UNIT-3

IOT APPLICATIONS IN INDUSTRIES

3.1 BUILDING AND HOME AUTOMATION

Introduction:

IoT-based Home Automation refers to the capacity to use internet-connected equipment to operate household appliances. It might involve pre-programming, complicated heating and lighting systems, as well as alarms and home security controls, all of which are connected via central hub and operated remotely via a smartphone application.

Major Parts of Home Automation System:

A Home Automation System consists of various components that work together to automate and control different aspects of a home environment. Following are the major parts of a typical home automation system:

1) **Sensors:** Sensors are devices that detect changes in the environment and convert them into electrical signals. Common types of sensors used in home automation include motion sensors, temperature sensors, humidity sensors, light sensors, door/window sensors, etc. These sensors provide data to the automation system to trigger actions or adjust based on the detected conditions.
2) **Actuators:** Actuators are devices that perform physical actions based on commands from the automation system. Examples of actuators used in home automation include light switches, motorized blinds or curtains, smart thermostats, smart locks and smart outlets. Actuators enable the automation system to control various devices and systems within the home.
3) **Controller or Hub:** The controller or hub is the central component of the home automation system that manages communication between sensors, actuators and other devices. It collects data from sensors, processes it and sends commands to actuators based on predefined rules or user input. The controller/hub may also provide a user interface for configuring settings, creating automation rules and monitoring the status of connected devices.
4) **Network Connectivity:** Home automation devices typically communicate with each other and with the controller/hub over a network. This network may be wired (e.g., Ethernet) or wireless (e.g., Wi-Fi, Zigbee, Z-Wave, Bluetooth). Network connectivity allows remote access to the automation system and enables integration with other smart devices and services.
5) **User Interface:** The user interface allows homeowners to interact with the home automation system and control connected devices. This interface may be provided through a mobile app, web portal, touchscreen panel or voice-controlled assistant. Users can use the interface to adjust settings, create automation schedules, receive notifications and monitor the status of their home environment.
6) **Automation Rules and Logic:** Automation rules and logic define the behaviour of the home automation system based on specific conditions and triggers. Users can configure rules to automate routine tasks, such as turning off lights when a room is unoccupied or adjusting thermostat settings

based on time of day. The automation system executes these rules automatically, reducing the need for manual intervention.

7) **Cloud Services:** Some home automation systems may leverage cloud services for data storage, processing and remote access. Cloud services enable homeowners to control their home environment from anywhere with an internet connection and provide additional features such as data analytics, firmware updates and integration with third-party services.

By integrating these major components, a home automation system can enhance convenience, comfort, energy efficiency and security for homeowners, creating a smarter and more connected living environment.

Applications:

1) **Smart Lighting Control:** Homeowners can remotely control and automate lighting systems using IoT-enabled smart bulbs, switches or dimmers. They can create schedules, adjust brightness levels and even integrate lighting with other smart devices for enhanced security or energy savings.
2) **Temperature and Climate Control:** IoT thermostats allow users to remotely monitor and control Heating, Ventilation and Air Conditioning (HVAC) systems. They can set temperature schedules, adjust settings based on occupancy or outdoor weather conditions and optimize energy usage for cost savings.
3) **Security and Surveillance:** IoT-based security systems provide homeowners with remote monitoring and control of cameras, motion sensors, door/window sensors and smart locks. Users can receive real-time alerts, view live video feeds and remotely arm/disarm security systems using their smartphones or tablets.
4) **Smart Home Appliances:** IoT-enabled appliances such as refrigerators, ovens, washing machines and dishwashers offer advanced features like remote monitoring, control and diagnostics. Users can receive notifications when tasks are completed, adjust settings and even initiate appliance cycles from anywhere.
5) **Energy Monitoring and Management:** IoT devices equipped with energy monitoring sensors allow homeowners to track and analyse energy consumption patterns in real-time. This data can help identify energy-intensive devices, optimize usage habits and reduce electricity bills.
6) **Water Leak Detection and Prevention:** IoT-based water leak detection systems use sensors to monitor plumbing fixtures and detect leaks or abnormal water usage. Users receive alerts on their smartphones in case of leaks, allowing for prompt action to prevent water damage and wastage.
7) **Voice Control and Integration:** Integration with voice-controlled assistants such as Amazon Alexa, Google Assistant or Apple Home Kit allows homeowners to control their IoT devices using voice commands.
8) **Automated Window Treatments:** IoT-enabled motorized blinds or curtains can be programmed to open or close automatically based on predefined schedules, sunlight intensity or room occupancy.

9) **Health and Wellness Monitoring:** IoT devices equipped with health monitoring sensors can track vital signs, sleep patterns and physical activity levels of household members. This data can be used for personalized health insights, early detection of health issues and remote monitoring of individuals.
10) **Integration with Smart Entertainment Systems:** IoT-based home automation systems can integrate with smart entertainment devices such as TVs, speakers and streaming platforms. Users can create custom entertainment scenarios, automate audio/video playback and control multimedia devices seamlessly.

Difference between IoT-based Home Automation System and Smart Home:

The terms "IoT-based home automation" and "smart home" are often used interchangeably, but there are some distinctions between the two concepts. The phrase "smart house" was coined by the American Association of Home Builders in 1984, but IoT smart houses became popular in the early 2000s.

1) **Scope and Complexity:**
   - **IoT-based Home Automation:** This term typically refers to the use of IoT technology to automate specific tasks or functions within a home, such as controlling lights, thermostats or security cameras. It focuses on automating individual devices or systems using IoT technology.
   - **Smart Home:** A smart home encompasses a broader concept that goes beyond individual device automation. It involves integrating multiple smart devices and systems throughout the home into a cohesive and interconnected ecosystem. A smart home may include various IoT-enabled devices, as well as sensors, actuators, controllers and centralized management systems.
2) **Interconnectivity and Integration:**
   - **IoT-based Home Automation:** In this context, IoT devices are often used independently to automate specific tasks or functions within the home. While they may be controlled remotely via smartphone apps or voice assistants, they may not necessarily communicate or integrate with other devices or systems.
   - **Smart Home:** A smart home emphasizes the integration and interconnectivity of different smart devices and systems. Devices and systems within a smart home are often interconnected and capable of communicating with each other to provide coordinated functionality and automation. For example, a smart home may integrate lighting, heating, security, entertainment and other systems to work together seamlessly.
3) **Functionality and Intelligence:**
   - **IoT-based Home Automation:** IoT devices used for home automation typically focus on automating specific tasks or functions based on predefined rules or user commands. While they may offer some level of intelligence or automation, their capabilities may be limited to individual device control.

- **Smart Home:** A smart home leverages advanced technologies such as artificial intelligence (AI), machine learning (ML) and data analytics to provide more sophisticated automation, predictive capabilities and personalized experiences. Smart homes may use data from sensors, user preferences and environmental conditions to make intelligent decisions and adapt to users' needs automatically.

3.2 RETAIL

Introduction:

Today, retail stores are constantly focusing on using the emerging technologies like cloud, mobile, RFID, beacons, etc., to provide connected retail services and better shopping experience to customers. Interestingly, IoT in retail and connected technologies are taking the retail industry by storm. 96% retailers are ready to make changes required to implement the Internet of Things in their stores.

Use of IoT in the smart retail is hugely related to GPS and RFID technologies that help brands in tracking the products throughout entire supply chain process. It gives visibility to the retails for tracking product conditions and movement. It also helps in tracking the location and for predicting an exact delivery time.

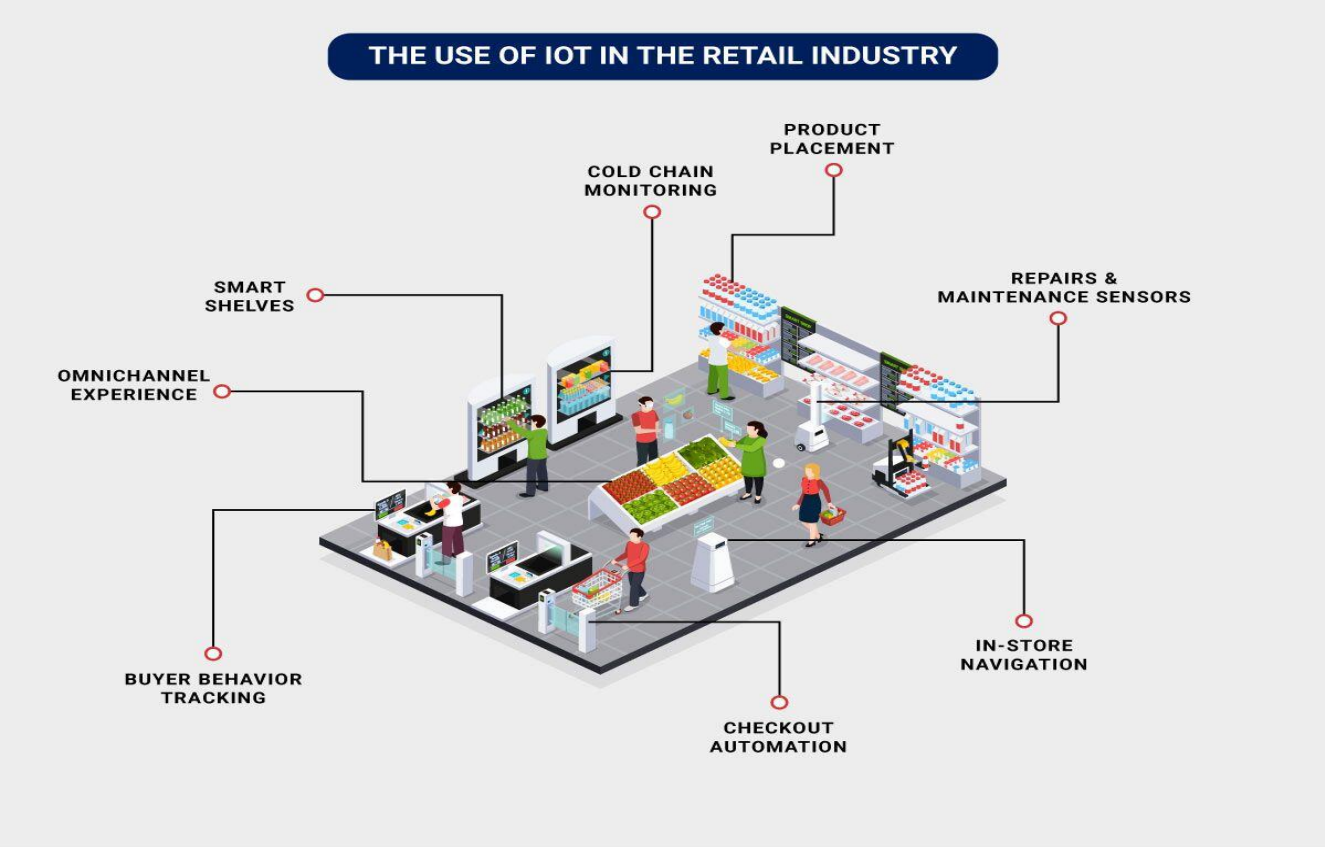
IoT-enabled technologies help in improving various factors such as effective monitoring of store space, proper inventory management and evaluation of customer behaviour. However, data security and high maintenance cost of IoT devices restrain growth of the market globally.

Benefits of IoT in Retail Industry:

1) Improves customer experience.
2) Improves floor management in-store.
3) Allows delivery of coupons and promotions on time.
4) Efficient inventory management.
5) Optimized supply chain management.

Use of IoT in Retail Industry:

1) **Smart Shelves:** IoT-enabled smart shelves automatically track inventory levels and detect when items need to be restocked. They can also display digital price tags and promotions, enabling dynamic pricing strategies and enhancing the in-store experience for customers.
2) **Cold Chain Monitoring:** Food spoilage in the grocery industry results in significant losses. Environmental sensors can be installed to track ambient conditions inside a food storage facility, cargo vessels and delivery vehicles to ensure food remains fresh and waste is reduced. They can help obtain precise data, like the temperature at which an item is being stored, how long it is spent in transit, etc. This information can help improve the quality of transportation for the goods in real-time – whether a product is being kept at temperatures too low or too high, avoiding a substantial loss.



3) **Product Placement:** Store managers can use the insights collected from sensors and video analytics to identify premium store areas. They can test the placement of different product types in other spots and determine the most profitable layout.
4) **Repairs and Maintenance Sensors:** Retailers can install commercial sensors for food storage facilities, parking sites and warehouses to track light, humidity, temperature and air quality. If any vital aspect is detected, an instant alert is triggered. Depending on the software, you can also generate reports to track trends and fluctuations over time and automate safety checks.
5) **In-store Navigation:** IoT devices with integrated technologies like Bluetooth, Wi-Fi, magnetic positions and augmented reality, etc., can facilitate in-store navigation to help customers navigate through the store and find the desired product.
6) **Checkout Automation:** Stores can use a variety of IoT Technologies, including motion-activated cameras, beacons and shelf-tracking tags, to provide a fully automated, cashier-less in-store shopping experience. Shoppers can walk in, pick the items they want, make the payment online, get a digital receipt on their smartphone and walk out.
7) **Buyer Behaviour Tracking:** IoT technology offers retailers valuable insights into buyer behaviour by providing real-time data on customer interactions with physical spaces, products and digital touchpoints IoT helps in tracking buyer behaviour in following way: food traffic analysis, dwell time analysis, customer journey mapping, product interaction tracking, personalised recommendations, queue management, customer feedback collection.

8) **Omnichannel Experience:** The increasing preference for online shopping has compelled retailers to blend in-store & virtual buying for a seamless experience. IoT devices make this possible by providing consumers with easy access to real-time stock availability in stores. Shoppers can load their carts online and try the products in-store. It ensures a hassle-free in-store experience with minimal time spent.

Examples of IoT in Retail Industry:

The Internet of Things in the retail industry has made significant advancements in retail, transforming traditional shopping experiences and driving operational efficiencies. From cashier-less stores to personalized shopping recommendations, IoT has revolutionized how retailers engage with customers and manage their operations. Here are a few examples of IoT in the retail industry, showcasing its diverse applications and impact:

1) **Amazon Go:** Amazon Go utilized IoT to create a seamless transaction process for their employees and customers. The tags attached to the products in their baskets are scanned automatically when the customer exists in the store. Smart tags act as an anti-theft prevention device while creating a smooth shopping experience
2) **Zara's RFID Inventory System:** Zara uses RFID tags to track inventory, providing real-time visibility into stock levels. This allows them to optimize inventory management, reduce out-of-stock situations, and improve operational efficiency.
3) **Walmart's Smart Shelves:** Walmart implemented IoT-enabled smart shelves that monitor inventory levels, track expiration dates and provide real-time updates. This system helps optimize product availability and reduce waste.

3.3 MEDIA

Introduction:

As the world becomes ever more integrated, IoT would help companies understand customers and their wants better, in turn allowing them to provide a smoother experience to the consumer. Companies could create detailed profiles for each customer, allowing them to personalise their content better and target ads.

The ability of IoT is to provide users with a personalised experience, advertisers with a much more accurate target and content creators with a bigger sandbox to create a more immersive experience makes it a profitable investment for media companies. During the COVID lockdowns, the soaring stock prices of media houses that adopted the IoT model, like Netflix, Hulu and HBOMax have proved that this is the future. The Internet of Things (IoT) in Media connects the digital and physical worlds.

It has four levels:

1) Data Acquisition
2) Data Consolidation
3) Data Hooks
4) Data Visibility

Impacts of IoT on Media Industry:

1) **Enhanced Content Creation:** IoT devices such as smart cameras and microphones enable media professionals to capture high-quality audio-visual content in various environments. This allows more immersive storytelling and the creation of compelling multimedia experiences.
2) **Improved Audience Engagement:** IoT-powered interactive experiences, such as augmented reality (AR) and virtual reality (VR) applications, provide viewers with more engaging and immersive content experiences.
3) **Personalized Content Delivery:** IoT devices and platforms collect data on user preferences, viewing habits and demographic information. Leveraging this data, media companies can deliver personalized content recommendations and targeted advertisements, enhancing the overall viewer experience and increasing audience satisfaction.
4) **Efficient Content Distribution:** IoT technology enables seamless content delivery across multiple channels and platforms. Smart TVs, streaming devices and set-top boxes equipped with IoT capabilities optimize bandwidth usage and ensure smooth streaming experiences for viewers, regardless of the device or network conditions.
5) **Real-Time Analytics and Insights:** IoT sensors collect data on audience behaviour, content consumption patterns and engagement metrics in real-time. Analysing this data provides media companies with valuable insights into audience preferences, content performance and trends that helps in data-driven decision-making and content optimization.
6) **Operational Efficiency:** IoT devices and solutions streamline media production workflows and enhance operational efficiency. Asset tracking and management systems powered by IoT technology enables efficient inventory management and maintenance scheduling, reduces downtime and improves resource utilization.
7) **Cost Savings:** IoT-enabled solutions optimize resource usage, reduce energy consumption and improve equipment maintenance practices, leading to cost savings for media companies. Predictive maintenance algorithms help to prevent equipment failures and minimize repair costs while energy management systems optimize energy usage and reduce utility expenses.
8) **Enhanced Security and Content Protection:** IoT-based surveillance cameras, access control systems and Digital Rights Management (DRM) solutions enhance security and protect valuable media assets. These solutions help prevent unauthorized access, piracy and content theft, ensuring the integrity and security of media content.
9) **New Revenue Streams:** IoT technology enables media companies to explore new revenue streams and business models. From subscription-based streaming services to targeted advertising and sponsored content partnerships, IoT-powered media platforms offer opportunities for monetization and revenue growth.

3.4 SUPPLY CHAIN

Introduction:

In the supply chain, Internet of Things devices are an effective way to track and authenticate products and shipments using GPS and other technologies. They can also monitor the storage conditions of products which enhances quality management throughout the supply chain. IoT devices have revolutionized Supply Chain Management (SCM). It's much easier to understand where goods are, how they are being stored and when they can be expected at a specific location.

Some examples of companies successfully using the power of IoT are Amazon, Volvo and Nissan Motor Co. Volvo uses IoT supply chain to track its vehicles' components from several countries and vehicle deliveries to its global customers. Nissan uses IoT supply chain to link its multiple industrial units. Amazon has been using a fleet of IoT-enabled robots to manage warehouse operations by scanning the QR code on packages. The role of IoT in supply chain management is vital for a business to grow.

Benefits of using IoT in Supply Chain Management:

1) Reassurance that goods are located where stakeholders say they are, both at rest and in motion.
2) Early identification of issues with goods getting lost or delayed.
3) Real-time shipment and inventory visibility and tracking.
4) Easier supply and demand planning as stakeholders know when they can expect to receive and process goods.
5) Better quality management due to keeping raw materials and processed goods in optimal conditions.
6) Efficient storage and distribution of products due to the easier location of goods in warehouses.

Examples of IoT Based Supply Chain Management:

1) **Walmart:** Walmart utilizes IoT sensors and RFID technology to track inventory levels in its stores in real-time. These sensors automatically monitor stock levels on shelves, triggering alerts when items need to be restocked. This ensures that shelves are consistently well-stocked, reducing out-of-stock situations and improving customer satisfaction.
2) **Maersk Line:** Maersk, one of the largest shipping companies globally, employs IoT technology to track and monitor shipping containers. IoT sensors installed in containers provide real-time information on location, temperature, humidity and other environmental conditions. This ensures the integrity of goods during transportation, particularly for perishable items and enables proactive management of any issues that may arise.
3) **Amazon:** Amazon utilizes IoT devices and technology in its warehouses to optimize inventory management and order fulfilment processes. IoT-enabled robots and conveyor systems automate tasks such as picking, packing and shipping that reduces the time and labour required for these operations. This enables Amazon to fulfil customer orders quickly and efficiently, even during peak demand periods.

4) **UPS:** UPS employs IoT technology to track and monitor its fleet of delivery vehicles. IoT sensors installed in vehicles collect data on factors such as location, speed, fuel consumption, and engine health. This data is analysed in real-time to optimize routes, schedule maintenance and improve fuel efficiency, ultimately reducing costs and enhancing service reliability.
5) **Coca-Cola:** Coca-Cola utilizes IoT technology to optimize its vending machine operations. IoT sensors installed in vending machines monitor inventory levels, sales data and machine health metrics in real-time. This enables Coca-Cola to ensure that machines are always stocked with the most popular beverages, anticipate maintenance needs and provide personalized marketing promotions to customers.
6) **DHL:** DHL (A global courier, package delivery and express mail service provider company named after its founder Dalsey, Hillblom and Lynn) uses IoT technology to offer end-to-end visibility and tracking of shipments throughout the supply chain. IoT devices installed in packages, vehicles and warehouses enable customers to track their shipments in real-time, from pickup to delivery. This transparency enhances customer satisfaction and enables DHL to provide proactive notifications in case of delays or issues.

Challenges of using IoT Based Supply Chain Management:

1) **Skill Gap:** The warehouse staff and vehicle drivers need to be trained and educated about the security practices and the guidelines for using corporate IoT-based supply chain management platforms.
2) **Data Storage Challenges:** The large pool of data that IoT systems generate is both a benefit and a challenge. There needs to be enough server power to store and process the collected data. In addition, there must be data governance policies to derive the right conclusions.
3) **Security Threats:** Before switching to fully connected systems, you need to have a secure IoT architecture. Vulnerabilities in data can result in outside attacks and leaks. By implementing machine learning (ML) and cryptographic hardware monitoring, managers can decrease security threats.
4) **Connectivity Issues:** IoT platforms and devices rely heavily on internet availability and other short distance technologies such as Bluetooth and NFC. As the internet coverage increases and 5G becomes available, this issue will resolve automatically.

3.5 ENVIRONMENTAL MONITERING

Introduction:

IoT environmental monitoring is a process that uses Internet of Things (IoT) technology to collect data about the environment, such as air quality, temperature and humidity levels.

The three main types of environmental monitoring are soil, atmosphere and water. IoT environment monitoring is used in a wide range of industries, from agriculture and forestry to urban planning, energy generation and distribution.

In the **Agricultural Sector,** IoT-based systems are used to monitor crops, soil health, water quality and weather conditions. This information can be used to inform decisions about pest control, fertilisation, irrigation and land management.

IoT-based systems in the **Energy Sector** are used to monitor emissions, air quality and weather conditions. Thus, helping public bodies, environmental agencies and companies to monitor and act to reduce negative environmental impact.

In **Urban Planning,** IoT-based systems can be used to monitor traffic congestion or air pollution levels in smart cities. This data can be used to inform decisions about how to reduce the environmental impacts of future urban development.

IoT based Environmental Monitoring is used for air quality monitoring, water quality monitoring, energy monitoring, commercial farming, toxic gas detection, animal conservation.

These IoT-based systems can be used to detect issues in the environment that are largely invisible, normalised or taken for granted.

Benefits of using IoT based Environmental Monitoring:

1) Improved understanding of the environment via data
2) Improved Efficiency
3) Increased Sustainability
4) Business Growth

Basic Steps of Environmental Monitoring using IoT:

1) **Observation (Monitor the Environment and Collect Data):** The first step in the environmental monitoring process is to observe and collect data. This involves using sensors or other IoT devices to measure factors such as air quality, temperature and humidity levels. These connected IoT devices gather data about the environment and transmit it to a central hub. From here, the data can be reviewed in real-time or used for further analysis off line.
2) **Analysis (Measure Data):** The next step is to analyse the data collected by IoT devices. This includes looking at trends over time, identifying areas of concern and any correlations between environmental variables, time of day, behaviours and the relationships between indoor and outdoor metrics. This data analysis can help businesses measure their environmental footprint and make informed decisions about how to reduce their environmental impact.
3) **Storage (Catalogue Data):** Once the data has been analysed, it needs to be stored so that it can be accessed in the future. IoT environmental monitoring systems make this easy by storing the data in a secure cloud-based database, allowing businesses to access the data whenever they need it and analyse how their environmental impact is changing over time.
4) **Action (Provide Actionable Insights from the Data and Analysis):** Finally, businesses need to be able to act based on the data that has been gathered and analysed. IoT-enabled environmental monitoring

systems can provide insights into how businesses can best reduce their environmental impact, such as by using renewable energy sources or introducing water conservation measures. These actionable insights may involve changing operational processes, implementing new technologies or even making changes to their overall business strategy.

Devices used for Environmental Monitoring:

1) **Sensors:** These measure air quality, temperature, humidity, light levels and other factors. They can also be used to detect chemical or water leaks.
2) **Data Loggers:** These record and store data over a set period of time. This can be used to measure changes in the environment over time or detect any sudden changes.
3) **GIS (Geographic Information System):** This combines mapping technology with real-time data to provide detailed visualisations of environmental conditions.
4) **Remote Monitoring Systems:** These systems allow users to monitor environmental conditions remotely and in real-time, providing timely insights into the state of their environment.
5) **Drone-based Systems:** Drones can be used to collect aerial data and conduct surveillance of an environment. This helps businesses monitor for potential problems or hazards, such as oil spills or illegal logging.
6) **IoT-Enabled Systems:** IoT-enabled systems collect data from multiple sources and provide a comprehensive view of the environment. These systems are used to measure long-term trends, identify areas of concern and monitor environmental changes over time.

3.6 INFRASTRUCTURE MANAGEMENT

Introduction:

Monitoring and controlling operations of urban and rural infrastructures like bridges, railway tracks, on and offshore wind-farms is a key application of the IoT. IoT devices can also be used to control critical infrastructure like bridges to provide access to ships. Usage of IoT devices for monitoring and operating infrastructure is likely to improve incident management and emergency response coordination and quality of service, up-times and reduce costs of operation in all infrastructure related areas.

Infrastructure Planning

Many cities and towns around the world are using IoT solutions to solve various urban problems, such as traffic congestion and to improve the safety and quality of life of their citizens. By placing IoT sensors in various parts of a city and on different kinds of infrastructure, cities can predict future resource needs and ensure that money is invested wisely.

Infrastructure Design

In order to prevent project delays, building firms have begun using Building Information Modelling (BIM). But during the COVID-19 lockdown, BIM has become increasingly important for firms to complete projects

on time. With COVID participants unable to physically meet at the site due to travel restrictions, BIM can be used to effectively design 'smart' infrastructure projects. Once a building is complete, data from IoT sensors can be pulled into BIM to help manage operations. Smart buildings can help keep energy usage patterns in check and regulate temperature trends when needed. The data can then be used to optimise future designs.

Infrastructure Sustainability

In order to reduce greenhouse gas emissions, construction field needs to adopt sustainable methods and practices. Sustainable designs do not mean just using eco-friendly, energy-efficient materials or relying on intelligent prefab technology but it involves creating an IoT network and allowing energy companies to drive greater efficiencies.

Infrastructure Construction

For example, cloud-based systems integrate information from the IoT to deliver key insights into projects, these systems allow diverse information to merge into a single broad platform so that decision-makers can manage a project more effectively. With so many processes simultaneously at play, these systems give decision-makers in infrastructure construction companies the power to monitor, track and analyse project performance 24/7. By reducing costs and reducing risks in each project, these systems increase profits for the companies.

Examples of IoT-based Infrastructure Management:

1) Smart Grids
2) Water Management Systems
3) Transportation and Traffic Management
4) Asset Tracking and Management
5) Building Automation Systems
6) Environmental Monitoring
7) Waste Management
8) Railway and Fleet Management
9) Smart City Infrastructure
10) Remote Monitoring and Control

3.7 MANUFACTURING

Introduction:

IoT connects consumers, manufacturers and products. The Internet of Things is a global technology that is transforming the industry and manufacturing sector.

Benefits of IoT in Manufacturing:

1) IoT recognize manufacturing delays and helps to identify the underlying causes.
2) Production units benefit majorly with automation of various processes in the manufacturing industry. This allows the maximum utilization of raw material and manufacturing components.
3) IoT leads to better allocation of resources. It allows users to shift their focus on clients and profits rather than worrying about tedious and time-consuming tasks.

IoT Applications in Manufacturing Industry:

1) Intelligent Product Enhancements
2) Dynamic Response to Market Demands
3) Improved Facility Service
4) Product Safety
5) Lower Costs, Optimized Resource Use and Waste Reduction
6) Quality Control
7) Predictive Maintenance
8) Inventory Management
9) Smart Packaging
10) Smart Metering
11) Supply Chain Management
12) Workshop Monitoring
13) Production Flow Monitoring
14) Digital Twins

3.8 PHARMACEUTICALS AND HEALTHCARE

Introduction:

In healthcare, IoT-based healthcare systems collect a variety of patient data and get inputs from doctors and medical professionals. All these devices can communicate with each other and take important actions that would provide timely help to save someone's life. The potential application of IoT in healthcare can improve a patient's health, healthcare employee productivity and hospital workflow.

Workflow of IoT Healthcare:

1) A sensor collects data from a patient, doctor or nurse inputs data.
2) AI-driven algorithms like Machine Learning (ML) are used to analyse the collected data.
3) The device decides whether to act or send the information to the cloud.
4) Doctors or health practitioners can make actionable and informed decisions based on the data provided by IoT healthcare solutions.

Advantages of IoT in Healthcare:

1) Research
2) Remote Medical Assistance
3) Tracking & Alerts
4) Simultaneous Reporting & Monitoring
5) Data Assortment & Analysis
6) End to End Connectivity & Affordability

Challenges of IoT in Healthcare:

1) Data Security & Privacy
2) Integrating Multiple Devices
3) Data Overload & Accuracy
4) Cost

Applications of IoT in Healthcare:

1) **Hearables:** Hearables are new-age hearing aids which have completely transformed the way people who suffered hearing loss interact with the world. Nowadays, hearables are compatible with Bluetooth which syncs your smartphone with it. It allows you to filter, equalize and add layered features to real-world sounds.
2) **Ingestible Sensors:** They are pill-sized sensors which monitor the medication in our body and warn us if it detects any irregularities in our bodies. These sensors can be a boon for a diabetic patient as would help in reducing/controlling occurrence or severity of symptoms and provide an early warning for critical health issues.
3) **Moodables:** Moodables are mood-enhancing devices which help in improving our mood throughout the day. Moodables are head-mounted wearables that send low-intensity currents to the brain which elevates our mood.
4) **Healthcare Charting:** IoT devices such as Audemix reduce much manual work which a doctor has to do during patient charting. It is powered by voice commands and captures the patient's data. It makes the patient's data readily accessible for review.
5) **Insulin Pens & Smart CGM (Continuous Glucose Monitor):** These devices are used for the real-time monitoring of blood glucose levels and data sharing over a dedicated mobile app. Patients with diabetes can use these devices to track their glucose levels and even send this data to their doctor and the relevant medical staff.
6) **Smart Video Pills:** A smart pill travels through a patient's intestinal tract to take its clear-cut picture. It can then send those pictures to a wearable device that is connected with dedicated medical applications. Smart pills are also helpful to visualize the gastrointestinal tract and colon remotely.

IoT Future Predictions in Health Care:

1) **Personalized Healthcare:** IoT devices will allow for real-time collection of health data, which can then be used to create tailored treatment plans for individual patients. This will lead to more effective treatment and better outcomes for patients.
2) **Remote Patient Monitoring:** With IoT, patients can be monitored remotely, allowing healthcare providers to keep track of their conditions and intervene when necessary. This will result in fewer hospital visits and readmissions, which will ultimately reduce healthcare costs.
3) **Predictive Maintenance:** IoT devices will help healthcare providers predict equipment failures and maintenance needs, ensuring that they can provide uninterrupted care to patients.
4) **Telemedicine:** Telemedicine services will be enabled by IoT devices, allowing patients to consult with doctors remotely. This will be especially useful for patients who live in remote areas or have mobility problems.

3.9 TRANSPORTATION

Introduction:

Internet of Things (IoT) has crucial applications in the transportation system. IoT plays an important role in all the field of transportation as air-transportation, water-transportation and land transportation. All the component of these transportation fields is built with smart devices (sensors, processors) and interconnected through cloud server or different servers that transmit data to networks.

IoT in transportation is not only for traveling from one place to another, but it also makes safer, greener and more convenient. For example, a smart car performs work simultaneously such as navigation, communication, entertainment, efficient and more reliable travel. IoT facilitates travellers to remain seamlessly connected to

every means of travel. The vehicle is connected with the variety of wireless standards to the internet such as Bluetooth, Wi-Fi, 3G, 4G, intelligent traffic system and even to other vehicles. Smart Traffic Management in Barcelona (Spain), Fleet Management with UPS, Smart Parking in San Francisco (USA), Connected Vehicles by Tesla, Smart Public Transportation in Singapore, Cargo Tracking with Maersk Line, etc are some real-world examples of IoT-based Transportation.

Applications of IoT in Transportation:

1) **Automated Toll and Ticketing:** The traditional tolling and ticketing systems are not only becoming outdated but they are also not proving to be effective for assisting the current flow of vehicles on the road. With the increased number of vehicles on the road, the toll booths have become busy and crowded as well on the highways and the drivers have to spend a lot of time waiting for their turn. The toll booths do not have enough resources and manpower to immediately assist many vehicles. Compared to traditional tolling and ticketing systems, IoT in transportation offers automated tolls. With the help of RFID tags and other smart sensors, managing toll and ticketing have become much easier for traffic police officers.

   The majority of advanced vehicles nowadays have IoT connectivity. Any vehicle which might be a kilometre away from the tolling station can easily be detected with the help of IoT technologies. This enables the lifting of the traffic barriers for the vehicles to pass through. However, the older vehicles do not have IoT connectivity, but the smartphones of the car owners can serve the same purpose as well, that is, taking automatic payments through phones linked to the digital wallet. This indicates that IoT in transportation is much more flexible and is compatible with new vehicles and demonstrate easy integration with older vehicles as well, for automated toll and ticketing procedures.

2) **Advanced Vehicle Tracking/ Transportation Monitoring:** Vehicle tracking or transportation monitoring systems have become the need of many businesses to manage their fleets and supply chain processes effectively. With the help of GPS trackers, transportation companies have smooth access to real-time location, facts and figures about the vehicle. This enables the transportation companies to

monitor their important assets in real-time. Apart from location monitoring, IoT devices can also monitor the driver's behaviour and can inform about the driving style and idling time. In fleet management systems, IoT has minimized the operating and fuel expenditures along with the cost of maintenance. As far as transportation monitoring is concerned, then it can be said that real-time tracking has made the implementation of smart decisions much easier, enabling the drivers to identify the issues in the vehicle immediately and take precautions where necessary.

3) Smart Traffic Management

4) Connected Vehicles

5) Public Transportation Management

6) Smart Parking Solutions

7) Cargo Tracking and Monitoring

8) Environmental Monitoring

9) Supply Chain Optimization

Advantages of IoT-based Transportation:

1) Reduced Environmental Impact
2) Better Customer Experience
3) Improved Safety
4) Improved Facilities
5) Real Time Monitoring and Tracking
6) Optimized Operations and Efficiency
7) Supply Chain Visibility and Transparency
8) Smart Infrastructure and Urban Planning