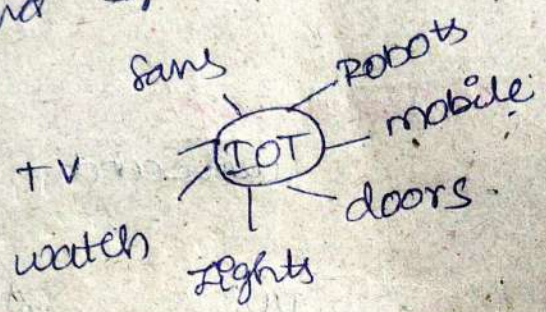
06/02/2024
Tuesday

IOT. It is a world of Interconnected things.

It describe the network of physical object "things" that are embedded with sensors, s/w and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.



Characteristics of IOT
=) Security and privacy
=) Automation and contr
=) Dynamic and self adapting
=) Self - configuring, Scalability
=) unique Identity, Heterogeneity
=) Integrated into information network
=) Interoperable communication protocols

Physical design of IOT
The "Things" in IOT usually refers to IOT devices which have unique identities and can perform remote sensing, actuatin and monitoring.

How IOT works
RFID -) Sensor -) Smart tech -) Nano tech
Radio frequency Identification.

IOT devices can,

- Exchange data with connected devices
- collect data from other devices and process the data
- send data to centralized servers
- perform some task locally.

Application layer

HTTP | COAP | WebSockets

MQTT | XMPP | DDS | AMQP

Transport layer

TCP | UDP

Network layer

IPv4 | IPv6 | 6LOWPAN

Data link layer

802.3 - Ethernet | 802.16 - WiMax | 2G/3G/LTE - cellular

802.11 - WiFi | 802.15.4 - LR.WPAN

Application layer

The application layer act as an interface between end-user and IOT, the user can utilize the data and manage the device through the set of application that runs in this layer.

The IOT can be tailored according to the requirement and it is possible to run a high-level smart application in this layer.

Transport layer

The transport layer provides with end to end connection between the source and the destination and reliable delivery of the services

Transport layer is known as the end-end layer

The transport layer takes the services from its upward layer which is the application layer and provides it to the network layer.

TCP → Transmission control protocol

UDP → universal Datagram protocol

Network Layer

Network layer is responsible for the transmission of data or communication from one host to another host connected in a network.

Rather than describing how data is transferred, it implements the technique for efficient transmission.

Data link layer

It provide the device to the Network layer.

Connecting IP address to the MAC address

Matching connections (mapping).

Logical design of IOT

Logical representations of an IOT system refers to an abstract representation of the entities and process without going into the low-level specifics of the implementation.

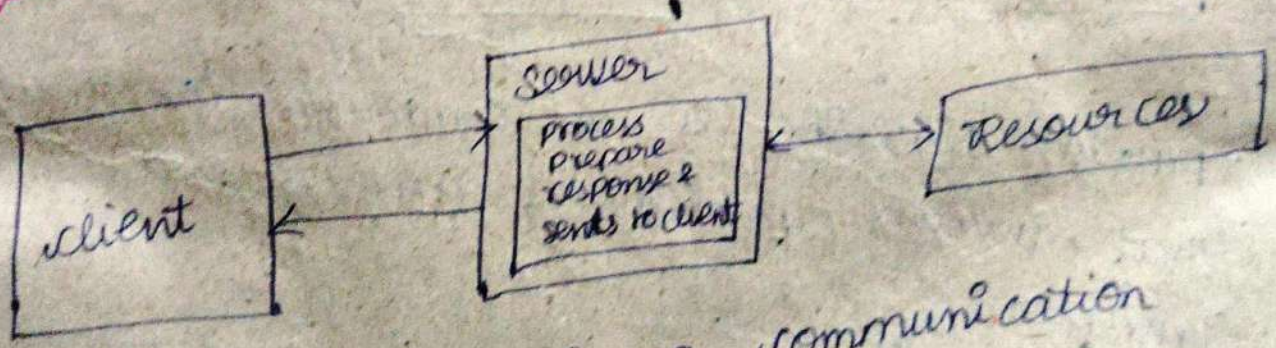
IOT functional blocks

* Device
* communication
* Services
* Management
* Security
* Application

IOT communication model

i) Request - Response
ii) publish - subscribe
iii) push - pull
iv) Exclusive pair

Request - Response communication model

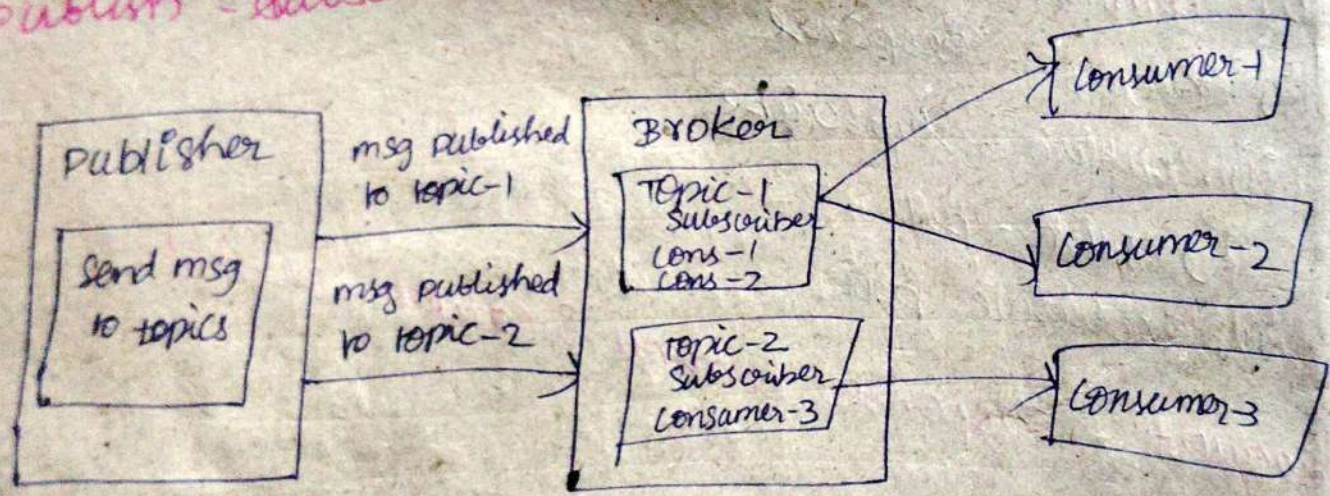


• Request - Response is a communication model in which the client sends request to the server and the server responds to the requests

- When the server receives a request, it decides how to respond, fetches the data, retrieves resources representations, prepares the response and then sends the response to the client

- Stateless communication model

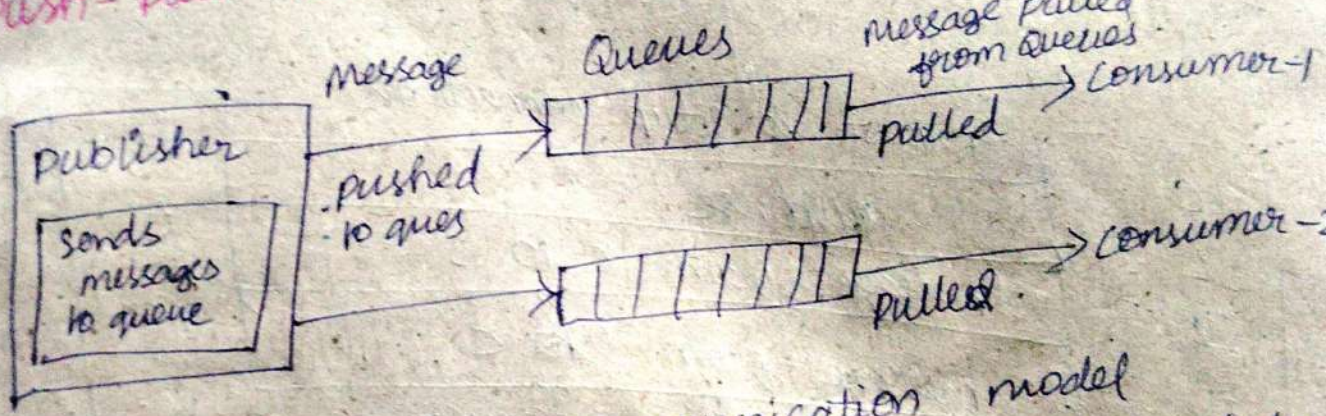
Publish - subscribe communication model



- Publish - subscribe is a communication model that involves publishers, brokers and consumers
- Publisher are the source of data
- publishers send the 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 subscribed consumers

Push-pull communication model

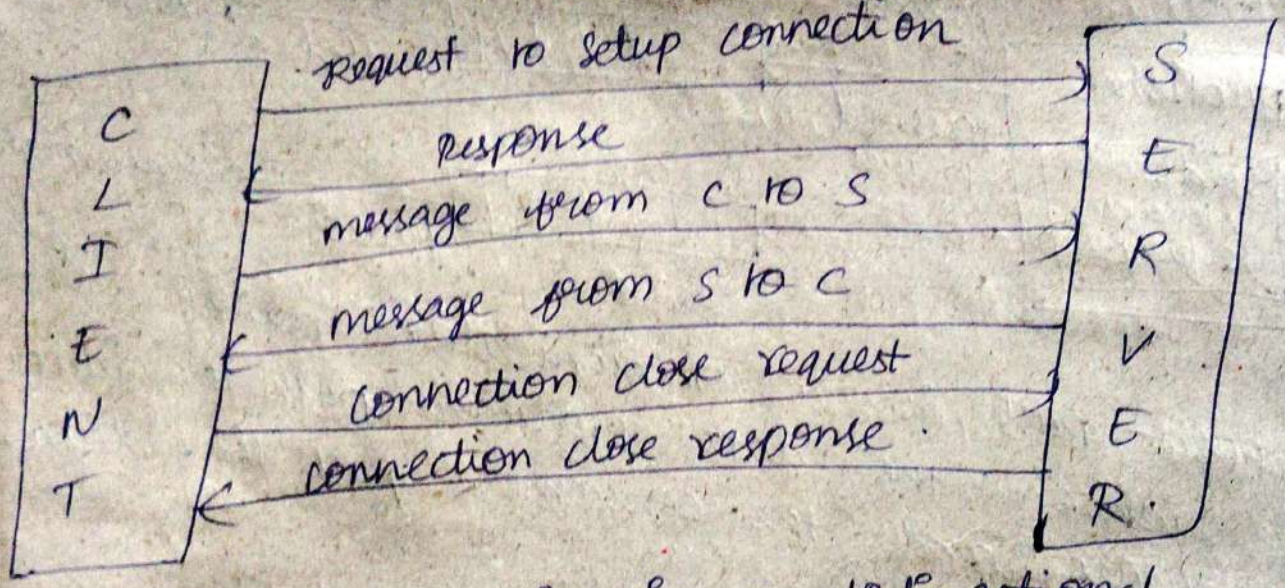


- push-pull is a communication model in which the data producers push the data to queues and the consumers pull the data from the queues
- producers do not need to be aware of the consumers
- Queues help in decoupling the messaging between the producers and consumers

• Queues also act as a buffer which helps in situations when there is a mismatch between the rate at which the producers push data and the rate at which the consumers pull data.

Exclusive pair communication model

Bi-directional



• The exclusive pair is a bidirectional, fully duplex communication model that uses a persistent connection between the client and server.

• once the connection is setup it remains open until the client sends a request to close the connection

• client and server can send messages to each other after connection setup.

API

IOT API are the interaction b/w an IOT device and the Internet or other element within the network

=) set of functions, protocols, routines and tools used for building application software.

IOT communication API'S

Generally, there are two API'S used for IOT communication.

=) REST - based communication APIS

=) WebSocket - based communication APIS

REST - based communication APIS

Representational state Transfer (REST) is a set of architectural principles by which you can design web services & web APIs that focus on a system resources and how system resources states are addressed and transferred

REST constraints

Client - Server

The principle behind the client-server constraints is the seperation of concerns

Eg

⇒ client should not concerned about storage. It is concern of server

⇒ server should not concern about user interface. It is concern of clients.

So this seperation allows clients and server to be independently developed and uploaded.

Stateless

Each communication should be independent of others.

Each request from client should include all the required information to understand the request.

Cacheable

Cache constraints requires that the data within a response to a request be implicity or explicitly labelled as cachable or non-cacheable.

If it is cacheable then the client is given right to reuse that response for later for equivalent requests.

Layered System

Layered system constraints, constraints the behaviour of components. such that each component can't see beyond the intermediate layers during interactions

Ex: A client can't tell if it is directly connected to server or immediate along the way

Uniform Interface

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

Code on demand

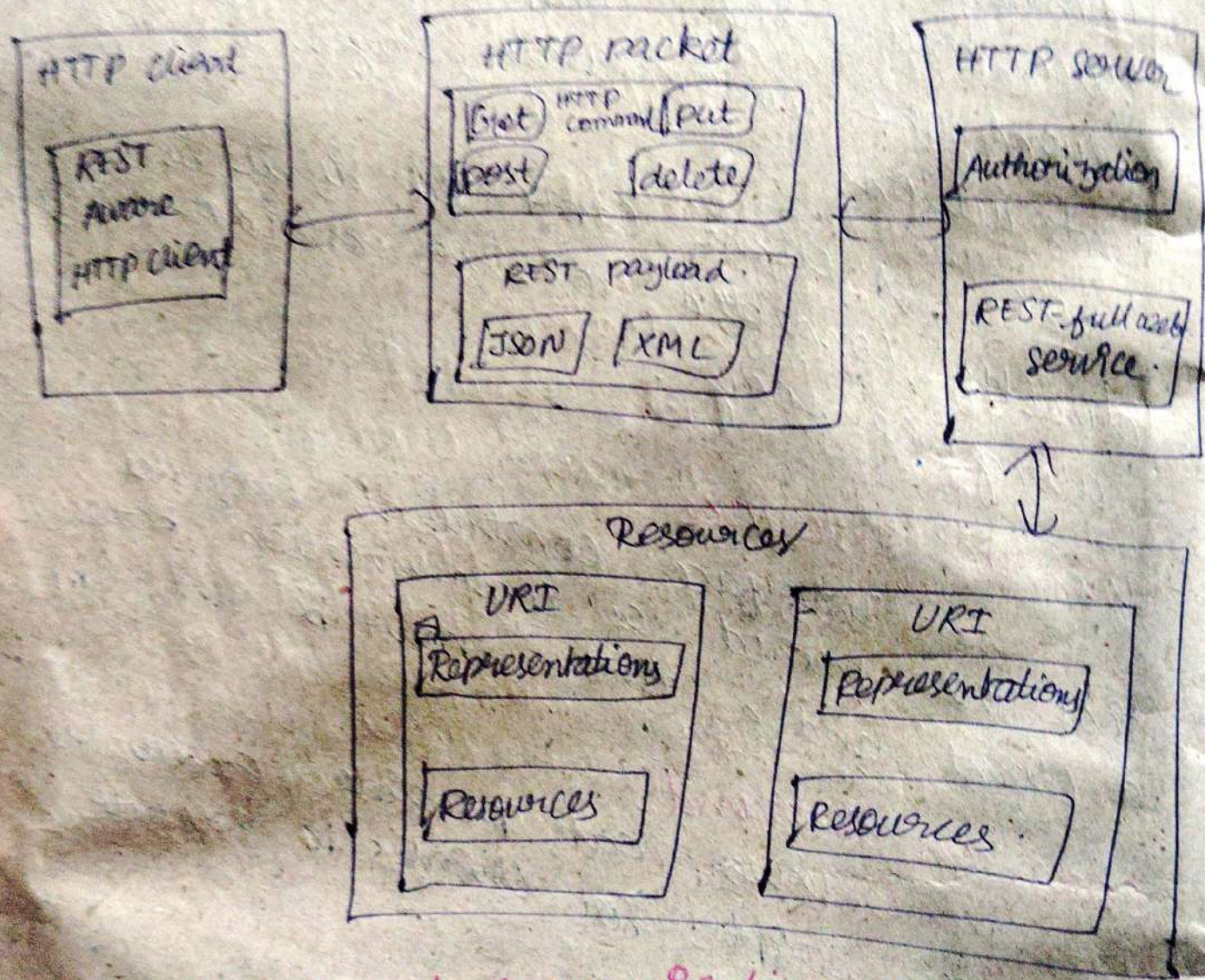
Server can provide executable code or scripts for clients to execute in their context

REST based communication API'S

=> follows request response communication model

=> Applies to components, connectors and data elements

Communication with REST API.

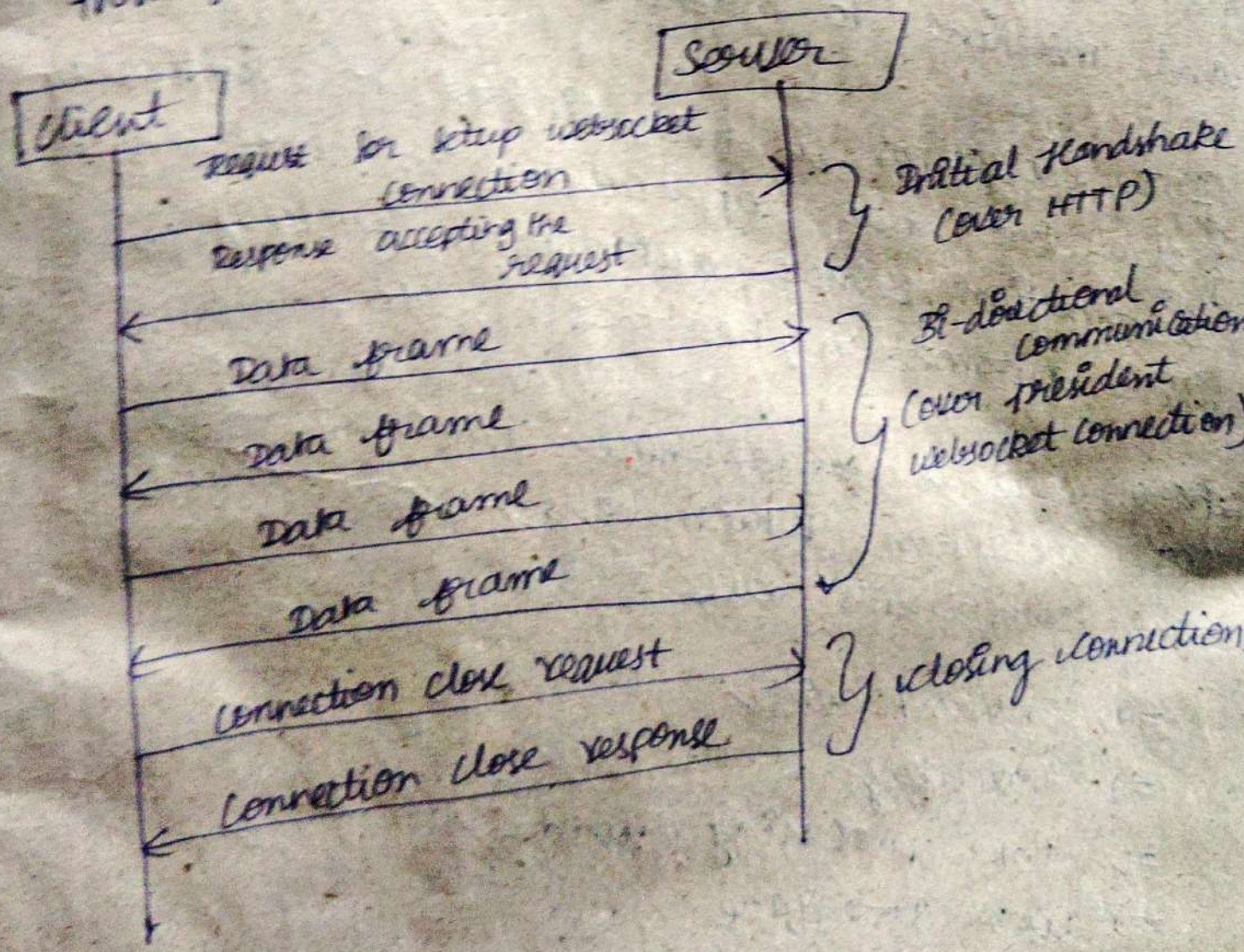


web-Socket based communication API's

* web-Socket APIs allow bi-directional, full duplex communication between client & servers.

* It follows exclusive pair of communication model.

- WebSocket APIs reduce the network traffic & latency as there is no overhead for connection setup & termination requests for each message
- WebSocket suitable for IOT applications that have low latency or high throughput requirement



Components of IOT ecosystems

Things or Device $\xrightarrow[\text{Data}]{\text{wireless}}$ Gateway $\xrightarrow[\text{Data}]{}$ cloud $\xrightarrow[\text{Data}]{}$ Analytics $\xrightarrow[\text{Data}]{}$ User Interface

IOT connects multiple device at a time. The internet thereby facilitating man to machine and machine to machine interactions

IOT ecosystems is not limited to a particular field, but has applications in home automation, vehicle automation, factory line automation, healthcare, etc,

There are 4 fundamental components of IOT ecosystem which tells us how IOT works. The components are

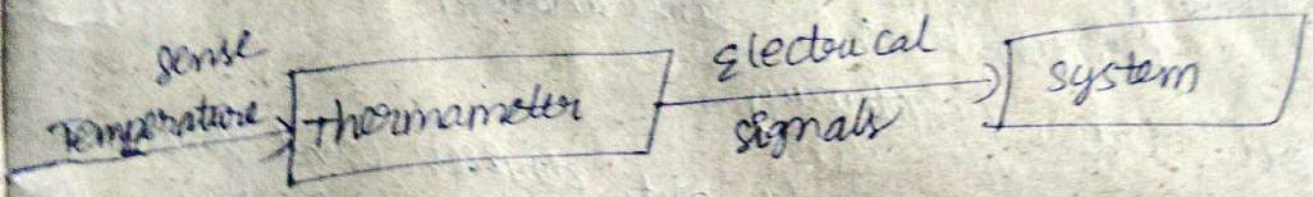
=) Sensors / Devices
=) Gateway
=) Data processing (cloud & Analytics)
=) User Interface

Sensors / Devices

=) Sensor is a hardware device that takes the input from environment and gives to the system by converting it

* Static
* Dynamic

Sensor classification
=) Passive & Active
=) Analog & digital
=) Scalar & vector



Actuator

It 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

~~environment~~ Actuators ~~—~~ System
(heat/motion)

Ex: motors, heaters, etc.

Cloud & Analytics

IOT cloud offers tools to collect, process, manage and store huge amount of data created by devices, applications & users

Distributed database management system are the most important component of IOT cloud

Analytics is the process of converting analog data from billion of smart device and sensors into useful insights which can be interpreted and used for detailed analysis

Big enterprise use the massive data collected from IOT device and utilize for this future business opportunities

User Interface

user Interface should be well designed, so that users can perform minimum efforts to operate the IOT devices through it

- like multicolor touch panels have replaced hand switches in our household ~~applicati~~ appliances.

Major components of IOT systems

i) sensors / Devices
ii) connectivity
iii) Data processing
iv) user Interface

Sensors

sensors help in collecting very minute data from the surrounding environment,

eg Pressure sensor
Humidity sensor
Temperature sensor

Connectivity

: Collected data is send to a cloud infrastructure but it needs a medium for transport.

. The sensors can be connected to the cloud through various mediums

of communications and transport such as cellular networks, satellite network, wi-Fi, bluetooth and many more.

Data processing

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

user-Interface

user-Interface is the information made available to the end-user in some way.

Transducer

convert a single signal from one physical form to another form

Domain specific

Cities
* Smart parking
* Smart lighting
* Smart roads
* Structural health monitoring
* Surveillance
* Emergency response

Energy
* Smart Grids
* Renewable Energy Systems
* Prognostics
future health of the machine in real time

Home automation
* Smart lighting
* Smart appliances
* Intrusion Detection
* Smoke / Gas Detectors

Environment
* Weather Monitoring
* Air pollution monitoring
* Noise pollution monitoring
* Forest fire detection
* Flood Detection

Logistics
* Route Generation & Scheduling
* Fleet tracking
* Shipment monitoring
Remote vehicle monitoring

Retail
* Inventory management
* Smart payments
* Smart vending machines

Industry
* Machine Diagnosis & prognosis
* Indoor Air Quality Monitoring

Agriculture
* Smart Irrigation
* Greenhouse control

Health & Lifestyle

* Health & Fitness monitoring
* wearable Electronics.

cloud computing

* transformative computing paradigm
* It delivers applications and services over the Internet.

Different forms of to cloud computing servic

* Infrastructure-as-a-service (IaaS)
* platform-as-a-service (PaaS)
* Software-as-a-service (SaaS)

Big data Analytics

converts raw data into actionable insights.

Eg * Sensor data generated by weather monitoring stations.

Big data analytics

⇒ Data cleansing, data munging, data processing and visualization.

- characteristics of big data
  - => volume
  - => velocity
  - => variety

- 5V's of big data
  - => velocity, volume, value, variety and veracity
- 10V's of big data
- 17V's of big data.

communication protocols

* Backbone of IOT systems
* Enable network connectivity & coupling to applications
* Allow devices to exchange data over the network

protocols

* Define the data exchange formats
* Data Encoding, addressing schemes for devices
* Routing of packets from source to destination.

Other functions

- Sequence control
- Flow control
- Retransmission of lost packets

Embedded Systems

Computer system : hardware & software embedded to perform specific tasks

Embedded system perform specific set of tasks

Ex: vending machine, washing machines

REST	WebSocket
* It is stateless protocol. It will not store the data	* It is stateful protocol. It will store the data
* It is uni-directional. only either server or client will communicate	* It is bi-directional. Message can be received or sent by both server or client
* It is Request-response model	* It is full duplex model
* Both Horizontal & Vertical scaling	* Only vertical scaling
* It depends upon the HTTP methods to retrieve the data	* It depends upon the IP address and port number to retrieve the data

⇒ this direct communication allows real-time monitoring, control, and automation of various processes and systems.

Applications

* Fleet management
* Vending machine
* Remote monitoring.

IOT	M2M
* Internet based connectivity	* Direct machine 2 machine communication
* Flexible and adaptable	* Tailored for specific use cases
* Efficient resource utilization	optimised resource utilisation
* Enhanced user experience	* Focused on machine communication
* Internet protocols are used such as HTTP, FTP and Telnet	* Traditional protocols and communication technologies techniques are used
* Internet connection is required for communication	* Devices are not dependent on the Internet

* It supports cloud communication	* It supports point-to-point communication.
* Involves the usage of both Hardware and software	* Mostly hardware-based technology
Business 2 Business (B2B) and Business 2 Consumer (B2C)	Business 2 Business (B2B)
* Supports open API integrations	* There is no support for open APIs.
* Information & service centric	* communication & device centric
* Horizontal enabler approach	* vertical system solution approach
Ex: smart wearables, Big data & cloud, etc.	* sensors, Data & Information, etc.

IOT enabling Technologies

* wireless sensor network
* cloud computing
* Big data Analytics
* communication protocols
* Embedded systems.

Component of a microprocessor / microcontroller

* CPU
* I/P
* Bus
* Memory
* Timer
* Interrupt
* serial port
* parallel port

Microprocessor - CPU for computers

Microcontroller - A single chip computer

Sensors

Two basic category

* Analog
* Discrete
  => Binary
  => Digital

Types of sensors

* Light sensor
* Temperature sensor
* pressure sensor
* position sensor
* Hall sensor
* flex sensor
* sound sensor
* ultrasonic sensor
* Touch sensor

RFID (Radio frequency ID)

* An Identification system
* Tagging and labelling.
* Tiny chips: Active, passive and battery
* Communication range 10cm to 200m.
* Standard frequency range
  * 120-150 kHz,
  * 13.56 MHz

RFID Applications.

* Tracking and Inventory control.
* Identification in supply chain systems
* Access to building and road tolls
* Devices such as RFID based temperature sensors.
* Business processes for payment, leasing, insurance & quality management.

~~Bluethe~~

Bluetooth

Bluetooth is a technology standard used to enable short-range wireless communication b/w electronic devices.

Support point-to-point and point to-multipoint

Average 1 MbPS - up to 3 MbPS.

Application

* wireless communication b/w devices
* short range sensor transmission
* share multimedia - pictures, video, music.
* A2DP - Advanced audio distribution profile.

Zigbee

It is a standards-based wireless mesh network used widely in building automation, lightning, smart city, medical & asset tracking.

Zigbee is usually used in mesh networks.

Why ZigBee

=> Low power, cost and size

=> Straightforward configuration.

=> Good support and documentation

=> Mesh Networking.

=> very low wakeup time.

Mesh

* A mesh network consists of series of nodes

* Each nodes must acquire and transmit its own data, as well as act as a relay for other nodes to propogate data

* ZigBee devices often form mesh networks.

Eg: wireless light switching
music school practice rooms

Zigbee applications

=) wireless environmental sensors
=) Medical devices
=) household automation.

wi-fi

It is an family of wireless Network protocols

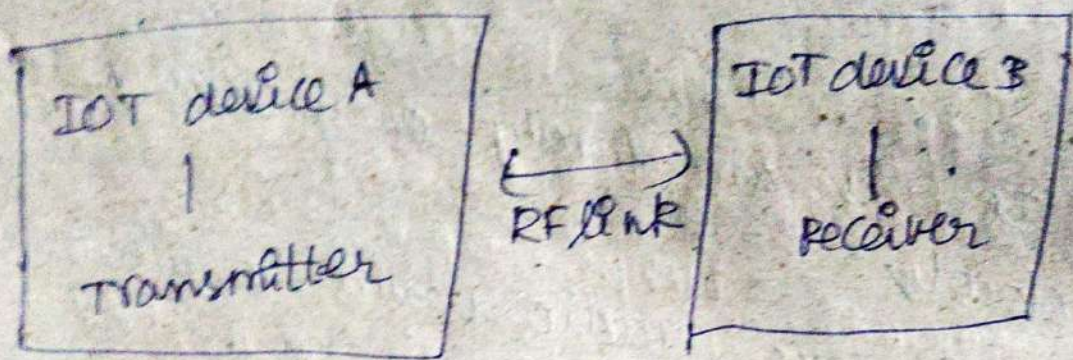
It uses radio waves to allow high speed data transfer over short distances

* Roaming
* Global standard
* Range
* High speed
* High power consuption

RF - link

RF (Radio frequency) enable wireless communication between devices, sensors, and networks, allowing data to be transmitted over the air without the need for physical connections.

* RF links are commonly used in various IOT applications due to their flexibility, scalability and ability to connect remote or hard-to-reach locations.



RF link used radio waves to transmit data wirelessly b/w IOT devices. This enables devices to communicate over short distances.

Mobile Internet

* A cellular Network or mobile network is a communication network.

* The network is distributed over land areas called cells, each served by at least one fixed-

location transceiver

Different Digital Cellular Technologies

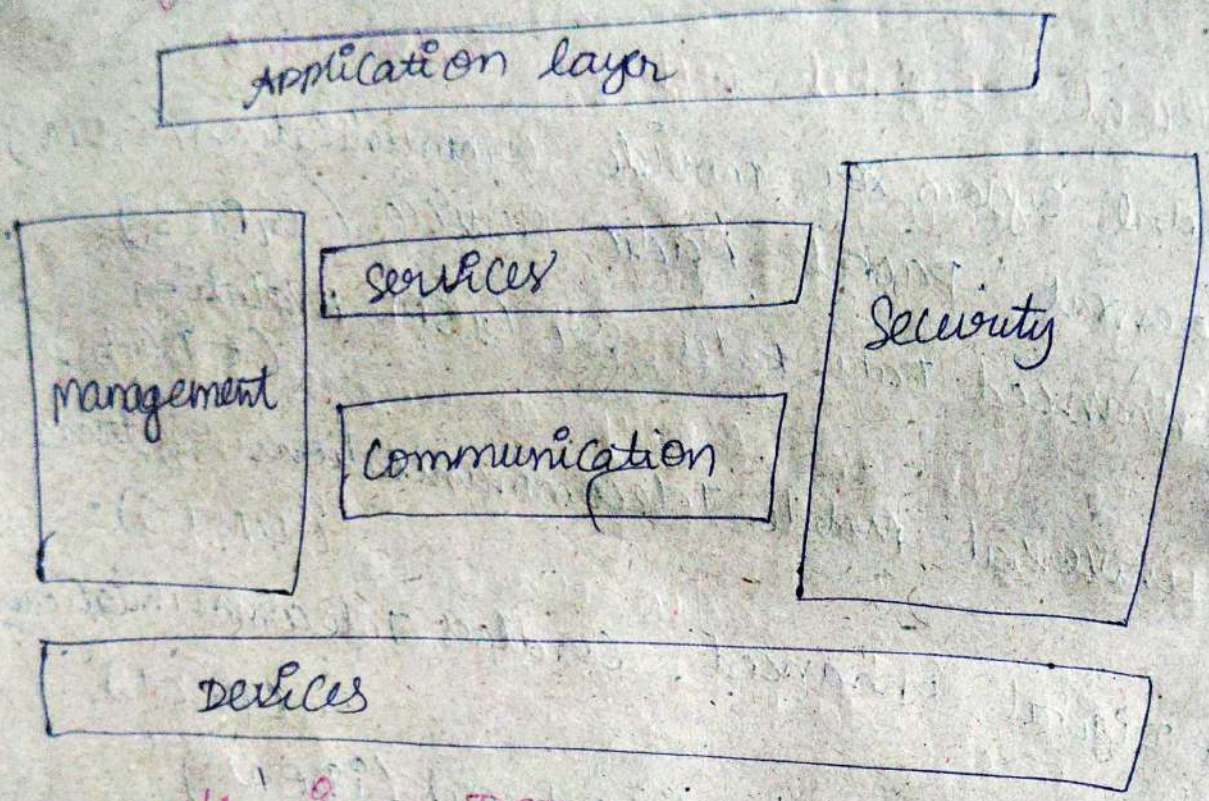
* Global System for mobile communication (GSM)
* General Packet Radio Service (GPRS)
* Enhanced Data Rates for GSM Evolution (EDGE)
* Universal Mobile Telecommunications Systems (UMTS)
* Digital Enhanced Cordless Telecommunication (DECT)
* Digital Enhanced Network (iDEN)

Wireless Communication

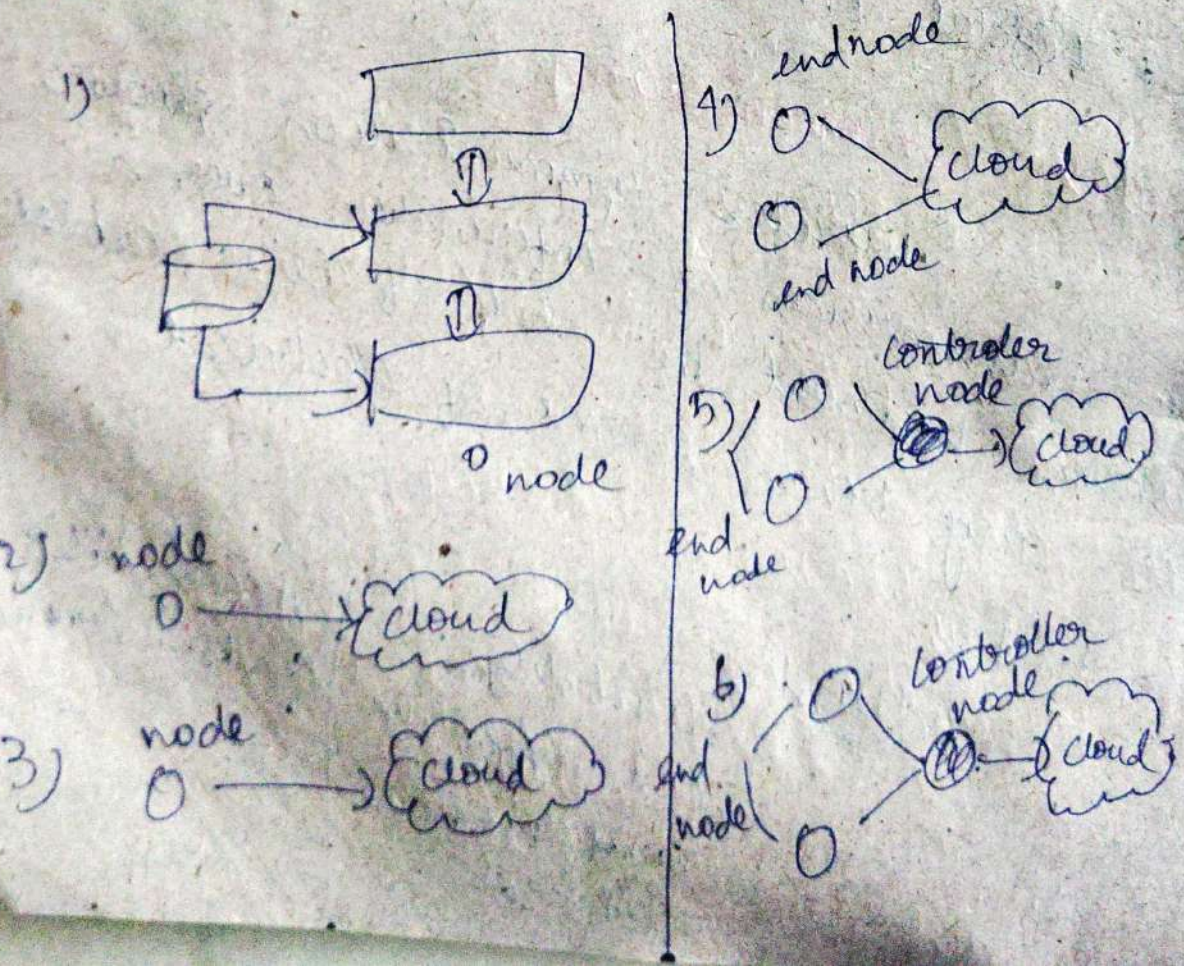
Wireless communication involves the transmission of information over a distance without the help of wires, cables or any other forms of electrical conductors.

Advantage
- flexibility
- cost effective
- convenience
- speed
- Accessibility
- Constant Connectivity

IOT functional block



6 levels in IOT



Wired network	Wireless Network
* Faster transmission speed	* slow transmission speed
* propagation delay is low	* propagation delay is high
* more secure & hence reliable	* less secure & hence less reliable
* less expensive	* more expensive
* maintance is complex	* No maintance
* Hub, switches	* wireless routers, access points

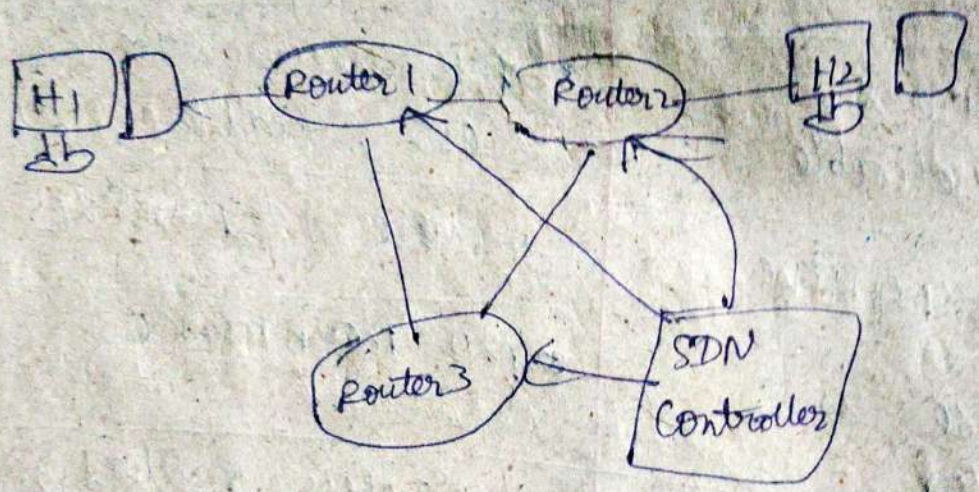
Embedded systems

* which contains both hardware and software
* This is IOT enabling technology because this will connect the people, cloud and software through the Internet
* Embedded system allows any device for intercommunication of other devices

Ex: personal computers: RAM, cache, keyboard, screen, CPU, interface, cloud accesses.

SDN

Software Defined Networking.



=) SDN. + architecture
(Software Defined Networking).

=) NFV + architecture
[Network function visualization]

=) SNMP
(simple network management protocol)

=) NETCONF
(Network configuration protocol).

=) YANG.

=) IOT System management with NETCONF - YANG.

Six levels of IOT

Level - 1 components are deployed locally

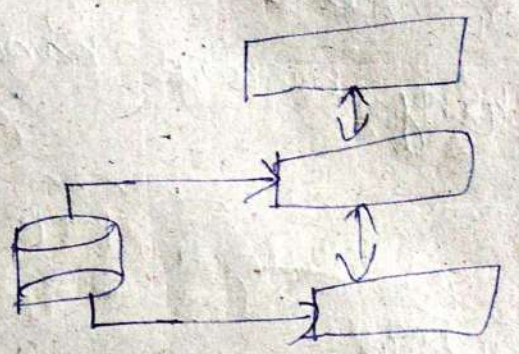
=) single node / device

=) perform, sensing, actuation, stores data, perform analysis and hosts the application

=) low cost, low complexity

=) Data involved is not big.

Ex: Home automation.



node

Level - 2 components are deployed locally except the level not computational Data

=) single node

=) Data stored in cloud

=) performs sensing, actuations and local analysis

=) Application is cloud based

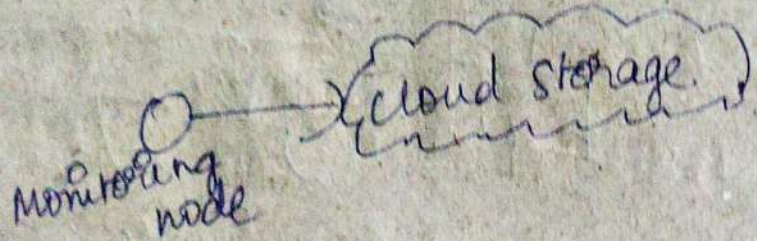
=) suitable for solution where the data involved is big

Eg: Smart Irrigation, small back

Level-3 (IOT systems has)

* Single node All components are deployed (local) & analysed but the cloud expect sensor & network connectivity part.
* It is analysed but the cloud expect
* Application is cloud based
* Suitable for solution where computational Intensive data is big
* Trigger alerts

Eg: ~~Tracking package handling~~ Eg: Smart Industry



Level-4

* Multiple nodes
* perform local analysis
* Data stored in cloud
* Application is cloud based
* Suitable for solution where computational Intensive multiple nodes are required
* contains local & cloud based observer nodes which can subscribe

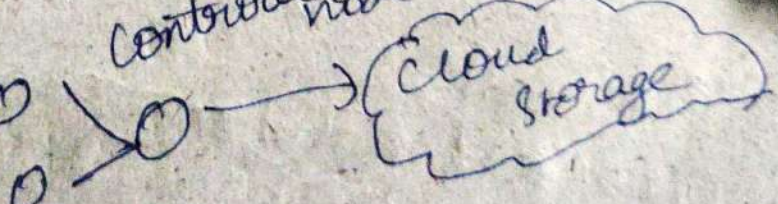
10. & receive Information collected in the cloud from IOT devices.

Eg: Noise monitoring, courier tracking.

Level - 5

* Multiple end nodes & 1 coordinator node.
* Data stored & analyzed in cloud computational intensive
* coordinator node collect data from end node and sends to the cloud.
* End node perform sensing and actuation.
* Suitable for solutions based on wireless sensor network.

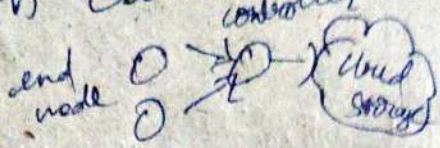
Eg: Forest fire detection.



Level - 6

Level - 6

⇒ Big data
⇒ multiple end node & one controller.
⇒ stored in cloud, cloud based application
⇒ Result visualized with cloud based application



⇒ Eg: weather monitoring.

The most suitable level for IoT devices is from level-2 to level-6 the devices is in real time & data is in cloude.

therefore level-6 is suitable.

computational Intensive