Introduction to IoT

IoT comprises things that have unique identities and are connected to internet.

Existing Devices such as Networked Computers or 4G enabled mobile phones, already have some unique identities(IP Address) and are also connected to internet.(URL)

The focus of IoT is in Configuring, Control and networking via the internet of devices or things that traditionally not associated with internet.(In this context traditional devices are Networked computers & 4G mobile phones).

Devices such as thermostats, utility meters, Bluetooth connected headset, irrigation pumps, electric circuits for electric car's engine can be consider as devices or things of IoT.

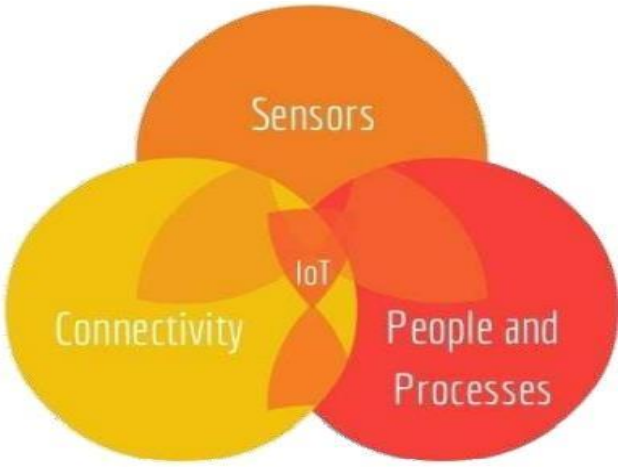
Figure: Demonstrates the need of Configuring, Control and networking via IoT

Father of the Internet of Things

In 1999, Kevin Ashton wrote 'Internet of Things' as a title on a PowerPoint presentation when he was Working at Procter and Gamble, he had come up with the idea of attaching RFID chips to consumer goods to levels in stores.

Components of IoT

Smart Systems and Internet of Things are driven by a combination of : 1) Sensors 2) Connectivity 3) People & Processes



Advantages of IoT

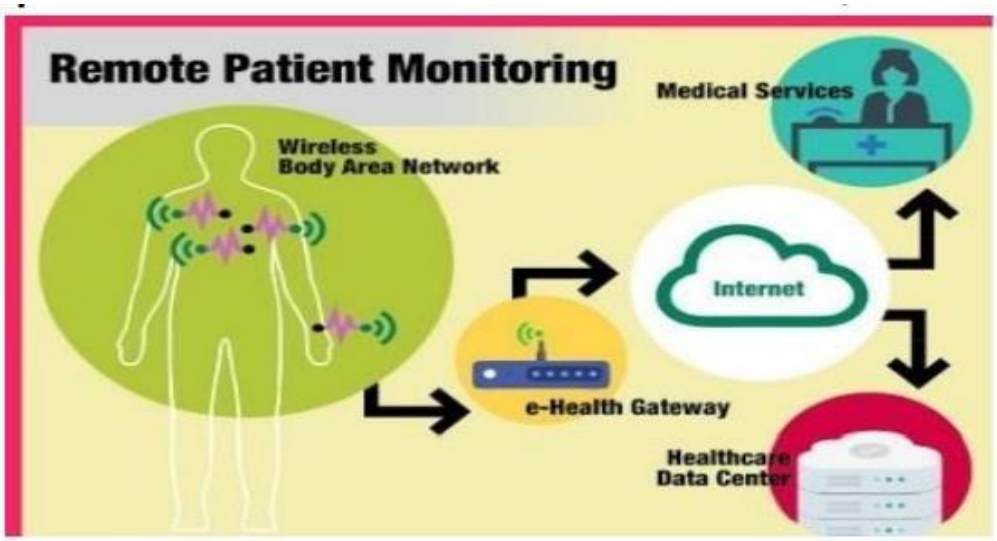
- Minimize human effort: As the devices of IoT interact and communicate with each other and do lot of task for us, then they minimize the human effort.

Ex: Home Automation using IoT

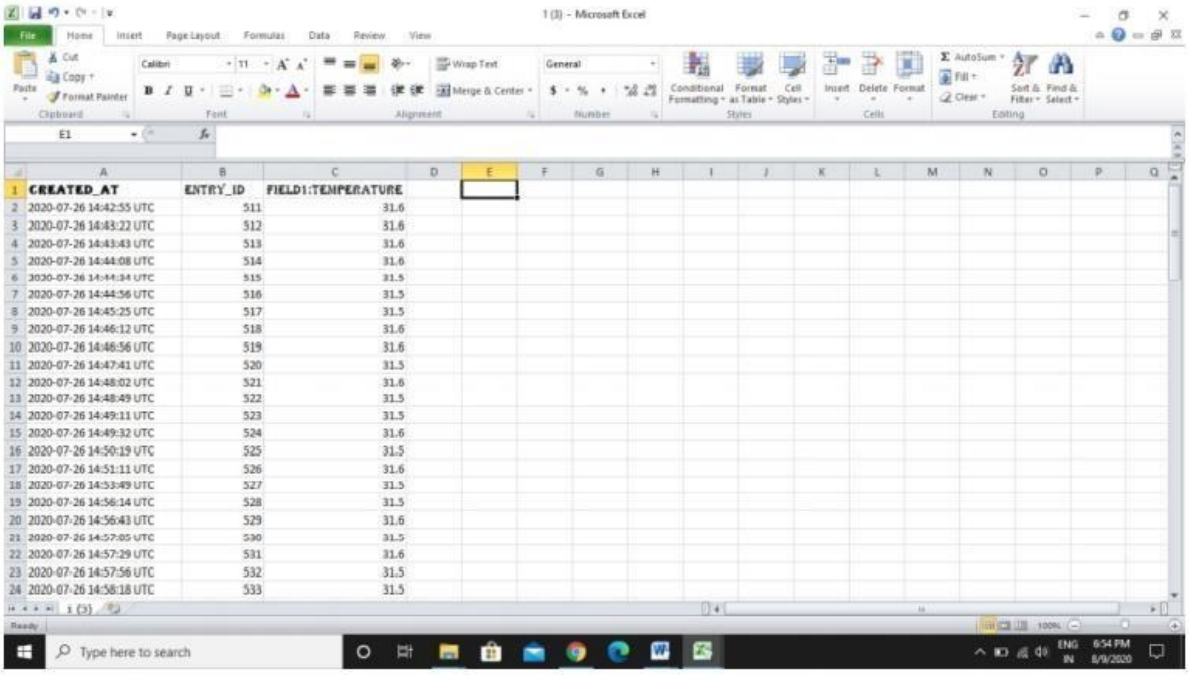
• Save time: As it reduces the human effort then it definitely saves out time. Time is the primary factor which can save through IoT platform.

Ex: Home Automation using IoT

• Enhanced Data Collection: By using IoT applications raw data can be enhanced to get proper information of the device/user.

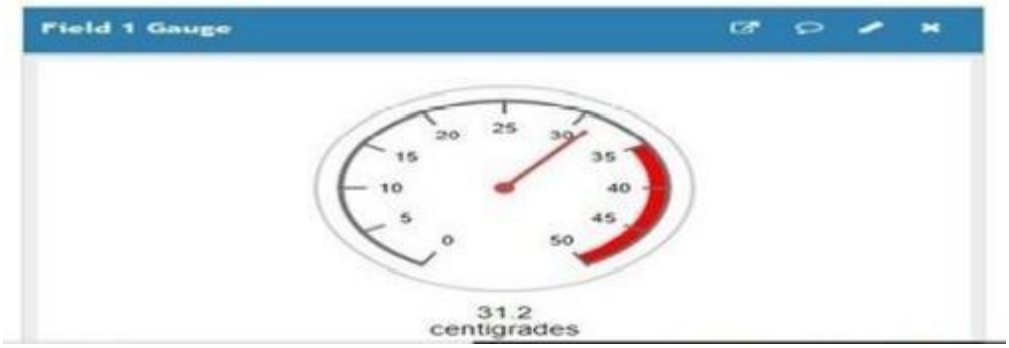


Storing the Patient data in EXCEL SHEET(Raw Data)



	A	B	C
1	CREATED_AT	ENTRY_ID	FIELD1:TEMPERATURE
2	2020-07-26 14:42:55 UTC	511	31.6
3	2020-07-26 14:43:22 UTC	512	31.6
4	2020-07-26 14:43:43 UTC	513	31.6
5	2020-07-26 14:44:08 UTC	514	31.6
6	2020-07-26 14:44:34 UTC	515	31.5
7	2020-07-26 14:44:56 UTC	516	31.5
8	2020-07-26 14:45:25 UTC	517	31.5
9	2020-07-26 14:46:12 UTC	518	31.6
10	2020-07-26 14:46:56 UTC	519	31.6
11	2020-07-26 14:47:41 UTC	520	31.5
12	2020-07-26 14:48:02 UTC	521	31.6
13	2020-07-26 14:48:49 UTC	522	31.5
14	2020-07-26 14:49:11 UTC	523	31.5
15	2020-07-26 14:49:32 UTC	524	31.6
16	2020-07-26 14:50:19 UTC	525	31.5
17	2020-07-26 14:51:11 UTC	526	31.6
18	2020-07-26 14:53:49 UTC	527	31.5
19	2020-07-26 14:56:14 UTC	528	31.5
20	2020-07-26 14:56:43 UTC	529	31.6
21	2020-07-26 14:57:05 UTC	530	31.5
22	2020-07-26 14:57:29 UTC	531	31.6
23	2020-07-26 14:57:56 UTC	532	31.5
24	2020-07-26 14:58:18 UTC	533	31.5

Temperature Monitoring using IOT Dashboard (Enhancement of Data)



Disadvantages of IoT

• **Security:** As the IoT systems are interconnected and communicate over networks. The system offers little control despite any security measures, and it can be lead the various kinds of network attacks.

• **Privacy:** Even without the active participation of the user, the IoT system provides substantial personal data in maximum detail.

• **Complexity**: The designing, developing, and maintaining and enabling the large technology to IoT system is quite complicated.

Applications of IoT:

•Smart Homes

•Smart Cities

•Environment

•Energy

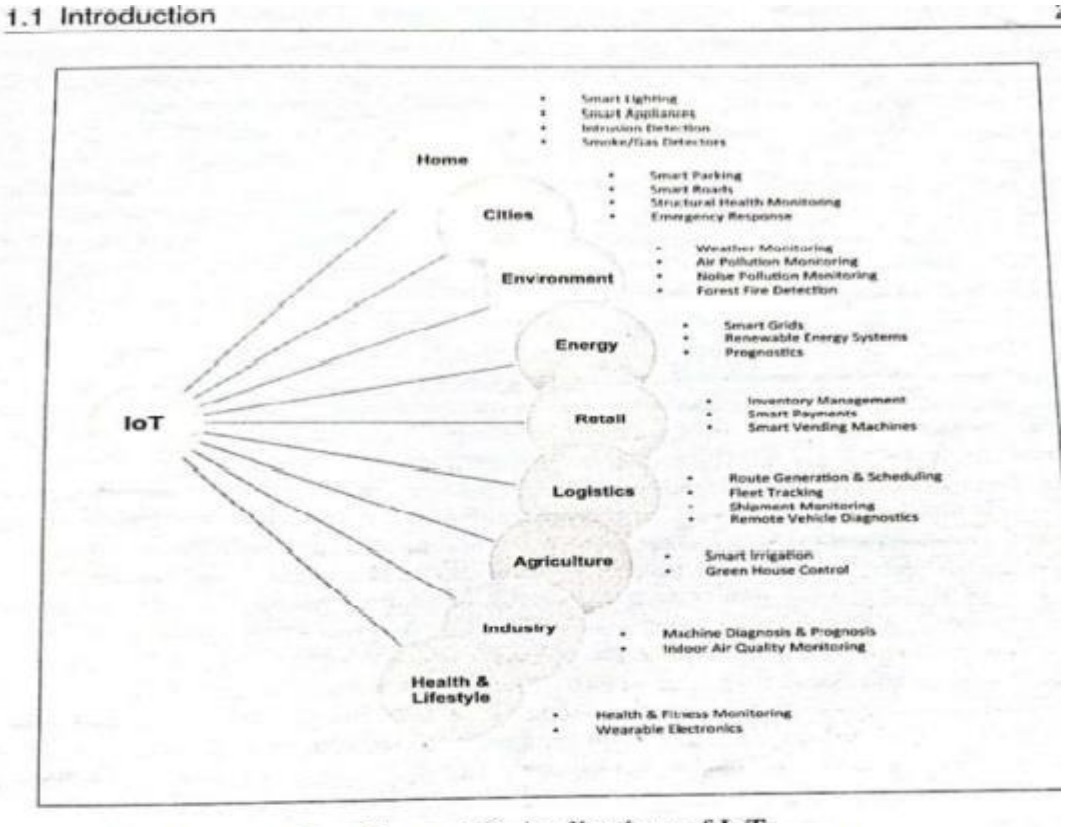
•Retail

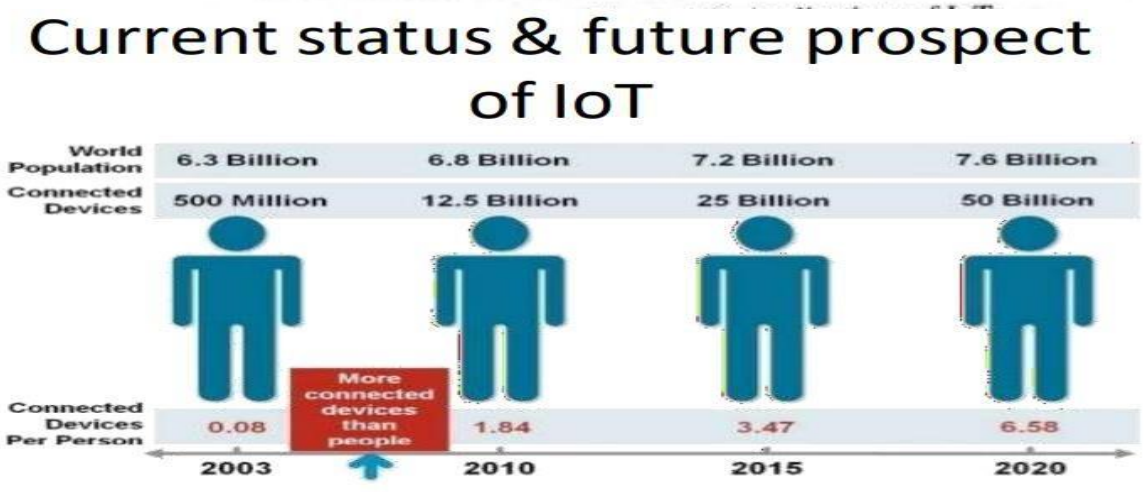
•Logistics

•Agriculture

•Industry

•Health & Lifestyle





By the year 2020, there will be a lot more connected devices than people on earth

In demographics, the world population is the total number of humans currently living, and was estimated to have reached **7.8 billion** people as of **June 2020**

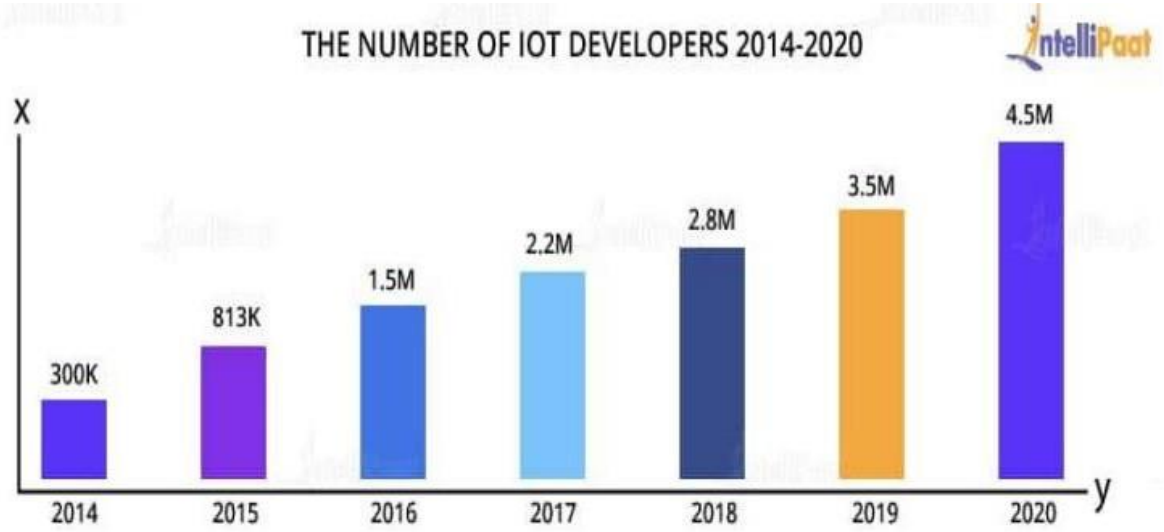
Future Scope of IoT

• IoT has gained a lot of popularity in lesser time. Also, the advancements in Artificial Intelligence and Machine Learning have made the automation of IoT devices easy.

• Basically, AI and ML programs are combined with IoT devices to give them proper automation. Due to this, IoT has also expanded its area of application in various sectors.

Career opportunities in IoT

The future scope of IoT in India is very high as there are 117,114 job openings for an IoT Developer .On the other hand, in the United States, the demand for an IoT Developer has jumped over 300 percent.

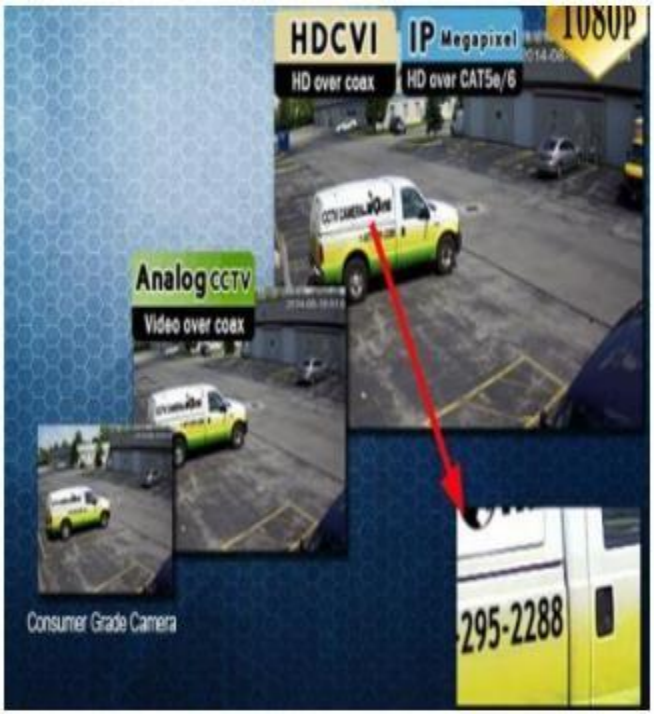


Salary of IoT Developers

The average salary provided to an IoT Developer in the United States is US$164,417 per year. In India, the average annual salary is 12 to 16 Lakhs.

IoT Definition

• A dynamic global network infrastructure with self configuring capabilities based on standard and interoperable communication protocols where physical and virtual things have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into information network, often communicate data associated with users and their environments.



Inferring information and knowledge from Data

• Raw Data doesn't have meaning until it is contextualized processed into useful information.

• Applications on IoT networks extract and create information from lower level data by filtering, processing, categorizing, condensing and contextualing the data.

• Information obtained is then organized and structured to infer knowledge the System and/or its Users

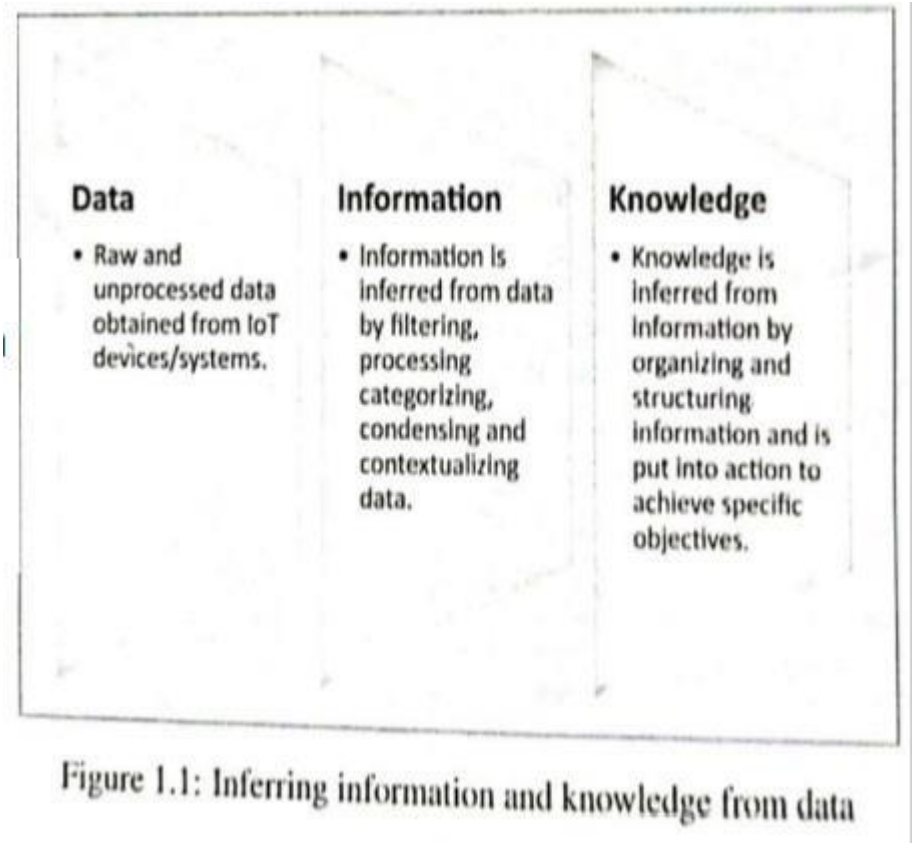


Figure 1.1: Inferring information and knowledge from data

Characteristics of IoT

- Dynamic & Self adapting.
- Self-configuring.
- Interoperable communication protocols.
- Unique Identity.
- Integrated into Information network.

Dynamic & Self adapting

• Adapt to changing context and take actions based on operating conditions, user context and sensed environment.

• Example: automatic adjustment of surveillance image quality based on motion detection

Self configuring:

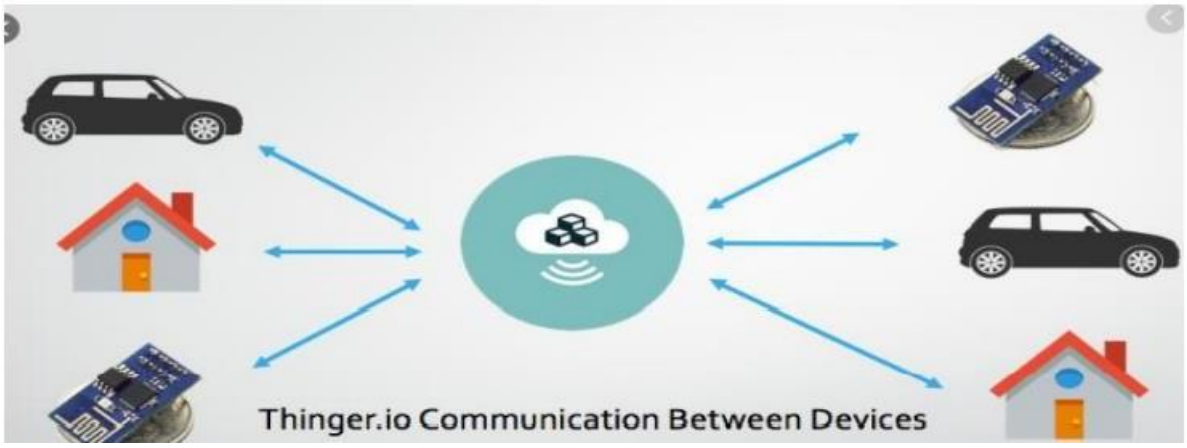
To configure themselves, setup the network, upgrade, etc. with minimal user intervention. Examples:

1. Android Mobile Auto update.

2. Auto Focus on Faces in Group Photo

Interoperable communication protocols

To communicate with other IoT devices and with the IoT infrastructure.



Unique Identity

Each IoT device has a unique identity and a unique identifier(e.g., IP address or URI), allowing:

Query the device

Monitor the state of the device

Control and configure them remotely

Integrated into Information network

In order to communicate and exchange data with other devices and systems an IoT device should have following Qualities:

Dynamic discovery of other devices

Capability of describing itself and understanding others

Capability to interact with others

Physical Design of IoT

• The "Things" in IoT usually refers to IoT devices which have unique identities and can perform remote sensing, actuating and monitoring capabilities.

• IoT devices can:

• Exchange data with other connected devices and applications (directly or indirectly) OR

• Collect data from other devices and process the data locally. OR

• Send the data to centralized servers or cloud-based application back-ends for processing the data OR

• Perform some tasks locally and other tasks within the IoT infrastructure, based on temporal and space constraints.

Generic block diagram of an IoT Device

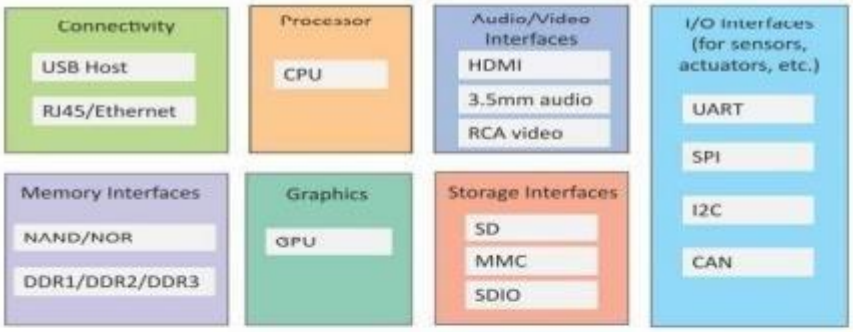
• An IoT device may consist of several interfaces for connections to other devices, both wired and wireless.

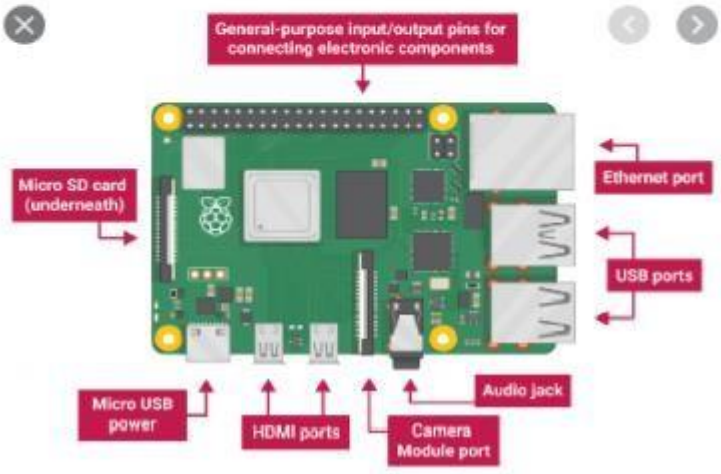
• I/O interfaces for sensors

• Interfaces for Internet connectivity

• Memory and storage interfaces

• Audio/video interfaces





Connectivity : these connective options enable the seemless transfer of data facilitating communication and data excahnge within the IoT network

Processor : processor such as central processing unit along with other processing units play a curical role in hadling data processing task within an IoT task

These processors are responsible for executing algorithms performing coputations and analyzing data by effectively processing data the IoT system can enchance the quality of decision making process

Audio/Video interface : These interfaces such as HDMI and RCA are utilized within an IoT system to capture and record audio and video content IoT Protocols

These interfaces enable the integration of audio/video recording capabilities allowing system together multimedia data for analysis and further proces..

I/O interfaces: include UART, SPI, I2C, CAN and others are utilizes to establish communication between sensors, actuators and iot systems.

These interface enable the exchange of signals facilitating the I/O of data to and from sensors and actuators

These enables the IotTsystems to interact with physical enviornment and respond to the stimuli.

Storage interfaces : It uses SD(secure digital), MMC(multi media card) and SDIO (SD input and output) are utilized to store the data generated by IoT devices

These interface provide a means to effectiently store and retriving data ensuring that imported information is preserved for further analysis for reference.

GPU(graphical processing unit) also place an significant role in controling activities of IoT system.

DDR facilitates fast and effecient data acess while GPU has specially design to handle intenceive graphics processing task.

These components contribute to overall performnace and functionality of IoT system ensuring smooth operations.

IoT Protocols helps to establish communication between IoT Device and cloud based server over the internet. IoT Protocols helps to send commands to IoT device and received data from an IoT device over the internet.

Link Layer

- 802.3 – Ethernet
- 802.11 – WiFi
- 802.16 – WiMax(LTE)
    - 802.15.4 – LR-WPAN
    - 2G/3G/4G

Network/Internet Layer

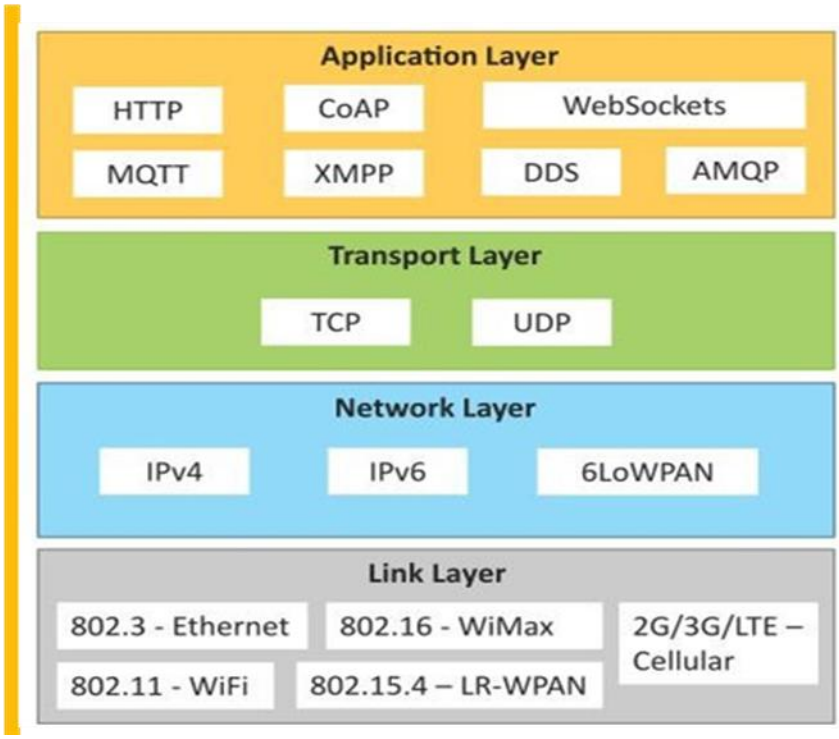
- IPv4
- IPv6
- 6LoWPAN

Transport Layer

- TCP
- UDP

Application Layer

- HTTP
- CoAP
- WebSocket
- MQTT
- XMPP
- DDS
- AMQP



LINK LAYER

- Link Layer determines how data is physically sent over the network's physical layer or medium.
- Local network connect to which host is attached. Hosts on the same link exchange data packets over the link layer using link layer protocols.
- Link layer determines how packets are coded and signaled by the hardware device over the medium to which the host is attached.

802.3-Ethernet:IEEE802.3 is a collection of wired Ethernet standards for the link layer.

- Eg: 802.3 uses co-axial cable.--- 10Mb/s
- 802.3i uses copper twisted pair connection.
- 802.3j uses fiber optic connection.
- 802.3ae uses fiber cable.---10Gbit/s

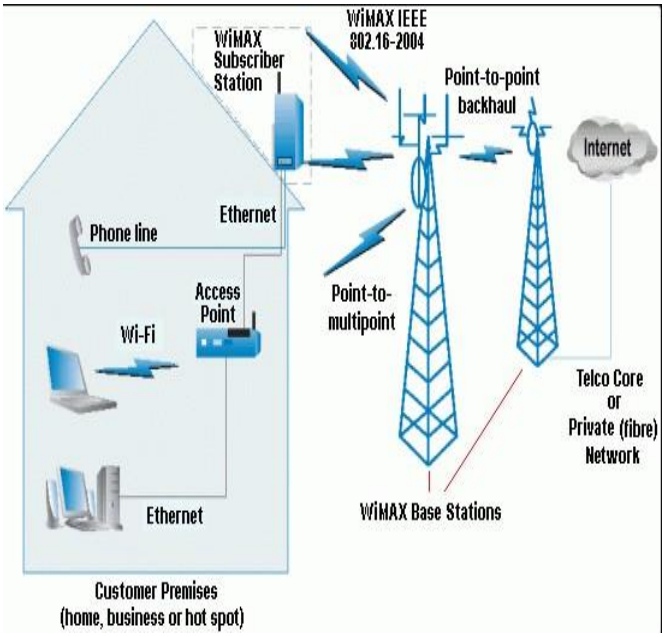
802.11-WiFi:IEEE802.11 is a collection of wireless LAN(WLAN) communication standards for the link layer.

- Eg: 802.11a operates in 5GHzband
- 802.11b & 802.11g operates in 2.4GHzband, 802.11n operates in 2.4/5GHzband
- 802.11ac operates in 5GHz band
- 802.11 ad operates in 60Ghz band.
- Data Rate: 1Mb/s to 6.75 Gb/s

802.16 - WiMax:

WiMAX technology is a wireless broadband communications technology based around the IEE **802.16** standard providing high speed data over a wide area. The letters of **WiMAX** stand for Worldwide Interoperability for Microwave Access (AXess), and it is a technology for point to multipoint wireless networking

- WiMax provide data rates from1.5 Mb/sto 1Gb/s.



- 802.15.4-LR-WPAN: IEEE802.15.4 is a collection of standards for low rate wireless personal area network(LR-WPAN). Basis for high level communication protocols such as ZigBee. Provides data rate from 40kb/s to250kb/s.

- 2G/3G/4G-MobileCommunication: Data rates from 9.6kb/s(2G) to 100Mb/s(4G).

Network/Internet Layer

- It is responsible for sending of ip datagrams from the source network to destination network.
- This layer performs the host addressing & packet routing .
- The datagrams contain the source and destination addresses which are used to route them from source to the destination across multiple networks.
- Host identifications is done using hierarchical IP addressing schemes as IPv4 & IPv6.

Note: 1.A datagram is a basic transfer unit associated with a packet-switched network provides connectionless communication service

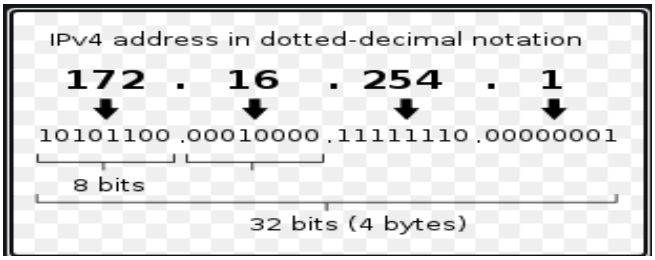
2.Datagrams are typically structured in header and payload sections.

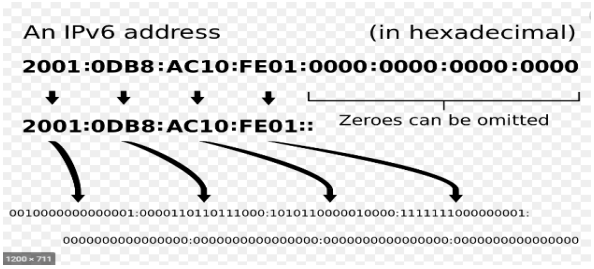
- **IPv4:** 32-Bit address scheme that allows total of 2^{32} or 4,294,967,296 addresses. As devices are increased IPv4 exhausted
- **IPv6:** 128-Bit address scheme that allows total of 2^{128} or $3.4*10^{38}$ addresses
- **6LoWPAN(IPV6 over Low power WPAN):**

It is a network protocol that defines encapsulation and header compression mechanisms.

It works with 802.15.4 link layer protocol & defines compression mechanism for IPv6 datagrams

GHz frequency range and provides data transfer rates of 250 Kb/s





Transport Layer

- Provides end-to-end message transfer capability independent of underlying network.
- Provides functions such as error control, Segmentation, flow control and congestion control.
- Two Types of Transport Layer Protocols

1. TCP(Transmission Control Protocol)
2. UDP (User Datagram Protocol)

TCP(Transmission Control Protocol)

- Most widely used Transport Layer Protocol used by web browsers (Http),email Programs(SMTP),File Transfer(FTP)

Advantages:

- Connection oriented.
- Reliable transmission of packets in order.
- Handshaking Full Duplex
- Error detection and retransmission
- flow control and congestion control

Disadvantages:

- Slow transmission
- More overhead

Transport Layer Protocols..

- **UDP:** (User Datagram Protocol) is an alternative communications protocol to Transmission Control Protocol (TCP) used primarily for establishing low-latency and loss tolerating connections between applications on the Internet.

Advantages

- Connection less
- Fast transmission
- Less overhead

Disadvantages

- Less reliable
- Optional Error control
- No Flow control
- No Congestion Control

TCP vs UDP

TCP	UDP
Connection oriented	Connection less
Reliable	Less reliable
Error control mandatory	Optional Error control
Slow transmission	Fast transmission
More overhead	Less overhead
Flow control	No Flow control
Congestion Control	No Congestion Control

Application Layer

- Defines how the applications interface with lower layer protocols to send data over the network.
- Enables process-to-process communication using port numbers(for example port 80 for HTTP, Port 22 for SSH,etc.)

Protocols:

- HTTP (Hyper Text transfer protocol)
- COAP (Constrained Application Protocol)
- Web Socket (Allows Full duplex communication)
- MQTT (Message Queue Telemetry Transport)

- XMPP (Extensible Messaging Presence Protocol)
- DDS (Data Distribution Service)
- AMQP (Advanced Message Queuing Protocol)

Application Layer Protocols

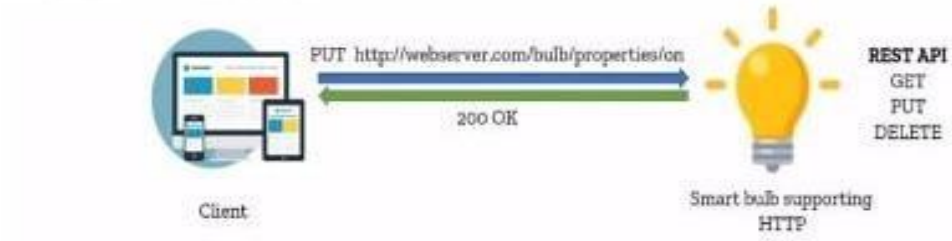
HTTP: The Hypertext Transfer Protocol

- Most widely used protocol of Application layer.
- Allows Half –Duplex communication.
- Asymmetric request-response client-server protocol.
- Stateless Protocol
  - --Server will not remember previous request.
  - -- Each HTTP Request is independent of other.
- Follows Request-response model where a client sends requests to server using HTTP commands

HTTP...

- HTTP protocol uses URIs to identify HTTP resources
- HTTP runs over TCP/IP to ensure packet delivery guarantee.
- HTTP included commands such as GET, PUT, POST, DELETE, HEAD, TRACE, OPTIONS, etc.

- How HTTP works in IoT.
- HTTP Implementation based on **REST** Standard.
- If any architecture follows REST standard the called as **RESTful**



Web Socket Protocol:

- Allows full –Duplex communication over a single socket connection for sending messages between client and server.
- Based on TCP.
- Web Socket allows streams of messages to be sent back and forth between the client and server while keeping TCP connection open.

- Web Socket works on all modern browsers viz., Firefox, Chrome etc..

How WebSocket works in IoT ?

- Useful for real time communication without any delay in an IoT applications.
- Faster
- Not Preferable for battery operated devices.

MQTT (Message Queue Telemetry Transport)

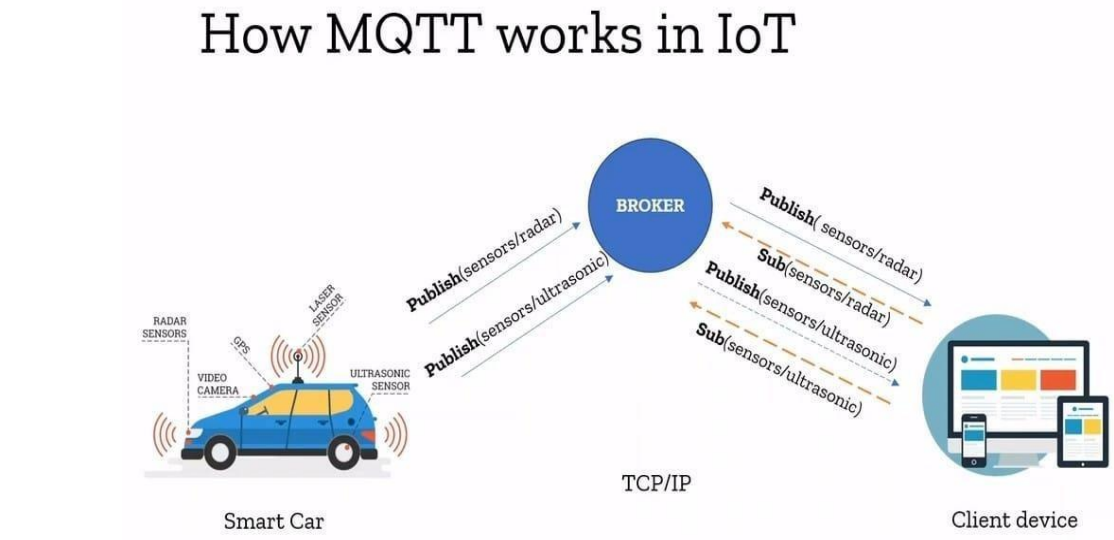
- Message Queue Telemetry Transport is light weight messaging protocol based on **publish-subscribe model.**
- Mostly widely used in IoT Applications, runs on **TCP/IP**
- Uses client server architecture, where the client(IoT device) connects to the server(also called as MQTT Broker) and publishes messages to topics on the server.
- The Broker forwards the messages to the clients subscribed to the topics.
- No **direct connection** between two clients/nodes, its always through Broker/Server
- Well suited for constrained environment where the devices have limited processing ,memory resources ,low power and low bandwidth.

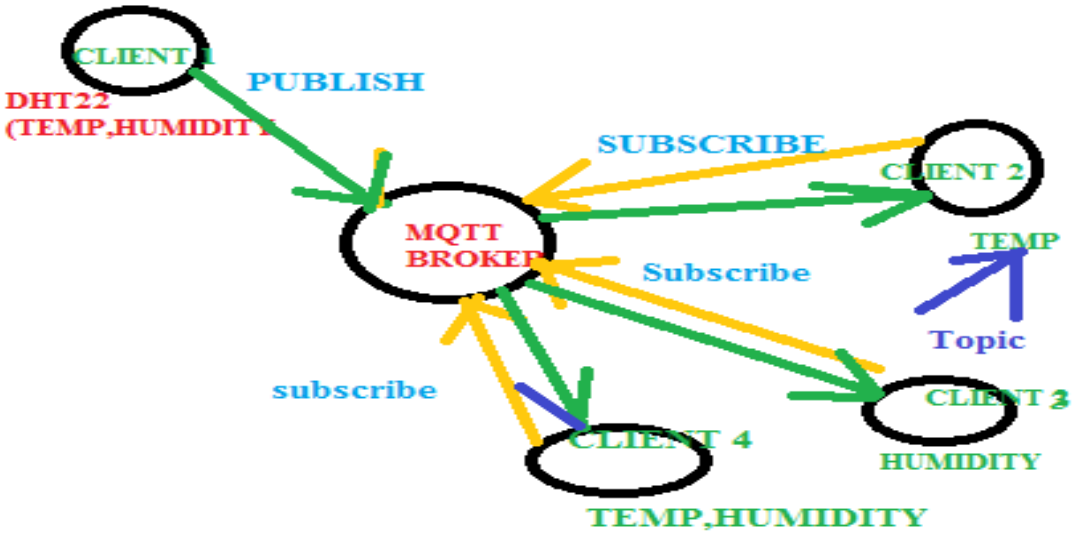
- Offers three levels of QoS

--QoS 0: Fire & Forget(No Guarantee of delivery)

--QoS 1: Delivery at least Once

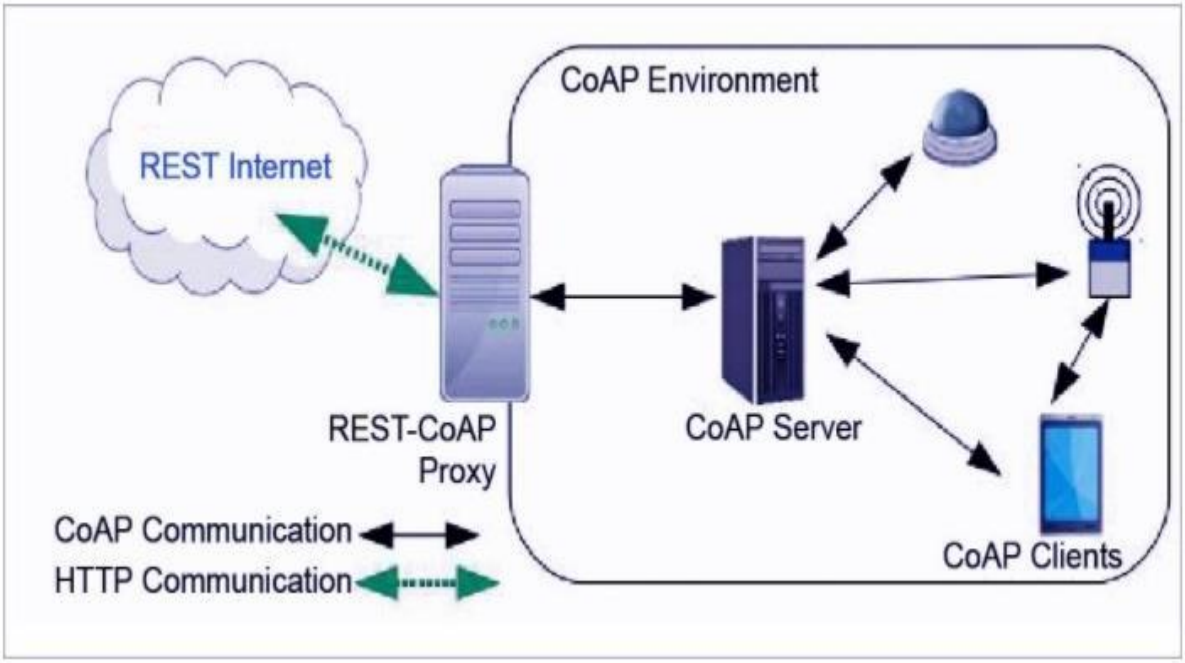
--QoS 2: Delivery exactly Once





CoAP (Constrained Application Protocol):

- Designed for machine-to-machine (M2M) applications such as smart energy and building automation.
- The Constrained Application Protocol (CoAP) is a specialized web transfer protocol for use with constrained nodes and constrained networks.(Low Power,low bandwidth,etc)
- Request-response model
- Runs on top of UDP
- CoAP uses Client-Server architecture where clients communicate with server using connectionless datagrams
- Direct Connection between Client & Client is possible.
- CoAP supports commands such as GET, PUT, POST, DELETE

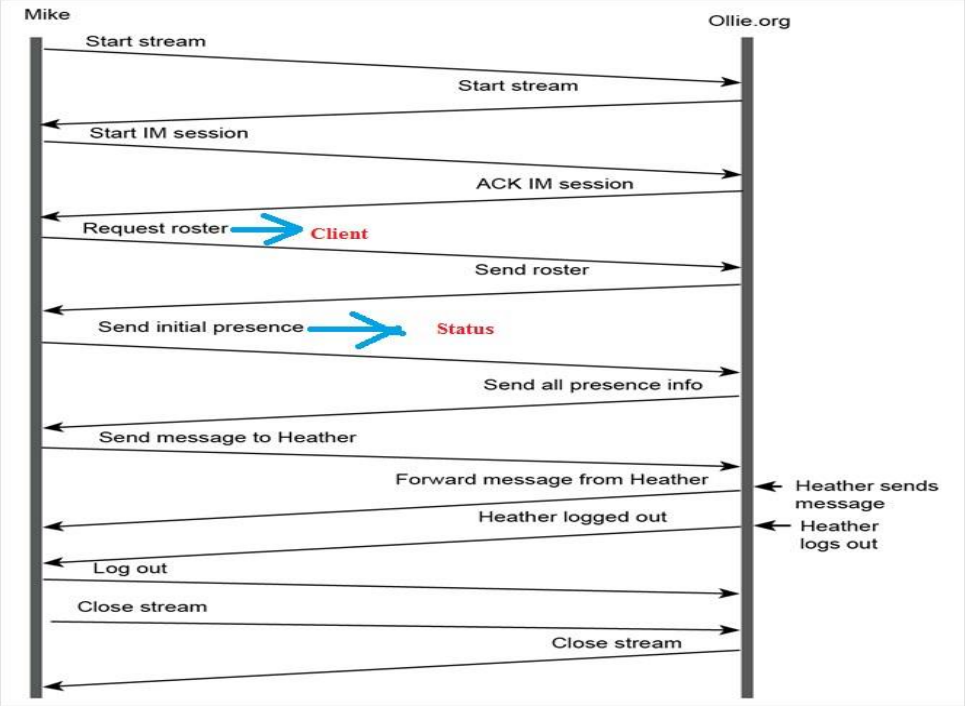


Implements **DTLS(Datagram Transport Layer security)** for secure message exchange in Transport layer

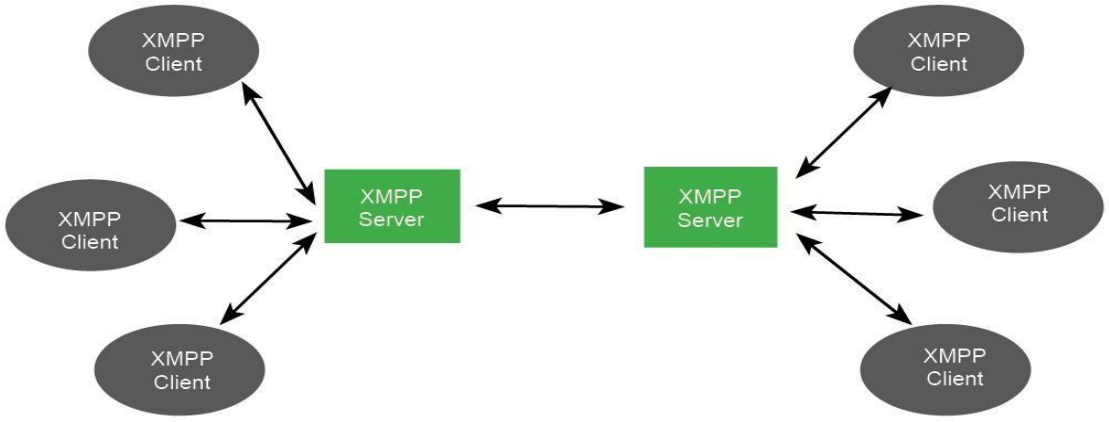
XMPP (**Extensible Messaging and Presence Protocol**) formerly known as Jabber, is a communications protocol based on XML (Extensible Markup Language)

- **X :** It means eXtensible. XMPP is a open source project which can be changed or extended according to the need.
- **M :** XMPP is designed for sending messages in real time. It has very efficient push mechanism compared to other protocols.
- **P :** It determines whether you are online/offline/busy. It indicates the state.

- **P :** XMPP is a protocol, that is, a set of standards that allow systems to communicate with each other.



- Wide range of applications including messaging, presence, data syndication(aggregated collection), gaming, group video calls
- Supports both client-to -server & Server -to - server communication paths.
- Used in chat apps.
- XMPP uses Port 5222 for the client to server (C2S) communication and utilizes Port 5269 for server to server (S2S) communication.

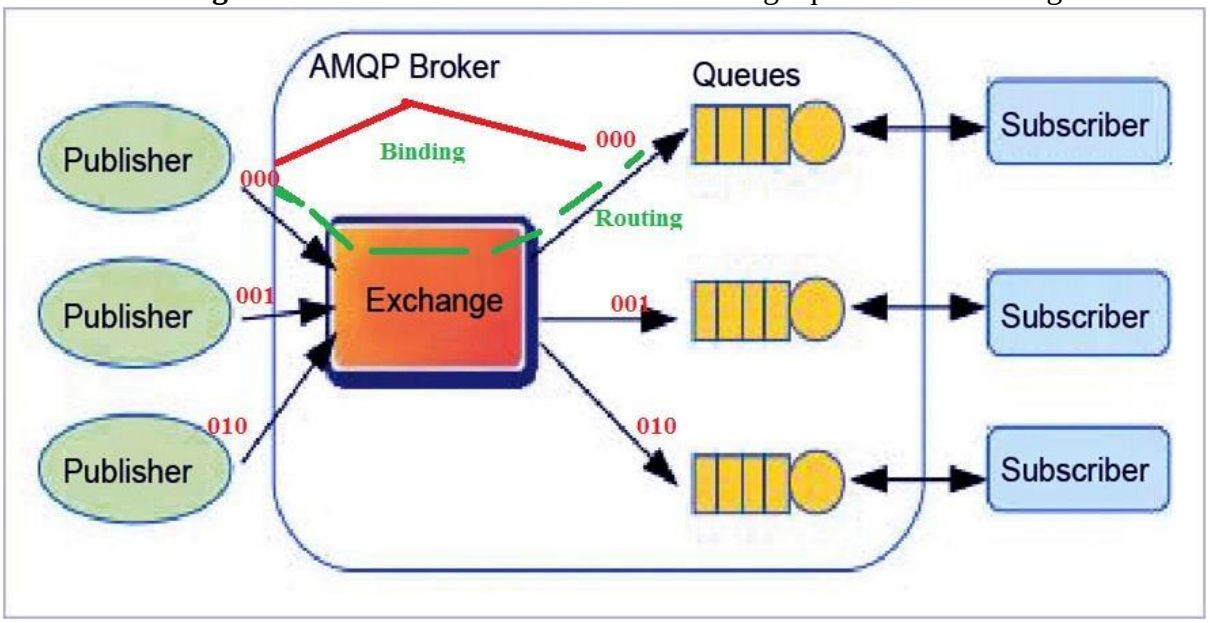


AMQP: Advanced Message Queuing protocol

- Open application layer for business messaging.
- Supports both Point-to-Point & Publisher/subscriber models, routing and Queuing.
- AMQP brokers receive messages from publishers(device which generates data)

and route them over connections to consumers.

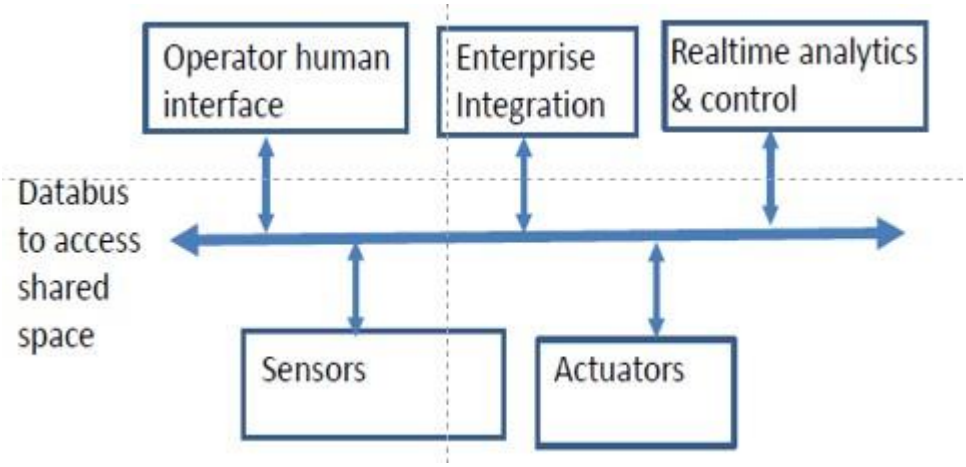
- Messages are either delivered by the broker to the consumers which have subscribed to the queues or the consumers can pull the messages from the queues.
- The AMQP protocol enables patron programs to talk to the dealer and engage with the AMQP model. This version has the following three additives, which might link into processing chains in the server to create the favored capabilities.
- **Exchange:** Receives messages from publisher primarily based programs and routes them to 'message queues'.
- **Message Queue:** Stores messages until they may thoroughly process via the eating client software.
- **Binding:** States the connection between the message queue and the change.



DDS: Data

Data distribution Service is a data centric middleware standard for Device to Device or machine to machine communication.

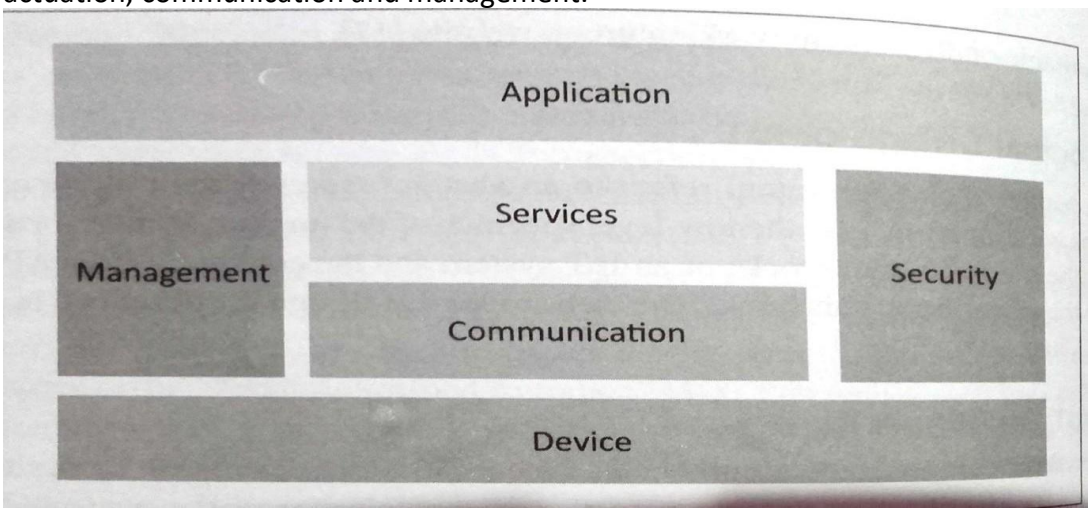
- Publish-Subscribe model.
- Publishers (IoT device which generates data) create topics to which subscribers(device which receives data) can subscribe.
- Provides Quality of service (Qos) control, configurable & reliability
- DDS makes use of multi casting to convey high-quality QoS to applications.



LOGICAL DESIGN of IoT

Refers to an abstract represent of entities and processes without going into the low level specifies of implementation.
1) IoT Functional Blocks 2) IoT Communication Models 3) IoT Comm. APIs

1) **IoT Functional Blocks:** Provide the system the capabilities for identification, sensing, actuation, communication and management.



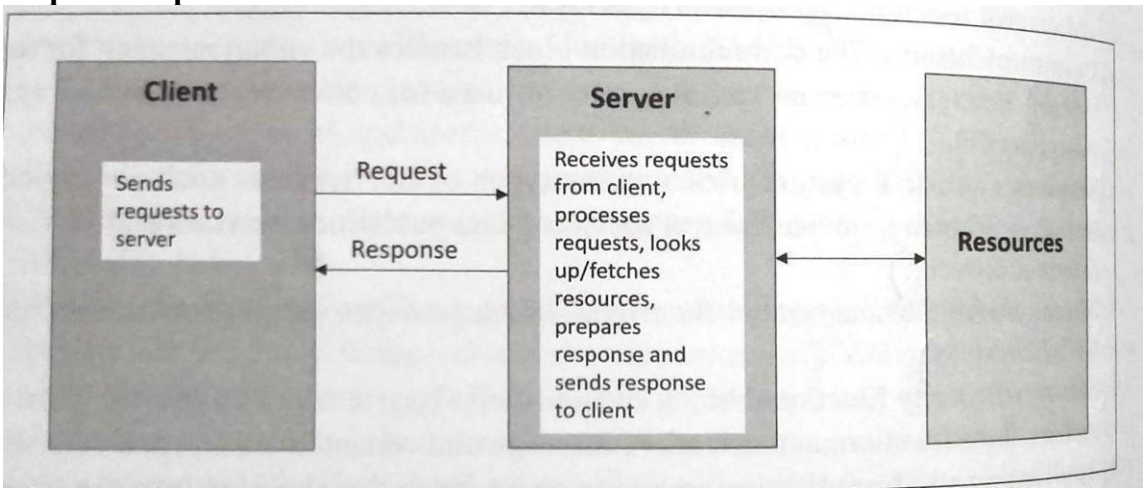
- **Device:** An IoT system comprises of devices that provide sensing, actuation, monitoring and control functions.

- **Communication:** handles the communication for IoTsystem.
- **Services:** for device monitoring, device control services, data publishing services and services for device discovery.
- **Management:** Provides various functions to govern the IoT system.
- **Security:** Secures IoT system and priority functions such as authentication ,authorization, message and context integrity and data security.
- **Application:** IoT application provide an interface that the users can use to control and monitor various aspects of IoT system.

2) IoT Communication Models:

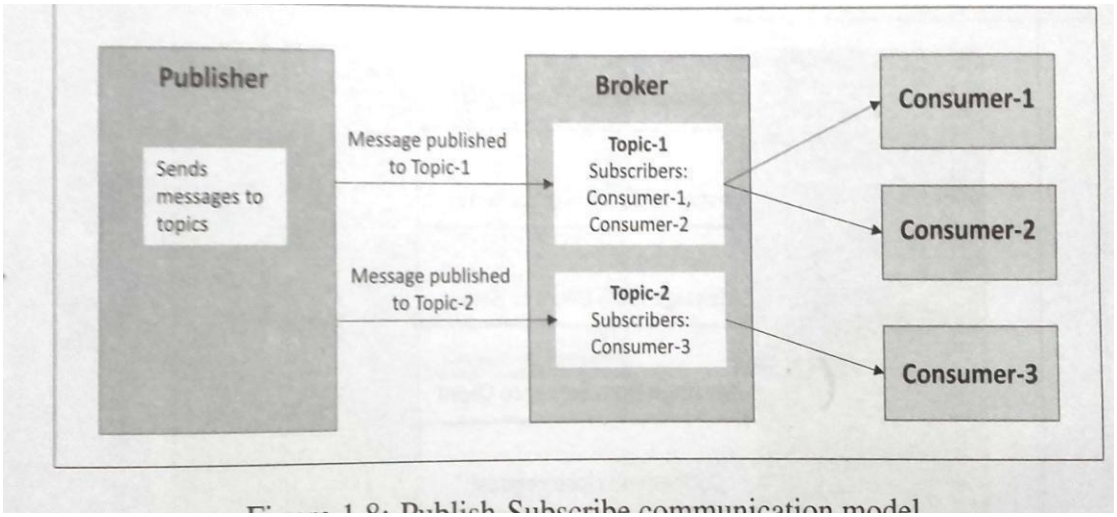
1) Request-Response 2) Publish-Subscibe 3)Push-Pull4) ExclusivePair

1) Request-Response Model:



In which the client sends request to the server and the server replies to requests. Is a stateless communication model and each request-response pair is independent of others.

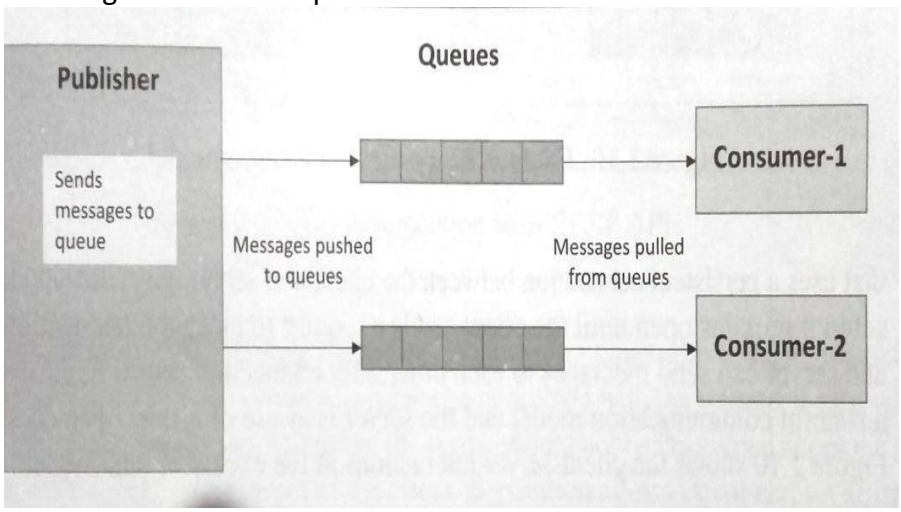
2) Publish-Subscibe Model:



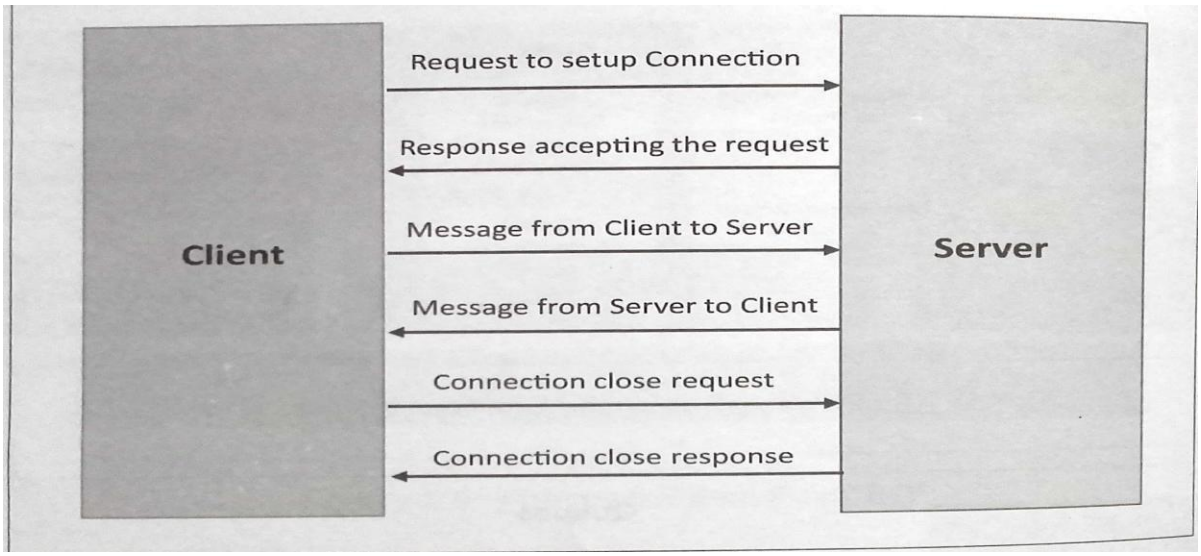
Involves publishers, brokers and consumers. Publishers are source of data. Publishers send data to

the topics which are managed by the broker. Publishers are not aware of the consumers. Consumers subscribe to the topics which are managed by the broker. When the broker receives data for a topic from the publisher, it sends the data to all the subscribed consumers.

3) **Push-Pull Model:** in which data producers push data to queues and consumers pull data from the queues. Producers do not need to aware of the consumers. Queues help in decoupling the message between the producers and consumers.



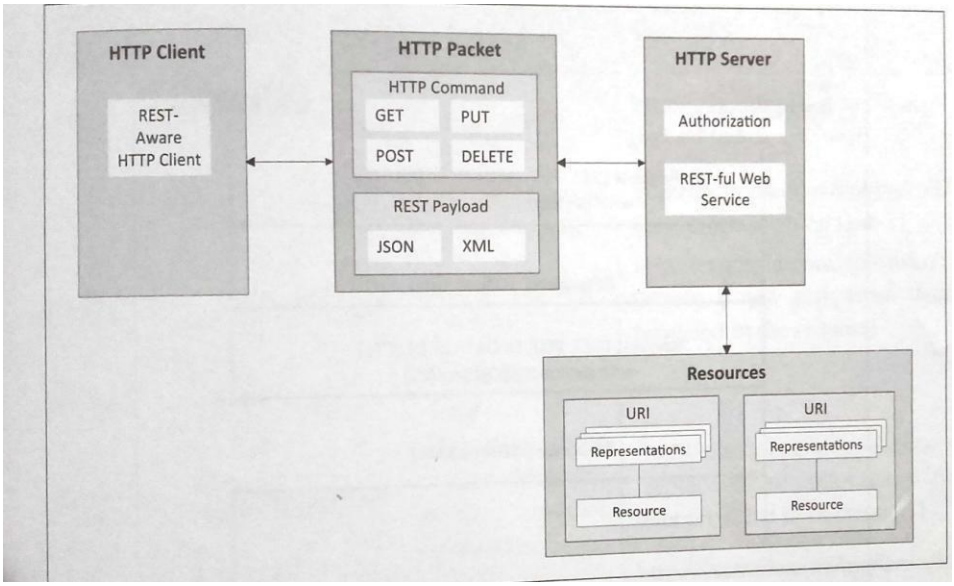
4) **Exclusive Pair:** is bi-directional, fully duplex communication model that uses a persistent connection between the client and server. Once connection is set up it remains open until the client send a request to close the connection. Is a stateful communication model and server is aware of all the open connections.



3) IoT Communication APIs:

a) REST based communication APIs(Request-Response Based Model)
b) WebSocket based Communication APIs(Exclusive PairBased Model)

a) REST based communication APIs: Representational State Transfer(REST) is a set of architectural principles by which we can design web services and web APIs that focus on a system_s resources and have resource states are addressed and transferred.
The REST architectural constraints: Fig. shows communication between client server with REST APIs.



Client-Server: The principle behind client-server constraint is the separation of concerns. Separation allows client and server to be independently developed and updated.
Stateless: Each request from client to server must contain all the info. Necessary to understand the

request, and cannot take advantage of any stored context on the server.

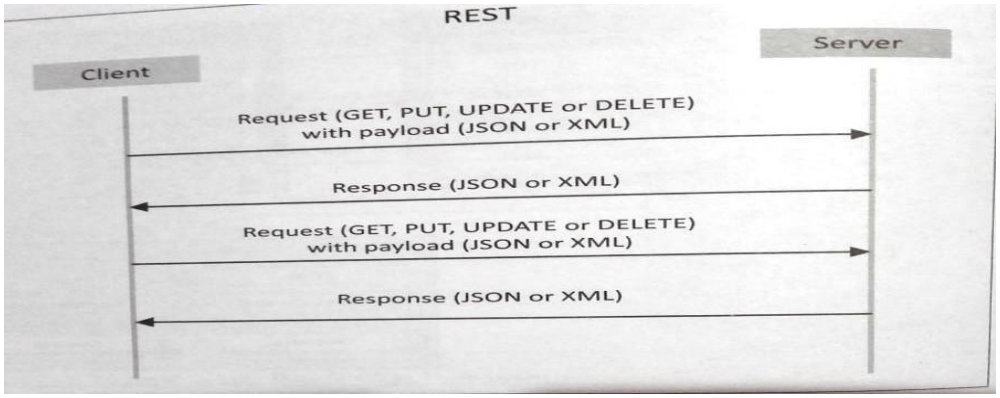
Cache-able: Cache constraint requires that the data within a response to a request be implicitly or explicitly labeled as cache-able or non-cacheable. If a response is cache-able, then a client cache is given the right to reuse that response data for later, equivalent requests.

Layered System: constraints the behavior of components such that each component cannot see beyond the immediate layer with which they are interacting.

User Interface: constraint requires that the method of communication between a client and a server must be uniform.

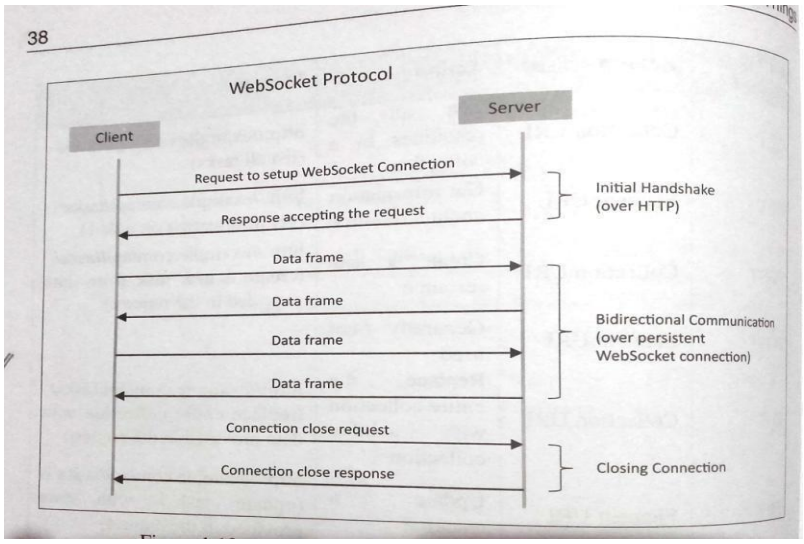
Code on Demand: Servers can provide executable code or scripts for clients to execute in their context. This constraint is the only one that is optional.

Request-Response model used by REST:



RESTful web service is a collection of resources which are represented by URIs. RESTful web API has a base URI(e.g: http://example.com/api/tasks/). The clients and requests tothese URIs using the methods defined by the HTTP protocol(e.g: GET, PUT, POST or DELETE). A RESTful web service can support various internet media types.

b) WebSocket Based Communication APIs: WebSocket APIs allow bi- directional, full duplex communication between clients and servers. WebSocketAPIs follow the exclusive pair communication model.


38
WebSocket Protocol
Client
Server
Request to setup WebSocket Connection
Response accepting the request
Initial Handshake
(over HTTP)
Data frame
Data frame
Data frame
Data frame
Bidirectional Communication
(over persistent
WebSocket connection)
Connection close request
Connection close response
Closing Connection

S.NO.	REST API	WEB SOCKET API
1.	It is Stateless protocol. It will not store the data.	It is Stateful protocol. It will store the data.
2.	It is Uni-directional. Only eiether server or client will communicate.	It is Bi-directional. Messages can be received or sent by both server or client.
3.	It is Request-response model.	It is Full duplex model.
4.	HTTP request contains headers like head section, title section.	It is suitable for real time applications. It does not have any overhead.
5.	It does not need memory or buffers to store the data.	It require memory and buffers to store the data.
6.	New TCP connection will be set up for each HTTP request.	Only Single TCP connection.
7.	Both horizontal and vertical scaling (we can add many resources and number of users both horizontally and vertically).	Only vertical scaling (we can add resources only vertically).
8.	It depends upon the IP address and port number to retrive the data.	It depends upon the HTTP methods to retrive the data.
9.	It is slower than web socket regarding the transmission of messages.	web socket transmits messages very fastly than REST API.

IoT Enabled Technologies:

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

1. Wireless Sensor Networks(WSN)

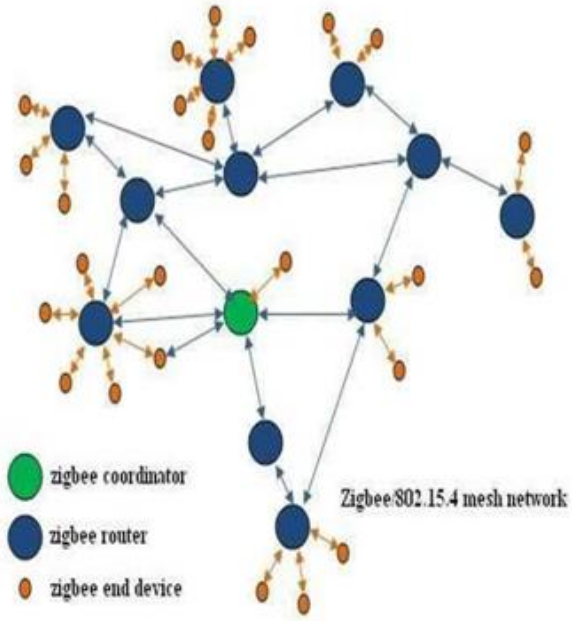
2. Cloud Computing

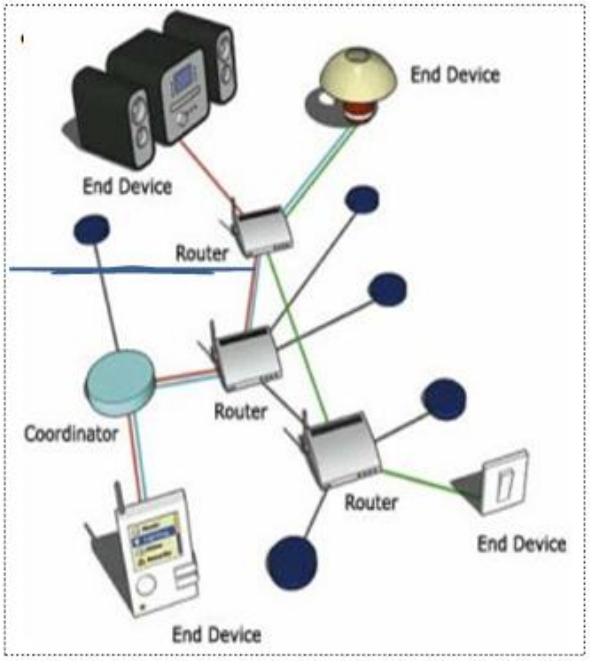
3. Big Data Analytics

Wireless Sensor Networks(WSN)

- Wireless Sensor Network(WSN) Comprises of **distributed devices with sensors which are used to monitor** the environmental and physical conditions.
- A WSN consist of a number of **end-nodes, routers and coordinators.**
- Each node have several **sensors attached**.
- Routers are responsible for **routing the data packets** from end-nodes to the coordinator.
- Coordinator **collects the data** from all the nodes & also acts as a gateway that connects the WSN to the internet.
- **Zigbee** is one of the most popular wireless technologies used by WSNs
- Zigbee is a **wireless technology** developed as an open global standard to address the unique needs of **low-cost, low-power wireless IoT networks**. The Zigbee standard operates on the **IEEE 802.15.4.**
- Zigbee operates at **2.4GHz frequency.**
- **Data rate: 20Kbps to 250KBps.**
- **Range: 10 to 100 meters.**
- WSNs have large numbers of nodes, manual configuration for each node is not possible. **The self-organizing capability** of WSN makes the network robust**.**
- In the **event of failure of some nodes or or addition of new nodes to the network, the network can reconfigure itself.**

ZigBee:

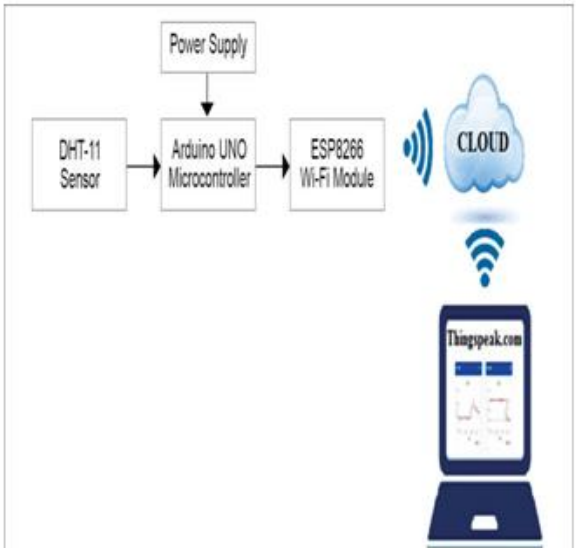




WSNs in IoT Systems:

- Weather Monitoring System: in which nodes collect temp, humidity and other data, which is aggregated and analyzed.
- Indoor air quality monitoring systems: to collect data on the indoor air quality and concentration of various gases.
- Soil Moisture Monitoring Systems: to monitor soil moisture at various locations.
- Surveillance Systems: use WSNs for collecting surveillance data(motion data detection).
- Smart Grids: use WSNs for monitoring grids at various points.
- Structural Health Monitoring Systems: Use WSNs to monitor the health of
- structures(building, bridges) by collecting vibrations from sensor nodes deployed at various points in the structure

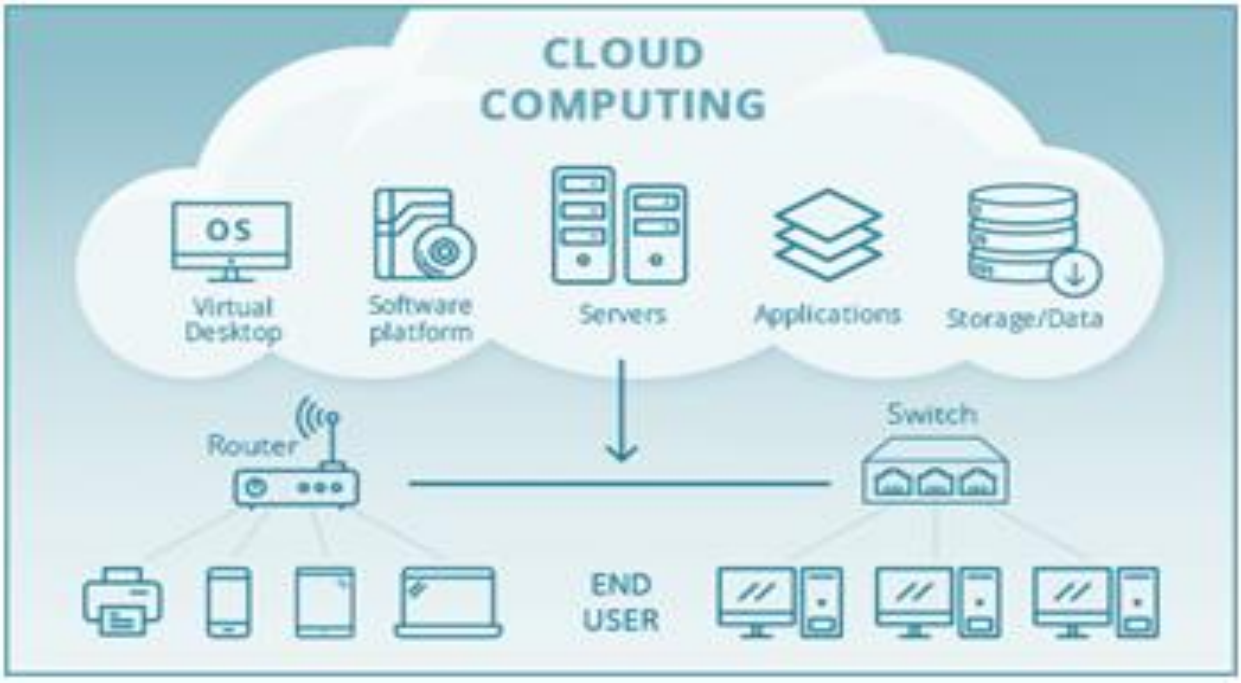
Weather Monitoring System



Cloud computing:

- Cloud computing is the on-demand availability of computer system resources, especially data storage (cloud storage) and computing power, without direct interaction by the cloud service provider.
- The computing and storage resources provided by cloud services are pooled to multiple users using multi tenancy, which allows multiple users to be serviced by the same physical hardware.
- Users are assigned virtual resources that run to top of the physical layer.
- Cloud Computing is both a combination of software and hardware based computing resources delivered as a network service.

Cloud computing Architecture:



Why Cloud Computing?

With increase in computer and Mobile user's, data storage has become a priority in all fields. Large and small scale businesses today thrive on their data & they spent a huge amount of money to maintain this data. It requires a strong IT support and a storage hub. Not all businesses can afford high cost of in-house IT infrastructure and back up support services. For them Cloud Computing is a cheaper solution. Perhaps its efficiency in storing data, computation and less maintenance cost has succeeded to attract even bigger businesses as well.

Cloud computing decreases the hardware and software demand from the user's side. The only thing that user must be able to run is the cloud computing systems interface software, which can be as simple as Web browser, and the Cloud network takes care of the rest. We all have experienced cloud computing at some instant of time, some of the popular cloud services we have used or we are still using are mail services like gmail, hotmail or yahoo etc.

While accessing e-mail service our data is stored on cloud server and not on our computer. The technology and infrastructure behind the cloud is invisible. It is less important whether cloud services are based on HTTP, XML, Ruby, PHP or other specific technologies as far as it is user friendly and functional. An individual user can connect to cloud system from his/her own devices like desktop, laptop or mobile.

Cloud computing harnesses small business effectively having limited resources, it gives small businesses access to the technologies that previously were out of their reach. Cloud computing helps small businesses to convert their maintenance cost into profit. Let's see how?

In an in-house IT server, you have to pay a lot of attention and ensure that there are no flaws into the system so that it runs smoothly. And in case of any technical glitch you are completely responsible; it will seek a lot of attention, time and money for repair. Whereas, in cloud computing, the service provider takes the complete responsibility of the complication and the technical faults.

Benefits of Cloud Computing

The potential for cost saving is the major reason of cloud services adoption by many organizations. Cloud computing gives the freedom to use services as per the requirement and pay only for what you use. Due to cloud computing it has become possible to run IT operations as a outsourced unit without much in-house resources.

Now in this Cloud Computing tutorial, we will learn the benefits of Cloud Computing. Following are the benefits of cloud computing:

1. Lower IT infrastructure and computer costs for users
2. Improved performance
3. Fewer Maintenance issues
4. Instant software updates
5. Improved compatibility between Operating systems
6. Backup and recovery

7. Performance and Scalability
8. Increased storage capacity
9. Increase data safety

Service and Deployment models of Cloud Computing:

Deployment models of Cloud Computing

Deployment in cloud computing comprises four deployment models: private cloud, public cloud,communitycloud and hybrid cloud.

Types of Clouds

There are four different cloud models that you can subscribe according to business needs. Following are the different Types of Clouds:

Figure :Types of Clouds

1. **Private Cloud:** Here**,** computing resources are deployed for one particular organization. This method is more used for intra-business interactions. Where the computing resources can be governed, owned and operated by the same organization.
2. **Community Cloud:** Here**,** computing resources are provided for a community and organizations.
3. **Public Cloud:** This type of cloud is used usually for B2C (Business to Consumer) type interactions. Here the computing resource is owned, governed and operated by government, an academic or business organization.

4. **Hybrid Cloud:** This type of cloud can be used for both type of interactions - B2B (Business to Business) or B2C (Business to Consumer). This deployment method is called hybrid cloud as the computing resources are bound together by different clouds.

Service models of Cloud Computing

- Cloud Services are offered to users in different forms.
- **Service models** are the reference models on which the Cloud Computing is based. These can be categorized into three basic service models as listed below:

1. **Infrastructure as a Service (IaaS)**
2. **Platform as a Service (PaaS)**
3. **Software as a Service (SaaS)**

.Infrastructure as a Service (IaaS)

- IaaSis the delivery of technology infrastructure as an on demand scalable service.
- IaaS provides users the ability to provision computing and storage resources. These resources are provided to the users as a virtual machine instances and virtual storage.
- Users can start, stop, configure and manage the virtual machines & virtual storage.
- Users can deploy operating systems and applications of their choice on the virtual resources provisioned in the cloud.
- Virtual resources provisioned by the users are billed based on pay-per-use paradigm.

Advantages:

- Enhanced Scalability.
- Flexibility.

Disadvantages:

- Security issues
- Service delays
- Network delays

Used by: System administrators

Example: AWS EC2 (Amazon Elastic Compute Cloud)

Amazon Elastic Compute Cloud (Amazon EC2) is a web service that

provides resizable computing capacity—literally, servers in Amazon's data

centers—that you use to build and host your software systems.

Platform-as-a-Service(PaaS)

- PaaS provides users the ability to develop and deploy application in cloud using the development tools, APIs, software libraries and services (OR)
- Provides OS +Programming language + API + Server + database
- No choice of OS, NO virtual machines/storage.
- Users can build, compile &run programs to develop Applications.
- Typically applications must be developed with a particular platform in mind
- Users are responsible for data manage & application resources.
- Multi tenant environments.

Advantages:

- Scalable & Cost effective
- Faster market for developers
- Easy deployment of web applications

Disadvantages:

- Must use language provided
- No virtual machines/storage.
- Vendor lock-in

Used by: Software Developers

Example: Google App Engine, AWS Elastic Bean Stack

Software-as-a-Service(SaaS)

- SaaS provides the user a complete software application or the user interface to the application itself
- The Cloud Service provider(vendor) manages the underlying cloud infrastructure including servers, network, operating system, storage and Application software.
- User is unaware of underlying architecture since managed by vendor.
- NO need to install software on PC
- Applications are provided through client interface(browser)
- Platform independent(mac, windows, linux)

Advantages:

- Universally accessible from any platform

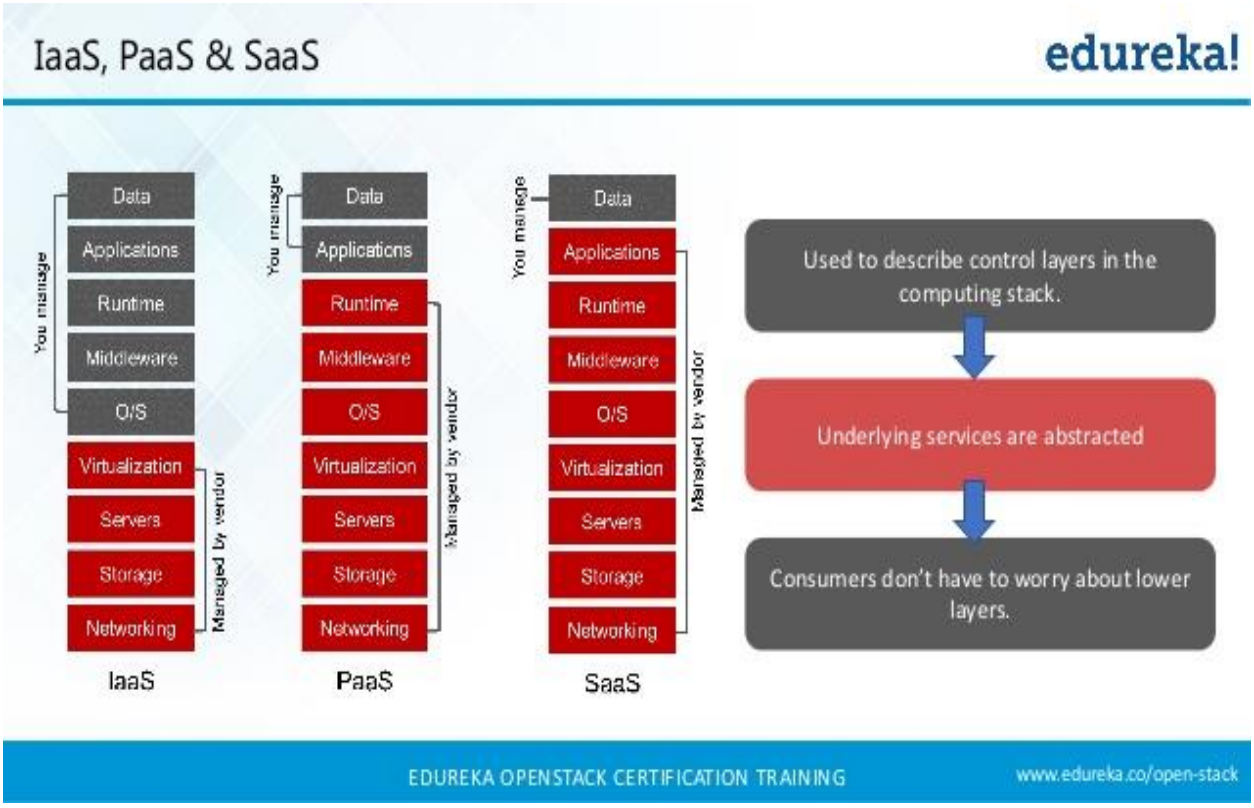
- Excellent for collaborative work
- Vendors provides modest software tools
- Allows for multi tenancy

Disadvantages:

- Less flexibility
- Browser issues
- Vendor lock-in

Used by: End Consumers

Example: Gmail, online office 365, Google Docs, online convertors--ilovepdf


IaaS, PaaS & SaaS
edureka!
Data
Applications
Runtime
Middleware
O/S
Virtualization
Servers
Storage
Networking
You manage
Managed by vendor
IaaS
PaaS
SaaS
Used to describe control layers in the computing stack.
Underlying services are abstracted
Consumers don't have to worry about lower layers.
EDUREKA OPENSTACK CERTIFICATION TRAINING
www.edureka.co/open-stack


Pizza as a Service
Traditional On-Premises (On Prem)
Infrastructure as a Service (IaaS)
Platform as a Service (PaaS)
Software as a Service (SaaS)
Dining Table
Soda
Electric / Gas
Oven
Fire
Pizza Dough
Tomato Sauce
Toppings
Cheese
Made at home
Take & Bake
Pizza Delivered
Dined Out
You Manage
Vendor Manages

Virtualization and Cloud Computing

The main enabling technology for Cloud Computing is Virtualization. Virtualization is a partitioning of single physical server into multiple logical servers. Once the physical server is divided, each logical server behaves like a physical server and can run an operating system and applications independently. Many popular companies's like VmWare and Microsoft provide virtualization services, where instead of using your personal PC for storage and computation, you use their virtual server. They are fast, cost-effective and less time consuming.

For software developers and testers virtualization comes very handy, as it allows developer to write code that runs in many different environments and more importantly to test that code.

Virtualization is mainly used for three main purposes **1) Network Virtualization 2) Server Virtualization 3) Storage Virtualization**

Network Virtualization**:** It is a method of combining the available resources in a network by splitting up the available bandwidth into channels, each of which is independent from the others and each channel is independent of others and can be assigned to a specific server or device in real time.

Storage Virtualization: It is the pooling of physical storage from multiple network storage devices into what appears to be a single storage device that is managed from a central console. Storage virtualization is commonly used in storage area networks (SANs).

Server Virtualization: Server virtualization is the masking of server resources like processors, RAM, operating system etc, from server users. The intention of server virtualization is to increase the resource sharing and reduce the burden and complexity of computation from users.

Virtualization is the key to unlock the Cloud system, what makes virtualization so important for the cloud is that it decouples the software from the hardware. For example, PC's can use virtual memory to borrow extra memory from the hard disk. Usually hard disk has a lot more space than memory. Although virtual disks are slower than real memory, if managed properly the

substitution works perfectly. Likewise, there is software which can imitate an entire computer, which means 1 computer can perform the functions equals to 20 computers.

Big Data Analytics:

- Big data is a collection of data sets whose volume, velocity ,variety is so large to that is difficult to store, manage, process and analyze the data using traditional databases and data processing tools.
- Big data analytics involves several steps starting from data cleansing, data munging(or wrangling),data processing and visualization.
- Big Data analytics is used to extract meaningful insights, such as hidden patterns, unknown correlations, market trends, and customer preferences.

Advantages:

- better decision making.
- Cost reduction
- New products & services.

Characteristics of Big data:

Volume: There is no limit for the volume of data, Big data analytics used for massive scaling of data which is difficult to store, manage and process using traditional databases & data processing architectures.

Velocity: velocity of data refers to how fast is generated & how frequently it varies.

Variety: Variety refers to the forms of the data such as text data, image ,audio, video and Sensor data

Communication Protocols:

- Communication Protocols form the back-bone of IoT systems and enable network connectivity and coupling to applications.
  - Allow devices to exchange data over network.
  - Define the exchange formats, data encoding addressing schemes for device and routing of packets from source to destination.
  - It includes sequence control, flow control and retransmission of lost packets

Note: Communication Protocols already discussed in IOT Protocols

Embedded Systems:

- Embedded Systems is a computer system that has computer hardware and software embedded to perform specific tasks.
- Key components of an embedded systems include micro processor/micro controller, memory(RAM, ROM, Cache), networking units(ethernet, wifi

adapters),input/output devices(keyboard, monitor display) and storage device like flash memory.

- Some embedded systems have specialized processors such as DSPs(Digital Signal processors),Graphics processors, Asps(Application specific processors)
- Embedded System range from low cost miniaturized devices such as digital watches to devices such as digital cameras, POS terminals, vending machines, appliances etc.