INTERNET OF THINGS

UNIT – 1

CHAPTER – 1

INTRODUCTION TO IoT

I. DEFINITION AND CHARACTERISTICS OF IoT

DEFINITION

A dynamic global network infrastructure with self–configuring based on standard and interoperable communication protocols where physical and virtual “things” have identified, physical attributes, and virtual personalities and use intelligent interfaces, often communicate data associated with users and their environment

II. CHARACTERISTICS OF IoT

Dynamic and self-Adapting: IoT devices and systems may have the capability to dynamically adapt with the changing contexts and take actions based on their operating condition. Ex: Surveillance cameras can adapt their modes based on whether it is day or night.

Self – Configuring: IoT devices may have self-Configuring capability allowing a large number of devices to work together to provide certain functionality. Ex: In a weather monitoring system, sensors placed across a large area use natural energy sources and receive remote updates or instructions from a central server, reducing the need for manual visits to update them.

Interoperable communication protocols: IoT devices can communicate with each other and with infrastructure using various interoperable communication protocols.

Unique Identity: Each IoT device possesses a distinct identity and identifier, such as an IP address or URI. Additionally, IoT systems feature intelligent interfaces that adjust according to context, facilitating communication with users and environmental factors.

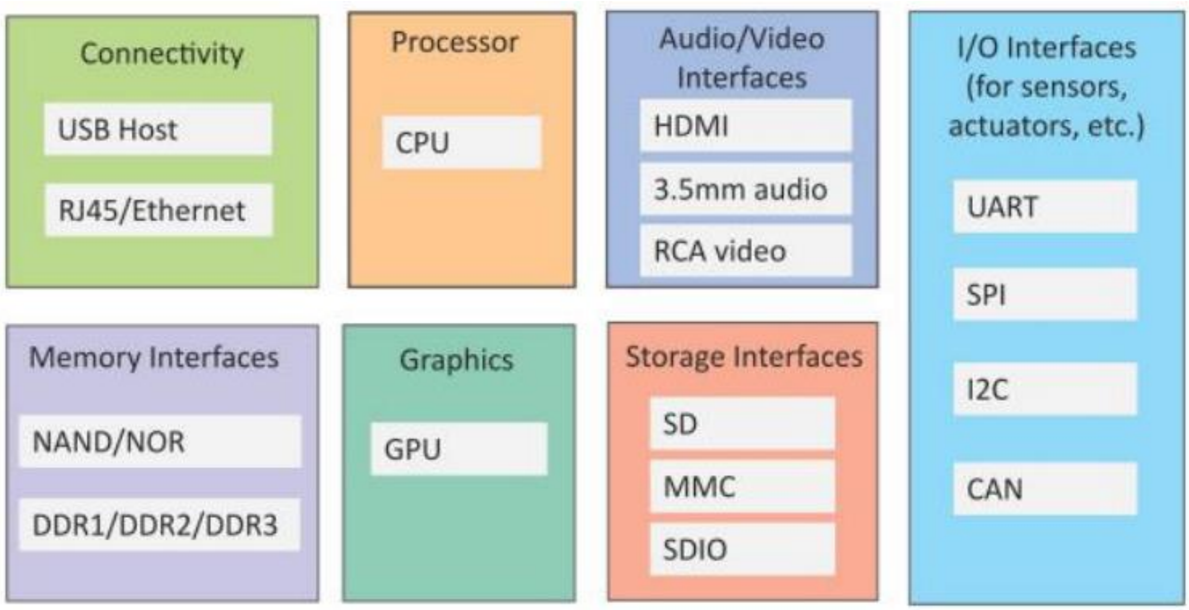
Integrated into information network: IoT devices are usually integrated into the information network that allows them to communicate and exchange data with other devices and systems.

Ex: When a weather monitoring node shares its abilities with another connected node, they can exchange data, enhancing IoT systems by combining device intelligence with infrastructure, which allows the aggregation and analysis of data from numerous weather monitoring nodes to predict the weather.

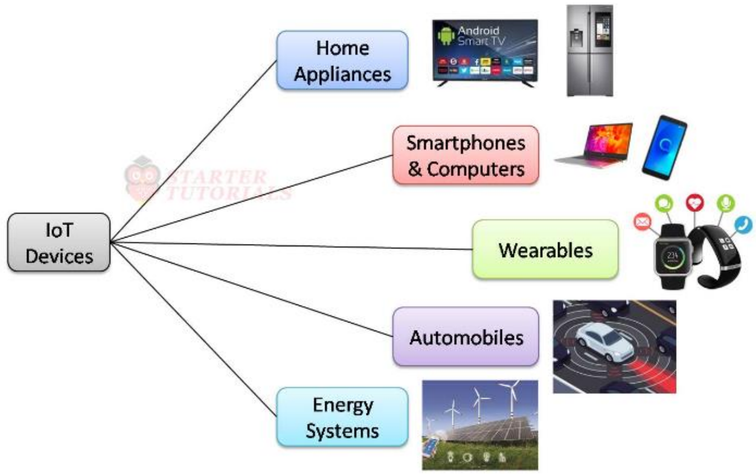
III. PHYSICAL DESIGN OF IoT

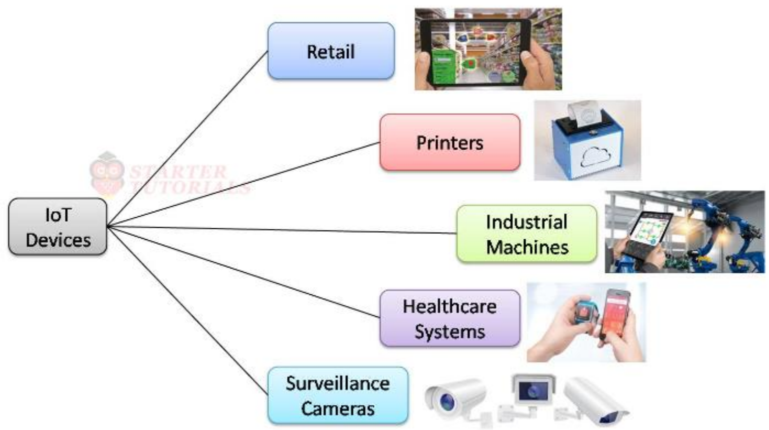
1) Things of IoT

- In IoT, "Things" are devices with unique identities that can sense, actuate, and monitor remotely. They share data with other connected devices and applications, either directly or indirectly. "Things" collect data from other devices and can process it locally or send it to centralized servers or cloud-based applications for further processing. They operate within constraints like memory, processing power, communication speed, and deadlines in the IoT infrastructure.
- IoT devices can connect to other devices through interfaces like sensors, the internet, memory, and audio-video connections, and they collect various data types such as temperature, humidity, and light intensity from onboard or attached sensors.

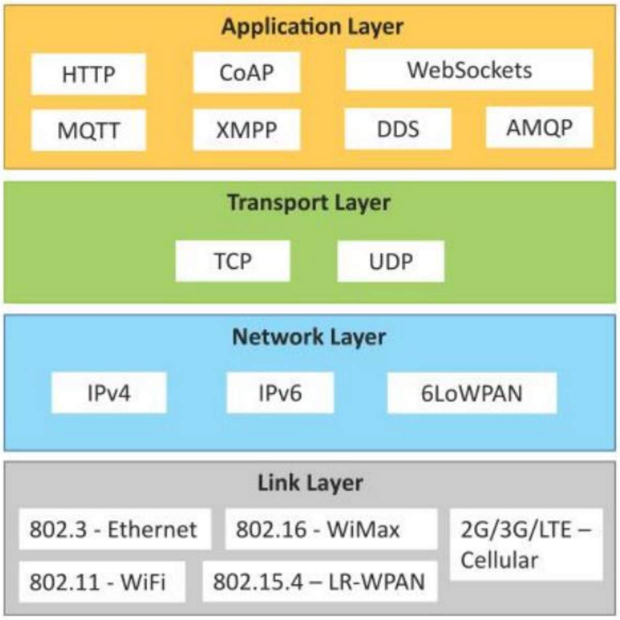


- IoT devices can also be varied types, for instance, wearable sensors, smart watches, LED light automobiles and industrial machines





2) <u>IoT Protocol</u>



Link Layer

The Link Layer protocol manages the physical transmission of data over the network's medium and facilitates communication between hosts within the local network connection by encoding and signaling packets through hardware devices.

802.3 Ethernet:

802.3 Ethernet encompasses various wired standards for the link layer, like 10BASE5 Ethernet using coaxial cable and 802.3.i for 10 BASET Ethernet over twisted copper pairs, offering data rates from 10 Mb/s to 40 gigabits per second or more. The shared medium, which can be coaxial cable, twisted pair wire, or optical fiber, facilitates communication among all network devices

802.1- WI-FI:

IEEE 802.11 is a set of wireless Local Area Network (WLAN) standards that define the link layer. Variants like 802.11a, 802.11b, 802.11g, and 802.11ac operate in different frequency bands—802.11a in the 5 GHz band, and 802.11b, 802.11g, and 802.11ac in the 2.4 GHz and 5 GHz bands.

802.16 WIMAX:

IEEE 802.16, also known as WiMAX, comprises wireless broadband standards with detailed link layer descriptions. WiMAX offers data rates ranging from 1.5 Mb/s to 1 Gb/s, with recent updates delivering speeds of hundreds of megabits per second for mobile stations

802.15.4 LR-WPAN:

IEEE 802.15.4 sets standards for Low Rate Wireless Personal Area Networks (LR-WPAN), forming the basis for protocols like Zigbee, with data rates beginning at 40 kb/s, ideal for affordable, low-speed communication suited to power-constrained devices.

2G / 3G / 4G mobile communications:

These are the different generations of mobile communication standards including second generation (2G including GSM and CDMA). 3rd Generation (3G including UMTS and CDMA2000) and 4th generation 4G including LTE.

Network / internet layer :

The network layer is responsible for sending IP data grams from the source network to the destination network, handling host addressing and packet routing using hierarchical IP addressing schemes like IPv4 or IPv6.

IPv4, the most widely deployed internet protocol, identifies devices on a network using hierarchical addressing schemes, utilizing a 32-bit address format capable of accommodating up to 2^32 addresses. Due to the increasing number of connected devices, IPv4 has been succeeded by IPv6.

IPv6: It is the newest versions of internet protocol and successor to IPv4. IPv6 uses 128 bit address schemes that are lost total of 2 128 are 3.4* 10 38 address.

6LoWPAN brings IPv6 protocol to low-power devices with limited processing capabilities, operating in the 2.4 GHz frequency range and providing data transfer rates of up to 50 kb/s.

Transport Layer:

The Transport layer protocols offer end-to-end message transfer capability regardless of the underlying network, establishing connections with or without handshake acknowledgement. They include functions like error control, segmentation, flow control, and congestion control.

UDP, in contrast to TCP, functions as a connection-less protocol, ideal for time-sensitive applications needing swift data exchange without connection setup. It operates in a transaction-oriented, stateless manner, without ensuring guaranteed delivery, message ordering, or duplicate elimination.

Application layer :

The application layer protocol facilitates the transmission of data between applications by encoding files and encapsulating them within the transport layer protocol, establishing process-to-process connections via ports.

HTTP (Hyper text transfer protocol): is an application layer protocol used for the World Wide Web, allowing clients to send requests to servers using commands like GET, PUT, POST, DELETE, HEAD, TRACE, and OPTIONS, operating on a stateless request-response model, and clients can include web browsers, IoT devices, mobile applications, or other software.

CoAP (Constrained Application Protocol): is designed for machine-to-machine applications in restricted environments, employing a request-response model over UDP, featuring a client-server architecture using connection-less datagrams, and supporting HTTP-like methods such as GET, PUT, and DELETE.

WebSocket: protocol allows bidirectional communication over a single socket connection, letting clients and servers exchange messages seamlessly. It's based on TCP and keeps the connection open for continuous message exchange, catering to various clients like browsers, mobile apps, and IoT devices for real-time

MQTT(Message Queuing Telemetry Transport): is a lightweight protocol using a publish-subscribe model where IoT devices connect to an MQTT broker to publish messages to topics, which are then forwarded to subscribed clients. Its efficiency and simplicity make MQTT well-suited for constrained environments.

XMPP(Extensible Messaging and Presence Protocol):enables real-time communication and XML data streaming between network entities, supporting applications like messaging, presence, gaming, multiparty chat, and voice calls, while facilitating the transmission of small XML data chunks in real time across both client-to-server and server-to-client communication paths.

DDS (Data Distribution Service): facilitates machine-to-machine communication through a publish-subscribe model, where publishers create topics for subscribers to receive data, offering quality of service (QoS) control and configurable reliability for effective communication.

AMQP (Advanced Message Queuing Protocol): enables business messaging with support for routing and queuing through both point-to-point and publish-subscribe models. Brokers in AMQP receive messages from publishers and deliver them to consumers over connections. Publishers transmit messages to exchanges, which then distribute copies to queues.

IV. Logical design of IoT

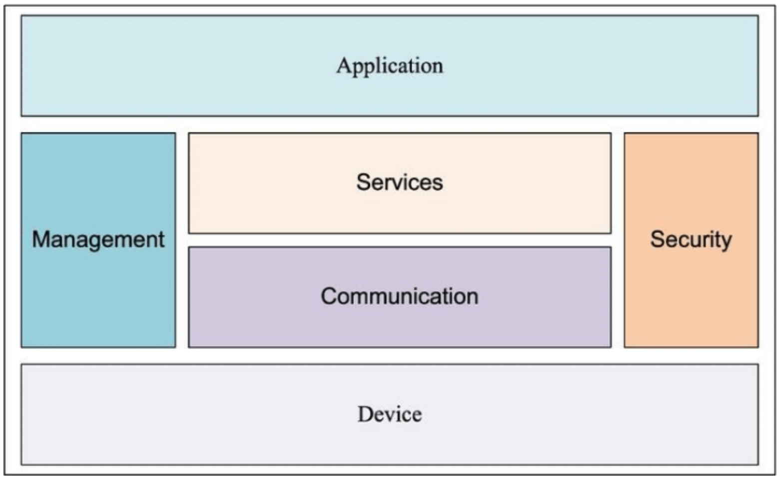
Logical design of an IoT system refers to an abstract representation of the entities and process without going into low level specification of the implementations .

Logical design of IoT contains the following parameters.

1) IoT functional block diagram

2) IoT Communication models

IoT Functional block diagram



An IoT system comprises of a number of functional blocks that provide the system the capabilities for identification , sensing, actuation ,communication and Management.

The function blocks are described as follows

Devices: An IoT system comprises of the devices that provide sensing, actuation, monitoring and control function

Communication: communication block handle the communication systems

Services : An IoT system uses various types of IoT services such as services for device monitoring ,device control services ,data publishing services and services for device discovery.

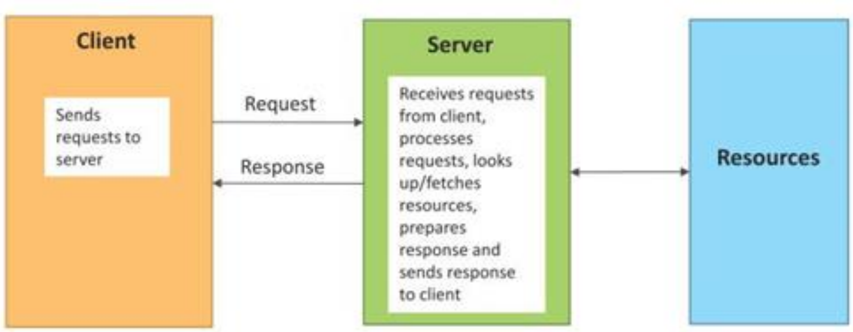
Management: Functional blocks provide various functions to govern the IoT system

Security: Security functional block security IoT system and by providing functions such as application authorization message and content integrity and data security.

Application: IoT application provides and interface that the user can used to control and monitor various aspects of the IoT system. Application also allow users to view the system status and view or analyze the processed to data.

IoT communication models

Request-Response communication Prorocol



This communication model consists of two parties:

I) Client ii) server

When the client requires any data, it sends a request to the server

The server upon receiving the request decides how to respond, fetch the data and sends its response to the client.

Each request-response pair is independent as it is a stateless model.

Ex: Online search engine: when we want to search anything we type a keyword in search bar it fetches all the data relevant to the word we typed and finds all the related websites, images,links on our screen.

Publish-Subscribe communication Protocol

This communication model consists of three parties:

1) Publisher re data producers or data generators
2) subscriber subscribers are data consumers and
3) Brokers are data mangers

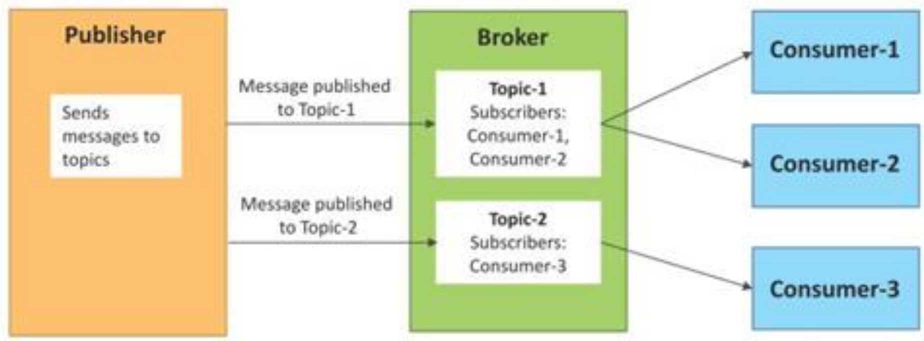
Publishers: They produce data related to various topics let us say sports, fashion, science and technology anything where publishers are not aware of subscribers.

Broker: Forms groups and categorizes of this data according to various topics be it sports, fashion etc

borker Identifies the subscribers who has subscribed to the topic 1 then send data related to topic 1 to those subscribers and so on. Publishers and subscribers are connected by the broker, which acts as the connection link.

Subscribers : subscribe various topics according to their interest and brokers/managers provide data to them depending upon their choice of subscription.

Ex: Social media platforms work on this model where we subscribe some channels, like someones pages or follow some one on social media platform then all the data related to that channel or pages they all appear on our timeline this is how they work because the broker are aware that we have liked that persons page or subscribe that persons channel.



Push-Pull communication model

This communication model consists of two parties:

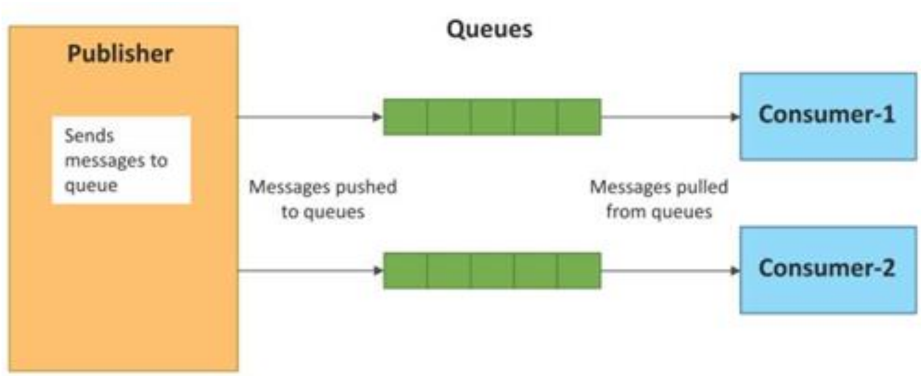
I) Data producer 2) Data consumers

Data producers generate data related to various topics and push this data into queues (waiting list)

Data consumers pull data out of these queues

Producers don't require awareness of consumers.

Ex" Social media platforms we scroll down various topics like videos, images, news items them one to our timeline you can visualize as a queue. This queue acts as a buffer or decoupling unit between the data producers and data consumers.if we subscribe some channel then all the data related to that channel comes into timeline from they are placed in the queue.

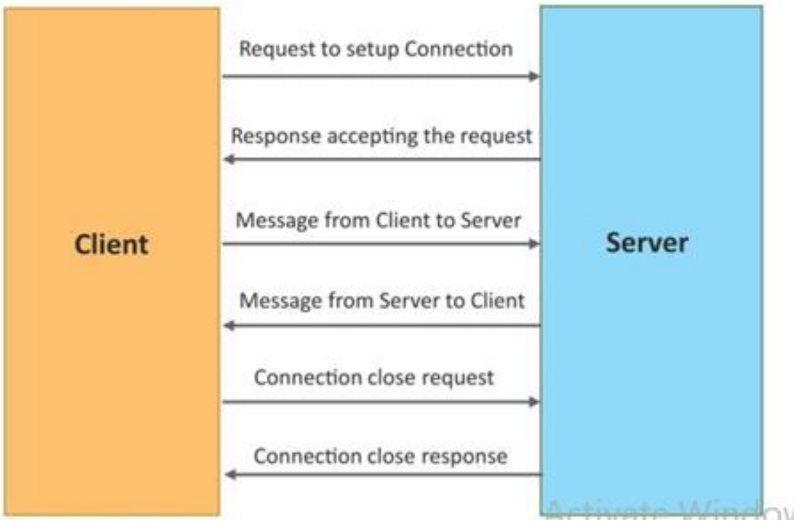


Exclusive pair

This communication model consists of two parties:

1) client 2) server

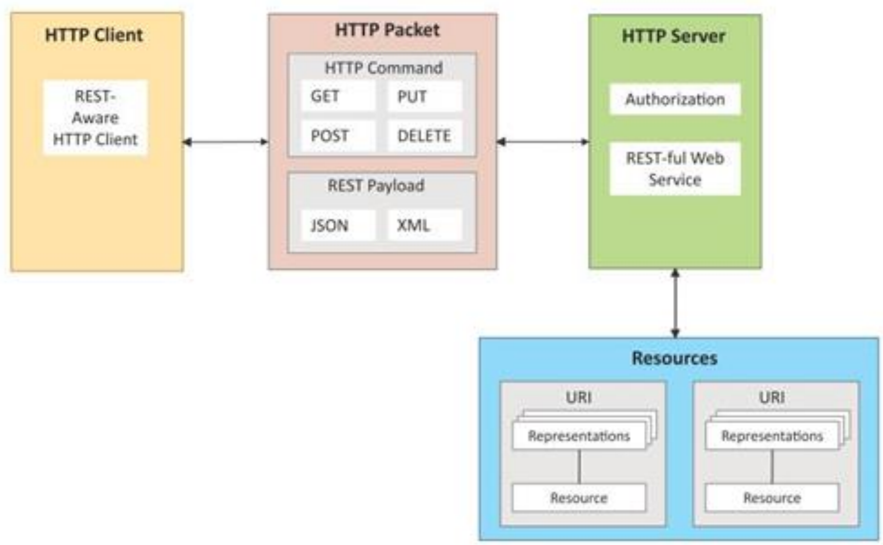
Exclusive pair is a bidirectional, fully duplex communication model with persistent connections between client and server, remaining open until the client requests closure. Both client and server can exchange messages after the connection is established. It's a stateful communication model, with the server aware of all open connections.



V. IoT communication APIs

REST-based communication API

REST-based communication API follows representational state transfer principles, focusing on system resources, their states, and addresses for transfer. REST APIs adhere to the request-response communication model, applying architectural constraints to components, connectors, and data elements.



Client server:

Separation of concerns in client-server architecture ensures that the client focuses on user interface while the server handles data storage, enabling independent deployment and updates for each component.

Stateless:

Each request from client to server must contain all the information necessary to understand the request , and cannot take advantage of any stored context on the server

Catchable:

By categorizing response data as catchable or non-catchable, the cache allows the reuse of data for similar requests, reducing redundancies and enhancing efficiency and scalability.

Layered system:

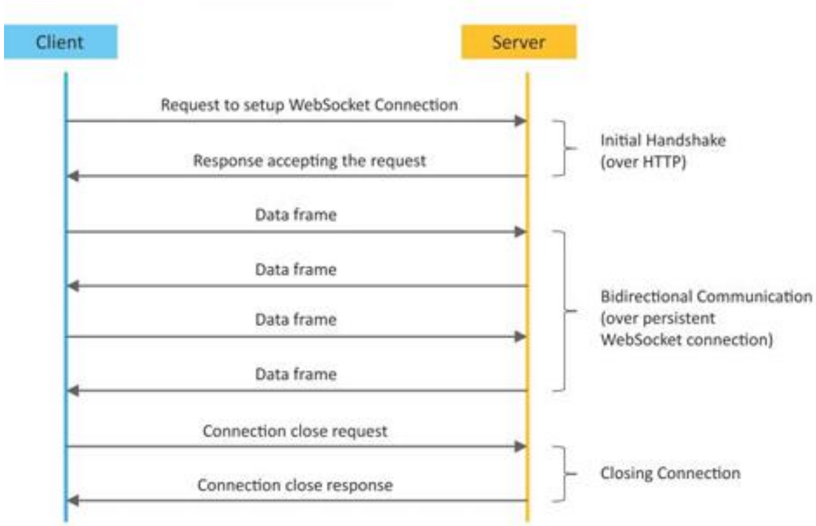
System constraints limit component behavior to interacting only with immediate layers, meaning a client cannot discern if it's connected directly to the end server or an intermediary. By enabling intermediaries to respond to requests rather than the tender server, system scalability can be enhanced

Uniform interface:

The uniform interface constraint mandates consistent communication between client and server, where resources are identified in requests and separate from the representations returned to the client. When the client holds a representation of a resource, it contains all necessary information to update or delete the resource.

Code on demand : Service can provide executable code script for clients to execute in their context.

Web Socket based communication API:



The Web Socket API enables bidirectional, full-duplex communication between client and server without requiring new connections for every message.

It starts with the client sending an HTTP connection setup request, recognized by the server as an upgrade request, followed by a handshake upon protocol support, enabling smooth data transmission. This decreases network traffic and latency by removing connection setup overhead for each message.

Difference between REST API and Web socket API

REST API	**Web Socket**
Stateless	Statefull
Request-response communication model	Full duplex
Each request involves setting up a new TCP connection	Single TCP connection
Header overload	No header overload
Not suitable for real time applications	suitable for real time

Vi. IoT enabling Technologies

IoT is enabled by several Technologies

1) Wireless sensor networks
2) Cloud computing
3) Big Data Analytics
4) Embedded system

Wireless Sensor Networks

A WSN consists of devices with sensors for monitoring, including end nodes, routers, and a coordinator, enabling data collection and internet connection.

IoT systems are described as follows

- Weather monitoring utilizes WSNs to collect temperature, humidity, and other environmental data for analysis.
- Indoor air quality monitoring systems employ WSNs to gather data on air quality and detect various gases.
- Soil moisture monitoring systems use WSNs to track moisture levels across different locations. Surveillance systems utilize WSNs for collecting motion detection data.
- Smart grids rely on WSNs for monitoring grid conditions at various points.
- Structural health monitoring systems utilize WSNs to monitor structural vibrations at multiple points within a structure.

Cloud Computing:

Cloud Computing enables the delivery of applications and services over the internet, permitting users to allocate computing resources on-demand and pay solely for their consumption. Users can access resources seamlessly across various devices without direct engagement with providers, while services facilitate multi-tenancy on shared hardware, available in diverse formats.

Infrastructure as a Service (IaaS) empowers users to allocate computing and storage resources in the form of virtual machine instances and virtual storage, providing them with the authority to initiate, terminate, customize, and oversee these resources, including deploying their chosen operating systems and applications. The Cloud Service Provider assumes responsibility for managing the foundational infrastructure.

Platform as a Service (PaaS) enables users to create and launch applications in the cloud using deployment tools, APIs, software libraries, and services provided by the Cloud Service Provider. The provider manages the foundational cloud infrastructure, which includes servers, networks, operating systems, and storage resources.

Software as a Service (SaaS) delivers complete software applications, encompassing both user interface and functionality, while the Cloud Service Provider assumes responsibility for overseeing the underlying cloud infrastructure, such as servers, networks, storage, and application software. Users can access SaaS applications via a lightweight client interface like a browser, compatible with various client devices, including smartphones running different operating systems.

Big Data Analytics

Big data refers to datasets with significant volume, velocity, or variety, challenging traditional storage, management, and analysis methods. Big Data Analytic s encompasses steps like data cleaning, munging, processing, and visualization.

1. Sensor data generated by IoT system such as weather monitoring stations
2. Health and fitness data generated by IoT devices such as wearable fitness band.
3. Data generated by IoT system for Location tracking of vehicle.
4. Data generated by retail inventory monitoring system.

Characteristics of data include:

Big data refers to vast quantities of data that pose challenges for traditional handling methods, prevalent in sectors such as IT, industry, and healthcare. This surge in data volume is driven by reduced storage and processing expenses, underscoring the need to extract insights for enhancing business operations and services.

Velocity: is a critical characteristic of big data, representing the speed at which data is generated and how frequently it changes. Modern IT, industrial, and other systems are producing data at ever-increasing speeds.

Variety: Variety refers to the forms of the data. Big data comes in for different forms such as structured or unstructured data including text data, audio, video and sensor data

Embedded Systems

Embedded systems combine hardware and software to perform specific tasks, distinct from general-purpose computers, and include components like microprocessors, memory, networking units, and specialized processors tailored for specific applications.

Domain-specific IoT

I. Applications of Home Automation

Smart lighting

- Smart lighting for homes helps in saving energy by adapting the lighting to the ambient condition and switching on/off or dimming the lights when needed.
- Key enabling technologies for smart lighting include solid-state lighting such as LED light and IP enabled the lights.
- For solid state lighting solution both spectral and temporal characteristics can be configured to adapt illumination to various needs. Smart lighting solutions for Home achieve energy saving by sensing the human movements and their environments and controlling the lights accordingly.
- Wireless enabled and internet connected lights can be controlled remotely from IoT applications such as a mobile or web application
- A solid-state lighting model is implemented on your wireless sensor network that provide services for sensing illumination changes and dynamically adjusting luminary brightness according to user preferences.

Smart Appliances

- Modern homes contain several appliances like TVs, refrigerators, music systems, and washer/dryers. Each appliance typically has its own controls or remote. Managing and controlling these appliances individually can be challenging.
- Smart appliances simplify management by allowing centralized control. They also provide remote status updates to users.
- Examples smart watches /dryers that can be controlled remotely and notify when the washing / driving
- cycle is complete smart thermostat
- smart refrigerator can keep track of the item stored and send update to the user when an item is low on stock.
- Smart TV Allows user to search and stream videos and movies from the internet on a local storage drive, search TV channel schedule and fetch news weather updates and other content from the internet.

Intrusion Detection:

- Home Intrusion detection system used security cameras and sensor such as PIR sensors and door sensor to detect intrusion and raise alert. Alerts can be in the form of an SMS and an email sent to the user.
- Advanced systems can even send detailed alert such as an image grab or a short video clip send to email attachment.
- cloud controlled intrusion detections system is described in that uses location aware services,

where the geo location of each node of your home automation system used independently detected and the stored in the cloud in the event of Institutions the cloud services alert the accurate neighbors who are using the home automation system is independently detected and stored in the cloud.

Smoke / Gas Detector

- Smoke detectors are installed in home and buildings to detect smoke that is typically and early sign of Fire.
- Smoke detectors use optical detection class ionization for sampling techniques to detect smoke. Alerts raised by smoke detectors can be in the form of signals to fire alarm system.
- Gas detectors can detect the presence of harmful gases such as carbon monoxide liquid Petroleum gas
- (LPG).
- A Smoke / gas detector raise alerts in human was this describing where the problem is send or an SMS or email to the user or the local fire safety department and provide visual feedback on its status the design of the system that detects gas leakage on smoke and it gives visual level indication.

II. Cities:

Smart Parking

- Finding a parking space during rush hours in crowded cities can be time consuming and frustrating. Star smart parking make the search for parking space easier and convenient for drivers.
- Smart parking for powered by IoT system that detect the number of empty parking slots and send the information over the internet to smart parking application back ends.
- These applications can be accessed by the drivers from smartphones, tablets and in car navigation system. In smart parking sensors are used for each parking slot, to detect whether the slot is empty or occupied. This information is aggregated by your local controller and then send over the internet to the database.

Smart Lighting

- Smart lighting system for road parks and building can help in saving energy. According to a IEA report, lightening is responsible for 19 % of global electricity use and around 6% of global Greenhouse gas emission.
- Smart lighting allows lighting to be dynamically controlled and also adapted to the ambient conditions. Smart lights connected to the internet can be controlled remotely to configure lighting schedules and lighting intensity.
- Smart Road Smart roads equipped with sensors can provide information on driving conditions, travel time estimates and alerts in case of poor driving conditions, traffic congestions and accidents.
- Such information can help in making the roads safe and help in reducing traffic jams.
- Information sense to from the roads can be communicated via internet to cloud based applications and social media and disseminated to the drivers who subscribed to such applications.

Structural Health Monitoring

- Structural health monitoring system uses a network of sensors to monitor the vibrations levels in the structures such as bridges and buildings.
- The data collected from the sensors is analyzed to assess the health of the structures. By analyzing the data, it is possible to detect cracks and mechanical breakdown, locate the damage to a structure and also calculate the remaining life of the structure.

Surveillance

- Surveillance of infrastructure, public transport and even in cities is required to ensure safety and security. City wide surveillance infrastructure comprising of large number of distributed and internet connected video surveillance cameras can be created.
- The video feeds from surveillance cameras can be aggregated in cloud-based storage solutions.

Emergency Response

- IoT Systems can be used for monitoring the critical infrastructure in cities such as building, gas and water pipelines, public transport and power substation systems.
- IoT systems for fire directions, gas and water leakage directions can help in generating alerts and minimizing their effects on the critical infrastructure.
- IoT systems for critical infrastructure monitoring enable aggregations and sharing of information is collected from large number of sensors. Cloud based architecture multi model information such as sensor data, audio, video feeds can be analyzed in near real time to detect adverse event.

III. Environment

Weather Monitoring

- IoT- based weather monitoring system can collect data from a number of sensors attached such as temperature, humidity, pressure etc. and send the data to cloud-based application and storage back-ends.
- The data collected in the cloud can then be analyzed and visualized by cloud-based application. Weather alerts can be sent to the subscribed users from such applications
- AirPi weather and air quality monitoring kit capable of recording and uploading information about temperature, humidity, air pressure light levels, UV levels, carbon monoxide Nitrogen dioxide and smoke level to the internet.

Air Pollution Monitoring

- IoT based air pollution monitoring system can monitor emission of harmful gases (CO_2, CO. NO, NO_2) by factories and automobiles using gases and dermatological sensors the collected data can be analyzed to make informed decisions on pollutions control approaches.
- In real time air quality monitoring system is presented that comprises of several distributed

monitoring stations that communicate via wireless with a backend server using machine to machine communication.

Noise Pollution Monitoring

- Noise pollution monitoring can help in generating noise maps for cities. Urban noise maps can help the policy makers in urban planning and making policies to control noise level near Residency areas, schools and parks.
- IoT based noise pollution smart metering system use a number of noise monitoring station that are deployed at different places in a city. The data on noise levels from the stations is collected on server or in the cloud.

Forest Fire Detection

- Forest fires can cause damage to natural resources, property and human life. There can be different causes of forest fires including lightening, human negligence, volcanic eruptions and sparks from rock Falls. Early deduction of forest fires can help in minimizing the damage.
- IoT based forest fire detection systems can use a number of monitoring nodes deployed at a different location in a forest. Each monitoring node collects measurements on ambient conditions including temperature, humidity, light levels.

River Flood Detection

- River flood can cause extensive damage to the natural and human resources and human life. River flood occurs due to continuous train for which cause the river level to rise and flow rates to increase rapidly. Early warnings of floods can be given by monitoring the water level and flow rate.
- IoT based river flood monitoring system uses a number of sensor nodes that monitor the water level using ultrasonic sensors and flow rate using the flow velocity sensors.

IV. Energy

- Smart grid is a data communication network integrated with electrical grid that collects and analyses data captured in real-time about power transmission, distribution and consumption. Smart grid Technology provides protective information and recommendations to utilities, their suppliers, and their customers on how best to manage power.
- Smart Grids collect data regarding electricity generation
- Smart fleet use high speed, fully integrated two-way communication real time information and power exchange.
- Smart meters can capture almost real time consumption, remotely control the conceptions of electricity and remotely switch off supply when required. power thefts can be prevented using smart metering by analyzing the data on power generation, transmission and consumption smart grid can improve efficiency throughout the electric system.

Renewable Energy System

- Due to the variability in the output from renewable energy sources such as solar and wind integrating them into the grid can cause grid stability and reliability problems.

- Variable output produces local voltage swing that can impact power quality. Existing grids were designed to handle power flow from centralized to generation source to the loads through Transmission and distribution lines.

Prognostics

- Energy systems (Smart grids, power plants, wind turbine forms) have a large number of critical components that must function correctly so that the system can perform their operations correctly.
- For example, a wind turbine has a number of critical components example bearing, turning gears, for instance that must be monitored carefully as wear and tear in such critical components or sudden change in operating conditions of the missions can result in failures.
- IoT based prognostic real-time health management systems can predict performance of machine or energy Systems by analyzing the extent of deviations of the system from its normal operating profiles.
- Analyzing massive amounts of maintenance data collected from sensors in energy systems and equipment can provide protections for the impending failures so that their reliability and availability can be improved.

V. Retail

Inventory Management

- Inventory management for retail has become increasingly important in recent years with the growing competition. while over stocking of products can result in additional storage expenses and risk understocking can lead to loss of revenue.
- IoT system using radio frequency identification RFID tags can help in inventory management and maintaining the right inventory levels.
- RFID tags attached to the products allow them to be tracked in real time so that the inventory levels can determined accurately and products which are low on stock can be replenished.
- Tracking can be done using RFID readers attached to the retail store shelves or in the warehouse.

Smart Payments

- Smart Payments solutions contact list payments powered by technology such as near field communication and Bluetooth.
- Near field communication is a set of standards for smartphones and other devices to communicate with each other by bringing them into proximity or by touching them.
- Customers can store credit card information in the NFC enabled Smartphones and make payment by bringing the smart phones and make payments by bringing the smart phones near the point-of-sale terminals.

Smart Vending Machines

- Smart vending machines, connected to the internet, enable remote inventory monitoring, dynamic pricing, promotions, and contactless NFC payments via smartphone apps. User preferences are remembered and shared across machines, offering a seamless interface for personalized vending experiences.

VI. Logistics

- Route Generation and Scheduling Modern transportation systems are driven by data collected from multiple sources which is process to provide a new service to the stockholders.

- By collecting large amount of data from various sources and processing the data into Useful information data driven.
- Transportation system can provide new services such as advanced route guidance dynamic vehicle routing anticipating customer demand for pickup and delivery problem, for instance route generations and scheduling systems candidate end-to-end using combinations of road patterns and transportation smooth and feasible schedule based on the availability of vehicles.

Fleet Tracking Vehicle

- Fleet tracking system using GPS technology to track the locations of vehicle in real time. Cloud based fleet tracking systems can be scaled up on-demand to handle large number of vehicles. Alerts Can be generated in case of deviation in planned routes.

Shipment Monitoring

- Shipment monitoring solutions for Transportation systems allow monitoring the conditions inside container. For example, containers carrying Fresh Food produce can be monitored to prevent spoilage of food.
- IoT based shipment monitoring system your sensor such as temperature pressure and humidity for instance to monitor the conditions inside the container and send the data to the cloud where it can be analyzed to detect food spoilage.

Remote Vehicle Diagnostics

- Remote vehicle diagnostic systems can detect faults in the vehicles warn of impending fault. These Diagnostic systems use on-board IoT devices for collecting data on vehicle operation such a speed, engine RPM, coolant temperature, fault code number, and status of the various vehicle subsystem such data can be captured by integrating on-board diagnostic systems with IoT devices using protocols such as CAN bus.

VII. Agriculture

Smart Irrigation

- Smart irrigation systems can improve crop yield while saving water. smart irrigation system using IoT devices with soil moisture sensors to determine the amount of moisture in the soil and realize the flow of water through the irrigation pipe only when the moisture level go below a predefined threshold.

Green House Control

- Green house structures with glass or plastic roofs that provide conducive environment for growth of plants.
- The Climatological conditions inside a Greenhouse can be monitored and controlled to provide the best conditions for growth of plants.
- The temperature, humidity, soil moisture, light and carbon dioxide levels are monitored using sensors and their climatological conditions are controlled automatically using actuation devices.

VIII. Industry:

Machine Diagnosis and Prognosis

- Machine prognosis refers to predicting the performance of a machine by analyzing the data and the current operating conditions and how much deviations exist from the normal operating conditions. Machine diagnosis refer to determining the causes of a machine fault.
- IoT plays a major role in both the prognosis s and Diagnostics of industrial machines.

Indoor Air Quality Monitoring

- Monitoring indoor air quality in factories is important for health and safety of the workers. harmful and toxic gas such as carbon monoxide, nitrogen monoxide and Nitrogen dioxide etc t can cause serious health problems.
- IoT based gas monitoring system can help in monitoring the indoor air quality using various gas sensors.

IX. Health And Lifestyle:

- Health and fitness monitoring wearable IoT devices that are low noninvasive and continuous monitoring of physiological parameters can help in continuous health and fitness monitoring.
- Wearable Electronics such as smart watches smart glasses wristband and fashion example Google glass for Moto 360 smart watches provide various functions and future to assist us in our daily activities and making as lead healthy Lifestyle.