Introduction to Internet of Things

Internet of things (IoT)

The Internet of things (IoT) is the inter-networking of physical devices, vehicles (also referred to as

“connected devices” and “smart devices”), buildings, and other items embedded with electronics,

software, sensors, actuators, and network connectivity which enable these objects to collect and

exchange data.

Characteristics:

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

Connectivity: Things in I.O.T. should be connected to the infrastructure, without connection nothing

makes sense.

Intelligence: Extraction of knowledge from the generated data is important, sensor generate data

and this data and this data should be interpreted properly.

Scalability: The no. of things getting connected to the I.O.T. infrastructure is increased day by day.

Hence, an IOT setup shall be able to handle the massive expansion.

Unique Identity: Each IOT device has an I.P. address. This identity is helpful in tracking the

equipment and at times to query its status.

Dynamic and Self-Adapting: The IOT device must dynamically adopt itself to the changing context.

Assume a camera meant for surveillance, it may have to work in different conditions and at different

light situations (morning, afternoon, night).

Heterogeneity: The devices in the IoT are heterogeneous as based on different hardware platforms

and networks. They can interact with other devices different networks.

Safety: Having got all the things connected with the Internet possess a major threat, as our personal

data is also there and it can be tampered with, if proper safety measures are not taken.

Application areas of IoT:

Smart Home: The smart home is one of the most popular applications of IoT. The cost of owning a

house is the biggest expense in a homeowner’s life. Smart homes are promised to save the time,

money and energy.

Smart cities: The smart city is another powerful application of IoT. It includes smart surveillance,

environment monitoring, automated transformation, urban security, smart traffic management, water

distribution, smart healthcare etc.

Wearables: Wearables are devices that have sensors and software installed which can collect data

about the user which can be later used to get the insights about the user. They must be energy

efficient and small sized.

Connected cars: A connected car is able to optimize its own operation, maintenance as well as

passenger’s comfort using sensors and internet connectivity.

Smart retail: Retailers can enhance the in-store experience of the customers using IoT. The

shopkeeper can also know which items are frequently bought together using IoT devices.

Smart healthcare: People can wear the IoT devices which will collect data about user's health. This

will help users to analyze themselves and follow tailor-made techniques to combat illness. The doctor

also doesn't have to visit the patients in order to treat them.

IoT Categories

IOT can be classified into two categories:

1. Consumer IoT(CIOT): The Consumer IoT refers to the billions of physical personal devices, such

as smartphones, wearables, fashion items and the growing number of smart home appliances, that are now connected to the internet, collecting and sharing data.

A Consumer IoT network typically entails few consumer devices, each of which has a limited lifetime of several years.

The common connectivity used in this kind of solutions are Bluetooth, WiFi, and ZigBee. These technologies offer short-range communication, suitable for applications deployed in limited spaces such as houses, or small offices.

2. industrial internet of things (IIoT): It refers to interconnected sensors, instruments, and other devices networked together with computers' industrial applications, including manufacturing and energy management. This connectivity allows for data collection, exchange, and analysis, potentially facilitating improvements in productivity and efficiency as well as other economic ben

BASELINE TECHNOLOGIES

There are various baseline technologies that are very closely related to IOT, They include: Machineto-Machine (M2M), Cyber-Physical Systems (CPS), Web Of Things(WOT)

a) Machine-to-Machine (M2M):

 Machine-to-Machine (M2M) refers to networking of machines (or devices) for the purpose of remote monitoring and control and data exchange.

 An M2M area network comprises of machines (or M2M nodes) which have embedded network modules for sensing, actuation and communicating various communication protocols can be used for M2M LAN such as ZigBee, Bluetooth, M-bus, Wireless M-Bus etc., These protocols provide connectivity between M2M nodes within an M2M area network.

 The communication network provides connectivity to remote M2M area networks. The communication network provides connectivity to remote M2M area network.

 The communication network can use either wired or wireless network (IP based). While the M2M are networks use either proprietary or non-IP based communication protocols, the communication network uses IP-based network. Since non-IP based protocols are used within M2M area network, the M2M nodes within one network cannot communicate with nodes in an external network.

 To enable the communication between remote M2M are network, M2M gateways are used

b) Cyber-Physical systems:

Cyber-Physical Systems (CPS) are integrations of computation, networking, and physical processes.

Embedded computers and networks monitor and control the physical processes, with feedback loops

where physical processes affect computations and vice versa.

In cyber-physical systems, physical and software components are deeply intertwined, able to operate

on different spatial and temporal scales, exhibit multiple and distinct behavioural modalities, and

interact with each other in ways that change with context.

c) Web of Things: web of things is a term used to describe approaches, software architectural style

of programming patterns that allow real world objects to be part of WWW. The major portion of the

WoT specification is the Thing Description. Thing is an abstract representation of a physical or virtual

entity. A Thing Description includes the metadata and interfaces of a Thing in a standardized way,

with the aim to make the Thing able to communicate with other Things in a heterogeneous world.

SENSOR

Sensor is a device used for the conversion of physical events or characteristics into the electrical

signals. This is a hardware device that takes the input from environment and gives to the system by

converting it.

For example, a thermometer takes the temperature as physical characteristic and then converts it

into electrical signals for the system.

Characteristics of Sensors

1. Range: It is the minimum and maximum value of physical variable that the sensor can sense or

measure. For example, a Resistance Temperature Detector (RTD) for the measurement of

temperature has a range of -200 to 800oC.

2. Span: It is the difference between the maximum and minimum values of input. In above example,

the span of RTD is 800 – (-200) = 1000oC.

3. Accuracy: The error in measurement is specified in terms of accuracy. It is defined as the

difference between measured value and true value. It is defined in terms of % of full scale or % of

reading.

4. Precision: It is defined as the closeness among a set of values. It is different from accuracy.

5.Linearity: Linearity is the maximum deviation between the measured values of a sensor from ideal

curve.

6.Hysteresis: It is the difference in output when input is varied in two ways- increasing and

decreasing.

7. Resolution: It is the minimum change in input that can be sensed by the sensor.

8. Reproducibility: It is defined as the ability of sensor to produce the same output when same input

is applied.

9. Repeatability: It is defined as the ability of sensor to produce the same output every time when the

same input is applied and all the physical and measurement conditions kept the same including the

operator, instrument, ambient conditions etc.

10. Response Time: It is generally expressed as the time at which the output reaches a certain

percentage (for instance, 95%) of its final value, in response to a step change of the input.

Classification of sensors:

Sensors based on the power requirement sensor is classified into two types: Active Sensors, Passive

Sensors.

Active Sensors: Does not need any external energy source but directly generates an electric signal

in response to the external.

Example: Thermocouple, Photodiode, Piezoelectric sensor.

Passive Sensors: The sensors require external power called excitation signal. Sensors modify the excitation signal to provide output.

Example: Strain gauge.

Sensors based on output sensor is classified into two types: Analog Sensors, Digital Sensors.

Analog Sensors

 Analog Sensors produces a continuous output signal or voltage which is generally proportional to the quantity being measured.

 Physical quantities such as Temperature, speed, Pressure, Displacement, Strain etc. are all analog quantities as they tend to be continuous in nature.

 For example, the temperature of a liquid can be measured using a thermometer or thermocouple (e.g. in geysers) which continuously responds to temperature changes as the liquid is heated up or cooled down.

Digital Sensors

 Digital Sensors produce discrete output voltages that are a digital representation of the quantity being measured.

 Digital sensors produce a binary output signal in the form of a logic "1" or a logic "0" , ("ON" or "OFF).

 Digital signal only produces discrete (non-continuous) values, which may be output as a signal "bit" (serial transmission), or by combing the bits to produce a signal "byte" output (parallel transmission).

Based on type of data measured sensor is classified into two types: Scalar Sensors and Vector Sensors.

Scalar Sensors

 Scalar Sensors produce output signal or voltage which generally proportional to the magnitude of the quantity being measured.

 Physical quantities such as temperature, color, pressure, strain, etc. are all scalar quantities as only their magnitude is sufficient to convey an information.

 For example the temperature of a room can be measured using thermometer or thermocouple, which responds to temperature changes irrespective of the orientation of the sensor or its direction.

Vector Sensors

 Vector Sensors produce output signal or voltage which generally proportional to the magnitude, direction, as well as the orientation of the quantity being measured.

 Physical quantities such as sound, image, velocity, acceleration, orientation, etc. are all vector quantities, as only their magnitude is not sufficient to convey the complete information.

 For example, the acceleration of a body can be measured using an accelerometer, which gives the components of acceleration of the body with respect to the x,y,z coordinate axes.

ACTUATOR

Actuator is a device that converts the electrical signals into the physical events or characteristics. It

takes the input from the system and gives output to the environment. For example, motors and heaters are some of the commonly used actuators.

Types of Actuators

1. Hydraulic Actuators: Hydraulic actuators operate by the use of a fluid-filled cylinder with a piston

suspended at the centre. Commonly, hydraulic actuators produce linear movements, and a spring is

attached to one end as a part of the return motion. These actuators are widely seen in exercise equipment such as steppers or car transport carriers.

2. Pneumatic Actuators: Pneumatic actuators are one of the most reliable options for machine motion. They use pressurized gases to create mechanical movement. Many companies prefer

pneumatic-powered actuators because they can make very precise motions, especially when starting and stopping a machine. Examples of equipment that uses pneumatic actuators include: Bus brakes,

Exercise machines, Vane motors, Pressure sensors

3.Electric Actuators : Electrical actuators, as you may have guessed, require electricity to work.

Well-known examples include electric cars, manufacturing machinery, and robotics equipment.

Similar to pneumatic actuators, they also create precise motion as the flow of electrical power is

constant.

4.Thermal and Magnetic Actuators : Thermal and magnetic actuators usually consist of shape

memory alloys that can be heated to produce movement. The motion of thermal or magnetic

actuators often comes from the Joule effect, but it can also occur when a coil is placed in a static

magnetic field. The magnetic field causes constant motion called the Laplace-Lorentz force. Most

thermal and magnetic actuators can produce a wide and powerful range of motion while remaining

lightweight.

5.Mechanical Actuators : Some actuators are mostly mechanical, such as pulleys or rack and pinion

systems. Another mechanical force is applied, such as pulling or pushing, and the actuator will

leverage that single movement to produce the desired results. For instance, turning a single gear on a

set of rack and pinions can mobilize an object from point A to point B. The tugging movement applied

on the pulley can bring the other side upwards or towards the desired location.

6. Soft Actuators: Soft actuators (e.g. polymer based) are designed to handle fragile objects like fruit

harvesting in agriculture or manipulating the internal organs in biomedicine.

They typically address challenging tasks in robotics. Soft actuators produce flexible motion due to the

integration of microscopic changes at the molecular level into a macroscopic deformation of the

actuator materials.

IOT COMPONENTS

Four fundamental components of IoT system, which tells us how IoT works.

i. Sensors/Devices

First, sensors or devices help in collecting very minute data from the surrounding environment. All of

this collected data can have various degrees of complexities ranging from a simple temperature

monitoring sensor or a complex full video feed.

A device can have multiple sensors that can bundle together to do more than just sense things. For

example, our phone is a device that has multiple sensors such as GPS, accelerometer, camera but

our phone does not simply sense things.

ii. Connectivity

Next, that collected data is sent to a cloud infrastructure but it needs a medium for transport.

The sensors can be connected to the cloud through various mediums of communication and

transports such as cellular networks, satellite networks, Wi-Fi, Bluetooth, wide-area networks (WAN),

low power wide area network and many more.

iii. Data Processing

Once the data is collected and it gets to the cloud, the software performs processing on the acquired

data.

This can range from something very simple, such as checking that the temperature reading on

devices such as AC or heaters is within an acceptable range. It can sometimes also be very complex,

such as identifying objects (such as intruders in your house) using computer vision on video.

iv. User Interface

Next, the information made available to the end-user in some way. This can achieve by triggering

alarms on their phones or notifying through texts or emails.

Also, a user sometimes might also have an interface through which they can actively check in on their

IOT system. For example, a user has a camera installed in his house, he might want to check the video recordings and all the feeds through a web server.

Service Oriented Architecture of IoT

SOA can also use to support IoT as a main contributing technology in devices or heterogeneous systems.

1.Sensing Layer: IoT can be defined as a worldwide interconnected network, where things or devises are controlled remotely. Interconnected things or devices are become easier, as more and more things are furnished with sensors and RFID technologies.

2.Networking Layer: Networking Layer is responsible to connect all device or things together so that

they can able to share the information with each other over the Internet. Moreover, network layer also

collects data and information from the present IT infrastructure for example ICT systems, power grids,

business systems, healthcare systems, and transportation systems.

3. Service Layer: This layer depends upon the technology used on the middleware layer which is

responsible for functionalities incorporate between applications and services in IoT. This middleware

technology also provides a cost-effective and efficient platform for IoT and this platform including

software and hardware components which can be reused when needed.

4. Interface Layer: The core responsibility of the interface layer has also simplified the

interconnection and management of things. Interface specific profile can be defined as the subset of

services that support interaction with the application used in a network

Challenges for IoT

1. Security: Security is the most significant challenge for the IoT. Increasing the number of connected

devices increases the opportunity to exploit security vulnerabilities, as do poorly designed devices,

which can expose user data to theft by leaving data streams inadequately protected and in some cases people’s health and safety can be put at risk.

2. Privacy: The IoT creates unique challenges to privacy, many that go beyond the data privacy

issues that currently exist. Much of this stems from integrating devices into our environments without

us consciously using them. This is becoming more prevalent in consumer devices, such as tracking

devices for phones and cars as well as smart televisions.

3. Scalability: Billions of internet-enabled devices get connected in a huge network, large volumes of

data are needed to be processed. The system that stores, analyses the data from these IoT devices

needs to be scalable.

4. Interoperability: Technological standards in most areas are still fragmented. These technologies

need to be converged. Which would help us in establishing a common framework and the standard

for the IoT devices. As the standardization process is still lacking, interoperability of IoT with legacy

devices should be considered critical. This lack of interoperability is preventing us to move towards

the vision of truly connected everyday interoperable smart objects.

5. Bandwidth: Connectivity is a bigger challenge to the IoT than you might expect. As the size of the

IoT market grows exponentially, some experts are concerned that bandwidth-intensive IoT

applications such as video streaming will soon struggle for space on the IoT’s current server-client

model.

6. Standards: Lack of standards and documented best practices have a greater impact than just

limiting the potential of IoT devices. Without standards to guide manufacturers, developers sometimes

design products that operate in disruptive ways on the Internet without much regard to their impact. If poorly designed and configured, such devices can have negative consequences for the networking

resources they connect to and the broader Internet.

7. Regulation: The lack of strong IoT regulations is a big part of why the IoT remains a severe

security risk, and the problem is likely to get worse as the potential attack surface expands to include

ever more crucial devices. When medical devices, cars and children's toys are all connected to the

Internet, it's not hard to imagine many potential disaster scenarios unfolding in the absence of

sufficient regulation

PROJECT DESIGN THINKING

In recent decades the number of vehicles on the world's roads has continued to increase. However, road capacity does notdevelop at the same rate, which generates a considerably increased congestion rate. To minimize this difficult problem, the researchers opted for intelligent and efficient use of existing infrastructure through adaptive traffic management. The various recent proposed approaches have been based on new technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and Big Data.

Traffic Management
Problem statement:
★Smart Traffic Management issues: Implementing technology like traffic cameras and sensors to monitor and control traffic in real-time.
Solution: Smart Traffic Management: Implementing technology like traffic cameras and sensors to monitor and control traffic in real-time.Road Design: Designing roads with appropriate capacity and safety features.Traffic Education: Educating the public about safe driving and alternative transportation options.
★Road Design issues: Designing roads with appropriate capacity and safety features.
solution: Widening Roads or Adding LanesExpanding road capacity by adding extra lanes or widening existing ones can alleviate congestion.
Design Thinking:
Understand the needs and pain points of commuters, pedestrians, cyclists, and drivers.Conduct surveys, interviews, and observations to gather insights into their experiences and frustrations

with traffic.Clearly define the specific traffic management problem you want to address. For example, it could be reducing congestion at a particular intersection during rush hours.Create a detailed problem statement that includes the key issues and challenges.Brainstorm potential solutions to the defined problem. Encourage creativity and diverse perspectives.Consider both high-tech and low-tech solutions, and don't dismiss any ideas at this stage.

Project idea:

A smart traffic management idea that combines technology and data-driven approaches to improve traffic flow and reduce congestion:

Traffic Flow Prediction and Dynamic Routing System

Project Objectives:

1. Real-time Traffic Monitoring: At the heart of this project is the establishment of a comprehensive traffic monitoring system, utilizing sensors, cameras, and data analytics to provide real-time insights into traffic conditions. This system will enable accurate, up-to-the-minute information for commuters and authorities alike.

2. Traffic Optimization Algorithms: We will develop advanced traffic optimization algorithms that take into account traffic patterns, congestion hotspots, and public transportation schedules. These algorithms will help reduce traffic bottlenecks, minimize travel times, and lower fuel consumption.

3. Integration of Smart Infrastructure: Collaborating with local municipalities, we will integrate smart infrastructure components such as adaptive traffic signals, variable message signs, and synchronized traffic light systems to improve traffic flow and reduce congestion.

4. Public Transportation Integration: Our project aims to enhance public transportation systems' efficiency and accessibility. By integrating public transport schedules and routes with the traffic management system, we will encourage more sustainable commuting options.

5. Safety Enhancements: Safety is a paramount concern. We will implement features such as pedestrian crosswalk optimization, real-time accident detection, and emergency vehicle prioritization to improve road safety for all users.

6. Data Accessibility: To empower both city planners and the public, we will create user-friendly interfaces and mobile applications that provide access to real-time traffic data, alternative routes, and travel recommendations.

7.Environmental Impact Reduction: By reducing congestion and optimizing traffic,we aim to lower emissions and contribute to a cleaner urban environment.

This project represents a collaborative effort among transportation experts, urban planners, data scientists, and local government authorities, all committed to creating smarter, more efficient urban transportation systems.

Through the implementation of an intelligent traffic management system, we envision cities that are more livable, sustainable, and economically vibrant.

As urbanization continues to grow, this project serves as a beacon of innovation, demonstrating how technology and data-driven solutions can revolutionize urban mobility, reduce stress, and improve the overall quality of life for urban residents.