## 1.4 IOT APPLICATIONS

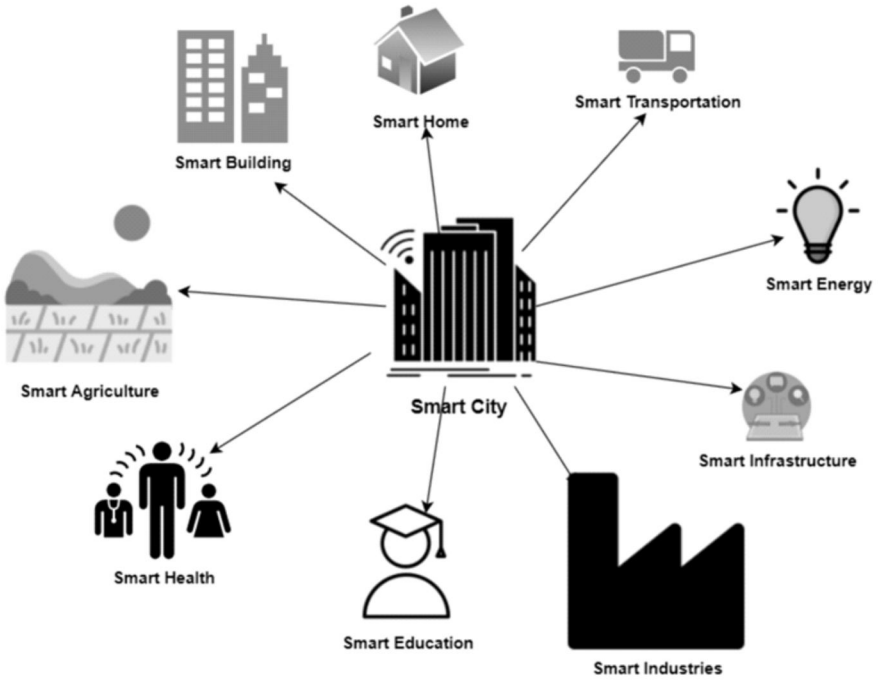
**Q7. Explain the Applications of Internet of Things.**

*Ans :* **(Imp.)**

The Internet of Things (IOT) is defined as a network of devices that feed data into a platform to enable communication and automated control. It connects physical devices to digital interfaces.

Internet of Things refers to a virtual internet connection from things, processes, people, animals and almost everything that we see around. It describes a situation where everything in our surrounding environment is made capable of automatically communicating with each other without any inter-human or human-to-machine interaction. Apart from the fact that it is a path-breaking discovery, it can also prove to be extremely beneficial in facilitating our lives to manifolds.

The Applications of IOT are explained below.




**1. Smart Home:**

Several IOT technologies are commonly used in smart homes to enable connectivity and automation. Such as

**(i) Smart Sensors**

Sensors play a crucial role in collecting data about the home environment. They can detect motion, temperature, humidity, light intensity, and more. These sensors provide valuable information for automating different functions in the smart home.

**(ii) Voice Assistants**

Voice assistants, such as Amazon Alexa or Google Assistant, have gained popularity in smart homes. They allow users to control devices and perform tasks using voice commands, offering a hands-free and intuitive control experience.

**(iii) Smart Appliances**

IOT-enabled appliances, such as refrigerators, washing machines, or ovens, can communicate with the central hub and provide information about their status, energy consumption, or maintenance requirements. This connectivity enables improved efficiency and optimization of appliance usage.

**(iv) Security Systems**

IOT has greatly improved home security systems. Smart security cameras, door locks, and motion sensors can send real-time alerts, and video feeds to homeowners' devices, enabling them to monitor and secure their homes remotely.

**(v) Energy Management**

IOT in smart homes allows for efficient energy management. Smart thermostats can understand user behavior and adjust temperature accordingly, refining energy usage. Smart lighting systems can automatically adjust brightness and switch off when everyone leaves the room, reducing energy waste.

**2. Smart agriculture**

Agriculture, as an industry, could massively benefit from the Internet of Things. The world's human population is estimated to grow to around 10 billion by 2050. As such, governments are prioritizing the scaling up of agricultural systems. This, combined with climate change, has farmers marrying technology to cultivation.

Sensors are used to provide details of soil chemistry and fertilizer profiles. CO2 levels, moisture, temperature, level of acidity, and the presence of appropriate nutrients all contribute to how good a harvest turns out to be.

Smart irrigation is an IOT application to regulate and efficiently use water for farming. The IOT system only initiates the water flow when the soil reaches a certain dryness level. It also stops the supply once a certain level of moisture is reached. This reduces wastage caused by human errors.

**3. Smarter cities**

A smart city is an urban city that uses sensors and cellular or wireless technology placed in ubiquitous places such as lamp posts and antennae. There are multiple facets in which one can incorporate IOT into the functioning of a city:

**(i) Traffic management**

Sensors on roads and traffic signals send data to the IOT systems. This data, accumulated over time, allows officials to analyze traffic patterns and peak hours. It also helps create solutions for bottle necks. Commuters can use this information to determine which areas are congested and what alternate routes can be used. A version of this already exists in third-party map services such as Google Maps.

**(ii) Pollution monitoring**

A pressing problem faced by every country in the world is air pollution. With existing sensors, one can easily measure parameters such as temperature, CO2 levels, smoke, and humidity. Smart cities leverage this to gather data about air quality and develop mitigation methods.

**(iii) Resource management**

The biggest factors in deciding a city's livability are waste, water, and electricity management.

With water management, sensors are attached internally or externally to water meters. These sensors provide information to understand consumption patterns. They detect faults in supply and automatically begin the necessary course of action. Trends in water wastage can be used to develop an efficient water recycling system.

IOT-enabled waste management systems produce a geographical mapping of waste production. These systems trigger the clearance process themselves; for example, by generating alerts when a trash bin is full. They also provide more insights into waste segregation and how people can improve waste processing.

Electricity management comes in the form of a smart grid, covered in detail in this article.

**(iv) Parking solutions**

Parking woes, while sounding insignificant, play a big part in traffic management. Smart parking solutions provide drivers with real-time information about empty spaces available.

**(v) Infrastructure management**

Public infrastructure such as street lamps, roads, parks, and gas supply lines cost a lot to maintain. Repair work in any of these causes disruptions to everyday functioning. IOT-based maintenance and monitoring systems lookout for signs of wear and tear while analyzing patterns. This proactive approach can save a city a lot of money.

**(vi) Disaster management**

The Internet of Things can be used to hook up disaster-prone areas to a notification system. A forest fire, for example, can be detected and curbed before it grows beyond control.

**4. Upgrading supply chain management**

Supply chain management (SCM) is a process that streamlines the flow of goods and services from raw material procurement to the customers. It involved inventory management, fleet management, vendor relationships, and scheduled maintenance.

During the pandemic, many businesses were affected by supply chain issues, especially when it caused a global shutdown in early 2020. As operations switched to being remote, it made sense for organizations to consider integrating IOT into their SCM processes.

The Internet of Things is used at multiple layers in the SCM process. Shipping companies use trackers to keep an eye on assets. They also analyze shipping routes to figure out the fastest and most fuel-efficient routes. Other parameters such as container temperature and humidity can also be monitored and controlled using IOT.

The IOT system allows managers to overhaul the supply chain process by enabling smart routing choices. This means that businesses can be confident in supply chain resilience.

**5. Smart healthcare**

The pandemic has accelerated the use of IOT in the healthcare industry. The Internet of Things provides a much more efficient link between patients, doctors, and pharmaceuticals. The traditionally reactive medical cycles can now be proactive.

Attaching sensors to a patient at home allows doctors to monitor them remotely. Continuous abnormality of parameters immediately alerts the doctor, creating preemptive action. Doctors can use this to monitor at-risk patients such as the elderly and those suffering from chronic diseases.

IOT is being used to optimize the manufacturing process at the pharmaceutical end. The direct result of this is lower drug prices. It is also used for intelligent inventory management.

**6. Smart grids**

Utility companies are turning to IOT to make energy provision more efficient. Appropriate sensors are installed in energy meters, transmission lines, production plants, and distribution points. This IoT system is called a smart grid.

**7. Smart wearables**

Another visible implementation of the Internet of Things is wearable technology. Wearable technology includes smartwatches, fitness trackers, smart eyewear, and even linked fabric.

The functionality of smartwatches varies from reading text messages and showing notifications to tracking locations and showing reminders. These wearables are helpful for parents tracking their children.

**8. Smart Industries**

The Internet of Things is all about giving physical devices more digital prominence. What better application for this than on a factory floor?

Industrial IOT (IIOT) is the Internet of Things at a factory level. IIOT is often referred to as the fourth wave of the industrial revolution or Industry 4.0.

## 1.5 RELATED FUTURE TECHNOLOGIES

**Q8. How IOT related to future technology?**

*Ans :* **(Imp.)**

**IoT Enabling Technologies**

IoT is enabled by several technologies including Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Embedded Systems, Security Protocols and architectures, Communication Protocols, Web Services, Mobile internet and semantic search engines.

**1) Wireless Sensor Network(WSN)**

Comprises of distributed devices with sensors which are used to monitor the environmental and physical conditions. Zig Bee is one of the most popular wireless technologies used by WSNs.

**WSNs used in IoT systems are described as follows:**

**(i) Weather Monitoring System**

In which nodes collect temp, humidity and other data, which is aggregated and analyzed.

**(ii) Indoor air quality monitoring systems**

To collect data on the indoor air quality and concentration of various gases.

**(iii) Soil Moisture Monitoring Systems**

To monitor soil moisture at various locations.

**(iv) Surveillance Systems**

Use WSNs for collecting surveillance data (motion data detection).

**(v) Smart Grids**

Use WSNs for monitoring grids at various points.

**(vi) Structural Health Monitoring Systems**

Use WSNs to monitor the health of structures (building, bridges) by collecting vibrations from sensor nodes deployed at various points in the structure.

**2) Cloud Computing**

Services are offered to users in different forms.

**(i) Infrastructure-as-a-service (IaaS)**

Provides users the ability to provision computing and storage resources. These resources are provided to the users as a virtual machine instances and virtual storage.

**(ii) Platform-as-a-Service(PaaS)**

Provides users the ability to develop and deploy application in cloud using the development tools, APIs, software libraries and services provided by the cloud service provider.

**(iii) Software-as-a-Service(SaaS)**

Provides the user a complete software application or the user interface to the application itself.

**3) Big Data Analytics**

Some examples of big data generated by IoT are

**(i)** Sensor data generated by IoT systems.

**(ii)** Machine sensor data collected from sensors established in industrial and energy systems.

**(iii)** Health and fitness data generated IoT devices.

**(iv)** Data generated by IoT systems for location and tracking vehicles.

**(v)** Data generated by retail inventory monitoring systems.

**4) Communication Protocols**

form the back-bone of IoT systems and enable network connectivity and coupling to applications.

**(i)** Allow devices to exchange data over network.

**(ii)** Define the exchange formats, data encoding addressing schemes for device and routing of packets from source to destination.

**(iii)** It includes sequence control, flow control and retransmission of lost packets.

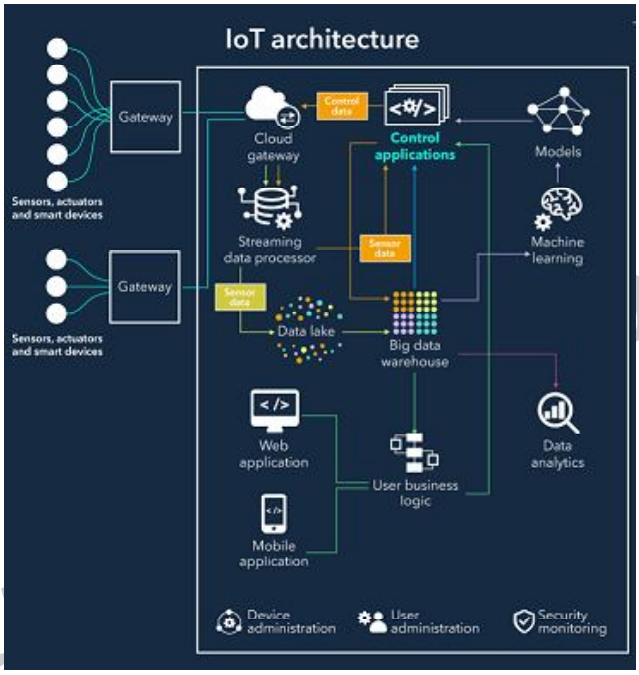
**5) Embedded Systems:** is a computer system that has computer hardware and software embedded to perform specific tasks. Embedded System range from low cost miniaturized devices such as digital watches to devices such as digital cameras, POS terminals, vending machines, appliances etc.,

## 1.6 INFRASTRUCTURE

**Q9. Explain the Infrastructure of IOT.**

*Ans :* **(Imp.)**

The Internet of Things (IOT) infrastructure refers to the interconnected network of devices, sensors, software, and communication technologies that enable the exchange of data and information between physical objects or "things." This infrastructure forms the foundation for building and deploying IOT applications across various domains such as smart cities, healthcare, agriculture, manufacturing, and more.




**The components of IOT infrastructure include:**

**1. Devices and Sensors**

These are physical objects embedded with sensors or actuators to collect data or perform actions. Examples include smart thermostats, wearable devices, industrial sensors, and more.

**2. Connectivity**

IOT devices rely on various communication protocols to transmit data. Common connectivity technologies include Wi-Fi, Bluetooth, Zigbee, RFID, cellular networks (3G, 4G, 5G), and Low Power Wide Area Networks (LPWAN) like LoRaWANor NB-IOT.

**3. Cloud Computing**

The cloud plays a crucial role in storing, processing, and analyzing the massive amounts of data generated by IOT devices. Cloud platforms offer scalability, flexibility, and the computational power needed for complex analytics.

**4. Data Analytics**

Analyzing the vast amount of data generated by IOT devices can provide valuable insights. Big data analytics tools and machine learning algorithms are often employed to derive meaningful information from the collected data.

**5. User Interfaces and Applications**

The end-user interacts with IOT applications through various interfaces, such as mobile apps or web dashboards, to monitor and control connected devices.

**6. Standards and Protocols**

Standardization is crucial for ensuring interoperability and compatibility between different IOT devices and systems. Common standards include MQTT, COAP, and protocols like HTTP and HTTPS.

**7. Things**

A "thing" is an object equipped with sensors that gather data that will be transferred over a network and actuators that allow things to act (for example, to switch on or off the light, to open or close a door, to increase or decrease engine rotation speed and more). This concept includes fridges, street lamps, buildings, vehicles, production machinery, rehabilitation equipment and everything else imaginable. Sensors are not in all cases physically attached to the things: sensors may need to monitor, for example, what happens in the closest environment to a thing.

**8. Gateways**

Data goes from things to the cloud and vice versa through the gateways. A gateway provides connectivity between things and the cloud part of the IOT solution, enables data preprocessing and filtering before moving it to the cloud (to reduce the volume of data for detailed processing and storing) and transmits control commands going from the cloud to things. Things then execute commands using their actuators.

**9.** Cloud gateway facilitates data compression and secure data transmission between field gateways and cloud IOT servers. It also ensures compatibility with various protocols and communicates with field gateways using different protocols depending on what protocol is supported by gateways.

**10.** Streaming data processor ensures effective transition of input data to a data lake and control applications. No data can be occasionally lost or corrupted.

**11. Data analytics**

Data analysts can use data from the big data warehouse to find trends and gain actionable insights. When analyzed (and in many cases – visualized in schemes, diagrams, info graphics) big data show, for example, the performance of devices, help identify inefficiencies and work out the ways to improve an IOT system (make it more reliable, more customer-oriented). Also, the correlations and patterns found manually can further contribute to creating algorithms for control applications.

**12. Machine learning and the models ML generates**

With machine learning, there is an opportunity to create more precise and more efficient models for control applications. Models are regularly updated (for example, once a week or once a month) based on the historical data accumulated in a big data warehouse. When the applicability and efficiency of new models are tested and approved by data analysts, new models are used by control applications.

**13.** Control applications send automatic commands and alerts to actuators, for example:

**14.** Windows of a smart home can receive an automatic command to open or close depending on the forecasts taken from the weather service.

**15.** When sensors show that the soil is dry, watering systems get an automatic command to water plants.

**16.** Sensors help monitor the state of industrial equipment, and in case of a pre-failure situation, an IOT system generates and sends automatic notifications to field engineers.

## 1.7 NETWORKS AND COMMUNICATIONS, PROCESSES

**Q10. Explain briefly about IOT Communication Parameters.**

*Ans :* **(Imp.)**

Communication protocols are the set of rules established between nodes to exchange information in a reliable and safe manner.

**The main aspects of a communication protocol**

Speed or Data Rate: the amount of information to be transmitted within a time duration. It is usually expressed in bps (bits per second), kbps, Mbps, or Gbps.

**Range**

the maximum distance between two intercommunicating nodes. It mainly depends upon the transmitting power, the frequency band used, and the type of modulation. It can be also affected by the meteorological conditions or the physical placement of the nodes. In Figure 1 you can see a rough graph of the data rate versus the range of various IOT network protocols.

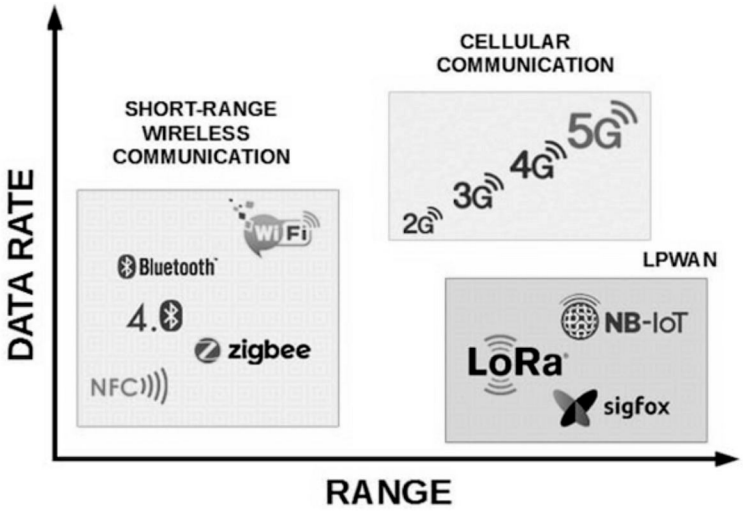



**Fig.: Data rate vs. range of various IOT network protocols.**

1. **Power Consumption**

   The amount of energy that a node needs to work within its lifetime. This parameter defines the need for permanent power or the use of a battery. Since there are many applications using batteries, thus power consumption is a critical parameter. This means it will affect other elements such as the number of sensors or the communication power transmission. Furthermore, since batteries have a limited lifetime, the power consumption can have a direct impact on the maintenance strategy.

2. **Interoperability**

   The capability to exchange information between nodes, even if they are of different types.

3. **Scalability**

   The challenge of deploying a higher number of nodes, increasing the number of end-users, as well as the amount of data to store and process without the need of migrating the technology.

4. **Cost**

   The price of installing and maintaining a specific technology. Power consumption, maintenance, and scalability have a big impact on the network cost.

5. **Network Topology**

   The way nodes communicate with each other. Topologies can be the same as those used in traditional networks. Star, mesh, point-to-point, and point-to-multipoint are some examples of topologies, which can be seen in Figure 2.

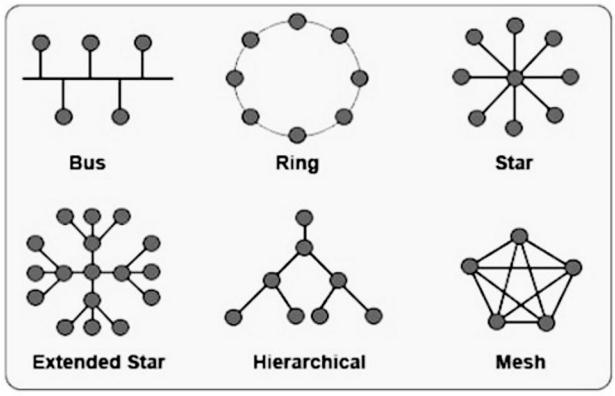



**Fig.: Examples of different network topologies.**

### Security

The way to protect data being sent and received. It is necessary to ensure that the communication transmitted between nodes arrives only at the intended nodes. The IOT technologies are already ubiquitous and they can communicate sensitive information to the users; thus, the communication needs to be protected against third parties.

### IOT Protocol Basics

Protocols allow nodes to have a structured way to interact between them. Since the needs and use cases of IOT devices have quickly evolved over the last few years, so have the protocols. All in all, there are mainly two types of protocols: network and data. This classification comes from the OSI (open systems interconnection) model, widely used in IT communication networks.

Below you can get a general understanding of the main IOT network protocols.

### Bluetooth

This protocol works within the frequency of 2.4 GHz, and can be used for short-range (< 100 m) applications. One step further into Its evolution is Bluetooth Low Energy (BLE), which presents a significant reduction in the power needed for this protocol. This type can be beneficial for the transmission of small amounts of data from sensors or wearables. An example node network layout can be seen in Figure 3.

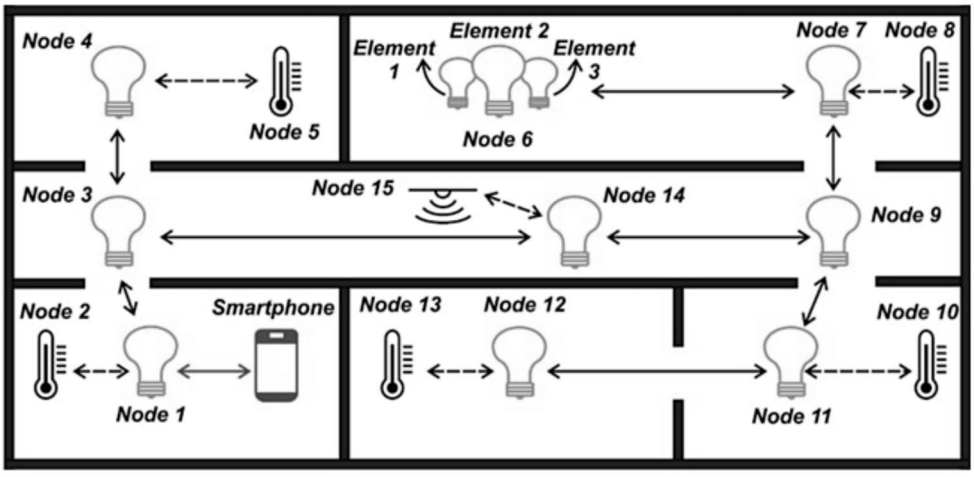



**Fig.: An example of Bluetooth IOT network nodes in a smart home.**

### Cellular

Current cellular infrastructure can be also used to extend the communication capabilities of IOT nodes. Depending upon the chosen band and the specific technology, it can be adequate for low power applications (e.g., 2G) as well as for high data rates applications (e.g., LTE). Additionally, there are subtypes of cellular communications, such as the LTE-M and NB-IOT, which were born to provide more data bandwidth or lower power use, respectively.

### LoRaWAN

It is a low-power, wide-area (LPWA) protocol designed for battery-powered systems. It operates in the sub GHz 433/868/915 MHz and within the 2.4 GHz. LoRaWAN networks generally follow star topologies, where the elements are: end nodes, gateways, and a set of servers. The OSI reference model can be seen in Figure 4.

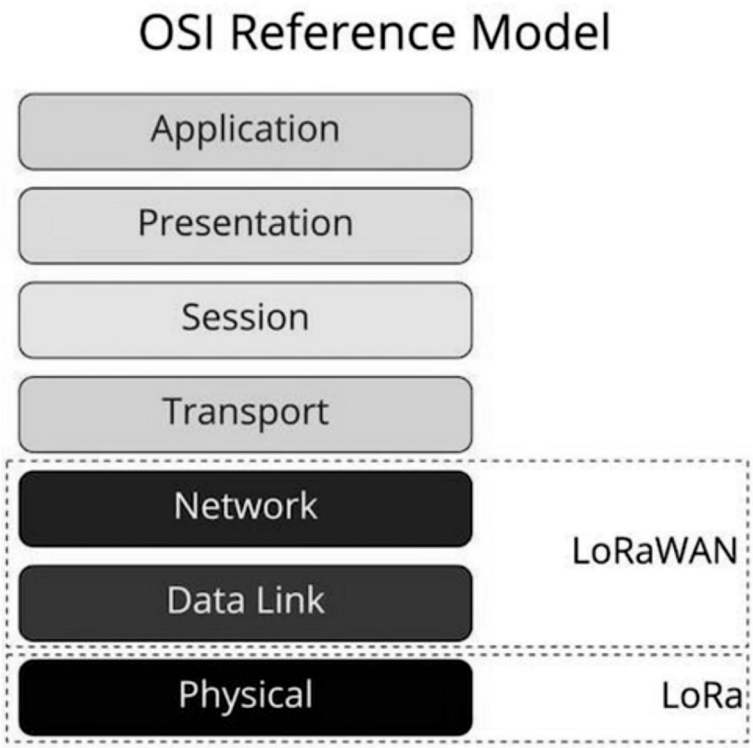



**Fig.: The OSI reference model for LoRa and LoRaWan.**

### Near field communications (NFC)

NFC works in the frequency band of 13.56 MHz and the range is a few centimeters. This type of communication is used to extend close-contact communications. In NFC there is an active node (such as a smartphone) generating an RF field that energizes a tag. It works in the frequency band of 13.56 MHz and the range is a few centimeters.

### Sigfox

Sigfox uses a technology-based ultra-narrow band (UNB) and it works in the ISM bands, requiring a dedicated infrastructure. It means that it can be globally used but a local operator is needed.

### Wi-FI

Working in the frequency of 2.4 GHz and 5 GHz, Wi-Fi connectivity is widely chosen because of its pervasiveness and high data rates. Its main drawback is its high power consumption, so it is not frequently used in battery-powered applications.

**Wi-Sun**

Wi-Sun is a field area network (FAN) protocol created by the Wi-Sun Alliance and designed to have a low power consumption and latency. It operates in the sub GHz frequency bands as well as in the 2.4 GHz band through a mesh topology.

**ZigBee**

This communication protocol works in the 2.4 GHz band, for short-range (<100 m) in restricted areas. ZigBee is made for transmitting small amounts of information, namely where really low latency is needed and is widely used in the industry and consumer applications. The ZigBee RF4CE was made to replace IR remote controls (e.g., TVs and DVD systems) and remove the need of having a line of sight between the remote control and the device.

**Z-wave**

Intended for home automation applications (Figure 5), working in ISM frequency bands and with a rate up to 100 Kbps. Its applications follow a mesh network topology performing up to 4 hopes.


**Fig.: An example application of a Z-Wave IoT network at home.**

**Q11. Explain Various types of IOT Communication.**

*Ans :* **(Imp.)**

**IOT Communication**

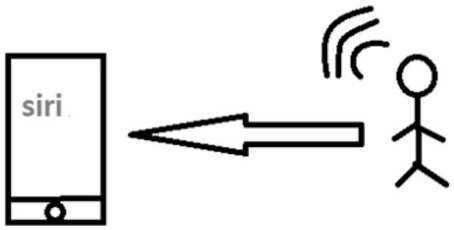
IOT is the connection of devices over the internet, where these smart devices communicate with each other exchange data , perform some tasks without any human involvement. These devices are embedded with electronics, software, network and sensors which help in communication. Communication between smart devices is very important in IOT as it enables these devices to gather, exchange data which contribute in success of that IOT product/project.

**Types of Communications in IOT**

The following are some communication types in IOT:-

**1. Human to Machine (H2M)**

In this human gives input to IOT device i.e as speech/text/image etc. IOT device (Machine) like sensors and actuators then understands input, analyses it and responds back to human by means of text or Visual Display. This is very useful as these machines assist humans in every everyday tasks. It is a combo of software and hardware that includes human interaction with a machine to perform a task.




**H2M communication**

**Merits**

This H2M has a user-friendly interface that can be quickly accessed by following the instructions. It responds more quickly to any fault or failure. Its features and functions can be customized.

**Examples:**

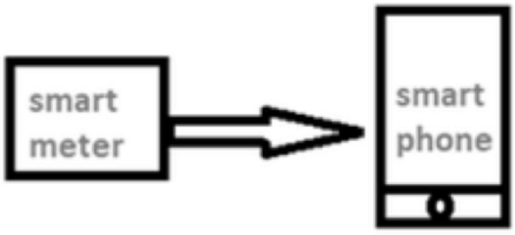
**(i)** Facial recognition.

**(ii)** Bio-metric Attendance system.

**(iii)** Speech or voice recognition.

**2. Machine to Machine (M2M)**

The process of exchanging information or messages between two or more machines or devices is known as Machine to Machine (M2M) communication.




**M2M communication**

**Advantages –**

This M2M can operate over cellular networks and is simple to manage.

It can be used both indoors and outdoors and aids in the communication of smart objects without the need for human interaction.

The M2M contact facility is used to address security and privacy problems in IoT networks.

Large-scale data collection, processing, and security are all feasible.

**Disadvantages**

In M2M, use of cloud computing restricts versatility and creativity.

Data security and ownership are major concerns here.

The challenge of achieving interoperability between cloud/M2M IoT systems is daunting.

M2M connectivity necessitates the existence of a reliable internet connection.

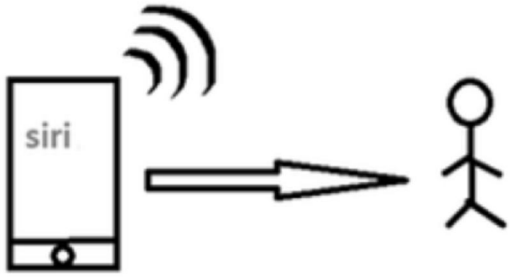
**Examples:**

**(i)** Smart Washing machine sends alerts to the owners' smart devices after completion of washing or drying of clothes.

**(ii)** Smart meters tracks amount of energy used in household or in companies and automatically alert the owner.

**Machine to Human M2H**

In this machine interacts with Humans. Machine triggers information (text messages/images/voice/signals) respective / irrespective of any human presence. This type of communication is most commonly used where machines guide humans in their daily life. It is way of interaction in which humans co-work with smart systems and other machines by using tools or devices to finish a task.




**M2H communication**

**Examples:**

**(i)** Fire Alarms

**(ii)** Traffic Light

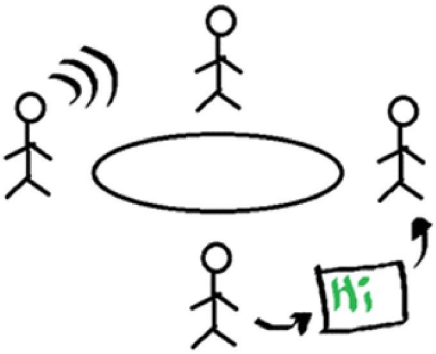
**(iii)** Fitness bands

**(iv)** Health monitoring devices

**4. Human to Human (H2H)**

This is generally how humans communicate with each other to exchange information by speech, writing, drawing, facial expressions, body language etc. Without H2H, M2M applications cannot produce the expected benefits unless humans can immediately fix issues, solve challenges, and manage scenarios.

The process of exchanging information or messages between two or more people is known as human to human (H2H) communication. This can be done through various means such as verbal, non-verbal, or written communication.




**H2H communication**

For, communication of IoT devices many protocols are used. These IoT protocols are modes of communication which give security to the data being exchanged between IoT connected devices. Example bluetooth, wifi, zigbee etc.

**Q12. Explain briefly about IOT Networking.**

*Ans :*

**Top of Form**

A.IOT network is the network with physical interconnected objects embedded with sensors, smart devices that connect and exchange data with other devices and systems without human intervention.

IOT networking involves a variety of components that work together to enable communication and data exchange between devices. Here are some key components of IOT networking:

**1. IOT Devices:**

**(i) Sensors**

Capture data from the physical environment. Examples include temperature sensors, humidity sensors, motion sensors, etc.

**(ii) Actuators**

Devices that perform actions based on received data. For example, turning on/off a switch or adjusting a valve.

**(iii) Microcontrollers/Microprocessors**

Embedded systems that control the operation of IoT devices, handle data processing, and manage communication.

**2. Communication Protocols:**

**(i) MQTT (Message Queuing Telemetry Transport)**

Lightweight and efficient publish-subscribe protocol for messaging.

**(ii) COAP (Constrained Application Protocol)**

Designed for resource-constrained devices and networks.

**(iii) HTTP/HTTPS**

Widely used for communication between IoT devices and cloud services.

**3. Wireless Technologies:**

**(i) Wi-Fi**

High-speed, short to medium-range wireless technology suitable for applications with power availability.

**(ii) Bluetooth**

Short-range communication technology commonly used in consumer devices.

**(iii) Zigbee**

Low-power, low-data-rate communication for applications like home automation and industrial control.

**(iv) LoRaWAN**

Long-range, low-power technology suitable for wide-area networks in applications like smart agriculture and smart cities.

**(v) NFC (Near Field Communication)**

Short-range communication for secure data exchange between devices in close proximity.

**4. Cellular Networks:**

**(i) 3G, 4G, 5G**

Cellular networks provide wide coverage and high data rates, suitable for mobile and remote IOT devices.

**5. Edge Computing Devices:**

**(i) Edge Gateways**

Devices that preprocess data at the edge of the network before sending it to the cloud, reducing latency and bandwidth usage.

**(ii) Edge Servers**

More powerful computing devices at the edge that can perform advanced analytics and processing.

**6. IOT Platforms:**

**(i) Device Management Platforms:** Facilitate the registration, provisioning, and management of IOT devices.

**(ii) Data Management Platforms**

Handle storage, retrieval, and analysis of data generated by IOT devices.

**(iii) Application Enablement Platforms**

Provide tools for developing and deploying IoT applications.

**7. Security Measures:**

**(i) Authentication and Authorization**

Verify the identity of devices and control their access to the network.

**(ii) Encryption**

Secure data transmission between devices and cloud services.

**(iii) Firewalls and Intrusion Detection Systems**

Protect against unauthorized access and potential attacks.

**8. IPv6:**

**(i) IPv6-enabled Devices**

With the growing number of IOT devices, IPv6 is crucial to provide a sufficient number of unique IP addresses.

**9. Network Management Tools:**

**(i) Monitoring and Analytics**

Tools that help monitor the performance of IOT networks and analyze data for insights.

**(ii) Remote Configuration and Firmware Updates**

Allow remote management and updates of IOT device software.

**10. Power Management Solutions**

**(i) Energy-Efficient Protocols**

Ensure that communication protocols are designed to minimize power consumption.

**(ii) Energy Harvesting**

Technologies that allow devices to generate energy from their surroundings, reducing reliance on external power sources.

These components collectively form the IOT networking ecosystem, and their proper integration and management are crucial for building efficient, scalable, and secure IOT solutions.

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**Q13. Explain the process of Networking Communication.**

*Ans :* **(Imp.)**

IOT networking communication processes involve the transmission and reception of data between IoT devices, as well as the interaction with the broader network infrastructure. The communication processes in IOT networks typically follow a series of steps:

**1. Device Initialization and Connection:**

**(i) Bootstrapping**

Devices initialize, connect to the network, and establish initial communication parameters.

**(ii) Network Discovery**

Devices may discover available networks and select the most suitable one based on factors such as signal strength and security.

**2. Device Registration and Authentication:**

**(i) Registration**

Newly connected devices register with the network or IoT platform.

**(ii) Authentication**

Devices undergo authentication processes to verify their identity and authorization to access the network.

**3. Data Sensing and Collection:**

**(i) Sensing**

IOT devices collect data from the physical environment using embedded sensors.

**(ii) Data Processing**

Devices may preprocess data locally to reduce the amount of data sent over the network.

**4. Data Packaging and Formatting:**

**(i) Message Packaging**

Data is organized into messages or packets for efficient transmission.

**(ii) Data Formatting**

The data may be formatted according to the communication protocol used (e.g., MQTT, CoAP).

**5. Communication Protocols:**

**(i) Selection**

Devices use predefined communication protocols (e.g., MQTT, CoAP) to exchange data with other devices or the cloud.

**(ii) Message Exchange**

Devices communicate through messages, which can be published, subscribed, requested, or responded to based on the protocol.

**6. Wireless Transmission:**

**(i) Selection of Wireless Technology**

Devices use wireless technologies (e.g., Wi-Fi, Bluetooth, Zigbee, LoRaWAN) to transmit data.

**(ii) Establishing Connection**

Devices establish connections based on the chosen wireless technology.

**7. Edge Processing (Optional):**

**(i) Local Processing**

Some data processing may occur at the edge device or gateway to reduce latency and bandwidth usage.

**(ii) Decision Making**

Edge devices may make local decisions based on processed data without relying on centralized cloud resources.

**8. Data Encryption and Security Measures:**

**(i) Encryption**

Data is encrypted to secure it during transmission.

**(ii) Security Protocols**

Security measures such as secure sockets layer (SSL) or transport layer security (TLS) are implemented to protect data integrity and confidentiality.

**9. Cloud Transmission (Optional):**

**(i) Data Upload**

Processed data is transmitted to the cloud for further storage, analysis, and application processing.

**(ii) Cloud Services Interaction**

Devices may interact with cloud-based services and applications.

**10. Feedback and Control (Optional):**

**(i) Control Commands**

Devices may receive control commands from the cloud or other devices.

**(ii) Feedback Transmission**

Devices provide feedback or acknowledgment of received commands.

**11. Device Management:**

**(i) Monitoring**

Continuous monitoring of device status and performance.

**(ii) Firmware Updates**

Remote management and updating of device firmware for improvements or security patches.

**12. Power Management:**

**(i) Sleep Modes**

Devices may enter sleep modes to conserve power when not actively transmitting or sensing.

**(ii) Power Optimization**

Strategies to optimize power consumption during communication processes.

These communication processes ensure the flow of data between IoT devices, edge devices, and cloud platforms while considering factors such as security, efficiency, and power consumption. The specific processes can vary based on the chosen communication protocols, wireless technologies, and the overall architecture of the IOT system.

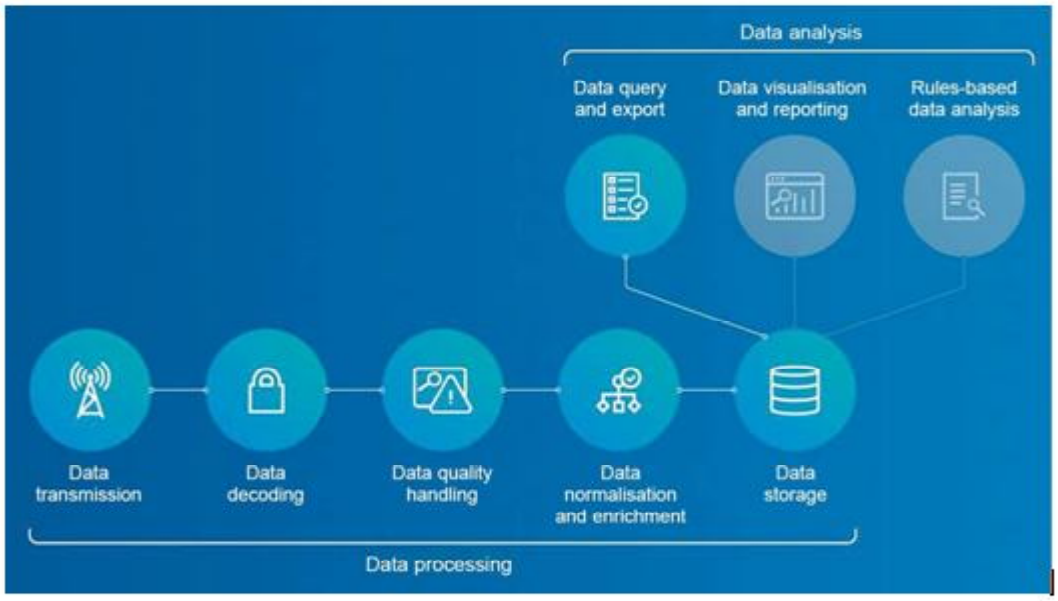
## 1.8 DATA MANAGEMENT

**Q14. Explain the data management system of Internet of Things.**

*Ans :* **(Imp.)**

The Internet of Things (IoT) device management enables users to track, monitor and manage the devices to ensure these work properly and securely after deployment.

Billions of sensors interact with people, homes, cities, farms, factories, workplaces, vehicles, wearables and medical devices, and beyond. The Internet of Things (IoT) is changing our lives from managing home appliances to vehicles. Devices can now advise us about what to do, when to do and where to go. Industrial applications of the IoT assist us in managing processes, and predicting faults and disasters. The IoT platforms help set and maintain parameters to refine and store data accordingly.




**Steps in IOT data management**

**(i)** Data management is the process of taking the overall available data and refining it down to important information. Different devices from different applications send large volumes and varieties of information. Managing all this IOT data means developing and executing architectures, policies, practices and procedures that can meet the full data lifecycle needs.

**(ii)** Things are controlled by smart devices to automate tasks, so we can save our time. Intelligent things can collect, transmit and understand information, but a tool will be required to aggregate data and draw out inferences, trends and patterns.

**(iii)** Developers and manufacturers of embedded systems and devices need to build systems that answer the demands of data management.

**(iv)** They need to design a data management framework compatible with all the software and hardware that play a role in collecting, managing and distributing data. The design needs to be efficient to accelerate time-to-market of the end-product.

**(v)** Data from IOT devices is used for analytical purposes. Information that businesses collect and store but remains relatively stagnant, because it is not used for analytical purposes, is called dark data. It includes customer demographic information, purchase histories and satisfaction levels, or general product data. To better understand customers, dark data is invaluable to businesses, as it allows them to uncover additional insights more efficiently.

**(vi)** Before the release of a product, IOT data management requires field tests. Data from the field tests helps improve the design and create a higher-quality product. Collecting field data post-launch helps in continuous product improvement with software updates and by identifying anomalies. This also provides important insights to support the development process of new products.

**The IOT data management**

In edge computing, data is processed near the data source or at the edge of the network. While in a typical cloud environment, data processing happens in a centralized data storage location. By processing and using some data locally, the IOT saves storage space for data, processes information faster and meets security challenges.

Edge computing, data governance policies and metadata management help firms deal with issues of scalability and agility, security and usability. This further assist them decide whether to manage data on the edge or only after sending it to the cloud.

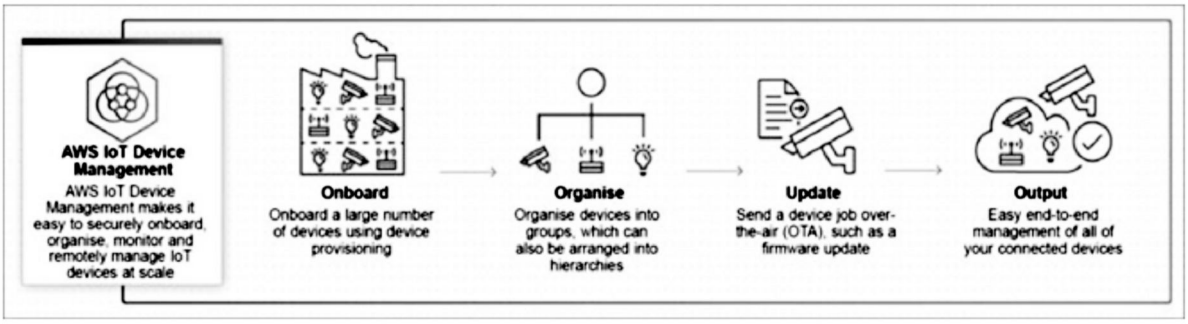
Sensors produce a large amount of data for edge gateway devices so that these can make decisions by analysing the data. These high-performance systems not only need to collect data in real time but also to organize and provide data to other systems.

Sensors and devices can connect indirectly through the cloud, where data is centrally-managed, or send data directly to other devices to locally collect, store and analyze the data, and then share selected findings or information with the cloud. Edge devices for data management help secure the most valuable data and reduce bandwidth cost. These also provide great performance, ownership over data and lower maintenance cost.

Edge devices run a Web-based dashboard that end-users can access to monitor the flow of data, so they can decide how various systems in demonstration and devices are running, and get notified by alarms. A large amount of data can be represented in the form of a graph for any desired range of time, and each point on the graph represents a record that can be found by searching the database, which stores a large quantity of data.

**AWS IOT device management**

This is critical across industrial, consumer and commercial applications such as an industrial and connected home. It enables customers to manage large and diverse device fleets such as operational technology systems, cameras, machines, vehicles, appliances and more.




**Working of AWS IOT device management**

It enables monitoring of usage and performance metrics for devices across industrial sectors such as manufacturing, oil and gas, and mining. It allows monitoring metadata and policy changes with service alerts to inform about any adjustments to the devices' configuration. It also allows detection of any unusual behaviour across a device and to take mitigating actions.

It provides secure on boarding, organizing, monitoring, troubleshooting and sending of firmware updates over-the-air (OTA). It enables adding device attributes like device name, type and manufacturing year, certificates and access policies to the IOT Registry. Then, it assigns them to devices, and makes connected devices ready for service quickly. This helps to quickly search and find any IOT device across the entire device fleet in near real time.

It is easy to find devices based on a combination of attributes like device ID, device state and type, so that action can be taken, in addition to troubleshooting. Actions such as reboots, factory resets and security patches can also be remotely executed.

**Q15. Explain the challenges of Data management.**

*Ans :* **(Imp.)**

With time, the number of IOT devices will increase, thus increasing the challenges for real-time processing and analysis to reduce time for storage.

Space has to be optimized for metadata like user IDs and passwords to ensure enough space for new information.

Functions such as adaptive maintenance, predictive repair, security monitoring and process optimization rely on real-time data. Selecting the right tools is a challenge because integration between different sensors should be proven and compatibilities confirmed.

When there is no connection, devices must still gain insights, make decisions and prepare for data distribution.

There are important factors behind an IOT device data management platform, including interoperability, scalability, security and standards offered by software technologies to build IOT products.

It is important to protect data from unauthorized access and tampering. Organizations need to be compliant with national rules and regulations on securing data.

IOT device data also need to be checked for quality. Having many different devices connected directly to cloud services presents a huge attack surface, which can be mitigated by channelling data through a secure gateway device.

## 1.9 SECURITY

**Q16. What are some of the main aspects of IoT device security?**

*Ans :* **(Imp.)**

The main aspects of IOT device security are

**(i) Software and firmware updates**

IOT devices need to be updated whenever the manufacturer issues a vulnerability patch or software update. These updates eliminate vulnerabilities that attackers could exploit. Not having the latest software can make a device more vulnerable to attack, even if it is outdated by only a few days. In many cases IOT firmware updates are controlled by the manufacturer, not the device owner, and it is the manufacturer's responsibility to ensure vulnerabilities are patched.

**(ii) Credential security**

IOT device admin credentials should be updated if possible. It is best to avoid reusing credentials across multiple devices and applications — each device should have a unique password. This helps prevent credential-based attacks.

**(iii) Device authentication**

IOT devices connect to each other, to servers, and to various other networked devices. Every connected device needs to be authenticated to ensure they do not accept inputs or requests from unauthorized parties.

For example, an attacker could pretend to be an IOT device and request confidential data from a server, but if the server first requires them to present an authentic TLS certificate (more on this concept below), then this attack will not be successful.

For the most part, this type of authentication needs to be configured by the device manufacturer.

**(iv) Encryption**

IOT device data exchanges are vulnerable to external parties and on-path attackers as they pass over the network — unless encryption is used to protect the data. Think of encryption as being like an envelope that protects a letter's contents as it travels through the postal service.

Encryption must be combined with authentication to fully prevent on-path attacks. Otherwise, the attacker could set up separate encrypted connections between one IOT device and another, and neither would be aware that their communications are being intercepted.

**(v) Turning off unneeded features**

Most IOT devices come with multiple features, some of which may go unused by the owner. But even when features are not used, they may keep additional ports open on the device in case of use. The more ports an Internet-connected device leaves open, the greater the attack surface — often attackers simply ping different ports on a device, looking for an opening. Turning off unnecessary device features will close these extra ports.

**(vi) DNS filtering**

DNS filtering is the process of using the Domain Name System to block malicious websites. Adding DNS filtering as a security measure to a network with IOT devices prevents those devices from reaching out to places on the Internet they should not (i.e. an attacker's domain).

**Q17. What is mutual TLS (MTLS)?**

*Ans :*

Mutual Transport Layer Security (MTLS) is a type of mutual authentication, which is when both sides of a network connection authenticate each other. TLS is a protocol for verifying the server in a client-server connection; MTLS verifies both connected devices, instead of just one.

MTLS is important for IOT security because it ensures only legitimate devices and servers can send commands or request data. It also encrypts all communications over the network so that attackers cannot intercept them.

MTLS requires issuing TLS certificates to all authenticated devices and servers. A TLS certificate contains the device's public key and information about who issued the certificate. Showing a TLS certificate to initiate a network connection can be compared to a person showing their ID card to prove their identity.

**Q18. What attacks are IOT devices most susceptible to?**

*Ans :*

**(i) Firmware vulnerability exploits**

All computerized devices have firmware, which is the software that operates the hardware. In computers and smartphones, operating systems run on top of the firmware; for the majority of IOT devices, the firmware is essentially the operating system.

Most IOT firmware does not have as many security protections in place as the sophisticated operating systems running on computers. And often this firmware is rife with known vulnerabilities that in some cases cannot be patched. This leaves IOT devices open to attacks that target these vulnerabilities.

**(ii) Credential-based attacks**

Many IOT devices come with default administrator usernames and passwords. These usernames and passwords are often not very secure — for instance, "password" as the password — and worse, sometimes all IOT devices of a given model share these same credentials. In some cases, these credentials cannot be reset.

Attackers are well aware of these default usernames and passwords, and many successful IoT device attacks occur simply because an attacker guesses the right credentials.

**(iii) On-path attacks**

On-path attackers position themselves between two parties that trust each other — for example, an IoT security camera and the camera's cloud server — and intercept communications between the two. IoT devices are particularly vulnerable to such attacks because many of them do not encrypt their communications by default (encryption scrambles data so that it cannot be interpreted by unauthorized parties).

**(iv) Physical hardware-based attacks**

Many IOT devices, like IOT security cameras, stoplights, and fire alarms, are placed in more or less permanent positions in public areas. If an attacker has physical access to an IoT device's hardware, they can steal its data or take over the device. This approach would affect only one device at a time, but a physical attack could have a larger effect if the attacker gains information that enables them to compromise additional devices on the network.

## 1.10 Device Level Energy Issues

**Q19. Explain about Device Level Energy Issues.**

*Ans :* **(Imp.)**

Implementing IOT- enabled Energy management in a developing country like India comes with its own set of practical issues and challenges. The challenges are as follows:

**(i) Infrastructure and Connectivity**

India has diverse geographical and infrastructural challenges, especially in remote and rural areas. Though we have gradually improved the connectivity across urban and rural areas and are one of the leading nations in the world in implementing 5G, we still have shadow zones having significantly weak or no network connectivity. Ensuring reliable internet connectivity and proper infrastructure for IOT devices can be a significant hurdle.

**(ii) Cost and Affordability**

The initial cost of deploying IOT devices and setting up the necessary infrastructure can be relatively high and therefore, can affect the cost of supply, from an electricity distributor's / retailer's perspective. Regulating the incidence of such costs, from a tariff setting perspective, can be challenging for policy makers and regulators.

**(iii) Data Security and Privacy**

IOT devices collect and transmit sensitive energy consumption data. Ensuring robust data security and privacy measures becomes crucial to protect consumers' information from potential cyber threats and unauthorized access.

**(iv) Interoperability and Standards**

Different manufacturers may have their own proprietary IOT systems, leading to compatibility issues and a lack of standardization. Ensuring interoperability among various devices and systems is vital for seamless integration and scalability.

**(v) Skilled work force and Awareness**

Deploying and maintaining IOT-enabled energy management systems requires a skilled workforce. In many cases, there might be a lack of trained personnel with expertise in IOT technologies.

**(vi) Power Supply Reliability**

In a country like India, where power # outages are not uncommon, ensuring continuous and reliable power supply to IOT devices is essential for their effective functioning.

**(vii) Regulatory and Policy frame work**

The lack of clear and supportive regulations around IoT implementation and data management can act as a barrier to adoption for businesses and investors.

**(viii) Scalability and Integration**

As the energy demand grows, the system should be scalable enough to handle increased data and devices. Integrating IoT-enabled solutions with existing energy infrastructure and systems can be complex.

**(ix) Maintenance and Upgrades**

Ensuring regular maintenance and timely upgrades of IOT devices is crucial for their long-term performance and efficiency. However, resource constraints can hinder effective maintenance in some cases.

**(x) Perception and Acceptance**

New technologies may face resistance or slow adoption due to skepticism or a lack of awareness about their benefits, especially in traditional or conservative sectors.

**(xi) Environmental Impact**

The production, deployment, and disposal of IOT devices can have environmental implications, and sustainable practices need to be considered.

Addressing these challenges requires a comprehensive approach, involving collaboration between government, industry, and technology providers. Here are some potential solutions:

**(xii) Government Support**

Enabling policies, incentives, and funding support can encourage IOT adoption in the energy sector.

**(xiii) Public private partnerships**

Collaborations between government agencies and private companies can help deploy IOT solutions cost-effectively.

**(xiv) Capacity building**

Invest in training programs to develop a skilled workforce capable of handling IOT technologies.

**(xv) Promote Indigenous solutions**

Encourage the development of locally manufactured IOT devices and components to reduce costs and promote self-reliance.

**(xvi) Data protection Measures**

Implement robust data security and privacy measures, complying with relevant regulations.

**(xvii) Awareness Campaigns**

Conduct awareness campaigns to educate consumers and businesses about the benefits and importance of IOT-enabled energy management.

**(xiii) Pilot Projects and Demonstrations**

Initiate pilot projects in specific regions to showcase the benefits and build trust among stakeholders.

By addressing these challenges pro actively, India can unlock the full potential of IOT-enabled energy management to improve energy efficiency, reduce wastage, and move towards a more sustainable energy future.

UNIT II

**INTERNET PRINCIPLES AND COMMUNICATION TECHNOLOGY :**

Internet Communications: An Overview – IP, TCP, IP protocol Suite, UDP. IP addresses – DNS, Static and Dynamic IP addresses, MAC Addressess, TCP and UDP Ports, Application Layer Protocols

HTTP, HTTPS, Cost Vs Ease of Production, Prototypes and Production, Open Source Vs Closed Source.

## 2.1 INTERNET COMMUNICATIONS

### 2.1.1 An Overview

**Q1. Describe about Internet Principles and communication technology.**

*Ans :* **(Imp.)**

**(i)** The Internet is the global system of interconnected computer networks that uses the Internet protocol suite (TCP/IP) to communicate between networks and devices. It is a network of networks that consists of private, public, academic, business, and government networks of local to global scope, linked by a broad array of electronic, wireless, and optical networking technologies.

**(ii)** The Internet carries a vast range of information resources and services, such as the interlinked hypertext documents and applications of the World Wide Web (WWW), electronic mail, telephony, and file sharing.

**(iii)** The Internet is the network that connects computers all over the world. It works according to a set of agreed-upon protocols. TCP (Transmission Control Protocol) and IP(Internet Protocol) are the most commonly-used protocols for using the Internet. (But there are others at lower levels.) The combination is simply known as TCP/IP.

**(iv)** The Internet is a packet switching system. Any message is broken into packets that are transmitted independently across the interment (sometime by different routes).

**(v)** These packets are called datagram's. The route chosen for each datagram depends on the traffic at any point in time. Each datagram has a header of between 20 and 60 bytes, followed by the payload of up to 65,515 bytes of data. The header consists of, amongst other data:

**i)** TCP/IP

**ii)** UDP

**iii)** IP Addresses

**iv)** Domain Names

**v)** The Domain Name System (DNS)

**vi)** Ports

**vii)** Sockets

**viii)** URLs

**(i) TCP/IP**

TCP/IP(Transmission Control Protocol) and IP(Internet Protocol)

- The Internet is the network that connects computers all over the world. It works according to a set of agreed-upon protocols. TCP (Transmission Control Protocol) and IP(Internet Protocol) are the most commonly-used protocols for using the Internet. (But there are others at lower levels.) The combination is simply known as TCP/IP.
- IP is concerned with routing. IP attaches the address of the destination of each packet. IP ensures that packets get to the right place.
- TCP is the higher-level protocol that uses the lower-level IP.

**(ii) UDP (User Datagram Protocol)**

UDP is an unreliable protocol, since:

- It doesn't guarantee that a packet will arrive.
- It doesn't guarantee that packets will be in the right order.

UDP doesn't re-send a packet if it is missing or there is some other error, and it doesn't assemble packets into the correct order.

**(iii) IP Addresses**

An IP address is a unique address for every host computer in the world. Consists of 4 bytes or 32 bits. This is represented in quad notation (or dot notation) as four 8-bit numbers, each in the range 0 to 255, e.g. 131.123.2.220.

IP addresses are registered so that they stay unique.

**(iv) Domain Names**

A domain name is the user-friendly equivalent of an IP address. It is used because the numbers in an IP address are hard to remember and use. It is also known as a host name.

**Example:**

cs.stmarys.ca

**(v) The Domain Name System**

A program, say a Web browser, that wants to use a domain address usually needs to convert it into an IP address before making contact with the server. The domain name system (DNS) provides a mapping between IP addresses and domain names. All this information cannot be located in one place, so it is held in a distributed database.

**(vi) Port Numbers**

To identify a host machine, an IP address or a domain name is needed. To identify a particular server on a host, a port number is used. A port is like a logical connection to a machine. Port numbers can take values from 1 to 65,535. A port number does not correspond to any physical connection on the machine, of which there might be just one. Each type of service has, by convention, a standard port number.

**(vii) Sockets**

A socket is the software mechanism for one program to connect to another. A pair of programs open a socket connection between themselves. This then acts like a telephone connection - they can converse in both directions for as long as the connection is open. (In fact, data can flow in both directions at the same time.) More than one socket can use any particular port. The network software ensures that data is routed to or from the correct socket.

**(viii) URL**

A URL (Uniform Resource Locator):

- is a unique identifier for any resource on the Internet
- can be typed into a Web browser
- can be used as a hyperlink within a HTML document
- can be quoted as a reference to a source

## 2.2 IP, TCP, IP PROTOCOL SUITE

**Q2. Explain briefly about TCP, IP protocol suite.**

*Ans :* **(Imp.)**

Protocols are sets of rules for message formats and procedures that allow machines and application programs to exchange information. These rules must be followed by each machine involved in the communication in order for the receiving host to be able to understand the message. The TCP/IP suite of protocols can be understood in terms of layers (or levels).

This figure depicts the layers of the TCP/IP protocol. From the top they are, Application Layer, Transport Layer, Network Layer, Network Interface Layer, and Hardware.

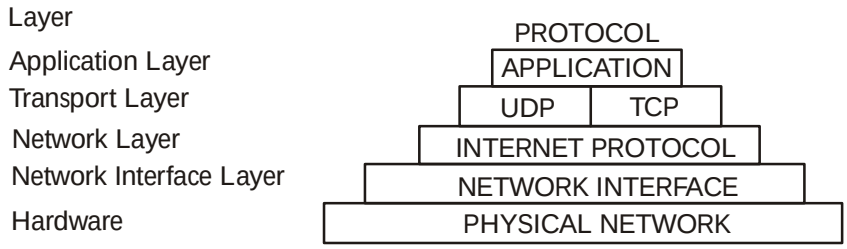



**Fig.: TCP/IP Suite of Protocols**

TCP/IP carefully defines how information moves from sender to receiver. First, application programs send messages or streams of data to one of the Internet Transport Layer Protocols, either the User Datagram Protocol (UDP) or the Transmission Control Protocol (TCP). These protocols receive the data from the application, divide it into smaller pieces called packets, add a destination address, and then pass the packets along to the next protocol layer, the Internet Network layer.

The Internet Network layer encloses the packet in an Internet Protocol (IP) datagram, puts in the datagram header and trailer, decides where to send the datagram (either directly to a destination or else to a gateway), and passes the datagram on to the Network Interface layer.

The Network Interface layer accepts IP datagrams and transmits them as frames over a specific network hardware, such as Ethernet or Token-Ring networks.

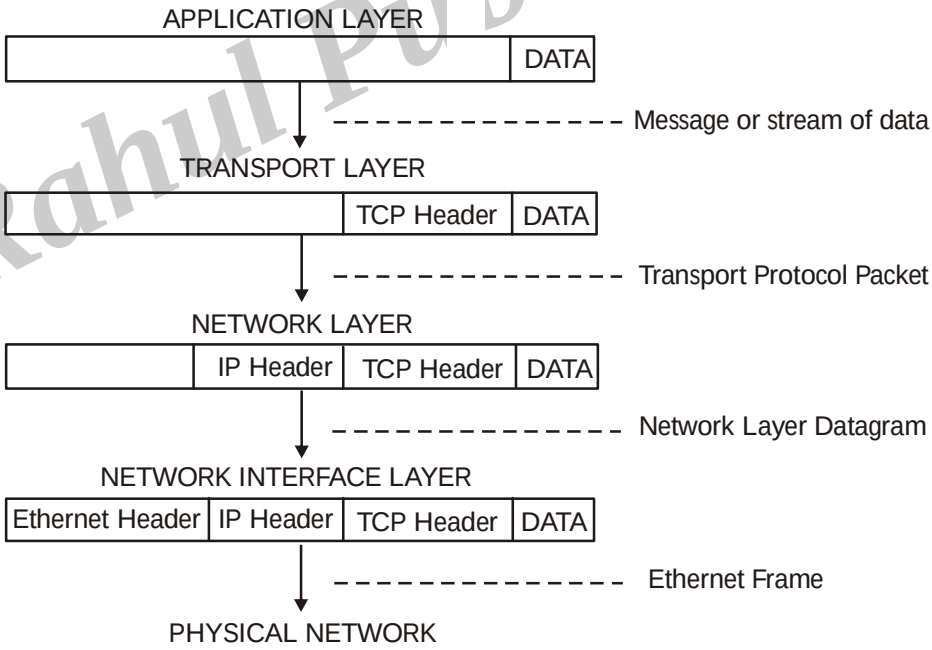



**Fig.: Movement of information from sender application to receiver host**

This figure shows the flow of information down the TCP/IP protocol layers from the Sender to the Host.

Frames received by a host go through the protocol layers in reverse. Each layer strips off the corresponding header information, until the data is back at the application layer.

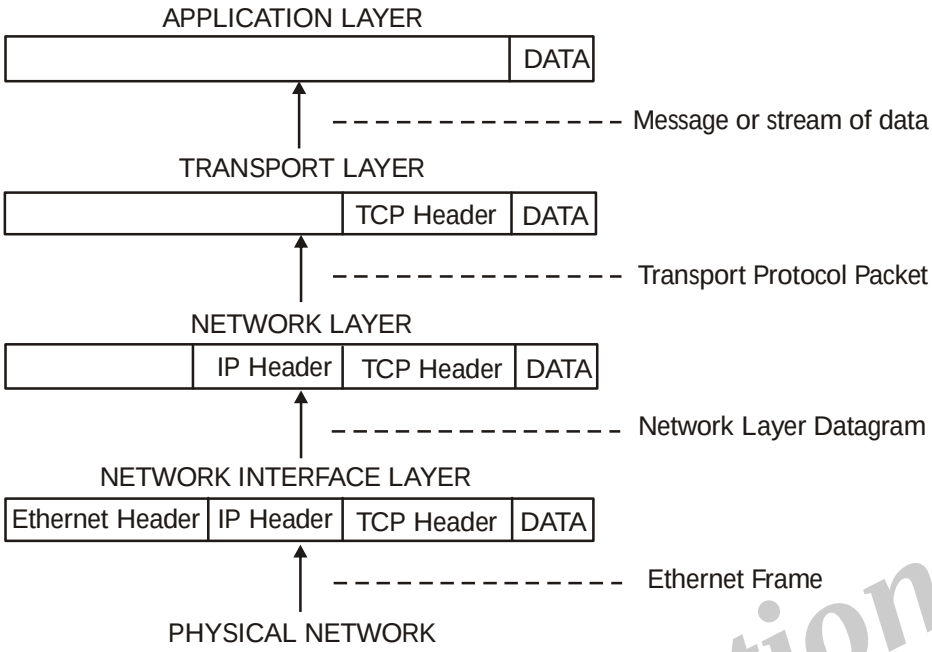



**Fig.: Movement of information from host to application**

This figure shows the flow of information up the TCP/IP protocol layers from the Host to the Sender.

Frames are received by the Network Interface layer (in this case, an Ethernet adapter).

Network Interface layer strips off the Ethernet header, and sends the datagram up to the Network layer. In the Network layer, the Internet Protocol strips off the IP header and sends the packet up to the Transport layer. In the Transport layer, the TCP (in this case) strips off the TCP header and sends the data up to the Application layer.

## 2.3 UDP, IP Addresses – DNS, Static and Dynamic IP Addresses

**Q3. Why does DNS use UDP?**

*Ans :*

- The Domain Name System, or shortly DNS, is the internet's address book, responsible for translating human-friendly domain names (like www.domain.net) into the numerical IP addresses (like 123.45.6.7) that computers use to communicate with each other.
- It acts as a distributed database, allowing quick and efficient DNS resolution of domain names to IP addresses (IPv4 and IPv6).
- Additionally, DNS is a part of the application layer.
- As you probably know, all application layer protocols require the use of a transport layer protocol like UDP (User Datagram Protocol) and TCP (Transmission Control Protocol). In the case of DNS, it prefers to utilize the not-so-reliable UDP protocol in most cases. Yet, occasionally it uses the more reliable TCP protocol.
- Both UDP and TCP are protocols used to send packets of data over the internet. They do that on top of the IP protocol, which means that they direct the packets to IP addresses.
- They are treated very similar on their way from the users' computers, through the routers and all the way to the end destination.

- DNS primarily uses UDP (User Datagram Protocol) for most of its operations.
- UDP is chosen for its speed, efficiency, and suitability for small, time-sensitive DNS queries and responses. UDP is used in the following cases:
- **Regular DNS queries:** When you enter a web address, UDP is used to send the query from your device to a DNS server.
- **DNS responses:** The DNS server sends the response, including the IP address, back to your device using UDP packets.
- **Caching:** DNS servers often cache previously resolved queries, allowing for faster responses using UDP without querying authoritative servers again.
- **Small data transfers:** DNS queries and responses are typically small, fitting well within UDP's maximum packet size of 65,535 bytes.
- **Stateless communication:** DNS operates on a stateless model, and UDP's stateless nature enables the efficient processing of multiple requests together.

**Q4. What are the differences between a Static IP and Dynamic address?**

*Ans :* **(Imp.)**



| S.NO | Static IP Address | Dynamic IP address |
|---|---|---|
| 1. | It is provided by ISP(Internet Service Provider). | While it is provided by DHCP (Dynamic Host Configuration Protocol). |
| 2. | Static ip address does not change any time, it means if a static ip address is provided then it can't be changed or modified. | While dynamic ip address change any time. |
| 3. | Static ip address is less secure. | While in dynamic ip address, there is low amount of risk than static ip address's risk. |
| 4. | Static ip address is difficult to designate. | While dynamic ip address is easy to designate. |
| 5. | The device designed by static ip address can be traced. | But the device designed by dynamic ip address can't be traced. |
| 6. | Static ip address is more stable than dynamic ip address. | While dynamic ip address is less stable than static ip address. |
| 7. | The cost to maintain the static ip address is higher than dynamic ip address. | While the maintaining cost of dynamic ip address is less than static ip address. |
| 8. | It is used where computational data is less confidential. | While it is used where data is more confidential and needs more security. |
| 9. | Simplifies the troubleshooting as the ip is always the same. | While dynamic ip increases the complexity of diagnosing the network issues. |

## 2.4 MAC Addressess

**Q5. What is MAC Address? Explain the format of MAC Address.**

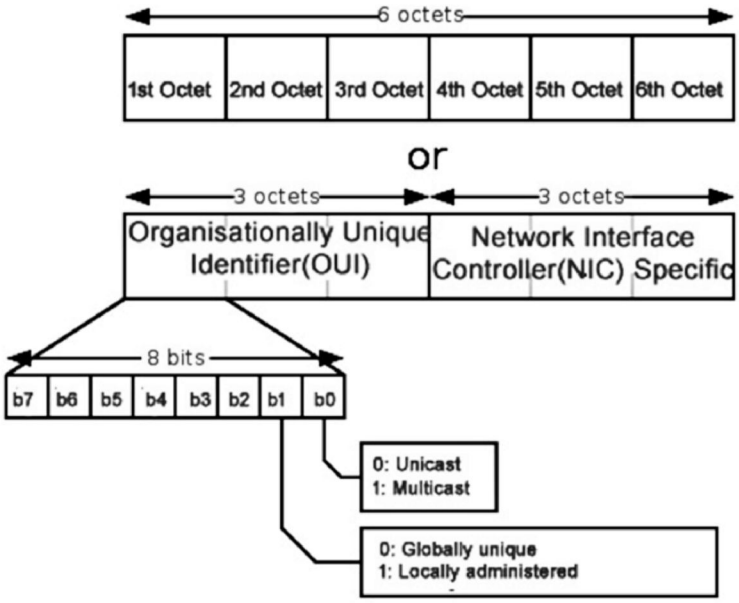
*Ans :*

To communicate or transfer data from one computer to another, we need an address. In computer networks, various types of addresses are introduced; each works at a different layer. A MAC address, which stands for Media Access Control Address, is a physical address that works at the Data Link Layer.

MAC Addresses are unique 48-bit hardware numbers of a computer that are embedded into a network card (known as a Network Interface Card) during manufacturing. The MAC Address is also known as the Physical Address of a network device. In the IEEE 802 standard, the data link layer is divided into two sublayers:

1. Logical Link Control (LLC) Sublayer
2. Media Access Control (MAC) Sublayer

The MAC address is used by the Media Access Control (MAC) sublayer of the Data-Link Layer. MAC Address is worldwide unique since millions of network devices exist and we need to uniquely identify each.




**Q6. Explain different types of MAC Address.**

*Ans :*

**1. Unicast**

A Unicast-addressed frame is only sent out to the interface leading to a specific NIC. If the LSB (least significant bit) of the first octet of an address is set to zero, the frame is meant to reach only one receiving NIC. The MAC Address of the source machine is always Unicast.

**2. Multicast**

The multicast address allows the source to send a frame to a group of devices. In Layer-2 (Ethernet) Multicast address, the LSB (least significant bit) of the first octet of an address is set to one. IEEE has allocated the address block 01-80-C2-xx-xx-xx (01-80-C2-00-00-00 to 01-80-C2-FF-FF-FF) for group addresses for use by standard protocols.

**3. Broadcast**

Similar to Network Layer, Broadcast is also possible on the underlying layer( Data Link Layer). Ethernet frames with ones in all bits of the destination address (FF-FF-FF-FF-FF-FF) are referred to as the broadcast addresses. Frames that are destined with MAC address FF-FF-FF-FF-FF-FF will reach every computer belonging to that LAN segment.

**Q7. State the advantages and disadvantages of MAC address.**

*Ans :* **(Imp.)**

**Advantages**

1. **Uniqueness:** Each MAC address is unique, which means that devices on the network can be easily identified and managed.
2. **Simplicity:** MAC addresses are easy to configure and manage, and do not require any additional network infrastructure.
3. **Compatibility:** MAC addresses are widely used and supported by a variety of networking technologies and protocols, making them compatible with many different systems.
4. **Security:** MAC addresses can be used to restrict access to a network by only allowing devices with authorized MAC addresses to connect.
5. **Fault-tolerance:** In case of hardware or software failure, a device can be easily replaced without affecting the network, as long as the new device has the same MAC address as the old one.
6. **Multicasting:** MAC addresses can be used for multicasting, allowing a single packet to be sent to multiple devices at once.
7. **Efficiency:** MAC addresses allow for efficient communication on the network, as they enable devices to quickly and easily identify and communicate with each other.
8. **Lower network overhead:** MAC addresses reduce network overhead by allowing devices to communicate directly with each other without the need for additional routing or addressing.
9. **Ease of troubleshooting:** MAC addresses can be used to troubleshoot network issues by identifying the source of problems and tracking network activity.
10. **Flexibility:** MAC addresses can be used to support a variety of network configurations and topologies, including peer-to-peer, client-server, and hybrid models.

**Disadvantages**

1. **Limited address space:** MAC addresses are 48-bit numbers, which means that there is a finite number of possible MAC addresses. This can lead to address conflicts if multiple devices have the same MAC address.
2. **Spoofing:** MAC addresses can be easily spoofed, allowing unauthorized devices to gain access to the network.
3. **Inefficiency:** MAC addresses are not hierarchical, which can make it difficult to efficiently manage large networks.
4. **Static addressing:** MAC addresses are typically assigned at the time of manufacture and cannot be easily changed. This can be a disadvantage in situations where devices need to be reconfigured or replaced.
5. **Limited scope:** MAC addresses are only used for identifying devices within a local network segment, and cannot be used to identify devices outside of this segment.
6. **Hardware-dependent:** MAC addresses are tied to the network interface card (NIC) of a device, which means that if the NIC fails or is replaced, the MAC address also changes.
7. **Lack of encryption:** MAC addresses are sent in plain text, which can make them vulnerable to interception and eavesdropping.
8. **No inherent security:** While MAC filtering can be used to restrict access to a network, MAC addresses themselves do not provide any inherent security features.
9. **MAC address collisions:** In rare cases, MAC addresses can collide, which can cause network disruptions and make it difficult to identify and manage devices on the network.

**Q8. Distinguish between MAC address and IP address.**

*Ans :*

| S.No. | MAC Address | IP Address |
|---|---|---|
| 1. | MAC Address stands for Media Access Control Address. | IP Address stands for Internet Protocol Address. |
| 2. | MAC Address is a six byte hexadecimal address. | IP Address is either a four-byte (IPv4) or a sixteen-byte (IPv6) address. |
| 3. | A device attached with MAC Address can retrieve by ARP protocol. | A device attached with IP Address can retrieve by RARP protocol. |
| 4. | NIC Card's Manufacturer provides the MAC Address. | Internet Service Provider provides IP Address |

## 2.5 TCP AND UDP PORTS

**Q9. Distinguish between TCP and UDP.**

*Ans :*

TCP and UDP ports are different, but they sometimes use the same port number. For example, UDP/53 and TCP/53 are both used for DNS, but they are different connection types. TCP ports comply with transmission control protocols, while UDP ports comply with user datagram protocols.

| PORT | Service | Description | Transport Protocol |
|---|---|---|---|
| 7 | Echo | Port just echoes whatever is sent to it. This feature can be used in many attacks, such as Smurf/Fraggle. | TCP and UDP |
| 20/21 | File Transfer Protocol (FTP) | Port used by FTP protocol to send data to the client | TCP |
| 22 | Secure Shell (SSH) | Used as secure replacement protocol for Telnet | TCP and UDP |
| 23 | Telnet | Port used by Telnet to remotely connect to a workstation or server (unsecured) | TCP |
| 25 | Simple Mail Transfer Protocol (SMTP) | Used to send E-Mail over internet | TCP |
| 53 | Domain Name System (DNS) | Port for DNS requests, network routing, and zone transfers | TCP and UDP |
| 67/68 | Dynamic Host Configuration Protocol (DHCP) | Used on networks that do not use static IP address assignment. | UDP |
| 80 | Hypertext Transfer Protocol (HTTP) | Used for browsing web-pages on a browser | TCP |
| 110 | Post Office Protocol (POP3) | Port used to retrieve complete contents of a server mailbox | TCP |
| 143 | Internet Message Access Protocol (IMAP4) | Internet Message Access Protocol (IMAP4) is a new protocol to read an email with a wider range of operations | TCP and UDP |
| 194 | Internet Relay Chat Protocol(IRC) | allows communication in form of text between multiple parties, one or more clients can connect to a centralized server. | TCP and UDP |
| 443 | HTTP with Secure Sockets Layer (SSL) | Port used for secure web traffic | TCP and UDP |
| 3389 | Remote Desktop Protocol(RDP) | Port used by remote desktop to remotely manage other windows system | TCP and UDP |

## 2.6 Application Layer Protocols

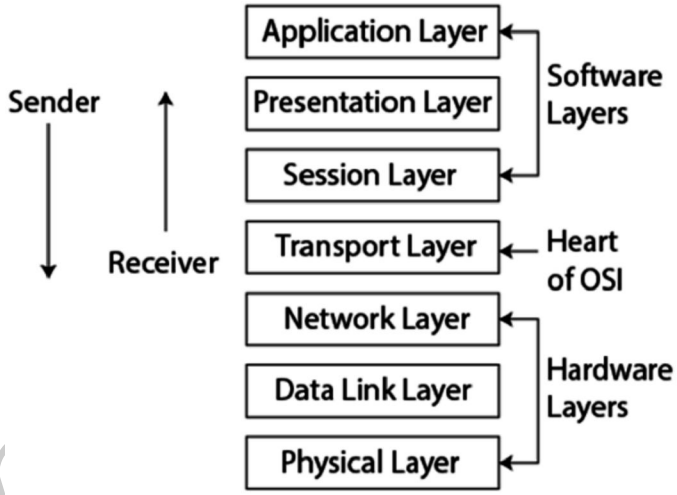
**Q10. Write about Application Layer Protocols and their functionality.**

*Ans :* **(Imp.)**

**List of Application Layer Protocols in Computer Networks**

The Application layer protocols in computer networks are a set of standards and rules that govern the communication between end-user appl

ications over a network. These protocols provide a specific services and functionality to support different types of application-level communication, including file transfers, email, remote terminal connections, and web browsing. Examples of Application layer protocols in computer networks include HTTP, FTP, SMTP, DNS, Telnet, SSH, NFS, SNMP, DHCP, and RIP. The use of these standardized protocols enables interoperability between applications running on different platforms and ensures that the applications can communicate effectively over a network.




The main function of the Application layer is to provide an interface between the end-user applications and the underlying communication infrastructure. It allows applications to send and receive messages, access resources, and perform other operations without having to know the details of the underlying communication technologies.

Here is the list of commonly used application layer protocols in computer networks

**1. HTTP**

HTTP is an application-level protocol that is widely used for transmitting data over the internet. It is used by the World Wide Web, and it is the foundation of data communication for the web.

HTTP defines a set of rules and standards for transmitting data over the internet. It allows clients, such as web browsers, to send requests to servers, such as web servers, and receive responses..

HTTP is used by a wide range of applications and services, including websites, APIs, and streaming services. It is a reliable and efficient way to transmit data, and it has proven to be a flexible and scalable solution for the growing demands of the internet.

**2. FTP**

FTP, or File Transfer Protocol, is a standard network protocol used for the transfer of files from one host to another over a TCP-based network, such as the Internet. FTP is widely used for transferring large files or groups of files, as well as for downloading software, music, and other digital content from the Internet.

FTP is generally considered an insecure protocol, as it transmits login credentials and files contents in clear text, which makes it vulnerable to eavesdropping and tampering.

**3. SMTP**

SMTP (Simple Mail Transfer Protocol) is a standard protocol for transmitting electronic mail (email) messages from one server to another. It's used by email clients (such as Microsoft Outlook, Gmail, Apple Mail, etc.) to send emails and by mail servers to receive and store them

**4. DNS**

DNS stands for "Domain Name System," and it is an essential component of the internet that translates domain names into IP addresses. A domain name is a human-readable string of characters, such as "google.com," that can be easily remembered, while an IP address is a set of numbers and dots that computers use to communicate with each other over the internet.

**5. Telnet**

Telnet is a protocol that was widely used in the past for accessing remote computer systems over the internet. It allows a user to log in to a remote system and access its command line interface as if they were sitting at the remote system's keyboard. Telnet was one of the first widely used remote access protocols, and it was particularly popular in the days of mainframe computers and timesharing systems

**6. SSH**

SSH (Secure Shell) is a secure network protocol used to remotely log into and execute commands on a computer. It's commonly used to remotely access servers for management and maintenance purposes, but it can also be used for secure file transfers and tunneling network connections.

**7. NFS**

NFS stands for "Network File System," and it is a protocol that allows a computer to share files and directories over a network. NFS was developed by Sun Microsystems in the 1980s and is now maintained by the Internet Assigned Numbers Authority (IANA).

**8. SNMP**

SNMP (Simple Network Management Protocol) is a standard protocol used for managing and monitoring network devices, such as routers, switches, servers, and printers. It provides a common framework for network management and enables network administrators to monitor and manage network devices from a central location

**9. DHCP**

DHCP stands for "Dynamic Host Configuration Protocol," and it is a network protocol used to dynamically assign IP addresses to devices on a network. DHCP is used to automate the process of assigning IP addresses to devices, eliminating the need for a network administrator to manually assign IP addresses to each device.

**10. RIP**

RIP (Routing Information Protocol) is a distance-vector routing protocol that is used to distribute routing information within a network. It's one of the earliest routing protocols developed for use in IP (Internet Protocol) networks, and it's still widely used in small to medium-sized networks.

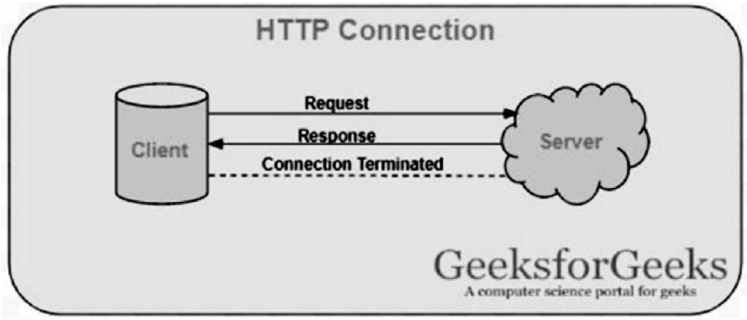
## 2.7 HTTP, HTTPS

**Q11. Define HTTP, state the characteristics of HTTP.**

*Ans :*

HTTP stands for HyperText Transfer Protocol. It is invented by Tim Berner. HyperText is the type of text which is specially coded with the help of some standard coding language called HyperText Markup Language (HTML). HTTP provides a standard between a web browser and a web server to establish communication. It is a

set of rules for transferring data from one computer to another. Data such as text, images, and other multimedia files are shared on the World Wide Web. Whenever a web user opens their web browser, the user indirectly uses HTTP. It is an application protocol that is used for distributed, collaborative, hypermedia information systems.




**Characteristics**

**1.** HTTP is IP based communication protocol that is used to deliver data from server to client or vice-versa.

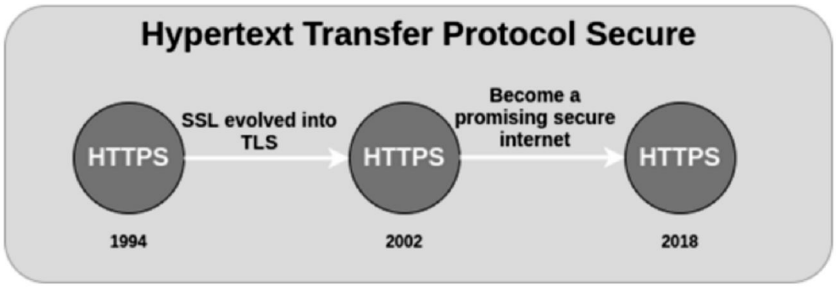
**2.** Any type of content can be exchanged as long as the server and client are compatible with it.

**3.** It is a request and response protocol based on client and server requirements.

**Q12. Define HTTPS. State the characteristics of HTTPS.**

*Ans :* **(Imp.)**

HTTPS stands for Hyper Text Transfer Protocol Secure. HTTP Secure (HTTPS), could be a combination of the Hypertext Transfer Protocol with the SSL/TLS convention to supply encrypted communication and secure distinguishing proof of an arranged web server. HTTPS is more secure than HTTP because HTTPS is certified by the SSL(Secure Socket Layer). Whatever website you are visiting on the internet, if its URL is HTTP, then that website is not secure.




**Characteristics**

**1.** HTTPS encrypts all message substance, including the HTTP headers and the request/response data. The verification perspective of HTTPS requires a trusted third party to sign server-side digital certificates.

**2.** HTTPS is presently utilized more frequently by web clients than the first non-secure HTTP, fundamentally to ensure page genuineness on all sorts of websites, secure accounts and to keep client communications.

**3.** In short, both of these are protocols using which the information of a particular website is exchanged between the Web Server and Web Browser. But there are some differences between these two. A concise difference between HTTP and HTTPS is that HTTPS is much more secure compared to HTTP.

**Q13. Write the difference between HTTP vs HTTPS.**

*Ans :*

| S.No. | HTTP | HTTPS |
|---|---|---|
| 1. | HTTP stands for HyperText Transfer Protocol. In HTTP, the URL begins with "http://". | HTTPS stands for HyperText Transfer Protocol Secure. In HTTPS, the URL starts with "https://". |
| 2. | HTTP uses port number 80 for communication. | HTTPS uses port number 443 for communication. |
| 3. | Hyper-text exchanged using HTTP goes as plain text i.e. anyone between the browser and server can read it relatively easily if one intercepts this exchange of data and due to which it is Insecure. | HTTPS is considered to be secure but at the cost of processing time because Web Server and Web Browser need to exchange encryption keys using Certificates before actual data can be transferred. |
| 4. | HTTP Works at the Application Layer. | HTTPS works at Transport Layer |
| 5. | HTTP does not use encryption, which results in low security in comparison to HTTPS. | HTTPS uses Encryption which results in better security than HTTP. |
| 6. | HTTP speed is faster than HTTPS. | HTTPS speed is slower than HTTP. |
| 7. | HTTP does not use data hashtags to secure data. | HTTPS will have the data before sending it and returning it to its original state on the receiver side. |
| 8. | HTTP is used to transfer text, video, and images via web pages. | HTTPS is used to transfer data securely via a network. |

## 2.8 Cost Vs Ease of Production, Prototypes and Production

**Q14. Explain briefly about prototype and production.**

*Ans :*

**1.** With the internet of things, we are always looking at building three things in para

- The physical things
- The electronics to make the thing smart, and
- The internet service that we'll conncet to

**2.** The prototype is optimized for ease and speed of development and also the ability to change and modify it.

**3.** Many internet of things projects start with a prototyping microcontroller, connected by wires to components on a prototyping board, such as 'breadboard', and housed in some kind of container. At the end of this stage, you'll have an object that works.

**4.** It's a demonstrable product that you can use to convince yourself, your business partners, and your investors.

**5.** Finally, the process of manufacture will iron out issues of scalling up and polish.

**Q15. Explain briefly about cost vs ease of open source software.**

*Ans :*

**1.** It is also worth considering the relationship between the costs (of prototyping and mass producing) of a platform against the development effort that the platform demands.

**2.** It is beneficial if you can choose a prototyping platform in a performance/ capabilities bracket similar to a final production solution.

3. For the first prototype, the cost is probably not the most important issue
4. if your device has physical interactions , you will find that a PC is not optimized for this kind of work.
5. For many beginners to hardware development, the Arduino toolkit is a surprisingly good choice.
6. An important factor to be aware of is that the hardware and programming choices you make will depend on your skill set

**AVR(AT8051), Arduino, Raspberry Pi Microcontroller, General Purpose Computers**

1. the smartphone or computer options are particularly convenient if you already have one available, at which point they are effectively zero-cost.
   - if your device has physical interactions , you will find that a PC is not optimized for this kind of work.
2. An electronics prototyping board, unsurprisingly, is better suited to this kind of work.
   - For many beginners to hardware development, the Arduino toolkit is a surprisingly good choice.
   - The input/output choices are basic and require an ability to follow wiring diagrams and, ideally, a basic knowledge of electronics.
   - Yet the interaction from a programming point of view is essentially simple— writing and reading values to and from the GPIO pins.
   - And the language is C++.
   - The IDE pushes the compiled code onto the device where it just runs, automatically, until you unplug it.

## 2.9 Open Source Vs Closed Source

**Q16. Define open source software. State the advantages of open source software.**

*Ans :* **(Imp.)**

**Meaning**

Open source software refers to the computer software which source is open means the general public can access and use. In short it is referred as OSS. The source code of open source software is public. It uses the code freely available on the Internet. This code can be modified by other users and organizations means that the source code is available for anyone to look at. The price of open source software is very less and there is no so much restrictions on users based on usability and modification of software. Some examples of open source software are Firefox, OpenOffice, Gimp, Alfresco, Android, Zimbra, Thunderbird, MySQL, Mailman, Moodle, TeX.

**Advantages**

- **Cost:** Open source software is generally free, which means organizations can use it without any licensing fees.
- **Customization:** Since the source code is available, developers can modify and customize the software to meet specific requirements.
- **Community Support:** Open source software has a large community of users who contribute to documentation, bug fixes, and improvements.
- **Security:** With open source software, security vulnerabilities can be detected and fixed quickly by the community.
- **Transparency:** Since the source code is open, users can see how the software works and what data it collects.

**Q17. Define closed source software. State the advantages of closed source software.**

*Ans :*

Closed source software refers to the computer software which source code is closes means public is not given access to the source code. In short it is referred as CSS. In closed source software the source code is protected. The only individual or organization who has created the software can only change it. The price of closed source software is high and users need to have valid and authenticated license to use the software. As is issues an authenticated license so it also put a lot restrictions on users based on usability and modification of software. Some examples of closed source software are Skype, Google earth, Java, Adobe Flash, Virtual Box, Adobe Reader, Microsoft office, Microsoft Windows.

**Advantages**

- **Technical Support:** Closed source software usually comes with professional technical support, which can be helpful for organizations that need assistance with setup, configuration, or troubleshooting.
- **Features:** Closed source software typically has more features than open source software, including advanced analytics, reporting, and data visualization tools.
- **Security:** Closed source software often has built-in security features and can provide better protection against cyber threats.
- **Integration:** Closed source software is often designed to work seamlessly with other enterprise software, making integration with existing systems easier.

**Q18. Distinguish between open source software and closed source software.**

*Ans :* **(Imp.)**

| S.No. | Open Source Software | Closed Source Software |
|---|---|---|
| 1. | Open source software refers to the computer software which source is open means the general public can access and use. | Closed source software refers to the computer software which source Closed source software refers to the computer software which source code is closes means public is not given access to the source code. |
| 2. | Open Source Software in short also referred as OSS. | Closed Source Software in short also referred as CSS. |
| 3. | The source code of open source software is public. | In closed source software the source code is protected. |
| 4. | This code can be modified by other users and organizations means that the source code is available for anyone to look at. | The only individual or organization who has created the software can only modify the code. |
| 5. | The price of open source software is very less. | The price of closed source software is high. |
| 6. | There is no so much restrictions on users based on usability and modification of software. | There is so much restrictions on users based on usability and modification of software. |
| 7. | Programmers compete with each other for recognition. | Programmers do not compete with each other for recognition. |
| 8. | Programmers freely provide improvement for recognition if their improvement is accepted. | Programmers are hired by the software firm/organization to improve the software. |
| 9. | If the program is popular then very large number of programmers may work on the project. | There is a limitation on the number of programmers/team who will work on the project. |
| 10. | It is purchased with its source code. | It is not purchased with its source code. |
| 11. | Open software can be installed into any computer. | Closed software needs have a valid license before installation into any computer. |
| 12. | Open source software fails fast and fix faster. | Closed source software has no room for failure. |
| 13. | In open source software no one is responsible for the software. | In closed source software the vendor is responsible if anything happened to software. |
| 14. | Examples are Firefox, OpenOffice, Gimp, Alfresco, Android, Zimbra, Thunderbird, MySQL, Mailman, Moodle, TeX, Samba, Perl, PHP, KDE etc. | Examples are Skype, Google earth, Java, Adobe Flash, Virtual Box, Adobe Reader, Microsoft office, Microsoft Windows, WinRAR, mac OS, Adobe Flash Player etc. |

UNIT III

**PROTOTYPING AND PROGRAMMING FOR IOT :**

Prototyping Embedded Devices Sensors, Actuators, Microcontrollers, SoC, Choosing a platform, Prototyping, Hardware platforms Arduino, Raspberry Pi. Prototyping the physical design Laser Cutting, 3D printing, CNC Milling. Techniques for writing embedded C code: Integer data types in C, Manipulating bits - AND, OR, XOR, NOT, Reading and writing from I/ O ports. Simple Embedded C programs for LED Blinking, Control of motor using switch and temperature sensor for arduino board.

## 3.1 Prototyping Embedded Devices Sensors

**Q1. Define Prototyping Embedded Devices ? What are the components of Prototyping Embedded Devices.**

*Ans :* **(Imp.)**

**Meaning**

Prototyping Embedded Devices in IoT development refers to the process of creating physical prototypes or models of devices that are capable of interacting with the physical world through sensors, actuators, and other hardware components. These prototypes serve as a tangible representation of the final IoT product, allowing developers to test concepts, validate designs, and assess the functionality of the device before full-scale production. It involves integrating microcontrollers, sensors, actuators, power sources, and other necessary components to create a functional IoT device prototype

**Components**

**i) Microcontrollers**

These are the central processing units (CPUs) of the embedded system, responsible for running the device's software, managing inputs from sensors, and controlling outputs to actuators.

**ii) Sensors**

Devices that detect and measure physical phenomena such as temperature, humidity, motion, light, and more. They provide input data to the microcontroller.

**iii) Actuators**

Components that convert electrical signals from the microcontroller into physical actions. Examples include motors, LEDs, relays, and solenoids.

**iv) Power Supply**

Provides electrical power to the entire system. This can be from batteries, USB, or external power sources.

**v) Peripherals**

Additional components such as resistors, capacitors, transistors, and connectors that are essential for interfacing sensors, actuators, and other devices with the microcontroller.

**vi) Communication Modules**

Optional components for IoT devices that enable communication with other devices or the internet. Examples include Wi-Fi modules, Bluetooth modules, LoRa modules, etc.

**Q2. What are the stages involved in Prototyping Embedded Devices for IoT?**

*Ans :*

The stages involved in Prototyping Embedded Devices for IoT typically include:

**i) Conceptualization**

Defining the purpose, goals, and initial specifications of the IoT device.

**ii) Design**

Creating schematics, layouts, and 3D models of the hardware components and physical enclosure.

**iii) Component Selection**

Choosing appropriate microcontrollers, sensors, actuators, and other components based on requirements.

**iv) Assembly**

Physically assembling the components into a working prototype.

**v) Programming**

Writing firmware or software to control the device, process sensor data, and interact with actuators.

**vi) Testing**

Conducting functional tests, usability tests, and performance tests to evaluate the prototype's behavior.

**vii) Feedback and Iteration**

Gathering feedback from stakeholders and users, and making iterative improvements to the prototype.

**viii) Refinement**

Fine-tuning the design, functionality, and user experience based on feedback and testing results.

**Q3. What are different types of Prototypes and explain the benefits of prototypes?**

*Ans :* **(Imp.)**

**Types**

**1. Functional Prototype**

A working model that demonstrates the core functionalities and interactions of the IoT device.

**2. Visual Prototype**

Focuses on the physical appearance and user interface of the device, often created using 3D modeling and rendering.

**3. Proof-of-Concept (PoC)**

A basic prototype to demonstrate the feasibility of the IoT solution, often usec d to secure funding or partnerships.

**4. Wireframe Prototype**

A simple, low-fidelity representation of the user interface and navigation flow.

**5. Paper Prototype**: Sketches or drawings of the device's interface and functionality, useful for early-stage ideation and feedback.

**Benefits**

**1. Early Validation**

Helps validate concepts and ideas before investin.

**2. Proximity Sensors:** Detect nearby objects without physical contact, used in touchless switches and obstacle detection.

**iii) Gas Sensors**

Detect various gases in the environment, important for safety and air quality monitoring.

**iv) Pressure Sensors**

Measure pressure changes, used in weather forecasting and altimeters.

**v) Accelerometers**

Measure acceleration forces, used in activity trackers, orientation sensing, and vibration monitoring.

**vi) IR (Infrared) Sensors**

Detect infrared radiation, used in proximity sensing and object detection.

**vii) Ultrasonic Sensors**

Measure distance using sound waves, used in robotics and distance measurement applications.

## 3.2 SENSORS

**Q4. Define Sensors. What are the different types of Sensors Used in IoT Prototyping?**

*Ans :* **(Imp.)**

**Meaning**

Sensors are devices that detect and measure physical phenomena from the environment. In IoT prototyping, sensors play a crucial role in gathering real-world data, such as temperature, humidity, motion, light, proximity, and more. They convert these physical inputs into electrical signals that can be processed by microcontrollers or SoCs.

**Types**

**i) Temperature Sensors**

Measure ambient temperature, used in climate control systems, weather stations, etc.

**ii) Humidity Sensors**

Measure moisture levels in the air, important for environmental monitoring.

**iii) Motion Sensors**

Detect movement or changes in position, used in security systems and automation.

**iv) Light Sensors**

Measure light intensity, used in automatic lighting systems and brightness control.

v) **Proximity Sensors:** Detect nearby objects without physical contact, used in touchless switches and obstacle detection.

vi) **Gas Sensors**

Detect various gases in the environment, important for safety and air quality monitoring.

vii) **Pressure Sensors**

Measure pressure changes, used in weather forecasting and altimeters.

viii) **Accelerometers**

Measure acceleration forces, used in activity trackers, orientation sensing, and vibration monitoring.

ix) **IR (Infrared) Sensors**

Detect infrared radiation, used in proximity sensing and object detection.

x) **Ultrasonic Sensors**

Measure distance using sound waves, used in robotics and distance measurement applications.

**Q5. What are the Benefits of Using Sensors in IoT Prototyping?**

*Ans :*

Following are the Benefits of Using Sensors in IoT Prototyping:

1. **Data Collection**

Sensors provide real-time data about the environment, crucial for IoT applications.

2. **Automation**

Sensor data can trigger automatic actions, improving efficiency and convenience.

3. **Smart Decision Making**

Microcontrollers process sensor data to make intelligent decisions, enhancing device functionality.

4. **Efficiency**

Sensors help optimize resource usage, leading to energy savings.

5. **Remote Monitoring**

IoT devices with sensors can be monitored remotely, providing convenience and accessibility.

6. **Alerts and Notifications**

Sensors can detect anomalies and send alerts, improving safety and security.

7. **User Interaction**

Sensors enable user interaction with IoT devices, enhancing user experience.

## 3.3 ACTUATORS

**Q6. What are actuators? Explain briefly.**

**OR**

**What are actuators? Explain different types of actuators.**

*Ans :* **(Imp.)**

**Meaning**

Actuators are devices that convert electrical signals into physical action or movement. In IoT prototyping, actuators play a vital role in enabling devices to interact with and manipulate the physical environment. They are responsible for turning on/off lights, moving motors, controlling valves, and more.

**Types**

**1. Hydraulic Actuators**

A hydraulic actuator uses hydraulic power to perform a mechanical operation. They are actuated by a cylinder or fluid motor. The mechanical motion is converted to rotary, linear, or oscillatory motion, according to the need of the IoT device. Ex- construction equipment uses hydraulic actuators because hydraulic actuators can generate a large amount of force.

**Advantages**

i) Hydraulic actuators can produce a large magnitude of force and high speed.

ii) Used in welding, clamping, etc.

iii) Used for lowering or raising the vehicles in car transport carriers.

**Disadvantages**

i) Hydraulic fluid leaks can cause efficiency loss and issues of cleaning.

ii) It is expensive.

iii) It requires noise reduction equipment, heat exchangers, and high maintenance systems.

**2. Pneumatic Actuators**

A pneumatic actuator uses energy formed by vacuum or compressed air at high pressure to convert into either linear or rotary motion. Example- Used in robotics, use sensors that work like human fingers by using compressed air.

**Advantages**

i) They are a low-cost option and are used at extreme temperatures where using air is a safer option than chemicals.

ii) They need low maintenance, are durable, and have a long operational life.

iii) It is very quick in starting and stopping the motion.

**Disadvantages**

i) Loss of pressure can make it less efficient.

ii) The air compressor should be running continuously.

iii) Air can be polluted, and it needs maintenance.

**3. Electrical Actuators**

An electric actuator uses electrical energy, is usually actuated by a motor that converts electrical energy into mechanical torque. An example of an electric actuator is a solenoid based electric bell.

**Advantages**

i) It has many applications in various industries as it can automate industrial valves.

ii) It produces less noise and is safe to use since there are no fluid leakages.

iii) It can be re-programmed and it provides the highest control precision positioning.

**Disadvantages**

i) It is expensive.

ii) It depends a lot on environmental conditions.

**Other actuators are:**

**1. Thermal/Magnetic Actuators**

These are actuated by thermal or mechanical energy. Shape Memory Alloys (SMAs) or Magnetic Shape Memory Alloys (MSMAs) are used by these actuators. An example of a thermal/magnetic actuator can be a piezo motor using SMA.

**2. Mechanical Actuators**

A mechanical actuator executes movement by converting rotary motion into linear motion. It involves pulleys, chains, gears, rails, and other devices to operate



## 3.4 MICROCONTROLLERS

**Q7. What are Microcontrollers ? Explain different Types of Microcontrollers.**

*Ans :* **(Imp.)**

Microcontrollers are small, self-contained computing units that contain a processor, memory, input/output ports, and other necessary components on a single chip. They are the "brain" of embedded systems and IoT devices, handling tasks such as data processing, controlling actuators, and interfacing with sensors.

**Types**

**1. Arduino**

Popular for its simplicity and extensive community support.

**2. Raspberry Pi**

More powerful with additional computing capabilities.

**3. ESP8266/ESP32**

Known for built-in Wi-Fi capabilities, suitable for IoT applications.

**4. PIC Microcontrollers**

Widely used in industrial and consumer electronics.

**5. STM32**

Feature-rich microcontrollers with various peripherals for IoT projects.

**6. Atmel AVR**

Commonly used in hobbyist projects and low-power applications.

**7. ARM Cortex-M Series**

Offers high performance and energy efficiency for IoT devices.

**Q8. Explain the uses of Microcontrollers.**

*Ans :* **(Imp.)**

Microcontrollers are used in a wide range of electronic devices and systems, including:

**1. Home Appliances**

Many home appliances, such as washing machines, refrigerators, and air conditioners, use microcontrollers to perform various functions, such as temperature control, timing, and monitoring.

**2. Automotive Systems**

Microcontrollers are used in automotive systems, such as engine control units, anti-lock braking systems, and airbag systems, to control various functions and ensure safe and efficient operation.

**3. Medical Devices**

Medical devices, such as insulin pumps, heart monitors, and blood glucose meters, use microcontrollers to perform various functions and provide accurate and reliable results.

**4. Industrial Control Systems**

Microcontrollers are used in industrial control systems, such as robotics, process control systems, and manufacturing equipment, to control and monitor various processes and operations.

**5. Consumer Electronics**

Many consumer electronics devices, such as digital cameras, gaming systems, and audio players, use microcontrollers to perform various functions and provide advanced features and capabilities.

**6. IoT Devices**

Internet of Things (IoT) devices, such as smart home systems, wearables, and environmental sensors, use microcontrollers to connect to the internet and perform various functions.

**7. Aerospace and Defense Systems**

Microcontrollers are used in aerospace and defense systems, such as satellites, avionics, and missiles, to control and monitor various functions and ensure safe and efficient operation.

**Q9. Explain the issues in microcontrollers.**

*Ans :*

Some of the most common issues that can arise with microcontrollers:

**1. Timing Issues**

Microcontrollers rely on precise timing to execute instructions and perform tasks. Any issues with timing can cause errors and malfunctions, which can be difficult to diagnose and fix.

**2. Power Issues**

Microcontrollers require a stable and consistent power supply to operate correctly. Any fluctuations or disruptions in the power supply can cause the microcontroller to malfunction or fail.

**3. Heat Issues**

Microcontrollers generate heat during operation, and excessive heat can damage the device or cause it to malfunction. Heat issues can be caused by poor design, inadequate cooling, or high ambient temperatures.

**4. Noise Issues**

Microcontrollers can be affected by electromagnetic interference (EMI) and radio frequency interference (RFI) from other electronic devices, which can cause errors and malfunctions.

**5. Code Issues**

The programming code used to control the microcontroller can contain errors and bugs, which can cause the device to malfunction or fail.

**6. Security Issues**

Microcontrollers can be vulnerable to security breaches, including unauthorized access, data theft, and malware attacks.

**7 Compatibility Issues**

Microcontrollers may not be compatible with other electronic components or devices, which can cause errors and malfunctions.

## 3.5 SYSTEM-ON-CHIP (SOC)

**Q10. Define SoC. Explain different types of socs.**

*Ans :*

**Meaning**

SoCs offer compact, integrated solutions for IoT prototypes, combining processing power, memory, connectivity, and peripherals into a single chip. This integration simplifies the design process, reduces component count, improves power efficiency, and provides scalability for future production .

**Types**

**i) SP32**

Features Wi-Fi and Bluetooth connectivity, suitable for IoT projects.

**ii) Raspberry Pi Compute Module**

Compact version of Raspberry Pi for embedded applications.

**iii) Nordic Semiconductor nRF52 Series**

Low-power SoCs with Bluetooth capabilities.

**iv) Qualcomm Snapdragon**

Offers high performance and connectivity for IoT devices.

**v) TI CC3200**

Dual-core SoC with Wi-Fi for IoT applications.

**vi) NXP i.MX Series**

Arm-based SoCs with multimedia and connectivity features.

**vii) Intel Quark**

Low-power SoCs designed for IoT and wearable applications.

**Q11. Explain the advantages and disadvantages of soc.**

*Ans :* **(Imp.)**

**Advantages**

**1. Cost-effectiveness**

By integrating multiple components onto a single chip, manufacturing costs are reduced, making SoC an economical solution. This is especially beneficial for large-scale production, where cost savings can be significant. Furthermore, the streamlined manufacturing process reduces the chances of component compatibility issues, resulting in higher yield rates and further cost reduction.

**2. Versatility**

With the integration of various components, SoC can be customized to meet specific application requirements. This flexibility allows for the development of specialized devices tailored to specific industries or tasks. For example, SoC can be optimized for automotive applications, medical devices, or Internet of Things (IoT) devices, among others. This adaptability makes SoC a highly sought-after solution for a wide range of industries.

**3. Simplifies the Design and Development Process**

With all the necessary components integrated into a single chip, engineers can focus on optimizing performance and functionality rather than dealing with complex inter connectivity issues. This streamlined approach accelerates the time-to-market for new products, giving companies a competitive edge in a fast-paced industry.

**Disadvantages**

**1. Potential for Increased Complexity**

As more components are integrated onto a single chip, the design and development process becomes more intricate. This complexity can result in longer development cycles and higher development costs. Additionally, debugging and testing can be more challenging due to the integrated nature of the system.

**2. Lack of Modularity**

In traditional systems, individual components can be upgraded or replaced independently. However, with SoC, upgrading or replacing a specific component often requires replacing the entire chip. This lack of modularity can be a limitation in certain scenarios, especially when technological advancements demand the integration of newer, more advanced components.

**3. Can Present Security Challenges**

Since all components are integrated, a vulnerability in one component can potentially compromise the entire system. This poses risks in industries where data security is of utmost importance, such as banking or healthcare. Robust security measures and thorough testing are paramount to mitigate these risks, but they add an additional layer of complexity to the development process.

## 3.6 ARDUINO, RASPBERRY Pi

**Q12. Explain briefly about Arduino.**

*Ans :* **(Imp.)**

**Meaning**

Arduino is an open-source electronics platform that encompasses both hardware and software components. It is designed to be accessible and user-friendly, making it an excellent choice for beginners in electronics and programming, as well as for advanced users looking to prototype and develop innovative projects. Here's a brief overview:

**Arduino Hardware**

**1. Microcontroller Boards**

Arduino offers a range of microcontroller boards with varying specifications to suit different project needs. Popular boards include Arduino Uno, Nano, Mega, and more.

**2. Input/Output Pins**

These boards feature digital and analog input/output pins that allow users to connect sensors, actuators, and other electronic components easily.

**3. Power Supply**

Arduino boards can be powered via USB, batteries, or external power sources, providing flexibility for different applications.

**Arduino Software**

**1. Arduino IDE**

The Arduino Integrated Development Environment (IDE) is a software tool used to write, compile, and upload code to Arduino boards. It provides a simple and user-friendly interface for programming.

**2. Programming Language**

Arduino uses a simplified version of C/C++ programming language, making it easier for beginners to learn and use.

**3. Library Support**

Arduino has a vast collection of libraries that contain pre-written code for various functions. This library support simplifies interfacing with sensors, actuators, displays, and communication modules.

**4. Community**

Arduino has a large and active community of developers, makers, and enthusiasts. This community provides tutorials, forums, and project ideas, fostering collaboration and knowledge-sharing.

**Q13. What is Raspberry Pi? Explain the Features of Rasapherry Pi.**

*Ans :* **(Imp.)**

**Meaning**

Raspberry Pi is a series of low-cost, credit card-sized single-board computers developed for educational and hobbyist purposes. It runs Linux-based operating systems and offers more computing power and connectivity options compared to microcontrollers like Arduino. Raspberry Pi is suitable for IoT projects requiring multimedia, networking, or web capabilities

**Features**

**1. Affordability**

Raspberry Pi boards are priced competitively, making them accessible to a wide range of users, including students and hobbyists.

**2. Compact Size**

The boards are small, typically the size of a credit card, yet pack considerable computing power, making them suitable for portable and embedded applications.

**3. Versatility**

Raspberry Pi can be used for a myriad of projects, including home automation, robotics, IoT (Internet of Things), media centers, retro gaming consoles, and much more.

**4. I/O Ports**

Raspberry Pi boards come with a variety of input/output (I/O) ports, including USB, HDMI, Ethernet, GPIO (General Purpose Input/Output), camera interface, and display interface. These ports enable connectivity to various peripherals and components.

**5. Operating Systems**

Raspberry Pi supports several operating systems, including Raspberry Pi OS (formerly Raspbian), Ubuntu, Windows 10 IoT Core, and others. Users can choose an OS based on their project requirements.

**6. Community Support**

Raspberry Pi has a vibrant and active community of users and developers. This community provides extensive resources, tutorials, forums, and projects, making it easier for users to get started and troubleshoot issues.

**7. Expandability**

One of the key features of Raspberry Pi is its expandability. The boards come with GPIO pins that allow users to connect a wide range of sensors, actuators, displays, and other peripherals. This expandability enables users to create custom and intricate projects.

**8. Processing Power**

While not as powerful as high-end desktop computers, Raspberry Pi boards feature sufficient processing power for most hobbyist and educational projects. The latest models have quad-core processors with clock speeds up to 1.5G Hz.

**Q14. What are Sensors, Actuators, Microcontrollers, and SoC in the context of electronics and IoT?**

*Ans :*

**i) Sensors**

Sensors are devices that detect and respond to inputs from the physical environment. They convert physical quantities (such as light, temperature, pressure, or motion) into electrical signals that can be processed by a microcontroller. Examples include temperature sensors, motion sensors, light sensors, and more.

**ii) Actuators**

Actuators are devices that convert electrical signals from a microcontroller into physical actions in the environment. They can be motors, solenoids, relays, LEDs, or any device that produces movement, light, or sound in response to a control signal.

**iii) Microcontrollers**

Microcontrollers are small computers on a single integrated circuit. They are the "brains" of an electronic system, responsible for processing inputs from sensors, making decisions based on programmed logic, and controlling actuators. Microcontrollers are essential components in IoT devices, providing computational capabilities in a compact form.

**iv) System-on-Chip (SoC)**

A System-on-Chip integrates various components of a computer or electronic system onto a single chip. In the context of IoT, SoCs often combine a microcontroller, memory, connectivity modules (such as Wi-Fi or Bluetooth), and other necessary components into a compact package. SoCs are efficient and cost-effective solutions for IoT devices.

## 3.7 Prototyping the Physical Design Laser Cutting, 3D Printing, CNC Milling

**Q15. What is Prototyping the Physical Design in Electronics and IoT Projects?**

*Ans :*

Prototyping the physical design in electronics and IoT projects involves creating a tangible representation of the product or system being developed. This phase focuses on the physical components, enclosures, and overall layout of the project. Various techniques and considerations are employed to prototype the physical design effectively.

Techniques for Prototyping the Physical Design

**1. Laser Cutting**

**i)** Laser cutting is a precise and efficient method for cutting materials such as acrylic, wood, or metal.

**ii)** It allows for creating intricate shapes and designs for project enclosures and structural components.

**iii)** Laser-cut materials can be assembled to form custom enclosures, frames, and mounting brackets.

**2. 3D Printing**

**i)** 3D printing is a popular technique for creating three-dimensional objects layer by layer from digital models.

**ii)** It offers flexibility in design and customization, allowing for the creation of complex shapes.

**iii)** 3D printed parts can be used for prototyping enclosures, housings, brackets, and mechanical components.

**3. CNC Milling**

**i)** CNC (Computer Numerical Control) milling uses computer-controlled machines to remove material from a workpiece.

**ii)** It is suitable for creating precise and detailed parts from various materials such as plastics, metals, and composites.

**iii)** CNC milling is used for prototyping structural components, mounting plates, and custom parts.

**4. Handcrafting and Assembly**:

**i)** Traditional hand tools and techniques can also be used for prototyping.

**ii)** Components can be manually cut, shaped, and assembled using tools like saws, drills, and fasteners.

**iii)** This approach is suitable for quick prototypes or when access to specialized equipment is limited.



## 3.8 TECHNIQUES FOR WRITING EMBEDDED C CODE: INTEGER DATA TYPES IN C, MANIPULATING BITS - AND, OR, XOR, NOT, READING AND WRITING FROM I/O PORTS

**Q16. What are Integer Data Types in C?**

*Ans :* **(Imp.)**

**i)** Integer data types in C are used to store whole numbers without fractional parts And They define the range and precision of values that can be stored .

**ii)** In C programming, integer data types are essential for storing whole numbers. These types have different sizes and ranges to accommodate various data requirements.

Here are the common integer data types:

**1.** **int**: The **int** data type is commonly used for storing integers within a certain range. It varies in size depending on the compiler, typically 2 or 4 bytes.

**Example:** int myInt = 10;

2. **short**: The **short** data type is smaller than **int**, usually 2 bytes. It is useful for saving memory when a smaller range of values is sufficient.

   **Example:** short myShort = 100;

3. **long**: The **long** data type is larger than **int**, typically 4 bytes or more. It allows for storing larger integers.

   **Example:** long myLong = 1000000;

4. **char**: The **char** data type is specifically used for storing characters in C, but it can also store small integers due to its size of 1 byte.

   **Example:** char myChar = 'A';

**Q17. What are Bitwise Operators in C and how are they used?**

*Ans :*

Bitwise operators are used to work with bits at the binary level, which is crucial for tasks such as device control, signal processing, and data manipulation. Here's how each operator works:

1. **& (AND Operator)**:
   - **i)** Performs a bitwise AND operation between two operands.
   - **ii)** The result is 1 only if both corresponding bits are 1.
   - **iii) Example:** result = operand1 & oper-and2;
2. **| (OR Operator)**:
   - **i)** Performs a bitwise OR operation between two operands.
   - **ii)** The result is 1 if at least one of the corresponding bits is 1.
   - **iii) Example:** result = operand 1 | operand2;
3. **^ (XOR Operator)**:
   - **i)** Performs a bitwise XOR (exclusive OR) operation between two operands.
   - **ii)** The result is 1 if the corresponding bits are different (one is 1 and the other is 0).
   - **iii) Example:** result = operand1 ^ operand2;
4. **~ (NOT Operator)**:
   - **i)** Performs a bitwise NOT (complement) operation on a single operand.
   - **ii)** Inverts each bit: 0 becomes 1, and 1 becomes 0.
   - **iii) Example:** result = ~operand;

## 3.9 Reading and Writing From I/ O Ports Control of Motor using Switch and Temperature Sensor for Arduino Board

**Q18. Explain briefly about Reading and writing from I/ O ports.**

*Ans :* **(Imp.)**

Reading and writing from I/O (Input/Output) ports is fundamental in embedded systems like Arduino. It involves communicating with external devices such as sensors, switches, LEDs, and motors.

**1. Reading from I/O Ports**

**i)** Reading from an I/O port involves retrieving data from an external device connected to a specific pin.

**ii)** For example, reading from a temperature sensor port provides the current temperature value.

**iii)** This data can be used for decision-making, display, or further processing within the microcontroller.

**2. Writing to I/O Ports**

**i)** Writing to an I/O port means sending commands or signals from the microcontroller to external devices.

**ii)** For instance, sending a HIGH signal to an LED port turns the LED on, while LOW turns it off.

**iii)** This process controls the behavior of connected devices, such as motors, LEDs, or relays.

## 3.10 SIMPLE EMBEDDED C PROGRAMS FOR LED BLINKING

**Q19. Explain the concept and implementation of LED blinking in embedded systems using C programming.**

*Ans :* **(Imp.)**

LED blinking is one of the most basic and fundamental tasks in embedded systems programming, often used for testing and as a starting point for more complex projects. Below is an overview of the concept and implementation:

**Concept**

LED blinking involves turning an LED (Light Emitting Diode) on and off at regular intervals to create a blinking effect. This task is achieved by controlling the state of a digital pin connected to the LED. When the pin is set to a high voltage (typically 5V), the LED turns on, and when set to a low voltage (0V or ground), the LED turns off.

**Implementation**

To implement LED blinking in embedded systems using C programming, we typically follow these steps:

**1. Include Necessary Libraries**

Depending on the microcontroller used, include the appropriate header files for I/O operations.

**2. Define Pin Configuration**

Define the pin to which the LED is connected. This pin will be configured as an output pin.

**3. Setup Function**

In the **setup()** function (or initialization routine), configure the defined pin as an output using the **pinMode()** function.

**4. Loop Function**

In the **loop()** function (main program logic), continuously toggle the state of the pin using the **digitalWrite()** function to turn the LED on and off at desired intervals.

**5. Delay Function**

Introduce a delay between switching the LED on and off to control the blinking rate. This delay is typically implemented using the delay() function, which pauses program execution for a specified duration.

## 3.11 Control of Motor Using Switch and Temperature Sensor for Arduino Board

**Q20. Explain the control of a motor using a switch and temperature sensor in an Arduino board.**

*Ans :* **(Imp.)**

Controlling a motor based on the state of a switch and readings from a temperature sensor is a common application in embedded systems. This scenario involves turning a motor on or off depending on whether a switch is pressed and also adjusting the motor speed based on temperature readings from a sensor. Below is an overview of how this can be implemented:

**Concept**

**i)** The switch will act as an input to determine the motor's state: on (pressed) or off (released).

**ii)** The temperature sensor will provide analog readings that can be used to adjust the motor speed based on the sensed temperature.

**iii)** When the switch is pressed, the motor turns on. When released, the motor turns off.

**iv)** The temperature reading can be used to control the motor's speed. For example, higher temperatures might indicate a need for increased cooling, which can be achieved by increasing the motor speed.

**Implementation**

**1. Include Necessary Libraries**

Include the required libraries for sensor and motor control. For example, the Servo library for motor control and necessary libraries for the temperature sensor.

**2. Define Pin Configuration**

Define the pins for the switch, motor, and temperature sensor.

**3. Setup Function**

In the setup() function:

**i)** Configure the switch pin as an input.

**ii)** Initialize the motor control, if using a motor shield or driver.

**iii)** Initialize the temperature sensor.

**4. Loop Function**

In the loop() function (main program logic):

**i)** Read the state of the switch using digital Read (SWITCH_PIN).

**ii)** If the switch is pressed (HIGH state), turn the motor on using motor control functions.

**iii)** If the switch is released (LOW state), turn the motor off.

**iv)** Read the temperature from the sensor using analog Read(TEMP_SENSOR_PIN).

**v)** Adjust the motor speed based on the temperature reading. For example, map the temperature range to motor speed values.

UNIT IV

**CLOUD COMPUTING AND DATA ANALYTICS :**

Introduction to Cloud storage models - SAAS, PAAS, IAAS. Communication APIs, Amazon webservices for IoT, Skynet IoT Messaging Platform. Introduction to Data Analytics for IoT - Apache hadoop - Map reduce job execution workflow.

## 4.1 Introduction to Cloud Storage Models

**Q1. What is Cloud Storage? Explain the features of Cloud Storage Systems.**

*Ans :* **(Imp.)**

**Meaning**

Cloud storage is a virtual locker where we can remotely stash any data. When we upload a file to a cloud-based server like Google Drive, OneDrive, or iCloud that file gets copied over the Internet into a data server that is cloud-based actual physical space where companies store files on multiple hard drives.

Most companies have hundreds of these servers known as 'server farms' spanning across multiple locations. So, if our data gets somehow lost we will not lose our data because it will be backed up by another location. This is known as redundancy which keeps our data safe from being lost.

There are two major providers in the field of cloud storage namely:

**(i) Amazon S3:** It enables file storage to multiple servers and offers file encryption wherein we can share the data publicly.

**(ii) Google Cloud:** It offers unlimited storage space. It also has the ability to resume the file transfer after a failure

**Features**

**1. Cost Saving**

Cloud data storage is affordable and also helps to back up data without resorting to additional data centers, and data can be automatically replicated from public to private clouds.

Costs associated with its hardware and maintenance, disaster recovery, etc. have also been reduced.

**2. Data Security**

With cloud computing, the business of confidential and sensitive information is more secure. The data is protected during transmission and the transmission is stable.

Cloud data is backed up to multiple servers, and if any one server crashes, the data is safe on the other servers.

**3. Scalability**

In online cloud storage services, there is no need to predict how much storage space will be required, the available resources can be adjusted, and cloud storage service providers and businesses only need to pay for their current needs.

Cloud storage also has the ability to add more capacity, improve performance, and new nodes to be added to the cloud and achieve goals.

**4. Accessibility**

With more and more devices in use today, cloud storage services can be accessed through tablets, smartphones, netbooks, and desktops. Users can access accounts from any Internet connection, such as a mobile browser, or a desktop system in the workplace.

**5. Synchronization**

This ensures that saved data and files are automatically updated on all devices. Therefore, the latest version of the file saved on the desktop can be used on the smartphone.

**6. Disaster recovery**

Cloud storage is also good for disaster recovery. Cloud storage always has a business-ready contingency backup plan as it provides a second copy of important files.

These files are saved and stored in remote locations and are accessible from anywhere and anytime via an internet connection.

**Q2. Explain difficult types of Storage Systems in the Cloud.**

*Ans :*

There are 3 types of storage systems in the Cloud as follows.

(i) Block-Based Storage System

(ii) File-Based Storage System

(iii) Object-Based Storage System

Let's discuss it one by one as follows.

**1. Block-Based Storage System**

**(i)** Hard drives are block-based storage systems. Your operating system like Windows or Linux actually sees a hard disk drive. So, it sees a drive on which you can create a volume, and then you can partition that volume and format them.

**(ii)** For example, If a system has 1000 GB of volume, then we can partition it into 800 GB and 200 GB for local C and local D drives respectively.

**(iii)** Remember with a block-based storage system, your computer would see a drive, and then you can create volumes and partitions.

**2. File-Based Storage System**

**(i)** In this, you are actually connecting through a Network Interface Card (NIC). You are going over a network, and then you can access the network-attached storage server (NAS). NAS devices are file-based storage systems.

**(ii)** This storage server is another computing device that has another disk in it. It is already created a file system so that it's already formatted its partitions, and it will share its file systems over the network. Here, you can actually map the drive to its network location.

**(iii)** In this, like the previous one, there is no need to partition and format the volume by the user. It's already done in file-based storage systems.

So, the operating system sees a file system that is mapped to a local drive letter.

**3. Object-Based Storage System**

**(i)** In this, a user uploads objects using a web browser and uploads an object to a container i.e., Object Storage Container.

This uses the HTTP Protocols with the rest of the APIs (for example: GET, PUT, POST, SELECT, DELETE).

**(ii)** For example, when you connect to any website, you need to download some images, text, or anything that the website contains.

For that, it is a code HTTP GET request. If you want to review any product then you can use PUT and POST requests.

**(iii)** Also, there is no hierarchy of objects in the container. Every file is on the same level in an Object-Based storage system.

**Q3. Explain different types of Cloud Storage.**

*Ans :*

There are four types of Cloud-Storage as detailed below:

**(i) Personal Cloud Storage**

It is a subset of public cloud-storage that stores individual's data in the cloud and provides the individual with access to the data from anywhere.

It also provides data syncing and data sharing across multiple devices. An example of personal cloud-storage is Apple iCloud.

**(ii) Public Cloud Storage**

It is where the enterprise and storage service provider are separate and there aren't any cloud resources stored in the enterprise's data center. The cloud-storage provider fully manages enterprise's public cloud storage.

**(iii) Private Cloud Storage**

The enterprise and cloud-storage provider are integrated in the enterprise's data center. Private cloud storage helps in resolving the potential for security and performance concerns while still offering the advantages of cloud-storage.

**(iv) Hybrid Cloud Storage**

It is a combination of public and private cloud-storage where critical data are stored in enterprise's private cloud while other data is stored in public cloud**.**

**Q4. Explain the Advantages and Disadvantages of Cloud Storage.**

*Ans :* **(Imp.)**

**Advantages**

The advantages of Cloud Storage include:

**(i) File Accessibility:** The files can be accessed at any time from any place so long as you have Internet access.

**(ii) Offsite Backup:** Cloud Storage provides organizations with offsite (remote) backups of data which in turn reduces costs.

**(iii) Effective Use of Bandwidth:** Cloud storage uses the bandwidth effectively i.e. instead of sending files to recipients, a web link can be sent through email.

**(iv) Security of Data:** Helps in protecting the data against ransomware or malware as it is secured and needs proper authentication to access the stored data.

**Disadvantages**

The disadvantages of Cloud Storage include:

**(i) Dependency on Internet Speed:** If the Internet connection is slow or unstable, we might have problems accessing or sharing the files.

**(ii) Dependency on a Third Party:** A third party service provider (company) is responsible for the data stored and hence it becomes an important pre-requisite in selecting a vendor and to examine the security standards prior investing.

**(iii) High Cost for Huge Data:** Organizations that require a large amount of storage may also find costs increase significantly even after the first few gigabytes of data stored.

**(iv) No/ Minimal Control over Data Storage Framework:** Since the cloud storage framework is entirely managed and monitored by the service provider, the customer has minimal control over it.

**Q5. Explain briefly about Cloud Storage Providers.**

*Ans :*

Consumers and businesses continue to reduce their need to rely on local storage by placing files and applications in the cloud. One has to choose a provider who will offer the maximum amount of low-cost storage and bandwidth, while still keeping your data safe.

**Free Cloud Storage**

Below is the list of some top rated Cloud Storage providers:

**Google Drive**

Google is one of the giants in cloud-storage. It offers:

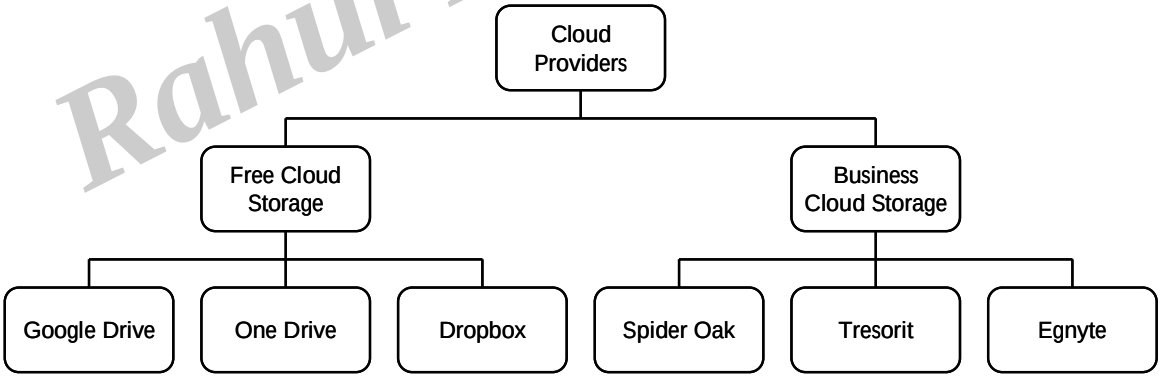
**(i)** **Free Data Storage up to 15GB:** Google Drive is one of the most generous cloud offerings. Google storage space is also shared with other Google services including Gmail and Google Photos. Mobile apps are also available for easy access for iOS and Android users.


**(ii)** **Backup and Sync Desktop App:** It lets you to synchronize files from PC to the cloud.

**(iii)** **G Suit Tools:** Includes online office tools for word processing, spreadsheets and presentations which make sharing files with others effortless.

**One Drive**

One Drive is particularly for Microsoft Windows users. It allows 5GB of free data storage. It has a great integration with Microsoft products. The files can be edited without downloading. File sharing in One Drive is possible with other users even if they aren't One Drive users.


**Dropbox**

It has a great storage support for third-party apps with web interface that remains streamlined and easy-to-use.


Dropbox has 2GB of storage space for new users. However there are other ways for boosting this space without paying, such as inviting friends (500MB for referral), completing getting started guide (250MB), etc.

There are desktop apps for Windows, Linux and Mac, and mobile apps including Android, iOS and even Kindle.

**Business Cloud Storage**

The examples of Business Cloud-Storage are as follows:

**Spider Oak**

Founded in 2007, Spider Oak is a collaboration tool, file hosting and online backup service. It allows users to access, synchronize and share data using a cloud-based server.

The main focus in Spider Oak is on privacy and security. The tool has a very basic design which makes the admin console and all central device management very straightforward to use. It also includes drag and drop feature for organizing files.

**Tresorit**

Founded in 2011, Tresorit is a cloud storage provider based in Hungary and Switzerland. It emphasizes on enhanced security and data encryption for businesses and personal users.

It allows you to keep control of your files through 'zero-knowledge encryption' which means only you and the chosen few you decide to share with and see your data

**Egnyte**

Founded in 2007, Egnyte provides software for enterprise file synchronization and sharing. It allows businesses to store their data locally and online.

It integrates with applications such as Office 365. This allows both remote and internal employees to access the files with ease.

## 4.2 SAAS, PAAS, IAAS

**Q6. What is IaaS ? State the advantages and disadvantages of IaaS.**

*Ans :*

**Meaning**

Infrastructure As A Service (IAAS) is means of delivering computing infrastructure as on-demand services. It is one of the three fundamental cloud service models. The user purchases servers, software data center space, or

network equipment and rent those resources through a fully outsourced, on-demand service model. It allows dynamic scaling and the resources are distributed as a service. It generally includes multiple-user on a single piece of hardware.

It totally depends upon the customer to choose its resources wisely and as per need. Also, it provides billing management too.

**Advantages**

**(i)** The resources can be deployed by the provider to a customer's environment at any given time.

**(ii)** Its ability to offer the users to scale the business based on their requirements.

**(iii)** The provider has various options when deploying resources including virtual machines, applications, storage, and networks.

**(iv)** It has the potential to handle an immense number of users.

**(v)** It is easy to expand and saves a lot of money. Companies can afford the huge costs associated with the implementation of advanced technologies.

**Disadvantages**

**(I)** **Complexity:** IaaS demands a considerable understanding of cloud computing to manage the infrastructure efficiently.

**(ii)** **Cost Predictability:** The pay-as-you-go model may lead to unpredictable costs.

**(iii)** **Vendor Lock-In:** Migrating to another provider can be challenging due to the varying standards and compatibility issues between providers.

**Q7. Define PaaS. Explain the advantages and disadvantages of PaaS.**

*Ans :*

**Meaning**

PaaS provides a platform including both hardware and software tools over the internet. This model abstracts developers from the underlying infrastructure complexities, enabling them to focus on developing their applications.

**(i) Use Case**

PaaS is ideal for developers aiming to concentrate on their coding without the need to manage the underlying infrastructure.

**(ii) Providers**

Google App Engine, AWS Elastic Beanstalk, and Microsoft Azure App Services are among the leading PaaS providers.

**Pros**

**(i) Easy Deployment**

PaaS handles everything from runtime, middleware, to operating systems, enabling developers to focus solely on their applications.

**(ii) Scalability**

PaaS platforms offer seamless scalability, adapting to your application's growing needs.

**Cons**

**(i) Limited Flexibility:** The convenience of PaaS could limit customization as developers are bound by the platform's capabilities.

**(ii) Vendor Lock-In:** Differences in services and standards across platforms could complicate migration, potentially leading to vendor lock-in.

**Q8. Define SaaS. Explain the advantages and disadvantages of SaaS.**

*Ans :*

**Meaning**

Software as a service, or SaaS, provides the entire application stack, delivering an entire cloud-based application that customers can access and use. SaaS products are completely managed by the service provider and come ready to use, including all updates, bug fixes, and overall maintenance. Most SaaS applications are accessed directly through a web browser, which means customers don't have to download or install anything on their devices.

**Advantages of SaaS**

(i) It is a cloud computing service category providing a wide range of hosted capabilities and services. These can be used to build and deploy web-based software applications.

(ii) It provides a lower cost of ownership than on-premises software. The reason is it does not require the purchase or installation of hardware or licenses.

(iii) It can be easily accessed through a browser along a thin client.

(iv) No cost is required for initial setup.

(v) Low maintenance costs.

(vi) Installation time is less, so time is managed properly.

**Disadvantages of SaaS**

(i) Low performance.

(ii) It has limited customization options.

(iii) It has security and data concerns.

**Q9. Compare and Contrast between IAAS, PAAS and SAAS.**

*Ans :* **(Imp.)**

| S.No. | Basis of | IAAS | PAAS | SAAS |
|---|---|---|---|---|
| 1. | **Stands for** | Infrastructure as a service. | Platform as a service. | Software as a service. |
| 2. | **Uses** | IAAS is used by network architects. | PAAS is used by developers. | SAAS is used by the end user. |
| 3. | **Access** | IAAS gives access to the resources like virtual mac-2 hines and virtual storage. tools for application. | PAAS gives access to run time environment to deployment and development | SAAS gives access to the end user. |
| 4. | **Model** | It is a service model that provides virtualized computing resources over the internet. | It is a cloud computing model that delivers tools that are used for the development of applications. | It is a service model in cloud computing that hosts software to make it available to clients. |

| | | | | |
|---|---|---|---|---|
| 5. | **Technical understanding.** | It requires technical knowledge. | Some knowledge is required for the basic setup. everything. | There is no requirement about technicalities company handles |
| 6. | **Popularity** | It is popular among developers and researchers. | It is popular among developers who focus on the development of apps and scripts. | It is popular among consumers and companies, such as file sharing, email, and networking. |
| 7. | **Percentage rise** | It has around a 12% incre-x cloud | It has around 32% increment. | It has about a 27 % rise in the cloud computing model. |
| 8. | **Usage** | Used by the skilled developer to develop unique applications. | Used by mid-level developers to build applications. | Used among the users of entertainment. |
| 9. | **Cloud services.** | Amazon Web Services, sun, vCloud Express. | Facebook, and Google search engine. | MS Office web, Facebook and Google Apps. |
| 10. | **Enterprise services.** | AWS virtual private cloud. | Microsoft Azure. | IBM cloud analysis. |
| 11. | **Outsourced cloud services** | Salesforce | Force.com, Gigaspaces. | AWS, Terremark |
| 12. | **User Controls** | Operating System, Runtime, Middleware, and Application data | Data of the application | Nothing |
| 13. | **Others** flexible. | It is highly scalable and the different businesses according to resources. | It is highly scalable to suit small, mid and enterprise level business | It is highly scalable to suit the |

## 4.3 COMMUNICATION APIS

**Q10. What is API? Explain the types and uses of APIs.**

*Ans :*

**Meaning**

Application Programming Interface, is a set of rules, protocols, and tools that allows different software applications to communicate with each other. It defines the methods and data formats that applications can use to request and exchange information, enabling seamless interaction between diverse systems, services, and platforms.

**Types of APIs:**

**(i) Web APIs (RESTful APIs)**

Web APIs, also known as RESTful APIs, are designed to be accessed over the internet using standard protocols like HTTP. They typically follow the principles of Representational State Transfer (REST) and provide access to web-based services, resources, and data.

**(ii) Library APIs**

Library APIs expose the functionality of software libraries or frameworks, allowing developers to use pre-built functions, classes, and modules in their applications.

**(iii) Operating System APIs**

Operating system APIs provide access to the underlying features and resources of an operating system, such as file systems, network interfaces, and hardware devices.

**(iv) Database APIs**

Database APIs facilitate interaction with databases, allowing applications to perform CRUD (Create, Read, Update, Delete) operations, execute queries, and manage data.

**Uses**

**(i) Integration:** APIs enable integration between different software systems, allowing them to exchange data and functionality seamlessly. For example, an e-commerce platform may use payment gateway APIs to process transactions.

**(ii) Automation:** APIs enable automation of repetitive tasks by allowing software applications to programmatically interact with external services and systems. For example, a social media management tool may use APIs to schedule posts across multiple social media platforms.

**(iii) Extensibility:** APIs allow developers to extend the functionality of their applications by integrating with third-party services, libraries, or platforms. For example, a mobile app may use mapping APIs to provide location-based services to users.

**(iv) Customization:** APIs enable customization of software applications by exposing configurable parameters and hooks for developers to modify behaviour or integrate additional features. For example, a content management system may provide APIs for developers to extend its functionality with custom plugins.

**Q11. Explain the Advantages and Disadvantages of APIs.**

*Ans :*

**Advantages**

**(i) Efficiency:** API produces efficient, quicker, and more reliable results than the outputs produced by human beings in an organization.

**(ii) Flexible delivery of services:** API provides fast and flexible delivery of services according to developers' requirements.

**(iii) Integration:** The best feature of API is that it allows the movement of data between various sites and thus enhances the integrated user experience.

**(iv) Automation:** As API makes use of robotic computers rather than humans, it produces better and more automated results.

**(v) New functionality**: While using API the developers find new tools and functionality for API exchanges.

**Disadvantages**

**(i) Cost:** Developing and implementing API is costly at times and requires high maintenance and support from developers.

**(ii) Security issues:** Using API adds another layer of surface which is then prone to attacks, and hence the security risk problem is common in APIs.

## 4.4 AMAZON WEBSERVICES FOR IOT, SKYNET IOT MESSAGING PLATFORM

**Q12. Explain the concept of AWS.**

*Ans :* **(Imp.)**

Amazon Web Services (AWS) offers a comprehensive set of services specifically designed to support Internet of Things (IoT) applications. These services provide scalable, secure, and reliable solutions for connecting, managing, and analyzing data from IoT devices.here are 3 key categories of IoT products on AWS namely:

1. **Devices Software:** It includes services such as the Free RTOS and AWS IoT Greengrass, etc.
2. **Connectivity & Control Services:** It includes services like AWS IoT Core, AWS IoT Device Defender & AWS IoT Device Management, etc.
3. **Analytics Services:** It includes services such as AWS IoT Events, AWS IoT Analytics, AWS IoT SiteWise& AWS IoT ThingsGraph, etc.

Now let's get an overview of each category and the IoT products associated with them.

**(i) Device Software**

Device Software is used to connect your devices and operate them at the edge.

- **FreeRTOS:** It is an open-source real-time operating system for embedded systems that can be used in IoT. It is suitable for programming low-power systems, their deployment, security, and connection.

  It is open and freely available under MIT open source license. It comes with a kernel and set of suitable libraries which we would need for different sectors.

  Using Amazon FreeRTOS we can connect the low power devices with the cloud's powerful services. Free RTOS can be easily reused and has high reliability.

  It comes with the features like micro-controllers support, FreeRTOS console, secure connection of devices, connectivity with cloud, etc

- **AWS IoT Greengrass:** AWS IoT Greengrass is an open-source runtime for IoT edge devices and cloud services. It is widely used by people in homes, factories, vehicles, and businesses.

  We can easily build intelligent device software on IoT Greengrass. It comes with features like local processing, messaging, data management, and other Machine learning interfaces.

  It also allows us to remotely manage the devices. It also makes the device smarter over time by keeping it up-to-date

**(ii) Connectivity & Control Services**

These services are used to secure, control, and manage your devices from the cloud.

- **AWS IoT Core:** AWS IOT core enables the IoT devices to securely and easily communicate with the cloud. It can support up to billion devices easily.

  It can also process trillions of messages at once and send them to suitable endpoints. It mainly helps devices that use protocols like MQTT over WSS to publish their messages.

- **AWS IoT Device Defender:** AWS IOT device defender is mainly used to secure a group of IoT devices. It is responsible for the safety of IoT devices.

  It enforces the safety measures such as identity, authentication, authorization of devices, and encryption of the device's data.

- **AWS IoT Device Management:** AWS IoT Device Management mainly helps in monitoring and tracking IoT devices. It is very much useful for the management of IoT devices.

  Using this we can remotely monitor the health of each device, problems with the devices, and necessary steps to be taken. The important benefit is that we can overlook the status of the fleet of devices all at once.

**(iii) Analytics Services**

The Analytics Services are used to work with IoT data faster to extract value from your data.

- **AWS IoT Events:** As the name indicates AWS IOT Events helps the user to watch over the devices by the events or notifications it sends. Its events are sent when an error occurs or when any actions need to be triggered.

  Using this we can build complex monitoring services for our IoT products. The major benefits of AWS IOT events include getting inputs from multiple sources,

Usage of simple logical expressions to recognize complex cases of events, Triggering actions based on the events, Automatically scaling the system to meet the IoT fleet's demands.

- **AWS IoT Analytics:** AWS IOT Analytics mainly analyzes and scales the IoT data. It easily supports up to petabytes of IoT data.

  So it is highly efficient. It eliminates the need to manage complex IoT infrastructure and helps in building fast and responsive IoT applications.

  It can be used to operate huge volumes of IoT data without needing to worry about the infrastructure needed for its processing.

  Since IoT data is highly unstructured and susceptible to false readings it is necessary to preprocess and analyze it properly for accurate and better results it can be done by AWS IOT analytics.

- **AWS IoT SiteWise:** AWS IoT Sitewise allows us to collect, model, and analyze the data from the industrial IOT devices which are at scale.

  We can also gain insights into industrial operations by configuring the suitable metrics using AWS IOT Sitewise. We can also effectively process the data on the local devices with IoT Sitewise Edge.

  Some benefits of it include, it collects the data from all the sources consistently, even identifies remote issues with quick monitoring, improving the cross-facility process with a central data source, process and monitoring the data on-premises for better shop floor applications.

- **AWS IoT ThingsGraph:** AWS IoT Things Graph is used to connect web services and other different devices visually for building IoT applications.

  It provides a drag and drop interface which makes it easy for us to build IoT applications easily by connecting devices and web services quickly.

  Some of the benefits of the IoT things graph include allowing us to build IoT applications faster, can easily create sophisticated workflows, very easily monitoring and managing the devices.



**Q13. Define Skynet IoT Messaging Platform. Explain the features.**

*Ans :* **(Imp.)**

**Meaning**

**Skynet IoT Messaging Platform**

Skynet IoT Messaging Platform is a cloud-based messaging service specifically designed for Internet of Things (IoT) applications. It offers a robust and scalable infrastructure for facilitating communication between IoT devices, applications, and backend systems.

Skynet IoT Messaging Platform provides various features and capabilities tailored to the unique requirements of IoT deployments. Here's an overview of Skynet IoT Messaging Platform:

**Features**

**1. Device Provisioning and Management**

Skynet IoT Messaging Platform allows for easy onboarding, provisioning, and management of IoT devices. It provides tools and APIs to register and configure devices, manage device metadata, and monitor device health and status.

**2. Message Routing and Pub/Sub**

The platform supports message routing and publish-subscribe (pub/sub) messaging patterns, enabling seamless communication between IoT devices and backend systems.

Messages can be routed based on predefined rules and criteria, ensuring efficient data exchange and processing.

**3. Scalability and Reliability**

Skynet IoT Messaging Platform is designed to handle high volumes of data and messages from millions of connected devices.

It provides scalable infrastructure and redundancy mechanisms to ensure reliable message delivery and minimize downtime.

**4. Security and Authentication**

Security is a top priority for IoT deployments, and Skynet IoT Messaging Platform offers robust security features to protect data and devices.

It supports authentication mechanisms, encryption, access controls, and secure communication protocols to ensure the confidentiality, integrity, and authenticity of IoT data.

**5. Real-time Data Processing**

The platform enables real-time data processing and analytics on IoT data streams. It provides tools for filtering, aggregating, and analyzing data in motion, allowing organizations to derive insights and take timely actions based on the latest IoT data.

**6. Integration with IoT Ecosystem**

Skynet IoT Messaging Platform integrates seamlessly with other components of the IoT ecosystem, including device management platforms, data analytics tools, and cloud services.

It provides APIs and SDKs for easy integration with third-party applications and services.

**7. Customization and Flexibility**

The platform offers customization options and flexibility to adapt to diverse IoT use cases and requirements.

Organizations can configure message routing rules, define custom protocols, and extend the platform's functionality using APIs and plugins.

**Q14. Explain the uses of Skynet IoT Messaging Platform.**

*Ans :*

**1. Smart Home Automation**: Skynet IoT Messaging Platform can be used to enable communication between smart home devices, such as thermostats, lights, and sensors, allowing users to remotely control and monitor their home environment.

**2. Industrial IoT (IIoT) Monitoring**

In industrial settings, the platform can facilitate communication between sensors, actuators, and control systems, enabling real-time monitoring and control of manufacturing processes, equipment, and facilities.

**3. Fleet Management**

For transportation and logistics companies, Skynet IoT Messaging Platform can support communication between vehicles, GPS trackers, and fleet management systems, providing real-time location tracking, route optimization, and vehicle diagnostics.

**4. Environmental Monitoring**

In environmental monitoring applications, the platform can enable communication between environmental sensors, weather stations, and data analysis tools, helping organizations monitor air quality, pollution levels, and weather conditions in real time.

## 4.5 INTRODUCTION TO DATA ANALYTICS FOR IOT

**Q15. Define is IoT Analytics? What are Components of IoT Analytics ?**

**(OR)**

**What are the seven key roles that data analysts play in the context of Internet of Things (IoT) projects?**

*Ans :* **(Imp.)**

**Meaning**

Internet of Things (IoT) Analytics refers to the process of collecting, processing, analyzing, and deriving insights from the vast amounts of data generated by IoT devices and sensors.

IoT analytics enables organizations to extract valuable insights, patterns, and trends from IoT data, leading to informed decision-making, optimization of operations, and creation of new business opportunities .

**Components**

**1. Determining Organizational Goals**

A data analyst's most crucial part is helping a business define its primary organizational objectives. This original step is vital for setting a business apart, outperforming challengers, and attracting the right audience.

Data analysts collaborate with staff and team members to monitor, track, gather, and analyze data, necessitating access to all available data used within the organization.

**2. Data Mining**

Data analysts gather and mine data from internet sources and company databases, conducting analysis and research. This research helps businesses understand market dynamics, current trends, competitor activities, and consumer preferences.

**3. Data Cleaning**

Data analysts play an essential part in data cleansing, a critical aspect of data preparation. Data cleansing involves correcting, identifying, and analyzing raw data, significantly improving decision making by providing accurate and precise data.

**4. Data Analysis**

Data analysts offer data entry services that include data analysis. They employ ways to efficiently explore data, excerpt relevant information, and give accurate answers to business-specific questions.

Data analysts bring statistical and logical tools to the table, enhancing a business's competitive advantage.

**5. Recognizing Patterns and Identifying Trends**

Data analysts excel in recognizing trends within industries and making sense of vast datasets. Their expertise in identifying industry trends enables businesses to enhance performance, estimate strategy effectiveness, and more.

**6. Reporting**

Data analysts convert essential insights from raw data into reports that drive advancements in business operations. Reporting is vital for monitoring online business performance and safeguarding against data misuse. It serves as the primary means to measure overall business performance.

**7. Data and System Maintenance**

Data analysts also contribute to maintaining data systems and databases, ensuring data coherence, availability, and storage align with organizational requirements.

Data analysts employ ways to enhance data gathering, structuring, and evaluation across various datasets.

**Q16. Explain the uses of IoT Analytics**

*Ans :*

IoT( Internet of Things) data analytics is pivotal for several reasons:

**1. Practicable Insights**

IoT devices generate massive amounts of data from various sources. Analyzing this data allows organizations to extract precious insights and make informed decisions.

By understanding patterns and trends, businesses can optimize processes, upgrade effectiveness, and enhance overall performance.

**2. Real- Time Decision**

Making IoT data analytics enables real- time processing and analysis of data aqueducts. This is particularly important in applications where quick decisions are essential, such as in industrial settings, healthcare monitoring, and smart megacity infrastructure.

Real- time insights empower organizations to respond instantly to changing conditions.

**3. Predictive Maintenance**

IoT data analytics can be used to predict when equipment or devices are likely to fail. By covering and analyzing performance data, organizations can apply predictive maintenance strategies, reducing time-out and minimizing the costs associated with unanticipated failures.

**4. Cost effectiveness Analyzing**

IoT data helps identify areas for optimization and cost reduction. Whether it's streamlining operations, enhancing resource utilization, or minimizing energy consumption, data analytics plays a crucial part in achieving cost effectiveness.

**5. Enhanced Customer Experience**

In sectors like retail and healthcare, IoT data analytics can be leveraged to understand customer behavior and preferences.

This information can be used to personalize services, enhance customer satisfaction, and tailor offerings to meet specific requirements.

**6. Security and Anomaly Detection**

With the increasing number of connected devices, security becomes a paramount concern. IoT data analytics can be applied to detect anomalies and possible security pitfalls.

By continuously monitoring data streams, organizations can identify unusual patterns that may indicate a security breach.

**7. Scalability and Flexibility**

As IoT ecosystems grow, traditional techniques of data analysis may become inadequate. IoT data analytics platforms are designed to handle the scalability and diversity of data generated by a multitude of devices.

This ensures that analytics capabilities can evolve alongside expanding IoT infrastructures.

**8. Regulatory Compliance**

In certain industries, there are regulatory demands regarding data collection, storage, and privacy. IoT data analytics platforms can help organizations adhere to these regulations by delivering tools for secure data management and compliance reporting.

**9. Innovation and Product Development**

Understanding how customers interact with IoT devices can inform the development of new products and services. Analytics on usage patterns and user feedback can guide innovation and lead to the creation of further effective and user-friendly solutions.

**Q17. What types of tools are commonly used for analytics in IoT applications?**

*Ans :*

There are several IoT analytics tools available that cater to different aspects of data processing, analysis, and visualization in the context of the Internet of Things( IoT).

**1. Microsoft Azure IoT Analytics**

Description Part of the Azure IoT Suite, it offers capabilities for processing and analyzing large quantities of IoT data. It includes tools for data storage, transformation, and querying.

**2. AWS IoT Analytics**

Description A service provided by Amazon Web Services( AWS), it allows users to clean, process, store, and analyze IoT data. It integrates with other AWS services for comprehensive IoT solutions.

**3. IBM Watson IoT Platform**

Description Offers analytics and AI capabilities for IoT data, allowing organizations to conclude actionable insights. It includes features for real-time data analysis and predictive maintenance.

**4. Google Cloud IoT Core and Cloud IoT Analytics**

Description Google Cloud offers IoT Core for device management and Cloud IoT Analytics for processing and analyzing IoT data. It integrates with other Google Cloud services for comprehensive data solutions.

**5. Thing Speak**

Description An IoT analytics platform by Math Works, it allows users to collect, analyze, and visualize IoT data in real- time.

It's well- suited for applications involving sensor data and monitoring. DescriptionC3.ai provides an IoT analytics platform that enables organizations to build and deploy AI-driven applications for various use cases, including predictive maintenance and energy management.

**6. Predix( by GE Digital)**

Description Predix is a platform specifically designed for industrial IoT applications. It provides tools for data analytics, machine learning, and application development in the artificial sector.

**7. Ubidots**

Description Ubidots is a cloud- based IoT platform that offers analytics and visualization tools. It's designed to simplify the process of building IoT applications and dashboards.

**8. Particle**

Description Particle provides an IoT platform that includes tools for device management, connectivity, and data visualization. It's suitable for IoT systems ranging from prototypes to product.

**9. Kaa IoT Platform**

Description Kaa is an open- source IoT platform that offers features for data analytics, device management, and application development. It provides flexibility for customization based on specific IoT project requirements.

## 4.6 Apache Hadoop - Map Reduce Job Execution Workflow

**Q18. What is Apache hadoop? What are components of Apache Hadoop?**

*Ans :*

Apache Hadoop is an open-source framework for distributed storage and processing of large datasets across clusters of commodity hardware. It is designed to handle big data applications that involve processing large volumes of structured and unstructured data.

Hadoop provides a scalable, fault-tolerant, and cost-effective solution for storing, processing, and analyzing massive amounts of data.

**1. Hadoop Distributed File System (HDFS)**

HDFS is a distributed file system that stores data across multiple machines in a Hadoop cluster. It provides high throughput and fault tolerance by replicating data blocks across different nodes.

**2. MapReduce**

MapReduce is a programming model and processing engine for parallel processing of large datasets. It breaks down data processing tasks into two phases: map and reduce.

Map tasks process input data and emit intermediate key-value pairs, while reduce tasks aggregate and process these intermediate results to produce final output.

**3. YARN (Yet Another Resource Negotiator)**

YARN is a resource management and job scheduling framework in Hadoop. It allows multiple data processing engines, such as MapReduce, Apache Spark, and Apache Tez, to run concurrently on the same cluster, efficiently sharing cluster resources.

**4. Hadoop Common**

Hadoop Common provides libraries and utilities that support other Hadoop modules. It includes common utilities, configuration files, and libraries used by various components of the Hadoop ecosystem.

**5. Hadoop EcoSystem Projects**

The Hadoop ecosystem includes a wide range of projects and tools that extend Hadoop's capabilities for data storage, processing, and analysis.

Some popular ecosystem projects include Apache Hive, Apache Pig, Apache HBase, Apache Spark, and Apache Kafka

## 4.7 Map Reduce Job Execution Workflow

**Q19. What is Map Reduce? Explain various steps to reduce the job execution.**

*Ans :* **(Imp.)**

**Meaning**

Hadoop MapReduce is the data processing layer. It processes the huge amount of structured and unstructured data stored in HDFS. MapReduce processes data in parallel by dividing the job into the set of independent tasks. So, parallel processing improves speed and reliability.

Hadoop MapReduce data processing takes place in 2 phases- Map and Reduce phase.

**(i) Map phase**

It is the first phase of data processing. In this phase, we specify all the complex logic/business rules/costly code.

**(ii) Reduce phase**

It is the second phase of processing. In this phase, we specify light-weight processing like aggregation/ summation.

**Steps of MapReduce Job Execution flow**

MapReduce processess the data in various phases with the help of different components. Let's discuss the steps of job execution in Hadoop.

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**1. Input Files**

In input files data for MapReduce job is stored. In HDFS, input files reside. Input files format is arbitrary. Line-based log files and binary format can also be used.

**2. InputFormat**

After that InputFormat defines how to split and read these input files. It selects the files or other objects for input. InputFormat creates InputSplit.

**3. InputSplits**

It represents the data which will be processed by an individual Mapper. For each split, one map task is created. Thus the number of map tasks is equal to the number of InputSplits. Framework divide split into records, which mapper process.

**4. RecordReader**

It communicates with the inputSplit. And then converts the data into key-value pairs suitable for reading by the Mapper. RecordReader by default uses TextInputFormat to convert data into a key-value pair.

It communicates to the InputSplit until the completion of file reading. It assigns byte offset to each line present in the file. Then, these key-value pairs are further sent to the mapper for further processing.

**5. Mapper**

It processes input record produced by the RecordReader and generates intermediate key-value pairs. The intermediate output is completely different from the input pair. The output of the mapper is the full collection of key-value pairs.

Hadoop framework doesn't store the output of mapper on HDFS. It doesn't store, as data is temporary and writing on HDFS will create unnecessary multiple copies. Then Mapper passes the output to the combiner for further processing.

**4. Combiner**

Combiner is Mini-reducer which performs local aggregation on the mapper's output. It minimizes the data transfer between mapper and reducer. So, when the combiner functionality completes, framework passes the output to the partitioner for further processing.

**5. Partitioner**

Partitioner comes into the existence if we are working with more than one reducer. It takes the output of the combiner and performs partitioning.

Partitioning of output takes place on the basis of the key in MapReduce. By hash function, key (or a subset of the key) derives the partition.

On the basis of key value in MapReduce, partitioning of each combiner output takes place. And then the record having the same key value goes into the same partition. After that, each partition is sent to a reducer.

Partitioning in MapReduce execution allows even distribution of the map output over the reducer.

**6. Shuffling and Sorting**

After partitioning, the output is shuffled to the reduce node. The shuffling is the physical movement of the data which is done over the network.

As all the mappers finish and shuffle the output on the reducer nodes. Then framework merges this intermediate output and sort. This is then provided as input to reduce phase.

**7. Reducer**

Reducer then takes set of intermediate key-value pairs produced by the mappers as the input. After that runs a reducer function on each of them to generate the output.

The output of the reducer is the final output. Then framework stores the output on HDFS.

**8. RecordWriter**

It writes these output key-value pair from the Reducer phase to the output files.

**9. OutputFormat**

OutputFormat defines the way how RecordReader writes these output key-value pairs in output files. So, its instances provided by the Hadoop write files in HDFS. Thus OutputFormat instances write the final output of reducer on HDFS.



**Q20. What is the execution workflow of a MapReduce job in Apache Hadoop?**

*Ans :*

**1. Job Submission**

The user submits the MapReduce job to the Hadoop cluster. The job includes the mapper and reducer functions, input data location, output data location, and other job configurations.

**2. Job Initialization**

Upon receiving the job submission, the Hadoop framework initializes the job. It assigns map tasks and reduce tasks based on the input data size and cluster availability. The framework also sets up the necessary infrastructure for task execution.

**3. Map Phase**

In this phase, the input data is divided into smaller chunks, and each chunk is processed by a separate map task. The map tasks apply the user-defined mapper function to each record in the input data and emit intermediate key-value pairs.

**4. Shuffle and Sort**

Once the map tasks have completed processing their input data, the intermediate key-value pairs are shuffled and sorted based on their keys. This phase ensures that all values associated with the same key are grouped together and ready for processing by the reducer tasks.

**5. Reduce Phase**

In this phase, the sorted intermediate key-value pairs are processed by the reduce tasks. Each reduce task applies the user-defined reducer function to the values associated with each key, producing the final output key-value pairs.

**6. Output Generation**

The output key-value pairs from the reduce tasks are written to the specified output directory in the distributed file system (e.g., HDFS). The output data typically represents the aggregated results of the MapReduce job.

**7. Job Completion**

Once all map and reduce tasks have finished processing and the output data has been written successfully, the Hadoop framework marks the job as completed. The user can then retrieve the output data from the specified location for further analysis or processing.

UNIT V

**IOT PRODUCT MANUFACTURING - FROM PROTOTYPE TO REALITY :**

Business model for IoT product manufacturing, Business models canvas, Funding an IoT Startup, Mass manufacturing - designing kits, designing PCB,3D printing, certification, Scaling up software, Ethical issues in IoT- Privacy, Control, Environment, solutions to ethical issues.

## 5.1 Business Model for IoT Product Manufacturing

**Q1. What are the fundamental components of a business model tailored for IoT product manufacturing, and how do they interconnect?**

*Ans :* **(Imp.)**

**(i)** The fundamental components of a business model for IoT product manufacturing encompass several interconnected elements.

**(ii)** The value proposition defines what unique benefits the IoT products offer to customers, which in turn influences the choice of target markets.

**(iii)** Revenue streams are determined by how the company plans to monetize its offerings, be it through direct sales, subscriptions, or licensing agreements.

**(iv)** Key partnerships are essential for accessing necessary resources, expertise, or distribution channels.

**(v)** Key activities and resources outline the operational aspects required for manufacturing and delivering IoT products, while the cost structure ensures profitability and sustainability.

**(v)** Distribution channels and customer relationships facilitate market reach and engagement, whereas effective positioning and branding differentiate the company from competitors. Regulatory compliance and scalability considerations ensure long-term viability and growth.



## 5.2 Business Models Canvas

**Q2. How does the Business Model Canvas assist in structuring and refining the business model for an IoT product manufacturing company?**

*Ans :* **(Imp.)**

**(i)** The Business Model Canvas is a powerful tool for structuring and refining the business model of an IoT product manufacturing company.

**(ii)** It provides a visual framework comprising nine key building blocks, including customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure.

**(iii)** By systematically analyzing each block, companies can gain a comprehensive understanding of their business model and identify areas for improvement or optimization.

**(iv)** The canvas encourages cross-functional collaboration and facilitates strategic decision-making by enabling stakeholders to visualize the interdependencies between different components of the business model.

**(v)** It also serves as a dynamic tool that can be continuously updated and adapted to reflect changing market conditions, technological advancements, or organizational priorities.

**Q3. Explain the framework of business model canvas.**

*Ans :*

The Business Model Canvas framework is a visual representation of the important aspects or parts to consider when designing a Business Model, these are

**1. Customer segments**

There may be several distinct groups of individuals or organizations that a business aims to reach, serve and create value for.

**2. Value proposition**

The value that the business creates for the customer segments including the products and services that deliver that value.

**3. Channels**

The means and ways through which a business reaches its customer segments to deliver its value proposition.

**4. Customer Relationships**

The nature of relationships that a business needs to establish with its customer segments.

**5. Revenue streams**

The sources through which the money flows into the business.

**6. Cost structure**

The costs incurred by a business to run.

## 5.3 FUNDING AN IOT STARTUP, MASS MANUFACTURING

**Q4. How can an IoT product manufacturing company effectively diversify its revenue streams beyond hardware sales? (Imp.)**

*Ans :*

**(i)** While hardware sales constitute a significant revenue stream for IoT product manufacturing companies, diversifying revenue streams can enhance financial stability and resilience.

**(ii)** One approach is to offer subscription-based services, such as software updates, data analytics, or premium support packages, which provide recurring revenue streams and foster long-term customer relationships.

**(iii)** Additionally, licensing proprietary technology or intellectual property to third parties can generate passive income streams while leveraging the company's technological expertise.

**(iv)** Revenue-sharing models, where the company receives a percentage of the value generated by its IoT products or services, can also be explored, especially in collaborative ecosystems or platform-based business models.

**(v)** Ultimately, diversifying revenue streams requires a deep understanding of customer needs, market dynamics, and strategic partnerships to capitalize on emerging opportunities and mitigate risks associated with hardware-centric business models.

**Q5. How do strategic partnerships contribute to the success of an IoT product manufacturing business, and how should they be cultivated and managed effectively?**

*Ans :* **(Imp.)**

**(i)** Strategic partnerships play a crucial role in the success of an IoT product manufacturing business by providing access to essential resources, expertise, distribution channels, or complementary technologies.

**(ii)** By leveraging strategic partnerships, companies can accelerate product development, enhance market reach, reduce costs, and mitigate risks associated with resource constraints or market uncertainties.

**(iii)** Cultivating and managing strategic partnerships effectively requires a proactive approach, based on mutual trust, shared objectives, and clear communication.

**(iv)** Companies should carefully evaluate potential partners based on their alignment with strategic goals, reputation, track record, and cultural fit.

**(v)** Establishing formal agreements or alliances that outline roles, responsibilities, and expectations can help mitigate conflicts and ensure alignment throughout the partnership lifecycle.

**(vi)** Continuous collaboration, feedback loops, and performance evaluations are essential for nurturing long-term, mutually beneficial relationships that drive innovation and sustained growth.

**Q6. How can an IoT product manufacturing company balance profitability and sustainability in its cost structure while maintaining competitiveness in the market?**

*Ans :* **(Imp.)**

**(i)** Balancing profitability and sustainability in the cost structure of an IoT product manufacturing company requires careful consideration of various factors, including material costs, labor costs, overhead expenses, research and development investments, and operational efficiencies.

**(ii)** Companies can enhance profitability by optimizing supply chain management, streamlining manufacturing processes, and negotiating favorable terms with suppliers and vendors.

**(iii)** Cost-saving measures, such as lean manufacturing principles, automation technologies, and energy-efficient practices, can reduce production costs without compromising quality or performance. Investing in innovation and continuous improvement initiatives can yield long-term cost advantages while fostering a culture of adaptability and resilience.

**(iv)** Moreover, incorporating sustainability considerations into the cost structure, such as eco-friendly materials, energy-efficient production methods, and waste reduction strategies, not only aligns with corporate social responsibility objectives but also enhances brand reputation and market competitiveness in an increasingly environmentally conscious marketplace.

**Q7. How can designing kits for IoT products contribute to scalability and cost-effectiveness in manufacturing?**

*Ans :*

Designing kits for IoT products allows for standardized packaging and assembly processes, streamlining manufacturing operations and reducing overhead costs. By pre-packaging components into kits, companies can achieve economies of scale in procurement, storage, and logistics. Moreover, modular kit designs enable easy customization and scalability, allowing companies to quickly adapt to changing market demands or product variations without significant retooling or reconfiguration.

**Q8. What are some best practices for designing kits that cater to a diverse range of users and skill levels?**

*Ans :*

Best practices for designing kits that cater to diverse users and skill levels include offering multiple assembly options, providing clear instructions with visual aids, and incorporating intuitive design features. Modular components with plug-and-play functionality can accommodate varying levels of technical expertise, while color-coded or numbered parts simplify identification and assembly. User testing and feedback loops can help identify potential pain points or usability issues, allowing for iterative improvements to enhance user satisfaction and accessibility.

**Q9. How can companies leverage kit design as a branding and marketing tool to differentiate their IoT products in the market?**

*Ans :*

Kit design presents an opportunity for companies to reinforce their branding and communicate their value proposition to customers. By incorporating brand elements such as logos, colors, and messaging into the packaging and instructional materials, companies can create a cohesive brand experience that resonates with users. Additionally, emphasizing the ease of assembly, quality of components, and potential applications of the IoT product can differentiate it from competitors and attract prospective customers.

**Q10. What role does sustainability play in the design of IoT product kits, and how can companies minimize environmental impact?**

*Ans :*

Sustainability considerations in kit design encompass materials sourcing, packaging design, and end-of-life disposal. Companies can prioritize eco-friendly materials, such as recyclable plastics or biodegradable packaging, to minimize environmental impact. Designing kits for compactness and efficiency in shipping can reduce carbon emissions associated with transportation. Moreover, offering recycling programs or incentivizing product return for refurbishment or recycling can promote circular economy principles and demonstrate a commitment to environmental stewardship.

## 5.4 DESIGNING PCB, 3D PRINTING

**Q11. What are the key considerations in designing printed circuit boards (PCBs) for IoT products, and how do they impact performance and manufacturability?**

*Ans :* **(Imp.)**

**(i)** Key considerations in PCB design for IoT products include component placement, signal integrity, power distribution, thermal management, and manufacturability.

**(ii)** Optimal component placement minimizes signal interference and reduces trace lengths, improving overall performance and reliability. Proper power distribution ensures stable operation and mitigates voltage drops or fluctuations.

**(iii)** Effective thermal management techniques, such as heat sinks or vias, prevent overheating and prolong component lifespan.

**(iv)** Designing for manufacturability involves adhering to industry standards, optimizing panelization, and minimizing production costs through efficient use of materials and assembly processes.

**Q12. How does miniaturization and integration of components impact PCB design for IoT devices, and what design strategies can mitigate associated challenges?**

*Ans :*

**(i)** Miniaturization and integration of components pose challenges such as routing congestion, thermal dissipation, and signal integrity issues in PCB design for IoT devices.

**(ii)** Design strategies to mitigate these challenges include using high-density interconnects (HDIs), multi-layer PCBs, and advanced routing techniques to optimize space utilization and minimize signal crosstalk.

**(iii)** Additionally, implementing efficient power distribution networks (PDNs) and thermal vias can enhance power integrity and heat dissipation, respectively.

**(iv)** Collaborative design tools and simulation software can facilitate iterative design optimization and verification, ensuring compliance with performance specifications and manufacturability requirements.

**Q13. How can companies ensure compliance with regulatory standards and certifications in PCB design for IoT products, and what are the consequences of non-compliance?**

*Ans :*

**(i)** Ensuring compliance with regulatory standards and certifications in PCB design for IoT products requires thorough testing, documentation, and adherence to industry-specific requirements.

**(ii)** Companies should consult relevant regulatory bodies and standards organizations to identify applicable regulations, such as electromagnetic compatibility (EMC), safety, and environmental directives.

**(iii)** Non-compliance can result in costly product recalls, legal liabilities, damage to brand reputation, and barriers to market entry.

**(iv)** Therefore, investing in compliance testing, certification processes, and ongoing regulatory monitoring is essential to mitigate risks and demonstrate commitment to product quality and safety.

## 5.5 CERTIFICATION, SCALING UP SOFTWARE

**Q14. What role do certifications play in the manufacturing and deployment of IoT products, and why are they important?**

*Ans :*

Certifications are essential in ensuring the quality, safety, and compliance of IoT products with industry standards and regulatory requirements. They serve as a validation of product performance, reliability, and interoperability, instilling confidence in customers and facilitating market acceptance. Certifications also demonstrate a company's commitment to product quality and compliance with legal and regulatory frameworks, mitigating risks associated with liability, recalls, or regulatory penalties. Moreover, certifications can unlock access to new markets, industries, or customers that require certified products, thereby expanding business opportunities and driving growth.

**Q15. What are some common certifications required for IoT products, and how do they vary across industries and regions?**

*Ans :*

Common certifications required for IoT products include electromagnetic compatibility (EMC), wireless communication standards (e.g., Wi-Fi, Bluetooth), product safety (e.g., UL, CE), environmental regulations (e.g., RoHS, REACH), and industry-specific standards (e.g., medical devices, automotive). Certification requirements

may vary across industries and regions due to differences in regulatory frameworks, market preferences, and end-user expectations. For example, IoT devices deployed in healthcare settings may require certification for data security and patient privacy, while automotive IoT applications may require certification for functional safety and reliability.

**Q16. What are the steps involved in obtaining certifications for IoT products, and how can companies streamline the certification process?**

*Ans :*

The steps involved in obtaining certifications for IoT products typically include: identifying applicable standards and regulatory requirements, conducting pre-compliance testing and assessments, preparing documentation and test reports, engaging with accredited testing laboratories or certification bodies, undergoing formal testing and evaluation, addressing any non-compliance issues, and obtaining certification or compliance marks. Companies can streamline the certification process by proactively addressing compliance considerations during the product development lifecycle, leveraging standardized testing protocols and pre-certified components, engaging with experienced consultants or certification experts, and maintaining documentation and traceability throughout the certification process.

**Q17 How can certifications contribute to product differentiation and competitive advantage in the IoT market, and what strategies can companies employ to leverage certifications effectively?**

*Ans :*

Certifications can contribute to product differentiation and competitive advantage in the IoT market by demonstrating compliance with industry standards, reliability, and performance benchmarks. Companies can leverage certifications effectively by prominently showcasing certified products in marketing materials, packaging, and online listings to build trust and credibility with customers. Moreover, companies can use certifications as a basis for product differentiation, emphasizing unique features or performance attributes that align with customer needs or market trends. Engaging with certification bodies, industry consortia, or regulatory agencies to influence standards development and participate in certification programs can also position companies as thought leaders and innovators in the IoT ecosystem.

**Q18. What are some emerging trends and future considerations in IoT product certification, and how can companies prepare for evolving regulatory landscapes and market demands?**

*Ans :*

Emerging trends in IoT product certification include the adoption of international standards, harmonization of regulatory frameworks across regions, and the emergence of sector-specific certification programs tailored to IoT applications. Companies can prepare for evolving regulatory landscapes and market demands by staying informed about industry trends, participating in standardization initiatives, and proactively addressing compliance requirements in product development and certification processes. Additionally, investing in agile and adaptable compliance strategies, such as modular design architectures and continuous testing frameworks, can enhance responsiveness to regulatory changes and ensure ongoing compliance with evolving certification requirements.

## 5.6 Ethical Issues in IoT - Privacy, Control Environment Solution to Ethical Issues

**Q19. What ethical considerations arise regarding control in IoT systems, and how do they impact user autonomy and agency?**

*Ans :*

**(i)** Ethical considerations regarding control in IoT systems revolve around issues of user autonomy, privacy, and consent. IoT devices often collect and process large amounts of data, raising concerns about user control over personal information and decision-making.

**(ii)** In some cases, automated systems may override user preferences or act without explicit consent, undermining individual autonomy and agency.

**(iii)** Moreover, centralized control architectures may concentrate power in the hands of a few stakeholders, exacerbating inequalities and limiting user choice. Ensuring transparent and user-centric control mechanisms, such as granular privacy settings, data ownership rights, and user-driven decision support systems, can empower users to maintain control over their IoT devices and data while fostering trust and accountability in the ecosystem.

**Q20. How do design choices influence user control and empowerment in IoT products, and what principles should guide ethical design practices?**

*Ans :*

**(i)** Design choices significantly influence user control and empowerment in IoT products.

**(ii)** Ethical design practices should prioritize user-centricity, transparency, and inclusivity to enhance user autonomy and agency. Principles such as privacy by design, data minimization, and user consent should guide the development of IoT systems, ensuring that users have meaningful control over their data and interactions with connected devices.

**(iii)** Providing clear user interfaces, intuitive control mechanisms, and informative feedback loops can facilitate user understanding and decision-making, empowering users to make informed choices about their IoT experiences.

**(iv)** Additionally, fostering co-creation and participatory design processes that involve diverse stakeholders can ensure that design decisions reflect user preferences, values, and needs, thereby promoting inclusivity and social responsibility in IoT development.

**Q21. What are the implications of centralized versus decentralized control architectures in IoT systems, and how do they impact user privacy, security, and autonomy?**

*Ans :*

**(i)** Centralized control architectures in IoT systems centralize decision-making and data processing functions in a single authority or platform, raising concerns about data privacy, security, and user autonomy.

**(ii)** Centralized systems may be vulnerable to single points of failure, data breaches, and abuse of power by centralized authorities, compromising user trust and control.

**(iii)** Decentralized control architectures distribute decision-making and data processing functions across multiple nodes or devices, enhancing resilience, scalability, and user autonomy. By empowering users to retain control over their data and interactions, decentralized systems can mitigate privacy risks and foster a more equitable and inclusive IoT ecosystem.

**(iv)** However, decentralized architectures also pose challenges such as interoperability, coordination, and governance, requiring careful consideration of trade-offs and design trade-offs to balance user needs and system requirements.

**Q22. How can regulatory frameworks and industry standards promote user control and ethical practices in IoT systems, and what role do stakeholders play in shaping policy and governance mechanisms?**

*Ans :*

**(i)** Regulatory frameworks and industry standards play a crucial role in promoting user control and ethical practices in IoT systems by establishing guidelines, requirements, and enforcement mechanisms to protect user rights and ensure accountability.

**(ii)** For example, data protection regulations such as the General Data Protection Regulation (GDPR) in Europe and the California Consumer Privacy Act (CCPA) in the United States mandate transparency, consent, and user control over personal data in IoT contexts.

**(iii)** Industry consortia, standards organizations, and multi-stakeholder initiatives can also develop voluntary codes of conduct, certification programs, and best practices to promote ethical behavior and responsible innovation in the IoT ecosystem.

**(iv)** Moreover, engaging diverse stakeholders, including policymakers, industry representatives, civil society organizations, and academic experts, in policy development and governance mechanisms can ensure that regulatory frameworks are informed by diverse perspectives, reflect societal values, and address emerging ethical challenges in IoT deployment and adoption.

**Q23. What strategies can IoT companies employ to prioritize user control, privacy, and autonomy in their products and services, and how can they foster a culture of ethical responsibility within their organizations?**

*Ans :*

**(i)** IoT companies can prioritize user control, privacy, and autonomy by embedding ethical considerations into all stages of the product lifecycle, from design and development to deployment and support.

**(ii)** Strategies include conducting privacy impact assessments, implementing privacy-enhancing technologies, and providing user-friendly tools and controls for managing data permissions and preferences.

**(iii)** Moreover, fostering a culture of ethical responsibility within organizations involves promoting awareness, education, and accountability among employees, stakeholders, and partners.

**(iv)** Establishing clear ethical guidelines, codes of conduct, and whistleblower protections can empower employees to raise concerns and report ethical violations, fostering a culture of transparency, integrity, and trust.

**(v)** Additionally, companies can engage with external stakeholders, including customers, regulators, and civil society organizations, to solicit feedback, address concerns, and demonstrate commitment to ethical principles and values in their operations and decision-making processes.

**Q24. What environmental considerations arise in the context of IoT deployment and proliferation, and how do they impact sustainability and resource management?**

*Ans :*

**(i)** Environmental considerations in IoT deployment and proliferation revolve around issues such as energy consumption, electronic waste (e-waste), and resource depletion. IoT devices consume energy during operation, data transmission, and processing, contributing to carbon emissions and environmental footprint.

**(ii)** Moreover, the rapid turnover of IoT devices and the proliferation of obsolete or outdated technologies contribute to the accumulation of e-waste, posing challenges for recycling, disposal, and environmental remediation.

**(iii)** Additionally, the extraction and use of raw materials, such as rare earth metals and minerals, in IoT device manufacturing contribute to resource depletion and environmental degradation.

**(iv)** Addressing these environmental challenges requires adopting sustainable design principles, energy-efficient technologies, and circular economy approaches to minimize environmental impact and promote resource stewardship throughout the IoT lifecycle.

**Q25. How can IoT companies reduce energy consumption and promote energy efficiency in their products and services, and what role do energy standards and certifications play in driving sustainable practices?**

*Ans :*

**(i)** IoT companies can reduce energy consumption and promote energy efficiency in their products and services by implementing energy-efficient design principles, optimizing software algorithms, and leveraging low-power communication protocols.

**(ii)** For example, using sleep modes, dynamic power scaling, and sensor fusion techniques can minimize power consumption without compromising functionality or performance.

**(iii)** Moreover, integrating renewable energy sources, such as solar or kinetic energy harvesting, can further reduce reliance on fossil fuels and mitigate carbon emissions associated with IoT deployments.

**(iv)** Energy standards and certifications, such as ENERGY STAR and EPEAT, provide benchmarks and guidelines for energy efficiency, enabling companies to benchmark their performance, demonstrate compliance with regulatory requirements, and differentiate their products based on sustainability criteria.

**Q26. What strategies can IoT companies employ to address electronic waste (e-waste) challenges and promote responsible end-of-life management of IoT devices, components, and materials?**

*Ans :*

**(i)** Strategies to address e-waste challenges and promote responsible end-of-life management of IoT devices include implementing extended producer responsibility (EPR) programs, designing products for disassembly and recyclability, and establishing take-back and recycling initiatives. Extended producer responsibility (EPR) programs require manufacturers to take responsibility for the collection, recycling, and disposal of their products at the end of their life cycle, incentivizing eco-design and sustainable materials management practices.

**(ii)** Designing products for disassembly and recyclability involves using modular components, standardized interfaces, and non-toxic materials to facilitate easy separation, refurbishment, and recycling of product parts and materials. Moreover, establishing take-back and recycling initiatives, such as trade-in programs or product stewardship schemes, can incentivize consumers to return obsolete or end-of-life IoT devices for proper disposal or refurbishment.

# FACULTY OF INFORMATICS

## M.C.A II Year III - Semester Examination

## MODEL PAPER - I

## INTERNET OF THINGS

Time : 3 Hours] [Max. Marks : 70

**Answer all the question according to the internal choice** **(5 × 14 = 70)**

**ANSWERS**

1. (a) What is IOT. Explain the components of IOT? **(Unit-I, Q.No.1)**

   (b) Explain the advantages and disadvantages of IOT? **(Unit-I, Q.No.3)**

OR

2. (a) Explain briefly about IOT Communication Parameters. **(Unit-I, Q.No.10)**

   (b) Explain briefly about IOT Networking. **(Unit-I, Q.No.12)**

3. (a) Explain briefly about TCP, IP protocol suite. **(Unit-II, Q.No.2)**

   (b) Why does DNS use UDP? **(Unit-II, Q.No.3)**

OR

4. (a) State the advantages and disadvantages of MAC address. **(Unit-II, Q.No.7)**

   (b) Distinguish between MAC address and IP address. **(Unit-II, Q.No.8)**

5. What are actuators? Explain different types of actuators. **(Unit-III, Q.No.6)**

OR

6. Explain the advantages and disadvantages of soc? **(Unit-III, Q.No.11)**

7. Explain the Advantages and Disadvantages of Cloud Storage. **(Unit-IV, Q.No.4)**

OR

8. Define Skynet IoT Messaging Platform. Explain the features of **(Unit-IV, Q.No.13)**

9. (a) How can an IoT product manufacturing company balance profitability and sustainability in its cost structure while maintaining competitiveness in the market? **(Unit-V, Q.No.6)**

   (b) How does the Business Model Canvas assist in structuring and refining the business model for an IoT product manufacturing company? **(Unit-V, Q.No.2)**

OR

10. (a) How does miniaturization and integration of components impact PCB design for IoT devices, and what design strategies can mitigate associated challenges? **(Unit-V, Q.No.12)**

(b) How can an IoT product manufacturing company effectively diversify its revenue streams beyond hardware sales? **(Unit-V, Q.No.4)**

# FACULTY OF INFORMATICS

## M.C.A II Year III - Semester Examination

## MODEL PAPER - II

## INTERNET OF THINGS

Time : 3 Hours] [Max. Marks : 70

**Answer all the question according to the internal choice** **(5 × 14 = 70)**

**ANSWERS**

1. (a) Explain the Strategic research and innovation directions. **(Unit-I, Q.No.6)**

   (b) How IOT related to future technology? **(Unit-I, Q.No.8)**

OR

2. (a) Explain Various types of IOT Communication **(Unit-I, Q.No.11)**

   (b) Explain the process of Networking Communication **(Unit-I, Q.No.13)**

3. (a) Describe about Internet Principles and communication technology. **(Unit-II, Q.No.1)**

   (b) What are the differences between a Static IP and Dynamic address? **(Unit-II, Q.No.4)**

OR

4. (a) Write about Application Layer Protocols and their functionality. **(Unit-II, Q.No.10)**

   (b) Explain briefly about prototype and production. **(Unit-II, Q.No.14)**

5. Define Prototyping Embedded Devices ? What are the components of Prototyping Embedded Devices. **(Unit-III, Q.No.1)**

OR

6. What is Raspberry Pi? Explain the Features of Rasapherry Pi ? **(Unit-III, Q.No.13)**

7. Compare and Contrast between IAAS, PAAS and SAAS. **(Unit-IV, Q.No.9)**

OR

8. Define is IoT Analytics? What are Components of IoT Analytics ? **(Unit-IV, Q.No.15)**

9. (a) What role do certifications play in the manufacturing and deployment of IoT products, and why are they important? **(Unit-V, Q.No.14)**

   (b) What are the fundamental components of a business model tailored for IoT product manufacturing, and how do they interconnect? **(Unit-V, Q.No.1)**

OR

10. (a) What are some emerging trends and future considerations in IoT product certification, and how can companies prepare for evolving regulatory landscapes and market demands? **(Unit-V, Q.No.18)**

(b) What role does sustainability play in the design of IoT product kits, and how can companies minimize environmental impact? **(Unit-V, Q.No.10)**

# FACULTY OF INFORMATICS

## M.C.A II Year III - Semester Examination

## MODEL PAPER - III

## INTERNET OF THINGS

Time : 3 Hours] [Max. Marks : 70

**Answer all the question according to the internal choice** **(5 × 14 = 70)**

**ANSWERS**

1. (a) Explain the Applications of Internet of Things. **(Unit-I, Q.No.7)**

   (b) Explain the features of The Internet of Things? **(Unit-I, Q.No.2)**

OR

2. (a) Explain about Device Level Energy Issues **(Unit-I, Q.No.19)**

   (b) Explain about Device Level Energy Issues **(Unit-I, Q.No.12)**

3. (a) What are the differences between a Static IP and Dynamic address? **(Unit-II, Q.No.4)**

   (b) Define HTTPS. State the characteristics of HTTPS. **(Unit-II, Q.No.12)**

OR

4. (a) Distinguish between open source software and closed source software. **(Unit-II, Q.No.18)**

   (b) Define closed source software. State the advantages of closed source software. **(Unit-II, Q.No.17)**

5. Define Sensors? What are the different types of Sensors Used in IoT Prototyping. **(Unit-III, Q.No.4)**

OR

6. Explain the control of a motor using a switch and temperature sensor in an Arduino board. **(Unit-III, Q.No.20)**

7. What is Cloud Storage? Explain the features of Cloud Storage Systems. **(Unit-IV, Q.No.1)**

OR

8. What is Map Reduce? Explain various steps to reduce the job execution. **(Unit-IV, Q.No.19)**

9. (a) How can designing kits for IoT products contribute to scalability and cost-effectiveness in manufacturing? **(Unit-V, Q.No.3)**

   (b) What environmental considerations arise in the context of IoT deployment and proliferation, and how do they impact sustainability and resource management? **(Unit-V, Q.No.24)**

OR

10. (a) How can designing kits for IoT products contribute to scalability and cost-effectiveness in manufacturing? **(Unit-V, Q.No.7)**

(b) What are some emerging trends and future considerations in IoT product certification, and how can companies prepare for evolving regulatory landscapes and market demands? **(Unit-V, Q.No.18)**