

Introduction :-

- ⇒ To make 2 different technologies communicate with each other, we need a gateway.
- ⇒ Many wireless sensors may be deployed in a zone to gather information. Out of all, a cluster head is chosen on the criterion-
 1. Energy levels
 2. Path discovery / recovery
 3. Hierarchy
- ⇒ The cluster head sensor communicates with the gateway, which in turn is sent to the Base station (e-Node).
The base station sends data to the User equipment (UE).
- ⇒ 2 different Sims can be used on a phone with 2 diff. bands.
- ⇒ For larger communication, Quality of service & Quality of experience is important.
To achieve high QoS & QOE, capacity must be higher.

$$C = B \cdot W \cdot \log_2(1 + SNR)$$

C is higher when the SNR is higher i.e. when noise interference is less.

- ⇒ In IoT, billions of devices/machines are connected to each other, incorporated by wireless/infrastructure based network.
- ⇒ If we can reconfigure the network architecture at any time, it is known as Infrastructure-less network. (WIFI - 802.11)
For a network in which we have a wired network as its backbone is called Infrastructure-Based network. (MANET)
- ⇒ 4G supports data rate of 200 Mbps.
- ⇒ To support trillions of devices, IPv6 was introduced.
IPv4 is numeric. (32 bit)
IPv6 is hexadecimal. (128 bit)
- ⇒ If we upload a file through FTP, from one device to other device, then the other device behaves as a server.
- ⇒ CAT 5 is used for ethernet.
CAT 6 is used for Gigabyte ethernet.

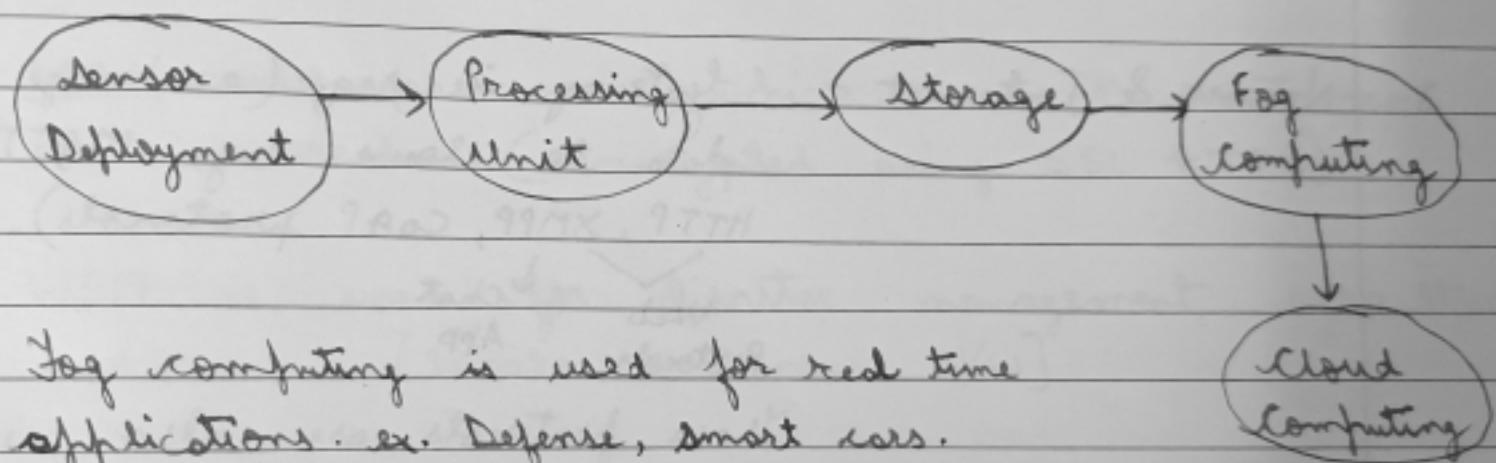
Assign 1: Design a system related with your mother's problem in her daily life

- 2. Name 5 different sensor - Tilt, Pressure, pH, IR, Ultrasonic, Temp
- 3. Identify moisture level without using sensor.

* Why IOT is important:

1. Real time
2. Automate everything
3. Automate control (remote control)
4. Live Data Processing.

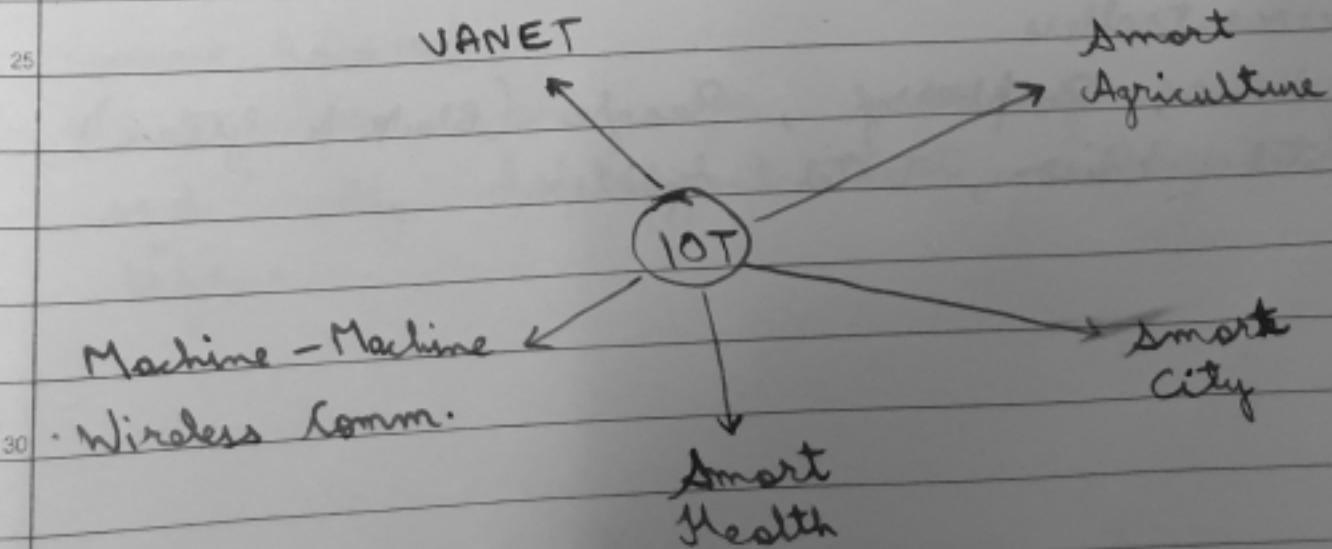
* Processes Involved:



Fog computing is used for real time applications. ex. Defense, smart cars.

VANET protocol is used for real time processing.
ex. RFID scanning.

* Applications:



* Requirements -

1. Sensors - Measures analog data, sends raw data, low power consumption, enabled with Bluetooth / Zigbee / WiFi / NFC.
2. Processing & Storage - Fetch data from sensors → conversion A/D → Driver Chk → Edge/Fog Computing → Cloud.
3. Network & Internet - Gateway is req. (exchange of data to cloud by MQTT, HTTP, XMPP, CoAP protocols)
 - Web Protocols
 - Chat App

These protocols are also used in M2M comm.
4. Cloud Computing - Aggregate data → Store data → relate data

⇒ Hardware Req. -

Microcontrollers

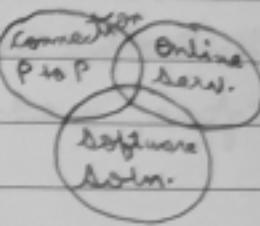
Arduino, Raspberry, Beagle (Black & Green),
Intel Edison, Intel Galileo

* Journey of IoT:

5.

WSN → DSR, TORA
(2005)

2.
Web 2.0
(2000-01)



11.
RFID (1999)

- Helps to manage things easily.

⇒ https used pre-www, which means the service is secured (encrypted using SSL + TTL)

⇒ 15. WSN is used for disaster management, agriculture use. [Wireless Sensor N/w]

⇒ Mobile / Cloud Computing provides
IaaS - Infrastructure As A Service

20. PaaS - Platform

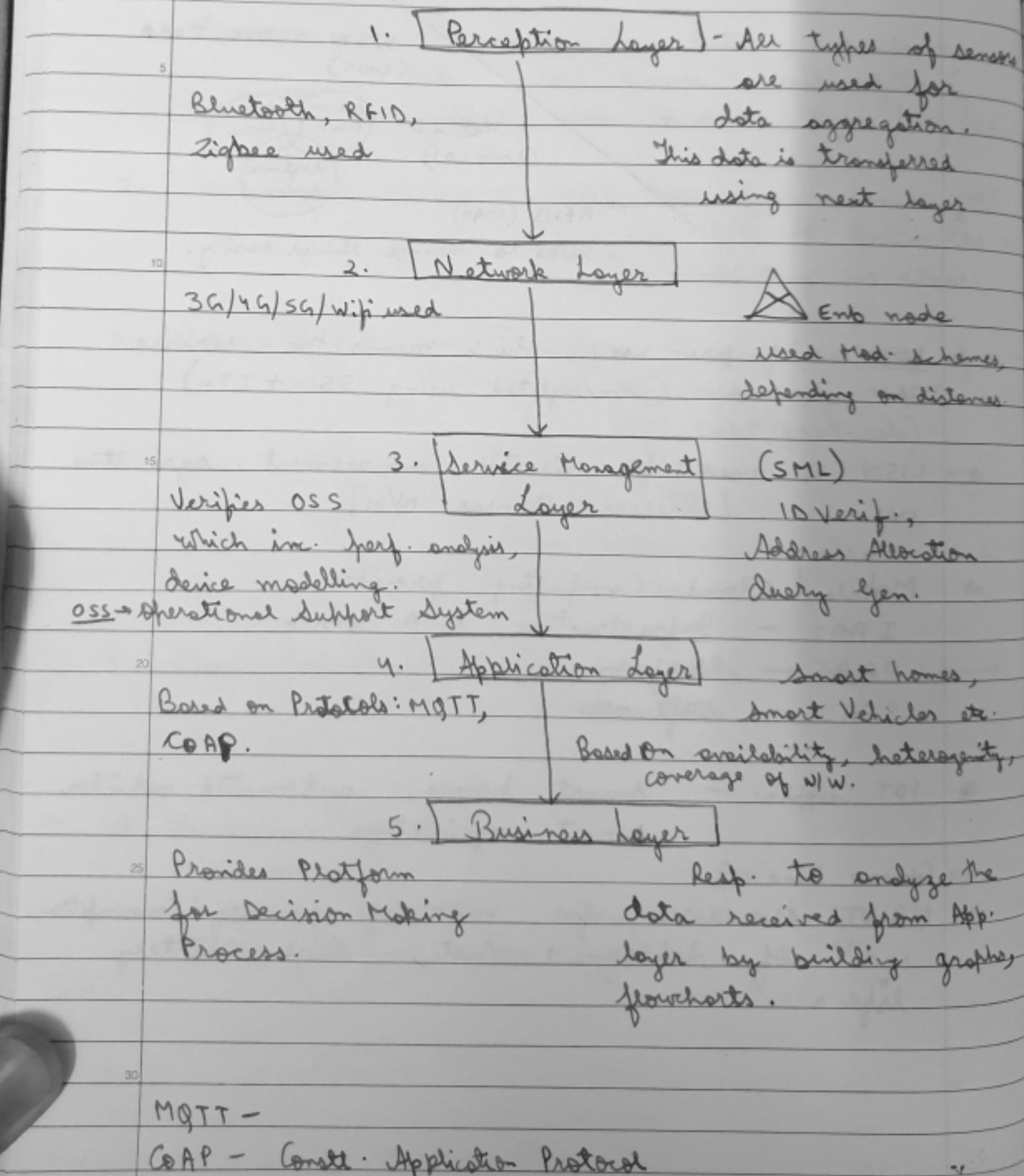
SaaS - Software

⇒ IoT appn. - Smart homes, automated vehicles, smart agriculture

25. [Narrow Band IoT]

⇒ NB1OT is used for redⁿ of energy consumption, redⁿ of deployment cost, high battery life.

* Layer Structure:



* Defining IoT -

IoT is the network of physical objects containing embedded tech. to communicate, sense & interact with their internal/external environment.

* IoT in Market -

Manufacture Industry (41%) - Smart Robots

Health Care (31%) - Portable Med. boxes

Retail (8%) - Smartphones, AI based purchasing

Security (7.5%) - Biometrics, Remote Sensors, IP Cameras.

Automation (12%) -

* Evolution of Connected devices -

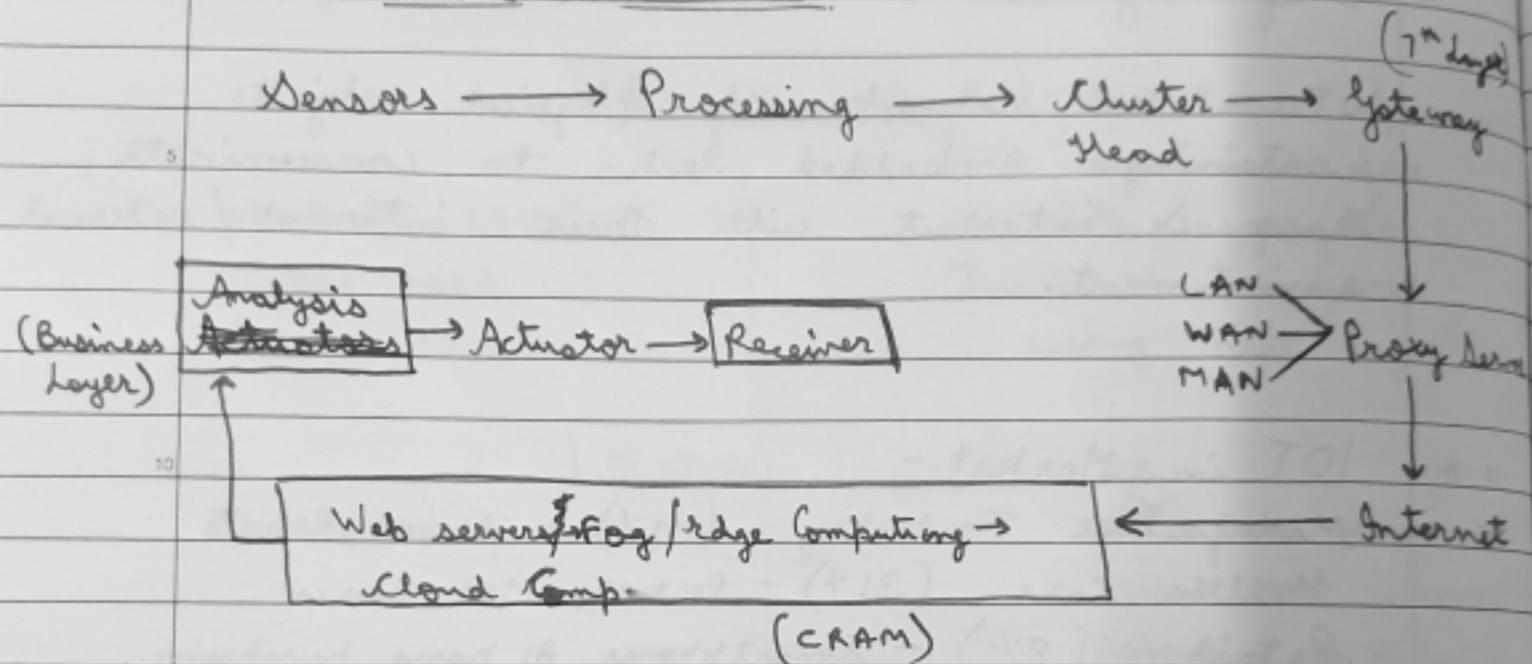
ATM → Web of Things → Smart Meters →

Digital locks → Smart homes, cities → Smart dust

* Technologies :-

RFID	WSN	IoT
Mobility	(Usually static) May be mobile.	Both static and dynamic.
Data-Base Required	Req.	Req. highly
Freq. Range	High → 13.56 MHz Low → 125-134.2 kHz 30 140-148.5 kHz	2.4 GHz (ISM)
Power Req.		

* Basic Architecture:



* IOT vs M2M:

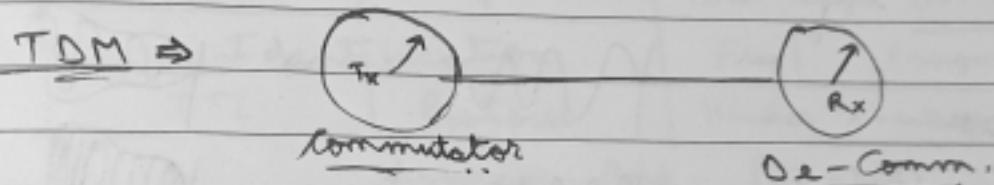
- There are 3 basic tech req. for IOT - M2M, CPS(Cyber Physical system), Web of Things.
- M2M refers to comm. & interaction b/w machine & devices, which occur via cloud infrastructure.
- M2M helps in fetching & uploading data from on cloud through sensors, using Zigbee, BT, 3G, 4G.
- M2M is a part of IOT , but vice-versa is not correct. i.e. IOT has a broader scope than M2M.
- IOT includes the notion of internet connectivity but there's no necessity for use of Telecom N/W, whereas M2M req. Telecom N/W.

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* IOT vs Web of Things:

- Web of Things provides the platform to access the IOT N/W, by using web tech. like HTML, PHP, Java script.
- To build Web of Things, we can use REST API to develop a platform
- Security issues is a big challenge in Web of Things (WOT) as compared to IOT.

- Access Tech. for Receivers →
- TDM — Interleaving, Interclocking
 - FDM
 - CDM
 - OFDMA



Speed of De-Comm. is double than Comm. to keep them in sync.

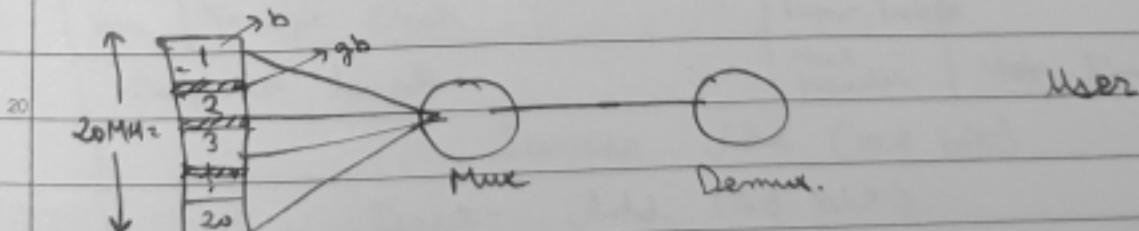
Frames are sent as messages.

1 Frame = 24 packets ; 1 packet = 8 bytes

$$\text{So, } 1 \text{ Frame} = 24 \times 8 = 192 + 1 = 193 \text{ bytes}$$

↓
(header)

FDM ⇒

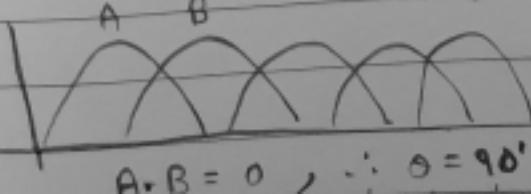


So, each user gets nearly 1 MHz (less than 1 MHz)
Some freq. Band is used to avoid ISI, so
a guard band is used b/w 2 divisions.

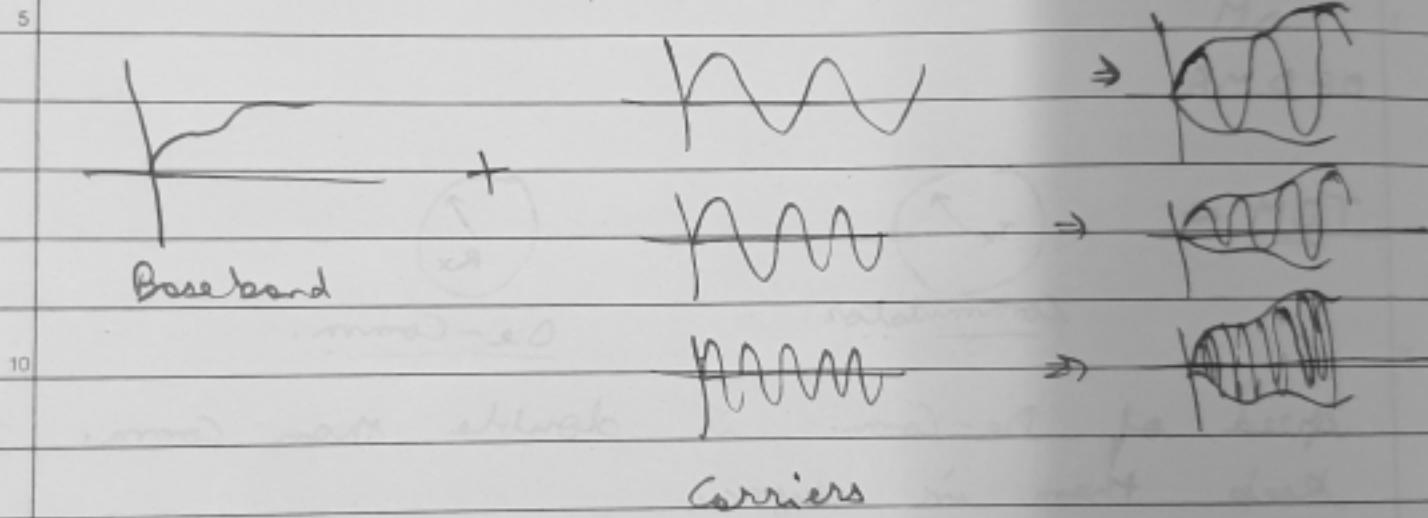
$$B.W. = 20.b + (20-1)gb$$

Limitation → Difficult to accommodate a no. of users in a fixed band

OFDM ⇒ (Orthogonal)



- ⇒ Communication is the exchange of useful information. Modulation is done to have an antenna of practical height.



⇒ Carriers may be divided into sub-carriers, which may be divided as per req.

⇒ FTP is used for transferring data from server to server.

⇒

* Formats of IPv4 vs IPv6 :-

IPv4 →

(32)

1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
Ver	IHL	Type of Service	Total length (for Allocation)
		Identification	Flag "F" fragment
TTL	Protocol		Header checksum (crc, parity)
		Source Add. (32-bit)	
		Dest. Add. (32 bit)	
	options		Padding

IPv6 →

(128)

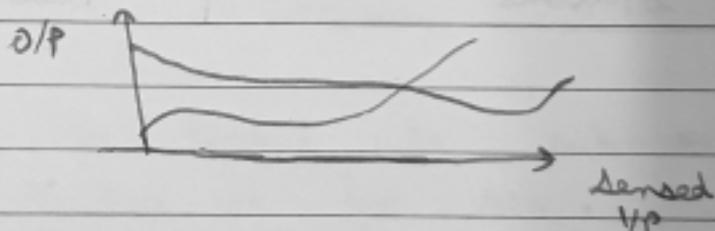
1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
Ver	Traffic Class		Flow Label
	Payload length		Next Header
			Hop limit
		Source Add (128 bit)	
		Dest. Add (128 bit)	

* Sensors :-

A sensor detects / senses and reflects the change in the ambient conditions or in the state of a device / system. It also helps in forwarding & processing the info. in a certain manner.

ex. IR, DHT, ultrasonic, Tilt sensors.

Mathematically, it senses & produces diff. char.



ex. Heat is converted to electrical signal in DHT.
Pressure is converted to " " in Barometer.

* Transducers :-

They convert / transduce one form of energy to other.

ex. Microphone converts sound to electrical signal.

→ Features of Sensors -

1. It is only sensitive to the properties to be measured. It is insensitive to any other condition.

ex. Temp. sensor is unaffected by pressure.

⇒ 2. Resolution of Sensors -

Resolution is the smallest change that a sensor can sense & reflect. i.e. quality / resolution should be high.

There are 2 types of sensors based on their O/P -

- i) Analog (High energy loss)
- ii) Digital (Resolution is better) (Has quantization error)

Based on Data type -

- i) Scalar
- ii) Vector/ Multimedia

⇒ All these devices work in the perception layer.

To publish the data on cloud from the perception layer, we require a set of rules, known as Protocols. e.g. MQTT.

* Actuators :-

It is a component of machine / system that controls the mechanism or the system.

It requires a control signal & source of energy, & this energy is converted into mechanical motion.

It may be mech., electronic, software based, human interaction.

⇒ Types - Hydraulic, electrical, thermal, mechanical.

* Functionality Based on IoT Protocol:

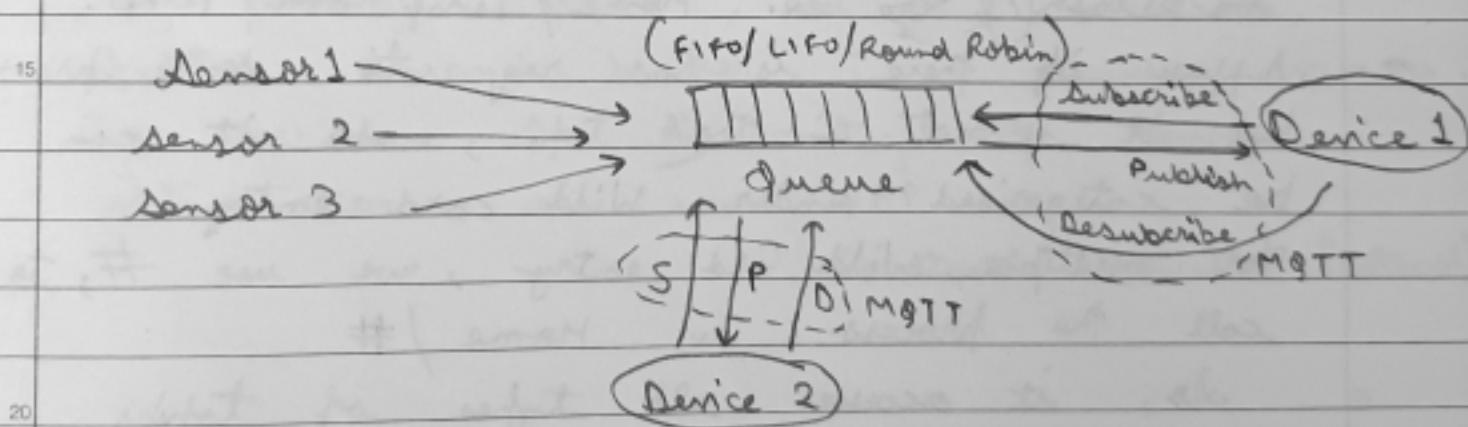
1. Connectivity - LOW PAN (Low Power Local Area N/w)
ex. Bluetooth, Zigbee
2. Identification - IPv4, IPv6
3. Communication - WiFi, Bluetooth
4. Discovery - Through DNS (Physical Web)
5. Data Protocols - MQTT, COAP, AMQP, WebSocket, Node
6. 15 Device Management -
7. Semantic - JSON, Web of Things
Helps in interfacing gateway with Cloud
8. 20 Multilayer Framework

* MQTT:

(Message Queue Telemetry Transport)

- It is ISO standard.
- It is public subscribed based light weight message protocol by using TCP/IP.
- Developed in 1995 & introduced in 1999.
- * MQTT was developed to provide connectivity between application & middle layer at one side & Net./Communication at other side.

⇒ Processors Involved in MQTT -



- As, MQTT is based on -
 - Subscribe, Publish, De-subscribe
 - Event - Driven
- The queue management is done by Broker. The central comm. point for the phenomena related to subscribe + publish & event driven, is MQTT broker.
- MQTT broker will dispatch all types of messages b/w sender to actual receiver, through message queue.

- In the duration of transfer of message, topic of info. should be incl.
↳ Provides routing info.
- One problem with MQTT is, it is not power optimised.
i.e. if 2 routing paths are possible, it is not able to select the best path, hence is not power optimised.
- Topic is just a simple string that has more hierarchy levels, separated by backslash (\) ex. Home / Living Room / Temp.
- Suppose if there is a req. to sense pressure, but it is not in the topic, so it can be categorised under Wild card entry.
For multiple Wild Card entry, we use #, to coll the process. ex. Home / #
So, it accesses all types of topics, under Home category.

ex. Fb Messenger using MQTT, Amazon services, Microsoft Azure, Adafruit
MQTT is used for everything IoT (e-IoT).

→ SMQTT (Secure MQTT)

Encryption & Decryption phenomena have been incorporated. In this case, through encryption, we can broadcast message to multiple nodes.

→ Processes in MQTT:-

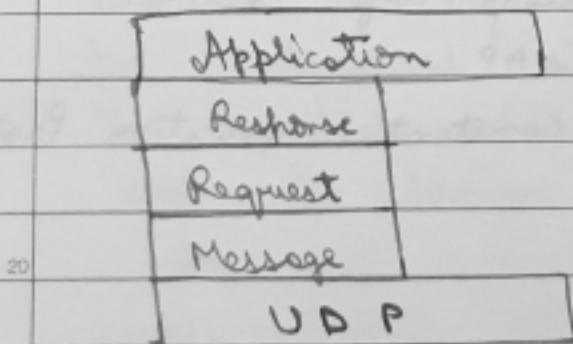
Setup → Encryption → Publish → Decryption

- In setup, subscriber & publisher register themselves to the broker & get the master key by random generation (ex. OTP)
- In second phase, data is encrypted through DES / 3DES / RSA / AES.
- Tunneling of data is done using IPsec.
- So, through MQTT, we can subscribe, publish through broker in a secured manner.
To overcome the disadvantage of power optimisation, we use CoAP
(Constant Application Protocol)

* CoAP

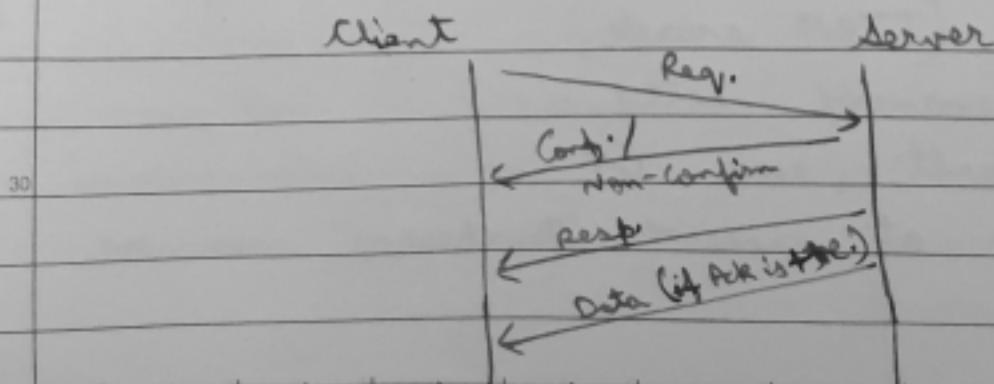
- This is a web transfer protocol.
- It is also called node to N/W transfer protocol.
- M2M comm is through CoAP, & not through MQTT.
- CoAP is based on Request - Response Topology, between end points.
- It is UDP based protocol.
(Asynchronous)
 - ↳ Bit by bit data is sent.
 - Not-lines are ex. of synchronous.

⇒ Position of CoAP (flow) :-



⇒ Processes in CoAP -

25 Confirmable
 Non-Confirmable (Piggyback)





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⇒ Features of Co-AP -

1. Overhead
2. URL & content type
3. Simple cache based processing, that helps to optimise the network for power consumption