Internet Of Things

Contributed By:
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Protocol → set of rules governing the exchange or transmission of data b/w devices.

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IoT → It is a highly distributed Network of smart objects embedded with electronic sensors, actuators and softwares. & each capable of dynamically generating, analysing and communicating intelligence that can be used to increase operational efficiency and power new business models and make life more easier and comfortable.

3/7/18

Characteristics of IoT :-

→ Dynamic and self adapting - It can adapt to the environment. Ex: A surveillence system can adapt no. of cameras dynamically.

→ Self configuring - Devices can configure themselves in association with IoT infrastructure.
Ex: Set of networking, Fetch latest software update with minimal user intervening.

It allows a large no. of devices to work together for providing certain functionality.

→ Interoperable communication protocols - It support different protocols for different devices. and which is interoperable.

→ Unique identity - IP address and Url are used for identity.

→ Integrated into information Network - IoT

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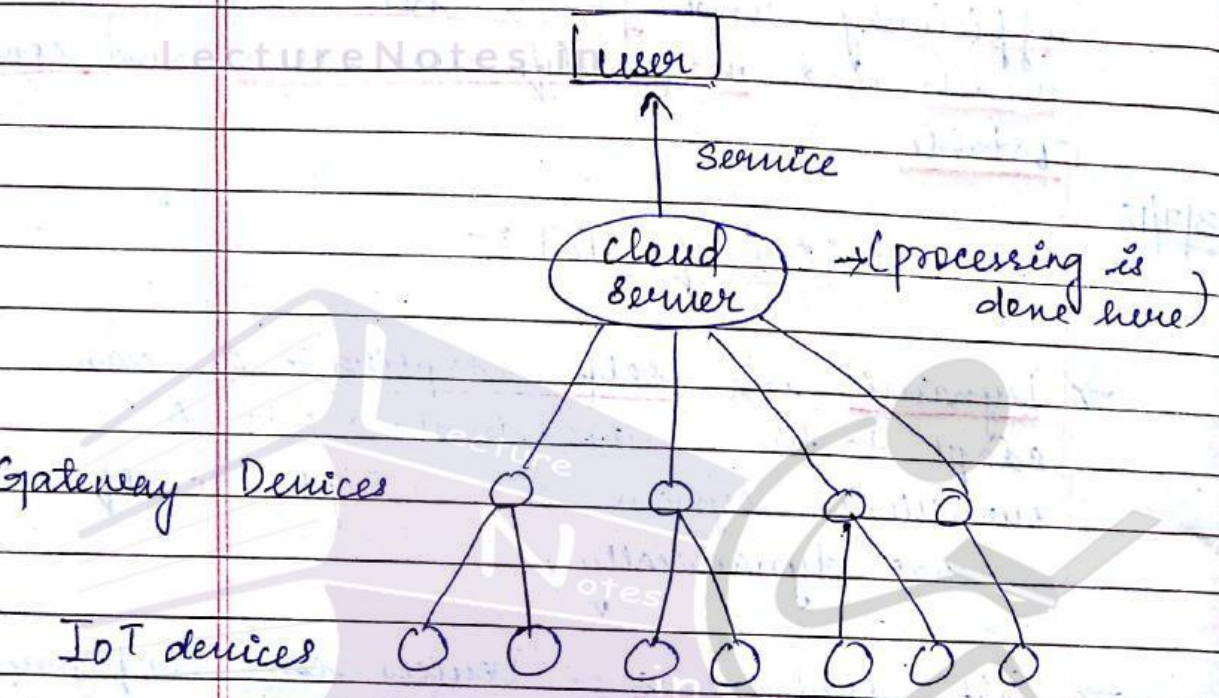
devices can be dynamically discovered in the network by other devices and have the capability to describe themselves to other devices or user application.

Structure of IoT System



Inferring information and knowledge from data in IoT.

Steps

Raw data obtained from IoT devices / system

⇓

information is ~~obtained~~ inferred from data by filtering, processing, categorising data

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↓

knowledge is inferred from information by organizing & structering information and put into action to achieve specific objective..

Applications of IoT :-

Home
→ Smart lighting
→ Smart appliances.
→ Intrusion detection
→ Smoke and gas detector

Cities
→ Smart Parking
→ Smart roads
→ Structural health monitoring
→ Emergency response.

Environment
→ Weather monitoring.
→ Air pollution monitoring
→ Noise pollution monitoring
→ Forest Fire detection.

Retail
→ Inventory management
→ Smart payment
→ Smart Vendory machine.

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Energy
- Smart grid
- Renewable energy stem
- Prognostics

Logistics
- route generation and scheduling
- fleet tracking
- shipment monitory
- Remote vehicle diagnosis.

Agriculture
- Smart irrigation
- Green house control

Industry
- Machine diagnosis and Prognosis
- Indoor air quality monitoring

Health
- health and fitness monitoring
- wearable electronics

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interface → It is a shared boundary across which two or more separate components of a computer system exchange information.

PHYSICAL STRUCTURE OF IOT

Connectivity interface
- USB, host
- RJ45 / Ethernet

Memory interface
- NANR / NOR
- DDR1 / DDR2 / DDR3

Audio/video interface
- HDMI
- 3.5 mm audio
- RCA

Processor
- CPU

Graphics
- GPU

Storage
- HD
- MFC
- SDIO

I/O Interface
- I2C
- Sensors
- Actuators
- UARTN, SPI

IoT devices may consist of several interfaces for connection with other devices both wired and wireless. These include I/O interface for sensor and actuators, interface for internet connectivity, memory or storage interface, audio and video interface, processor and graphics interface.

IoT device can collect various types of data through the onboard sensors or attached sensors such as temperature, humidity and light

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intensity. The sensed data can be communicated either to other devices or to cloud based servers.
Ex: Smart phones, wearable electronics, vehicles, industrial, cameras etc.

* NETWORKING AND DATA COMMUNICATION CONCEPTS

Data represents information

telecommunication - refers to communication at a distance

Data communication - Exchange of data between two devices via transmission medium such as cable.

→ Network - set of devices (referred to as nodes) connected by a communication link.

Components of Network :-

→ Sender
→ receiver
→ message / data
→ communication medium — wired / wireless.

→ protocols - set of rules used by the devices for communication.

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Sender —data→ Receiver

There are some network criteria.

- performance
  - ↳ transmit time
  - ↳ response time
  - ↳ throughput
  - ↳ delay

- Reliability is the frequency of failure and time to recover from it.

- Security ~~deter~~ deals with authentication, authorization and integrity.

Internet

Network of networks all over the world.

TCP/IP is the protocol used in internet.

NETWORK MODEL

→ OSI model
→ TCP/IP model

→ OSI Model → reference model
- Open Source Interconnection Mode
- 7 layers are there
  - i) Physical
  - ii) data link

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Host is a computer or other device that communicates with other hosts on a network. Hosts on a network include clients & servers.

iii) Network
iv) Transport
v) Session
vi) Presentation
vii) Application

Functions of layers

i) Physical Layer:
→ Representation of data bits. (converts bits into electromagnetic signal & decides the type of medium for better communication)
→ Signal to bits or bits to signal
→ defines data rate (No. of bits sent per unit time)
→ clock synchronization (sender & receiver clock should be synchronized)
→ Topology (to represent dynamically the network connectivity)
- Star
- Bus
- Ring
- Mesh

→ Transmission mode (full mobile duplex / half walkie talkie duplex)
→ Line configuration - point to point / remote or multipoint → wifi

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ii) Data Link layer: responsible for moving a frame from one hop to next hop within a single network.
functions of data link layer are :-
→ Framing
→ Physical addressing - MAC address. (physical add. will be assigned to each frame i.e the source and the destination.)
→ Flow control (between each node)
→ Error control "
→ Congestion control (Traffic) (to avoid data loss in the medium)
→ Access control → to access limited resource among multiple users

iii) Network layer: (Host to Host delivery)
→ Logical addressing (IP address)

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Each process is identified by a unique no. known as Port address (Port no.) which is assigned by transport layer.

→ Routing

→ ~~Transport Layer~~

~~• Process to~~

iv) Transport Layer : responsible for process-to process delivery of data.

→ Process to Process communication.

→ Segmentation and reassembling.

entire data is divided into segments and each segment is assigned a unique id, through which combining of segments is known as reassembling

→ connection control

connection oriented	connection less
(Takes more time as before transfering the data, the connection is first established) (Mobile phones)	(Takes less time, as there is no time for establishment of connection) (whatsapp)

→ Flow control (end to end flow control)

→ Error control (end to end)

(dialog control, synchronization)

v) Session Layer : It allows a system to enter into a dialog where it allows the communication b/w 2 processes to take place either in half duplex or full duplex mode.

→ Session management – Session creation

– session maintenance

– session ending

→ synchronization. (helps in minimizing data loss)

vi) Presentation Layer.

→ Translation (From device to network type & vice versa)

→ Encryption (to secure the data)

→ compression. (size of data is compressed so that it can be easily transferred through the Network)

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vii) Application Layer:

→ Provides service to the user
→ File transfer, access & management
→ Mail service → uses SMTP
→ Directory service.

The communication b/w local m/c and remote m/c for transfer of file and data access.

→ TCP/IP model :-

i) Physical layer
ii) Datalink layer / Link layer
iii) Network layer / Internet layer
iv) Transport layer
v) Application layer.

It is a protocol suit.

Types of addresses

1) Physical address – MAC address
2) Logical address – IP address
3) Process address – Port address
4) Specific address – Url

18/7/18 IoT Protocols

Application Layer
HTTP, COAP, Websocket, MQTT, XMPP, DDS, AMQP

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The link layer determines how the data is physically set over the networks physical layer or medium.

Transport layer

TCP, UDP

Network layer

IPV4, IPV6, 6LOWPAN

Link layer

Ieee 802.3 → Ethernet
Ieee 802.16 → wimax
Ieee 802.11 → wifi
Ieee 802.15.4 → WPAN

2G|3G|4G → cellular networks.

IoT Link Layer Protocols

i) Ieee 802.3 → Ethernet-
- It is a collection of wired ethernet standards.
It uses 10 BASE5 Ethernet over a coaxial cable.
Ieee 802.3i
- It uses 10 BASE T ethernet over copper twisted pair cable.
Ieee 802.3j
- 10 BASE F ethernet over fiber optic cable.
Ieee 802.3ae
- 10 Gbits/s ethernet over fiber optic cable

different ethernet cables are used for connectn using different data rate.

Data rate for ethernet is from 10mbps to 40Gbps.

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Ieee 802.11 - Wifi
- collection of wireless local area network (WLAN) standards.

Ieee 802.11a
- operates on 5 GHz band.

Ieee 802.11b ug
- operates on 2.4 GHz Band.

Ieee 802.11n
- operates on 2.4/5 GHz band.

Ieee 802.11ac
- operates on 5 GHz band.

Ieee 802.11ad
- operates on 60 GHz band

Data rate is from 1 mbps to 6.75 Gbitps.

Ieee 802.16 - Wimax (used for wireless metropolitan area network)

It is a collection of wireless broadband standards for wireless metropolitan area network.

It operates on 10 - 66 GHz or 2 - 11 GHz

Data rate of wimax is 1.5 mbps to 1 Gbps.

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Recent updates i.e Ieee 802.11m provides data rate of 100 mbps for mobile stations and 1 Gbps for fixed stations.

Ieee 802.15.4 – LRWPAN
name of the protocol.

It is a collection of wireless standards for low rate wireless personal area network (LRWPAN) such as ~~GPP~~. Zigbee.
Data rate is from 40kBps to 250 KBps. It is used in low cost and low speed power constraint devices.
battery

It operates on 2.4 GHz freq. band.

2G/3G/4G mobile communicatn

These are different generations of mobile communication standards. 2G uses GSM and CDMA technique.
GSM – global system for mobile communication.
Speed – 14.4 kbps, Bandwidth – 25 MHz
It support digital data transmission.

introduced in 2001 ← 3G uses UMTS (universal mobile Telecommunicatn system) and CDMA 2000 Technology
Speed – 3.1 Mbps
It support multimedia data.
Bandwith – 25 MHz

2009 ← 4G uses LTE (Long term Evolution). It supports high speed communication and uses IP based packets.
Speed – 100 Mbps
Bandwidth – 100 MHz

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IOT devices based on these standards can communicate over cellular networks.

Data rate is from 9.6 Kbps to 100 mBps.

IOT Network Layer Protocols :-

* IPV4 (Internet Protocol Version 4)
* IPV6
* 6LOWPAN

IPV4

→ It is used to identify the devices on a network using a hierarchical addressing scheme.

→ It uses a 32 bit address scheme that allow 2^{32} addresses.

→ It is succeeded by IPV6.

→ It does not garranty delivery of packets.

IPV6

→ It is the newest version of Internet Protocol & successor of IPV4

→ It uses 128 bit addressing scheme that allows 2^{128} addresses.

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6LOWPAN

→ 6 full form – IPV6 over Low Power Wireless Personal area Network

→ It brings IPV6 protocol to the Low Power devices which has limited processing capabilities.

→ It operates in 2.4 GHz freq. band.

→ Data rate is 250 Kbps

→ It works with Ieee 802.15.4 link layer Protocol.

IoT Transport Layer Protocols :- (Provides process to process message transfer capability)

TCP
UDP

TCP (Transmission Control Protocol)

→ TCP is the most widely used Transport Layer Protocol that is used by the web browser along with the Applicatn layer protocol such as http, https, smtp, FTP

→ It is a connectn oriented state free protocol and ensures reliable transmission of packets in order, and follows handshaking mechanism.

→ It provides error detection, Flow control and congestion control functionality.

→ provides error detection capability so that duplicate packet can be discarded & lost packet are retransmitted

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UDP (User Datagram Protocol)

→ It is a connection less protocol. It is useful for time sensitive application that are very small units to exchange and do not ~~require~~ want the overhead of connection setup.

→ It is a transaction oriented & stateless protocol.

→ It does not provide guaranteed delivery, ordering of messages & duplicate eliminatn

16/7/18 IoT Application Layer Protocols

↳ defines how the applicatns interface with the lower layer protocols to send the data over the network.

- http
- COAP
- Websocket
- MQTT
- XMPP
- DDS
- AMQP

↳ includes commands like GET(), PUT(), POST(), DELETE() etc. to implement request response model.

→ http (hypertext tranfer protocol)

→ It is a web Tranfer protocol that work with www.

→ It uses Url (uniform resource locator) to identify resources on the web.

→ Each request is independent of the each.

- COAP (Constraint application Protocol)

→ It is also a web Tranfer protocol like http that is used for machine to machine communication.

constraint means a limitatn or restrictn

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Socket :-
interface or connectn from the applicatn & the transport layer.

→ It is used for constraint environment for constraint devices & constraint network.

→ It uses a request response model for communication in client server architecture.

→ It runs on top of UDP.

WebSocket

→ It allows full duplex communicatn over single socket between client and server based on TCP.

→ It allows stream of messages to be communicated keeping the TCP connection open. The client can be webbrowser, mobile application or IOT device.

MQTT (Message Queue Telemetry Transport)

→ It is a light weight messaging protocol, based on publish - subscribe model

→ It uses client server architecture
publisher are the server and client are the subscribers or customer.

→ This protocol is essential for constraint env. where devices have limited processing, mem. resources & network bandwidth is low.

XMPP (Extensible messaging and Presence Protocol)

→ It is used in real time communication and streaming of XML data between network entities.

→ decentralised protocol & uses client server arch. where client to server & server to server communicatn takes place.

DDS (Data Distributed Service)

→ It is a Data ~~symetric~~ centric protocol used ~~from~~ for device to device or m/c to m/c communicatn

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→ It uses publish-subscribe model for transfering data

→ It provides quality of service control with reliability.

AMQP (Advance Message Queuing Protocol)

→ It supports both publish-subscribe model & point-to point model. In publish-subscribe model A broker is used which receives publisher data and sent them to subscribers.

IoT Security Challenges

1. Secured constrained device
2. Authorize and authenticate devices
3. Manage device updates.
4. Secure communication
5. Ensure data privacy and ~~utility~~ integrity
6. Ensure web, mobile and cloud Applications.
7. Ensure high availability.
8. Detect vulnerabilities, incidence & manage it.
9. Predict and Prompt security issues.

1. Secured constrained devices

→ IoT devices have limited amount of storage, memory & processing Capabilities

→ The devices often need to operate on low power when running on batteries.

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→ Security approaches that rely heavily on encrypt are not a good fit for these constraint devices because they are not capable of performing complex encryption, decryption quickly enough to be able to transmit data securely in real time.

→ Light weight encryption algo. are used which is not as secure as the normal computing devices.

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2. Authorize and authenticate devices

Devices must establish their identity before they can access gateway and offstream data services and application.

Authenticatn & Authorization is critical for IoT system and many results security failure because of light weight encryption algo. and unchanged passwords from their default values.

3. Manage device updates

Updating the device including security patches to firmware or s/w that runs on IoT devices and gateways (antivirus kind) presents a no. of challenges. Ex: It is needed to keep track of which updates are available & apply updates consistently across distributed env. with heterogeneous devices that communicates through a range of different working protocols.

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redacting → edit text - or uncertain obscure (part of text) for security purposes.

4. Secure Communication
Ensuring secure communicatn across the network, b/w devices and cloud services applicatns is challenging because many IoT devices don't encrypt messages before sending them over the network.

5. Ensure data privacy and integrity
It requires secure processing including redacting sensitive data before it is stored. It requires resilient (able to withstand) approach for ensuring the integrity of IoT data.

6. Ensure web, mobile and cloud Applications
Web, mobile & cloud apps and services are used to manage access and process IoT devices and data. So they must be secured as part of a multilayered approach to IoT security.

7. Ensure high availability
As we come to rely more on IoT within our day to day lives developers must consider the availability of IoT data, the ~~new~~ web and mobile applications that rely on that data as well as our access to the physical things managed ~~the~~ by IoT systems and also IoT system should recover quickly when problem arise.

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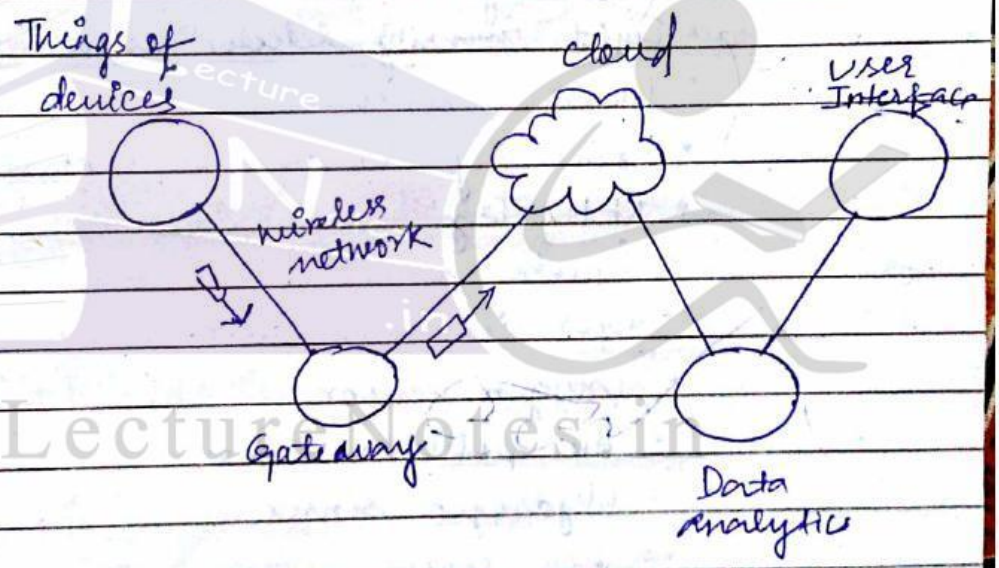
8. Detect vulnarability and incidents

Despite best effort security, vulnarabilities and breaches are inevitable. we need to detect if IoT system has been compromised.

In large scale IoT systems, the complexity of system in terms of no. of devices connected, ~~or~~ variety of devices, applicatn, services and communication protocols involved can make it difficult to identify and detect the vulnarabities and incidents.

Components in IoT



Components

1. Smart devices and sensors
2. Communication module
3. Gateway
3.5. cloud
4. Data analytics
   ↳ Big data
5. User interface
6. Power sources
7. controller service
8. Resources.
9. Database
10. Application

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collecting data.

1. Smart devices and sensors

→ Smart devices are attached with sensors and actuators

→ Sensors are continuously collecting data from the env. and transmit it to next layer.

→ Smart devices has control unit that controls all the sensors and operations.

→ Some common sensors :-

- Temp. sensor
- Pressure sensor
- Humidity sensor
- Light intensity detector sensor.
- Moisture sensor
- Proximity detection sensor.
- RFID Tag
- Smoke sensor.
- Gps detection sensor.
- Oxygen sensor
- Air pollution sensor
- Hydrogen sensor
- CO_2 sensor

Most of the model smart devices and sensors can be connected to low power wireless networks like wifi and ~~Gig~~ Zigbee, bluetooth, Z-wave & LORAWAN

2) Gateway

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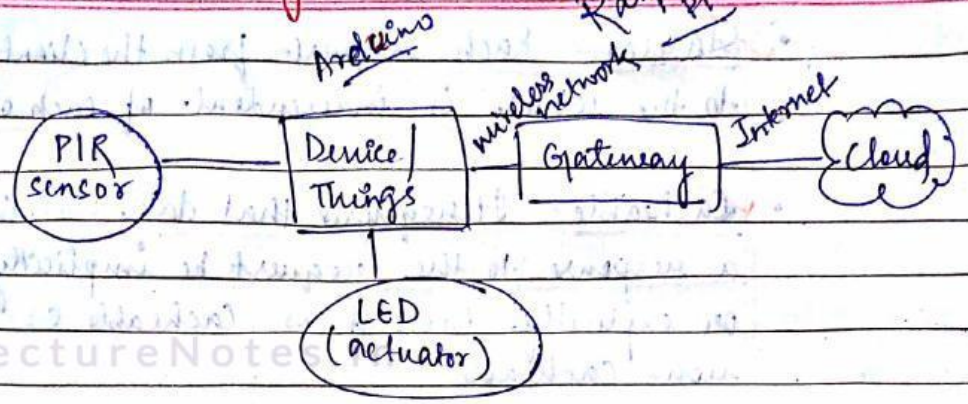
Gateway can be configured to perform pre-processing of the collected data from thousands of sensors locally before transmitting it to the next stage.



IoT gateway manages bi-directional data traffic b/w different networks and protocols. It translates the different network protocols and makes sure the inter-operability of connected devices and sensors.

3) Communication Module
- communication protocols — TCP/IP, OSI module
- " API
- " technologies

IoT communication API - (Application Programming Interface)
→ It is a set of tools, protocols and libraries used for building s/w applications.

2 types of communication API's for IoT:-
1) REST based communication API.
2) Web-socket " "

1) REST based communication API
REST- Representational state Transport. It is used for designing web services for IoT.
Constraints of REST:-
- Client-server constraint - A/c to this constraint client and server are independent of each other.

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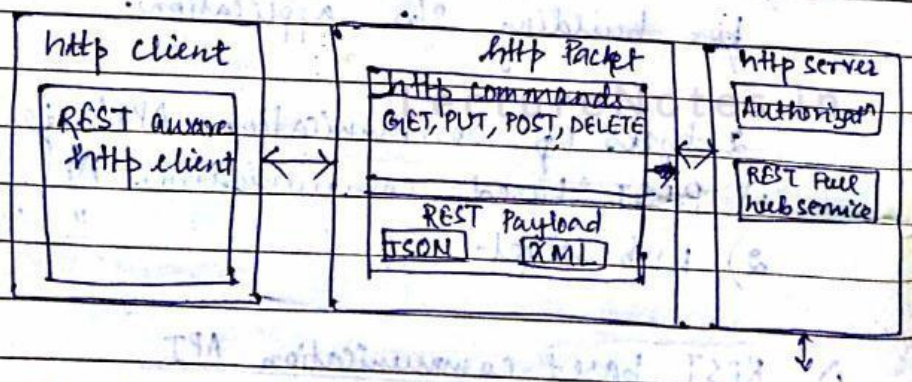
REST is a web service

- **Stateless** - Each request from the client to the server is independent of each other.
- **Cacheable** - It requires that data within a response to the request be implicitly or explicitly labelled as cacheable or non-cacheable.
- **Layered system** - Each component cannot see beyond the immediate layer.
- **Uniform interface** - Method of communication b/w client and server should be uniform.
- **Code-on-demand** - Server can provide executable code or script to client on demand. This constraint is optional.

Communication b/w client and server using REST API's



Payload - Data ie exchanged b/w client & server. Data is either in the form of JSON or XML.

JSON & XML are data representation techniques used in the web.

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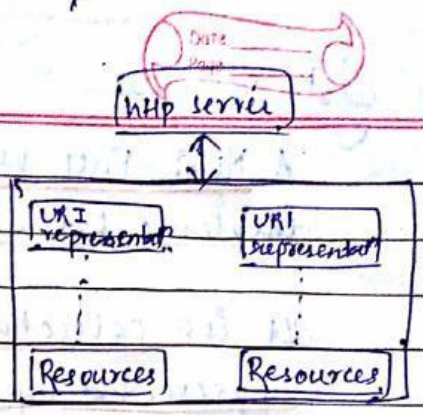
URI - Uniform resource identifier.

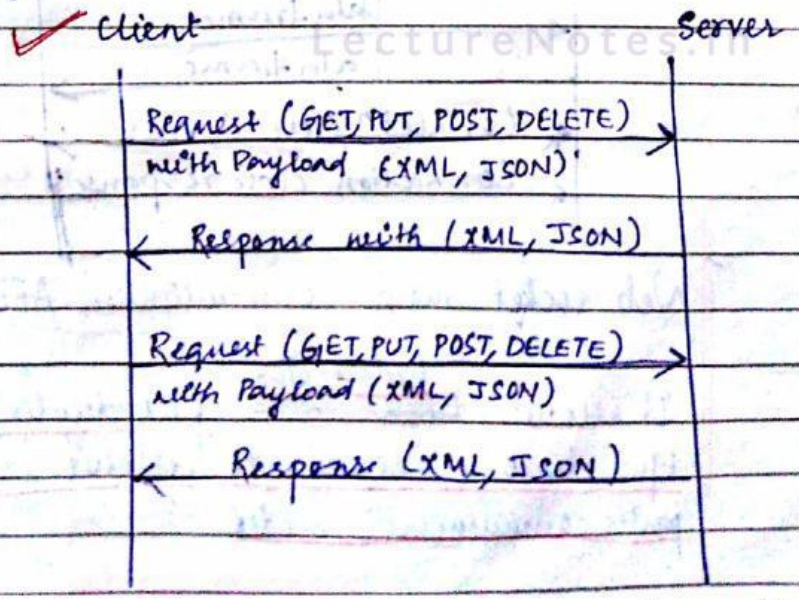


drawn below the http server.

http - hyper text transfer protocol
XML - Extensible Markup Language
JSON - Java Script object Notation

GET - get information of resource.
PUT / UPDATE - when this command is executed, it is update resource / task with data attached with request.
POST - create a new resource / task
DELETE - Delete a resource / task

Interaction in the request response model used by REST.



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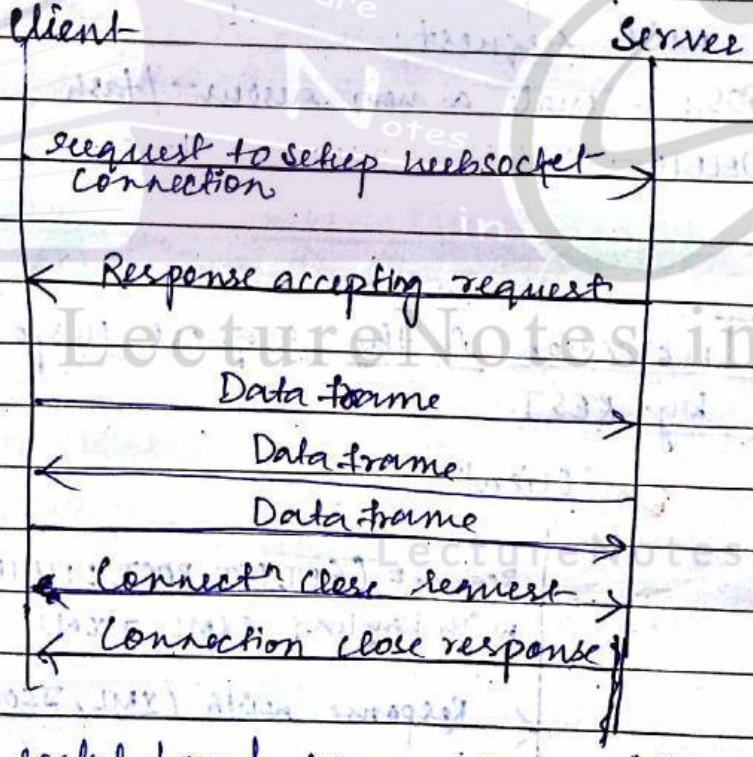
A REST Full web service is a web API implemented http and REST principles.

It is a collection of resources which are represented by URI.

The clients send request to these URIs using the methods defined by http Protocol. The server process client request to authorization and respond with the services requested by the client.

Web-Socket based communication API :-



Web socket based communication API :-

It allows ~~high~~ bidirectional full duplex communicatn b/w client & server - It follows exclusive pair communicatn model.

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Unlike request response API such as REST, The web Socket API allows full duplex communicatn & do not require a new connectn to be set up for each msg to be send.

It begins with a connectn setup request send by the client to the server. If the server supports web socket protocols then it responds to the ~~and~~ client request with connectn setup.

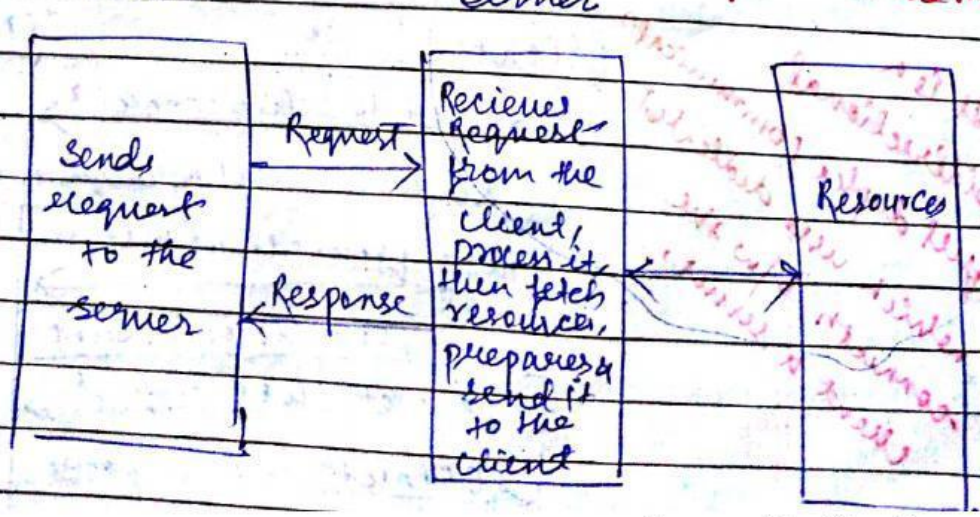
After connection is set up they send data to each other in full duplex mode.

Communication models :-

1. Request-response model
2. publish-subscribe model
3. push-pull model
4. Exclusive pair model

1. Request-response model

- communicatn model in which the client sends a request to a server & the server responds to the request



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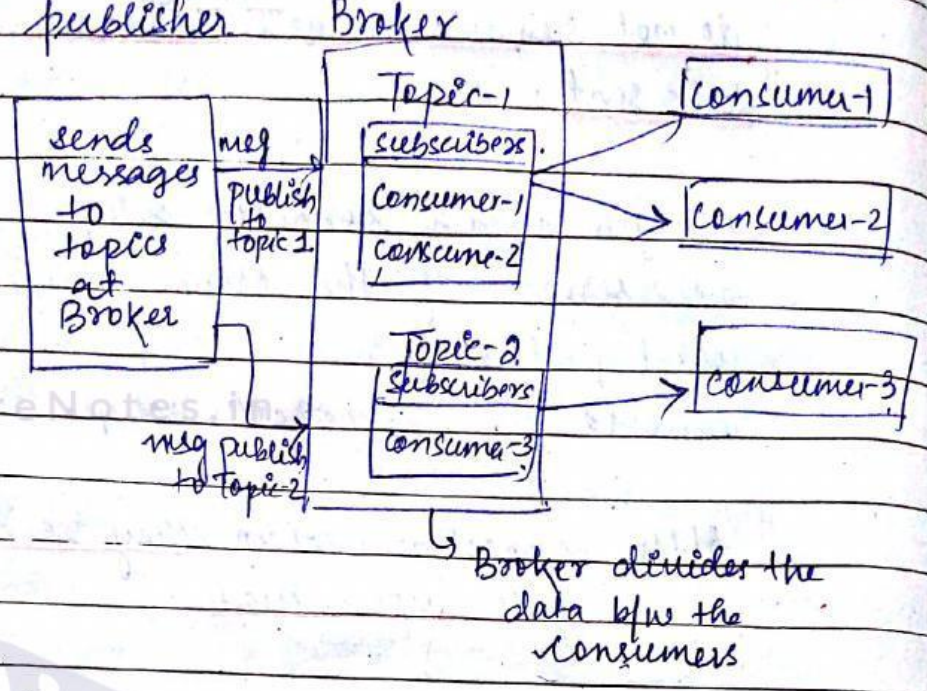
(2) publish-subscribe model

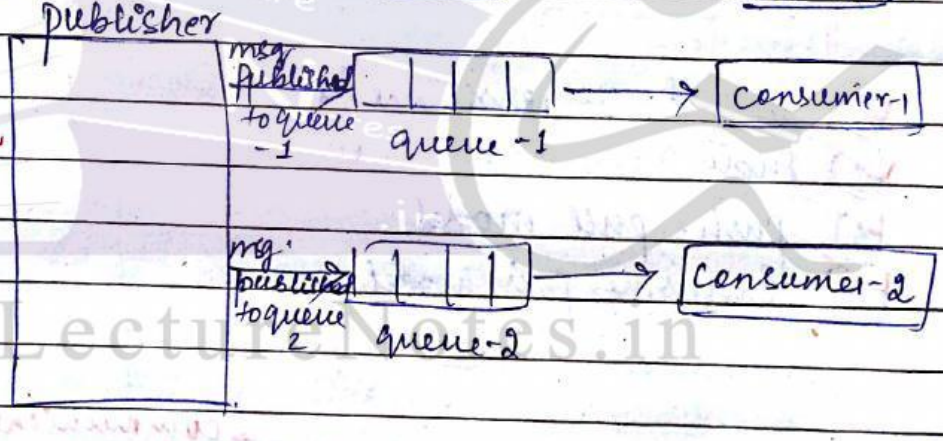
Involves publishers, brokers and consumers.



Broker divides the data b/w the consumers

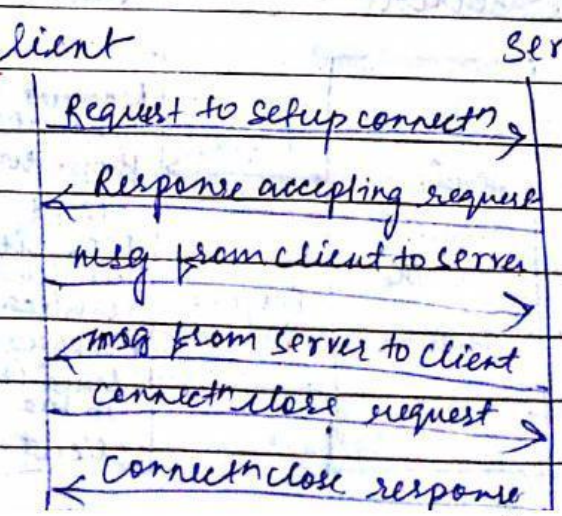
(3) push-pull model

Communication model in which the producer push data to queues. Here the producer do not need to be aware of the consumer.



(4) Exclusive pair model

It is a bidirectional full duplex communication which uses dedicated connection b/w the client & server.



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Resource

Resources are software components on the IoT devices for accessing, processing and storing sensor info. or controlling actuators connected to the device.

Controller Service

It is a native service that runs on the device and interacts with the web services.

Database

It stores the data generated by IoT at local or in cloud server.

Web Service

Web services are open standard based web applications that interact with other web applications for the purpose of exchanging data.

Example :- REST over http and Web socket over TCP.

Data analysis Component

It is used for analysing the IoT data and generate results in a form which are easy for the user to understand.

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Application

It provides interface to the user to control and monitor IoT systems and allow the user to view the system status and processed data.

Cloud Computing

Cloud Computing is a model that enable ubiquitous, convinient, ondemand and network based configurable computing resources and services such as network, servers, storage and applications.

~~Ch~~ Characteristics of CC :-

1. Broad Network access
2. Resource spooling
3. Metered service
4. Multitenancy

Service models of CC :-

1. IaaS (Infrastructural as a Service)
2. Paas (Platform as a service)
3. saas (Software as a Service)

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Communication Technologies

- RFID
- Bluetooth
- Zigbee
- wifi
- RF links
- Mobile Internet
- wired communication technologies

① RFID (Radio Frequency Identification)

RFID Reader generates radio signals.
Tag is used to store some info./data.

It is a wireless communicatn technology that incorporates the use of electromagnetic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object such as animal or person and tracking them

Passive tag - depends on RFID reader for energy

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RFID reader continously sends the radio-waves. when the object is in the range of the reader, RFID sends the feedback signal back to the reader.

In RFID, signal is not line of sight unlike barcode.

→ Multiple objects can be identified at the same time

RFID tag is attached with the object.

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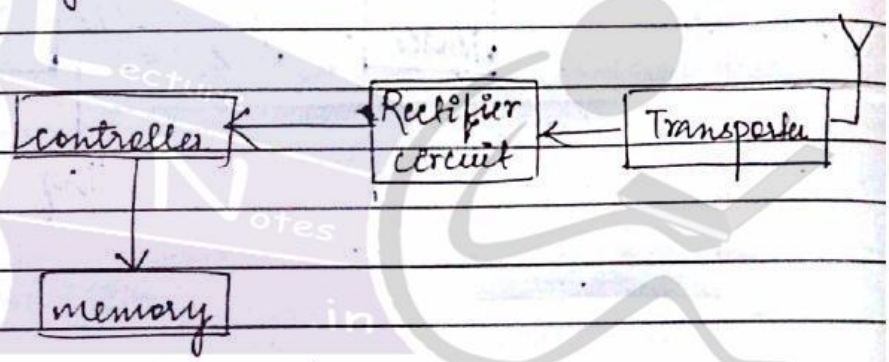
RFID Tag



when RFID tag recieves electromagnetic signal from the RFID Reader. It is converted to electric signal, rectified by the Rectifier circuit & stored using capacitors.

This energy is supplied to the controller & memory for their work.

There are 3 types of RFID tags :-

i) Active tag

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Each tag includes a radio antenna that allows it to recieve signals from the reader.

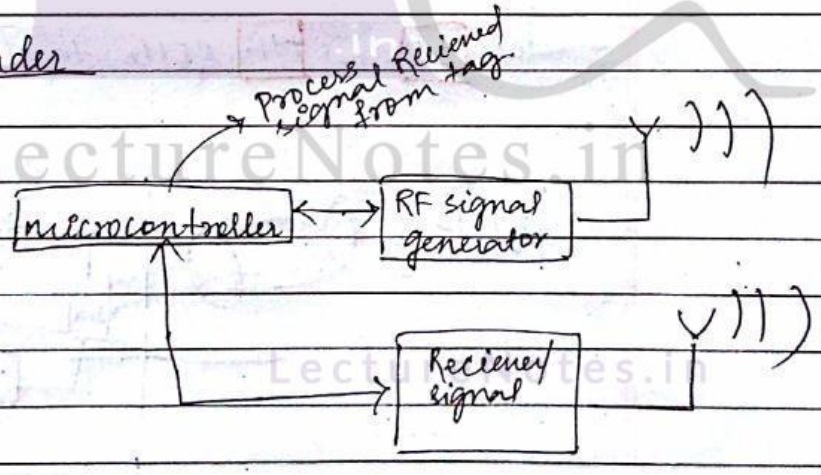
ii) Passive tag
iii) Semi-passive tag

Active tag has its own power supply for transmitting signal back to the RFID Reader and managing its own circuit.

Passive tag does not have its own power source, it rely on the radiowave coming from the reader for both managing circuit & transmitting signal back to the reader.

Semipassive tag has its power supply for managing the circuit but rely on the radiowaves coming from the reader for transmitting signal back to the reader.

RFID Reader



RFID Reader performs following operation :-

i) It ~~reduce~~ induces enough power into the tag
ii) Synchronization of clock is done in the tag
iii) It acts as a carrier for return data from the tag

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Tags need to be less than 1m away from the reader

Date
Page

Frequency of operation in RFID :-

- → Low Frequency 125 – 134 KHz
- → High " 13.56 MHz
- → Ultra high " 860 – 960 MHz.

Working Principle of RFID :-

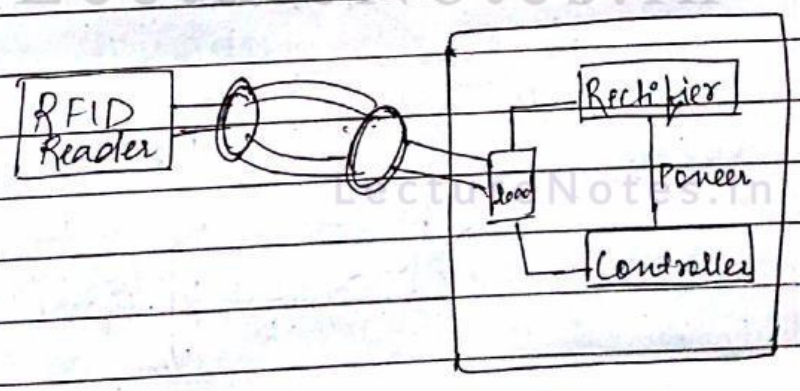
Two working principle

(1) inductive coupling / Near field coupling

(2) Electromagnetic coupling / Far field coupling

(1) inductive coupling

- uses LF and HF RFID tags



→ when the tag receives signal from the Reader because of coupling electric voltage is generated, Rectified by the Rectifier circuit and stored in capacitor.

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→ Power is supplied to the controller and memory.
→ Clock is synchronized
→ If we change impedance of the load, then current flowing through this load will change.
→ Switching on and off the load, parent will be switch on or off.
→ Switching on & off generates voltage in the RFID Reader.
→ Switching on & off is done acc. to the data that is to be send to the reader in the form of voltage. ~~total~~ level.

Active Tag

The diagram is same as Inductive coupling.

(2) Far Field coupling

→ RFID Reader continously send signal towards RFID tag. In response RFID tag send back signal to the reader.

→ Data is send to the reader using diff. voltage level for diff. data.

→ Voltage levels can be controlled by varying impedence in the load

RFID and Barcode are 2 different forms of technology that are used for reading and collecting data.

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Bluetooth :-

→ Short range wireless personal area network standard.

→ devices are connected in adhoc fashion.

→ Packet-based protocol with master/slave architecture.

data is transferred in the form of packets

→ Ieee 802 15.1 standard of Ieee for bluetooth.

→ It uses 2.4 GHz to 2.485 GHz frequency band

→ uses guard band of 2MHz and 3.5MHz

→ It uses frequency hopping spread spectrum (FHSS) with time division duplexing (TDD)

→ Range is upto 100 meters

→ Data rate is 1mbps

Types of nodes in Bluetooth :-

1. master node - Determines hopping sequence
2. Slave node - synchronize hopping sequence
3. Parked node - Do not participate actively but can be activated when reqd.
4. Stand by node → Do not participate.

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- 1 master node
- upto 7 slaves nodes are possible

Addressing in bluetooth:

2 Addresses are used.
- Active member address (AMA) uses 3 bits.
- Parked member address (PMA) uses 8 bits

Bluetooth topology :-

2 types :-
(1) Piconet
(2) Scatternet

Bluetooth is a wireless technology standard for exchanging data over short distances in a personal area network, using frequency band from 2.4 to 2.485 GHz

The term piconet is used to refer to the network formed by one device & all devices found within its range.
Up to 10 piconets can exist within a single coverage area.

Devices in piconet have a logical address of 3 bits, for a max. of 8 devices.
Devices in parked mode are synchronized, but not have their own physical address in the piconet.

Last Page

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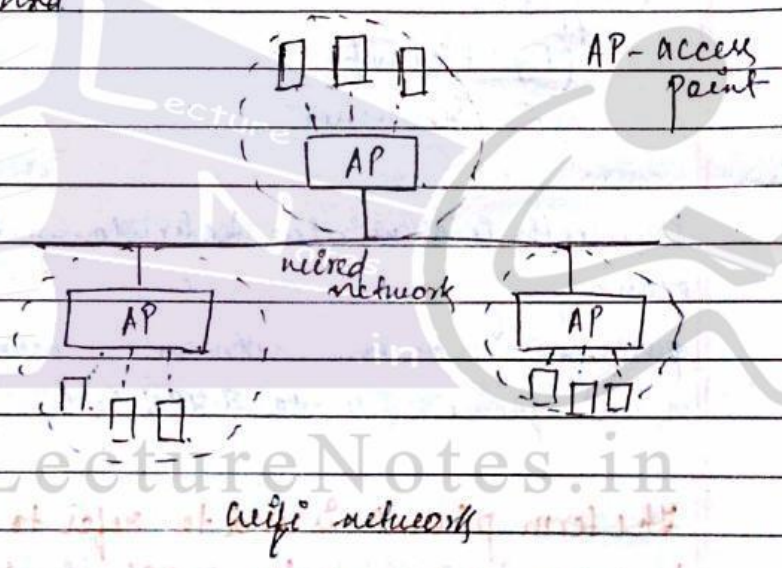
Wifi (Wireless Fidelity)

→ Ieee 802.11
→ WLAN
→ Range upto 300 feet
→ Data Rate upto 1Gbps
→ uses 2.4 GHz freq. band
→ It is a wireless technology an alternative to wired technology which is used for connecting devices in wireless mode.

Wifi is a generic term that refers to Ieee 802.11 Standard



Working of wifi :-

A wifi hotspot is created by installing an access point to an internet connection.

An AP acts as a base stat^n.

When wifi enabled devices, encounter a hotspot signal. The device can connect to the wifi network wirelessly.

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A single AP can support upto 30 users at a time & can function within a range of 100 to 150 feet indoor & upto 300 feets outdoors.

Many access points can be connected to each other via ethernet cables to create a single large cable/network.

Power Sources in IoT

Three power sources options are there:-

1. Main electricity
2. Batteries
3. Harnesting

(1) ME

For many applicatn's we may only need to plug in the connected devices to the ME power.
Ex: In home automatn system connected light bulbs can draw energy from existing electric wiring in the home.

(2) Batteries

It is used in the portable IoT devices, wireable electronics, it may be rechargeable or one time use. Capacitors can also be used for storing charges.

(3) Harnesting

Energy is converted from ambient form into electricity. Ex: solar cells, converting light into electricity, converting air into

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heat, motion & chemical energy into electricity.

Mobile Internet :-

Mobile internet hotspots :-

→ Smart phone hotspot.
→ Mobile hotspot
→ vehicle hotspot
→ Stationary broadband hotspot (wimax)

Accessing internet from a device that has a cellular network connectn is known as mobile internet.

A device converts cellular 3G, 4G signals to wifi and vice-versa.

As long as a cellular signal is available, a device creates a local wifi hotspot to provide access to the internet for some no. of wifi devices nearby.

The wifi speed depends mostly on the cellular connectn.

Different types of Hotspot :-

SPH

→ Smart Phone is used as hotspot or router.

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MH

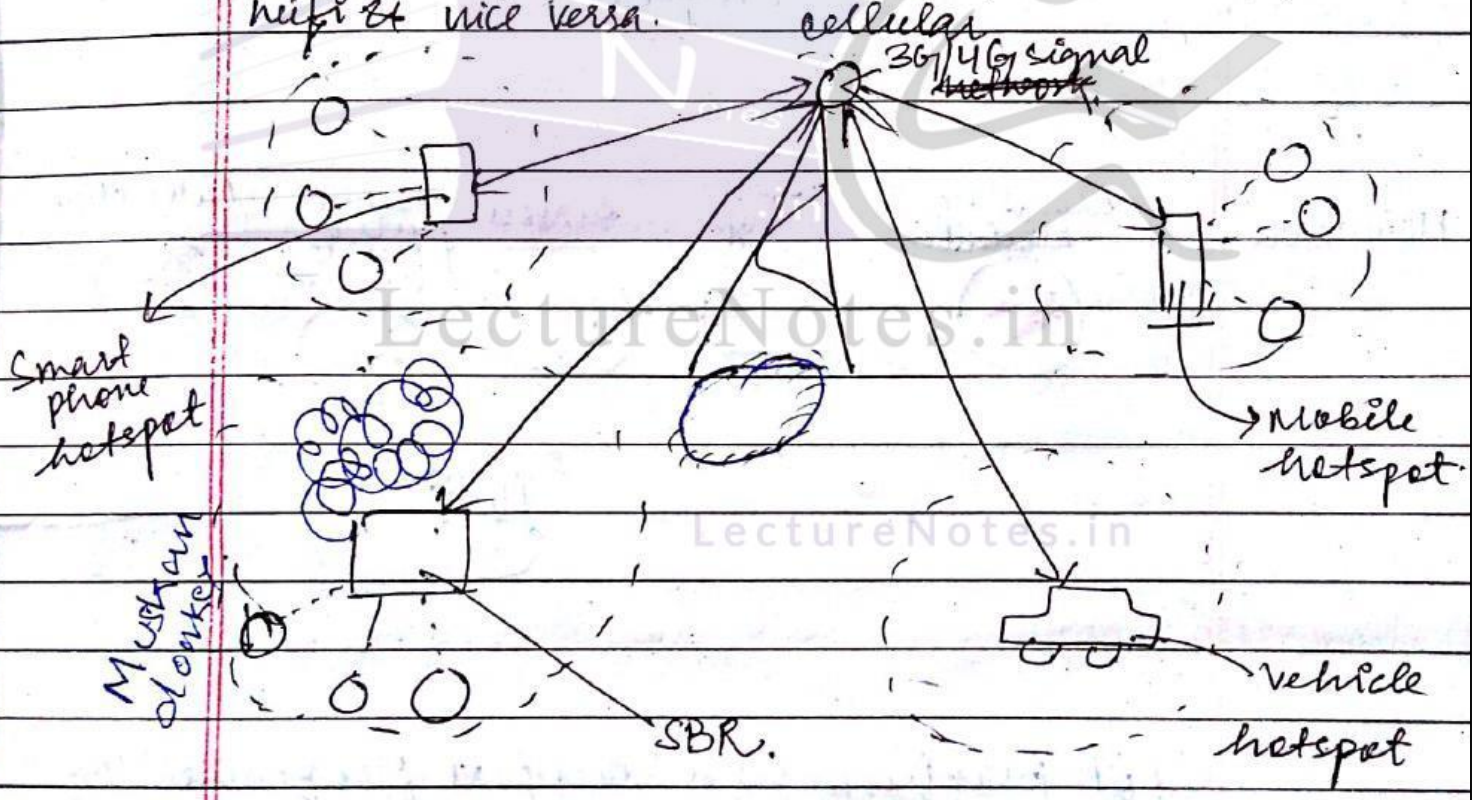
→ A dedicated small device can be made mobile wireless router or hotspot

VH

→ A built-in unit is used in a vehicle that Provide wifi hotspot inside the cabin of the vehicle to all passengers.

SBR

→ A stationary device that converts cellular signal to wifi & vice versa.



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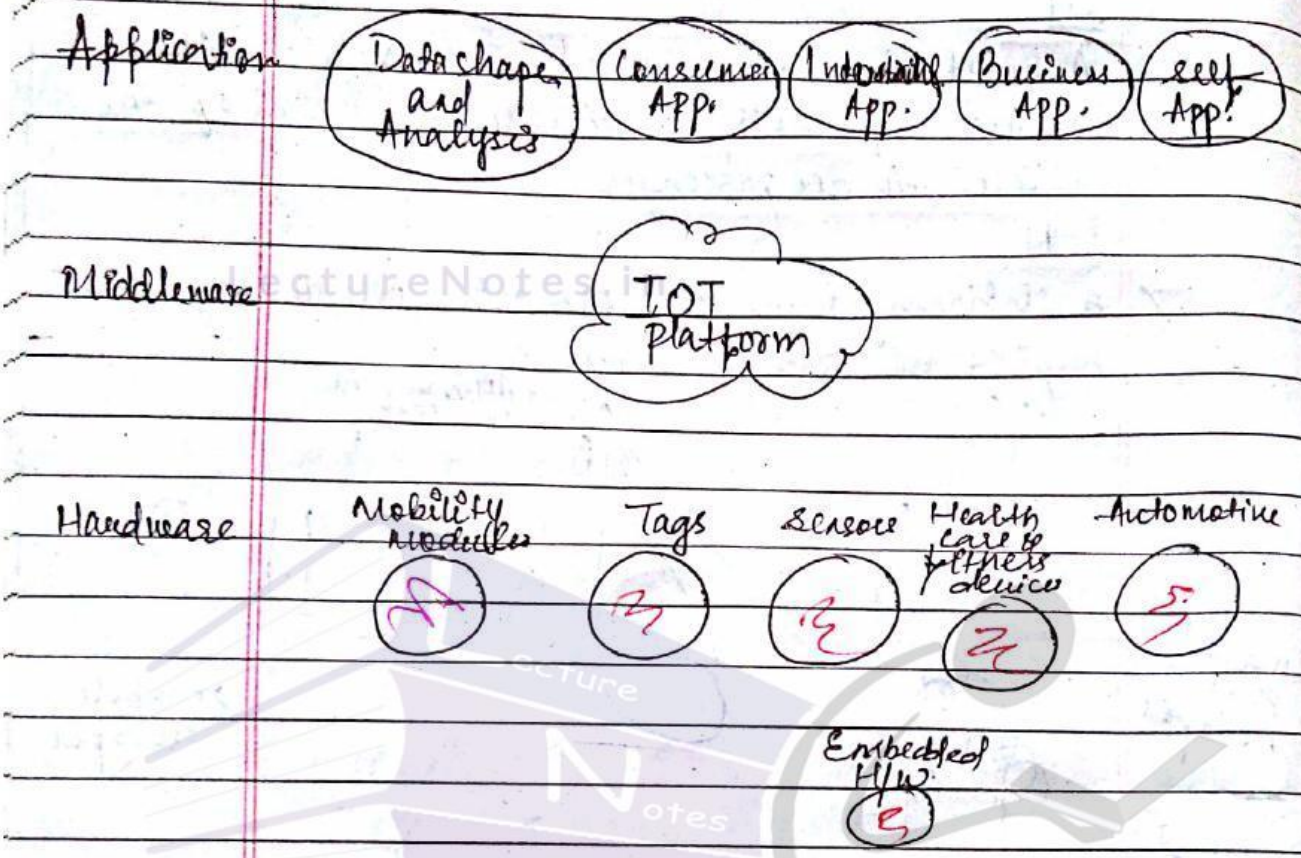
IoT Platform :-



IoT platform is a support & software that connects edge H/w, access points and data networks to other part of value chain. It is referred to as middleware soln. whose purpose is to funct^n as mediator b/w the H/w and app. layer.

Its primary task includes data collect^n from devices over diff. protocols and network topology, demo device config. and control, device management & firmware updates.

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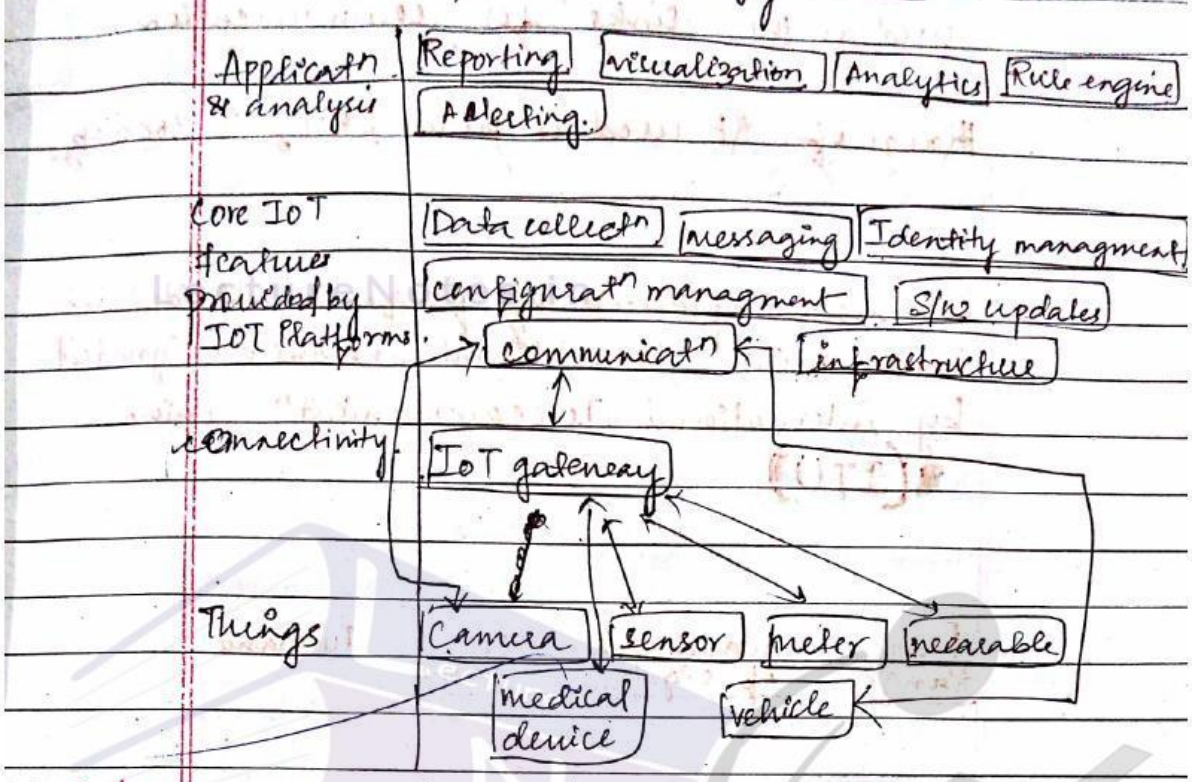
IoT Platform technology stack



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Some components Providing IoT Platform

- Amazon webservice
- Microsoft azure
- Thingworx IoT platform
- IBM watson
- CISCO IOT cloud connect
- salesforce IOT cloud

RF links

13/8/18

A radio frequency signal refers to a wireless em signal used as a form of communicatn in wireless communicatn system known as RF link.

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when freq. inc. wavelength dec.

The radio waves of em radiation are used as the links for communication

Range of RF used is from 3KHz to 300GHz

The radio spectrum of freq. is divided into bands with conventional names designated by international Telecommunicat^n union (ITU)

Freq. Range	wavelength of signal	ITU name	Fullname
3-30KHz	$10^8 - 10^4$ Km	VLF	Very Low Freq.
30-300 KHz	1 - 10 Km.	LF	Low Freq.
300 KHz - 3MHz	100m - 1 Km	MF	Middle Freq.
3MHz - 30MHz	10m - 100m	HF	High Freq.
30MHz - 300MHz	1m - 10m	VHF	Very High Freq.
300MHz - 3GHz	10cm - 1m	UHF	ultra HF.
3GHz - 30GHz	1cm - 10cm	SHF	Super HF
30GHz - 300GHz	1mm - 1cm	EHF	Extremely HF.

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Typical frequencies

For radio - 88MHz
TV Broadcast - 200 MHz
GSM phones - 900MHz.
GPS - 1.2GHz
Bluetooth - 2.4GHz
wifi - 2.4GHz
3G - 1.8 - 2.5GHz (WCDMA, UMTS)
4G - 2-8 GHz (LTE)
VANET - 2.4GHz - 5.8 GHz.

Wired communication in IoT

2 types :-

1) Internal communicatn
2) External communicatn.

Internal communication interface

- I2C, (inter integrated circuit)
- SPI (Serial peripheral interface bus)

External communication interface

- Ethernet port
- RS-232 port
- RS-485
- UART
- USART
- USB

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Mini computer used in IoT

(1) Raspberry Pi

(2) Arduino

Raspberry Pi

RP is a low cost mini computer with the physical size of a credit card.

It runs various flavours of Linux OS and can perform almost all task that a normal desktop computer can do.

It also allow interfacing, sensors & actuators to the general purpose i/o pins.

~~Compare~~

Since RP runs Linux OS it supports python out of box.

Component in Raspberry Pi board

1. DSI connector Display
2. SD card slot
3. Micro USB power
4. HDMI (used for multimedia)
5. CSI connector camera
6. ~~USB port~~ Ethernet
7. USB port
8. Status LED

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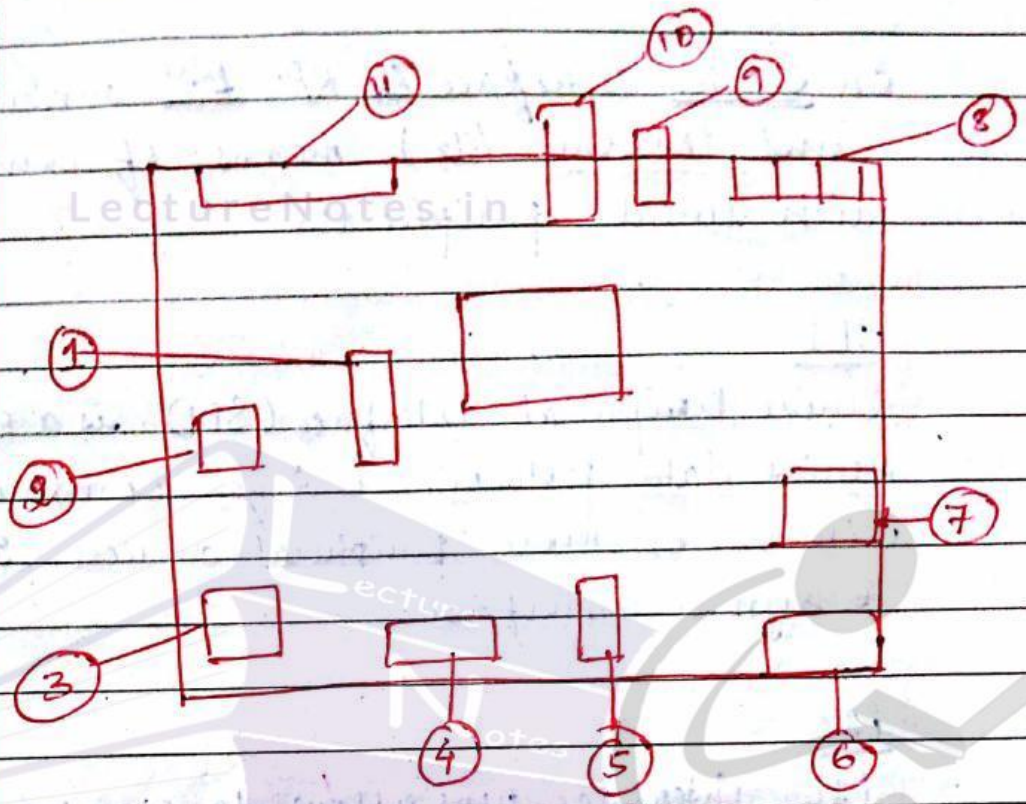
(9) Audio Jack
(10) RCA video (for connecting CD, DVD)
(11) GPIO Header (General purpose Input output)



Linux on Raspberry Pi

- Raspbian (It is based on debian optimized for RP
- ARCH.
- Fedora - It is based on fedora optimized for RP.
- RaspBMC - Based on XBMC media center distribution optimized for RP.

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Raspberry Pi Interfaces :-

- Serial Interface
- SPI Interface
- i2c Interface.

In Serial Interface RP are recieved (Rx) and transmit (Tx) means of communication with serial peripherals.

SPI

Serial Peripheral Interface (SPI) is a sync. serial data protocol. used for communicating with one or more peripheral devices. It is a sync. interface.

i2c

i2c interface pins allow to connect hfw modules.

It allows sync. data transfer with just two pins namely SDA (data line) and SCL (clock line)

Based on speed there are 3 types of i2c namely
→ slow (speed < 100 kbps)
→ Fast (400 Kbps)
→ High speed (3.4 mbps)

It uses a bus which connects processor EEPROM, sensors and real time clock.

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Arduino

Arduino is a open source electronics platform based on easy to use h/w and s/w.

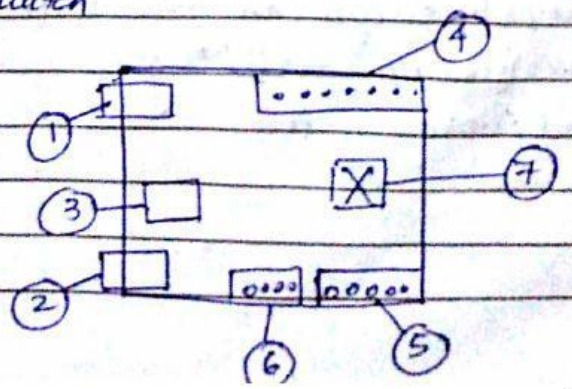
Arduino boards are able to read inputs such as light on a sensor, a finger on a button or a message and turn it into an o/p. activating a motor, turning on a LED, publishing something online etc.

we can tell the boards what to do by sending a set of instructn to the microcontroller on the board.

Arduino programming language, Arduino s/w (IDE) can be used to write programs for giving instructns.

Important Parts of Arduino board :-

1) USB Connector.
2) Power Connector
3) Automatic Power Switch
4) Digital pins 4.5) Analogue skills
5) Power pins
6) Reset switch



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Advantages of Arduino :-

(1) Inexpensive

Arduino boards are relatively inexpensive compare to other microcontroller platform.
The cost is less than 50US $

(2) Cross platform

Arduino software ID runs on windows, machintos and linux OS.

(3) Simple clear programming env.

It is easy to use for begginers & flexible enough for advance user.

(4) Open source and extensible s/w

The Arduino s/w is published as a open source tool. The lang. can be expanded through C++ libraries.

It is based on AVR C prog. language.

(5) Open source and extensible h/w.

The ckt design can make their own version of the module extending the arduino board and improving it.

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IOT Standardization :-

Many of the modern standards for the internet do not suffice for supporting IOT efficiently and economically since IOT did not exist when these protocols where designed and implemented.

Additionally since the infrastructure for IoT has not been fully developed. many IoT devices have been implemented with proprietory protocols making it difficult for them to communicate with one another.
So, IOT Standardisation is reqd. to create more inter operability..
~~The protoc~~

Application layer

HTTP, COAP, WEBSOCKET, MQTT XMPP, DDS, AMQP

Transport layer TCP and UDP

Network layer

IPV4, IPV6, 6LOWPAN

Link layer

802.3 Ethernet 802.16 WiMax 80.211 WiFi 802.15.4 LRWPAN 2G/3G/4G

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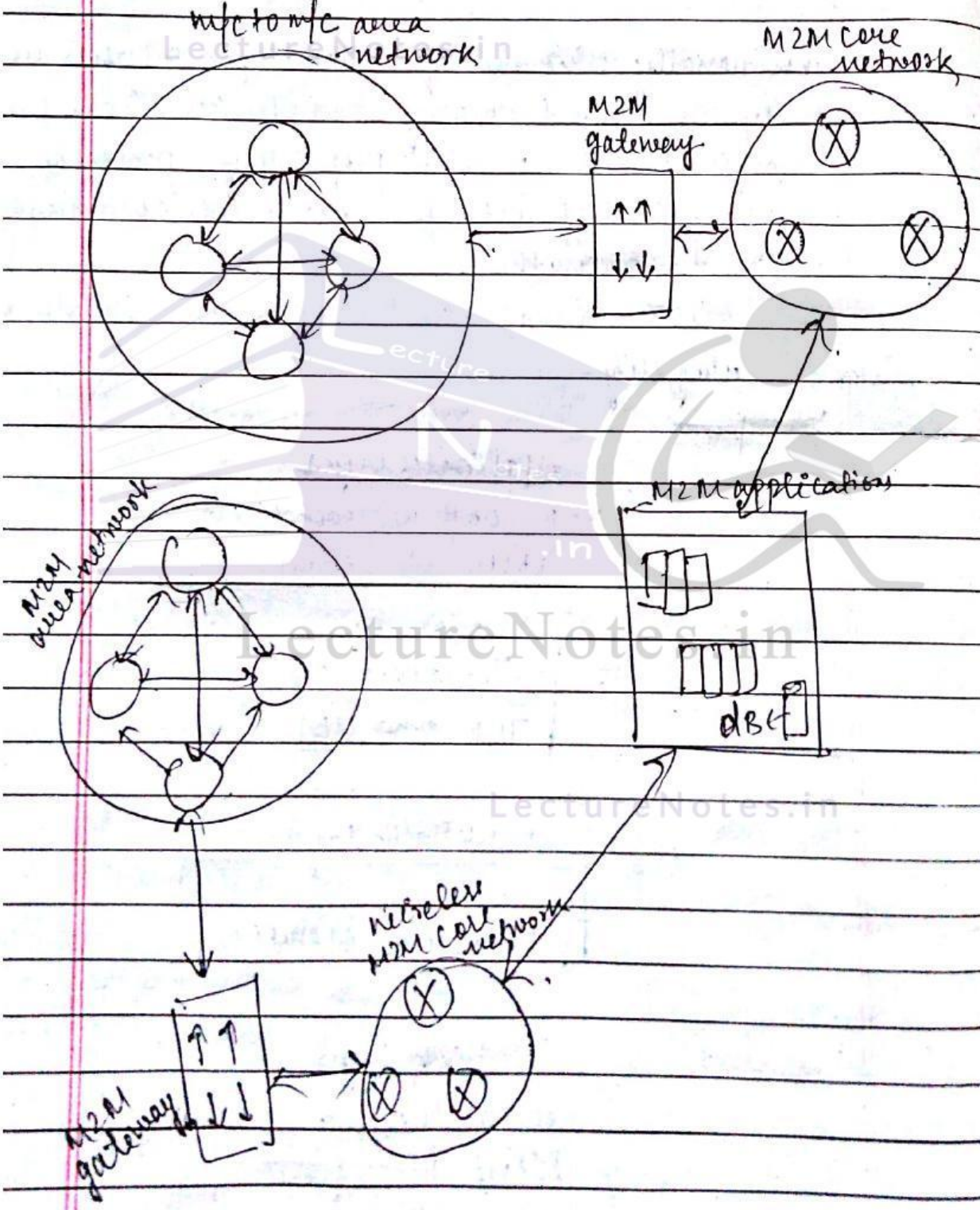
M/c to M/c (M2M)

M/c to M/c refers to direct communicat° b/w machines or devices using any communication channel including wired and wireless.



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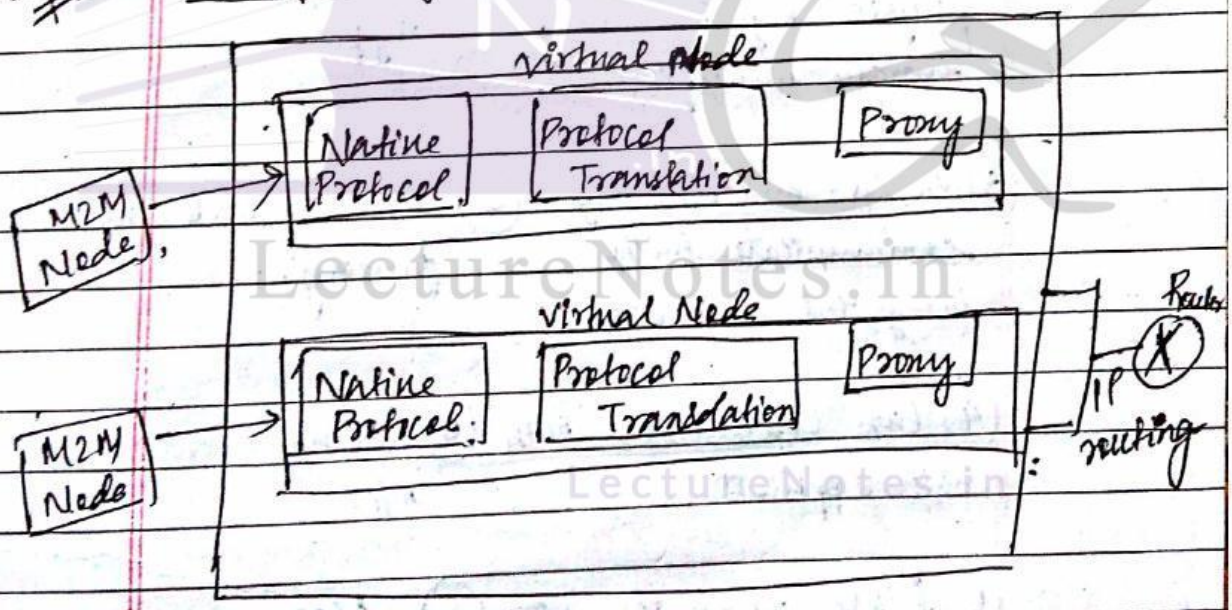
It is a networking of machines for the purpose of remote monitoring, control and data exchange. M2M area comprises of m/c (M2M nodes) which has embedded h/w modules for sensing, actuation and communication.

Various communicatn protocols can be used in M2M local area networks such as zigbee, bluetooth, modbus, m-bus, powerline communicatn, 6LOWPAN and Ieee802.15.4

M2M area network uses either proprietory or non-IP based communication but the communication network uses IP based network.

21/8/18 M2M gateway :-



Since Non-IP based Protocols are used within M2M area network. The M2M nodes within one network cannot communicate with nodes in an external network.

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To enable communicatⁿ ~~b/w~~ b/w remote M2M networks, M2M gateways are used.

Difference b/w IoT and M2M

IoT	M2M
(1) IP based communicatⁿ Protocol is used	(1) Non-IP based or proprietory communicatⁿ Protocol used in M2M area network and gateway enables communicatⁿ with external network.
(2) Things in IoT are physical object having unique identifications.	(2) Homogeneous machine types.
(3) Things can directly communicate with integrated network	(3) Communicate via gateway.
(4) Can communicate with user applicatⁿ.	(4) Communicatⁿ is b/w m/c
(5) More emphasis is on s/w	(5) More emphasis is on H/w.
(6) Data collectⁿ & analysis is done at the cloud	(6) Data collectⁿ & analysis is done at the m/c.

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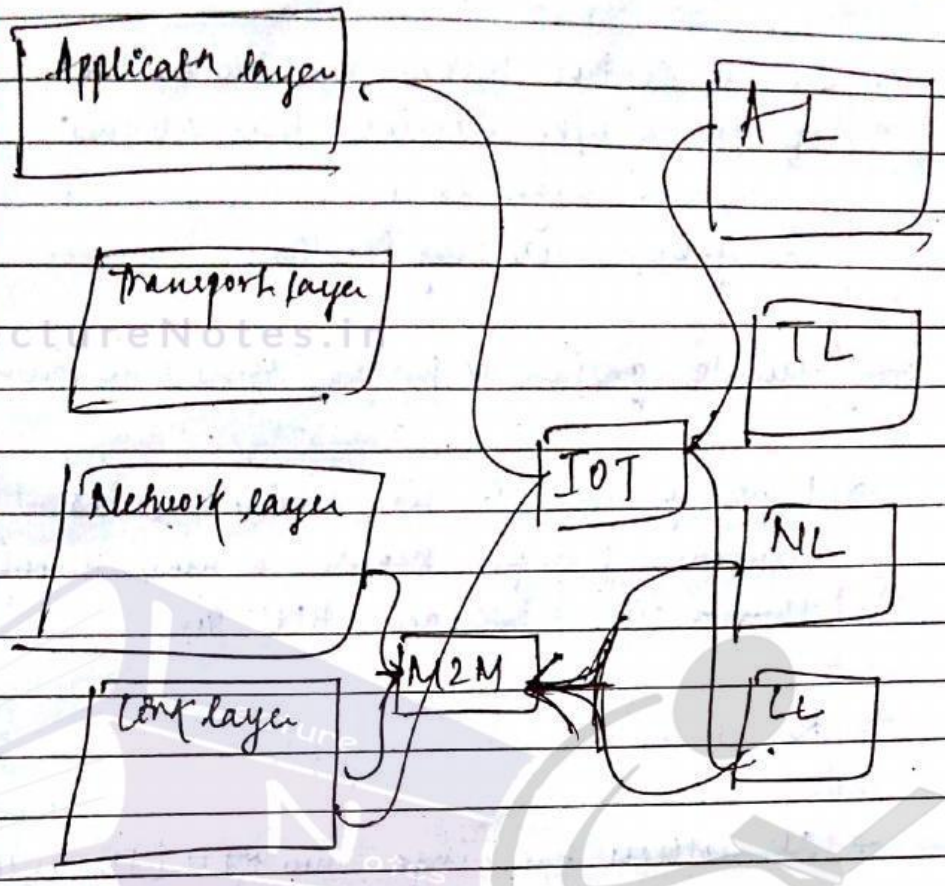
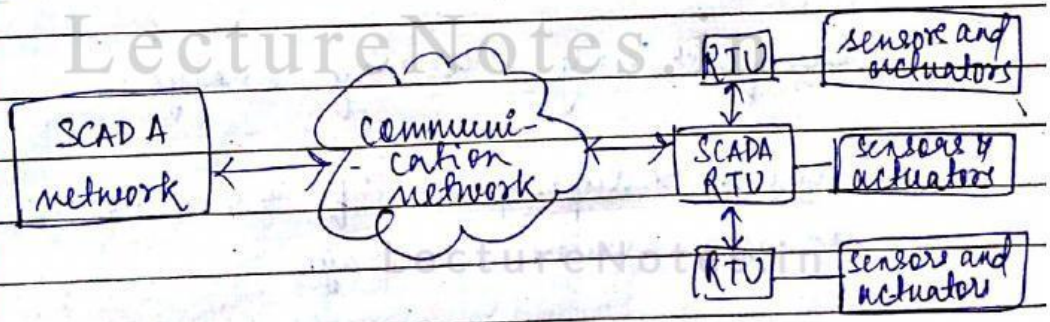
Communicatn Protocols in IOT vs M2M



28/8/18 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)



Components of SCADA system:-

- → Remote terminal unit (RTU)
- → sensors
- → actuators
- → SCADA master
- → HMI (Human machine Transfer)

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RTU

- Programmable Logic control (PLC)
- Intelligent electronic device (IED)

→ In is a control system architecture consisting of s/w & h/w elements that allows industrial org. to control industrial processes locally or remote ~~log~~ locations.

→ Monitor, gather & process real time data

→ Directly interact with devices such as sensors, pumps, motors & more through Human m/c interface (HMI s/w)

→ Record events into a log file

→ It collects the info. via RTU (PLC or IED)

→ Transfer it back to the control site

→ Carry out any necessary analysis.

→ Control & display that info on a no. of operator screens or displays.

→ Imp. parts include master station, remote terminal unit (TLC or IED) & the communicat^n b/w them.

→ The key attribute of SCADA system is its ability to perform a supervisory operation over a variety of other proprietory devices.

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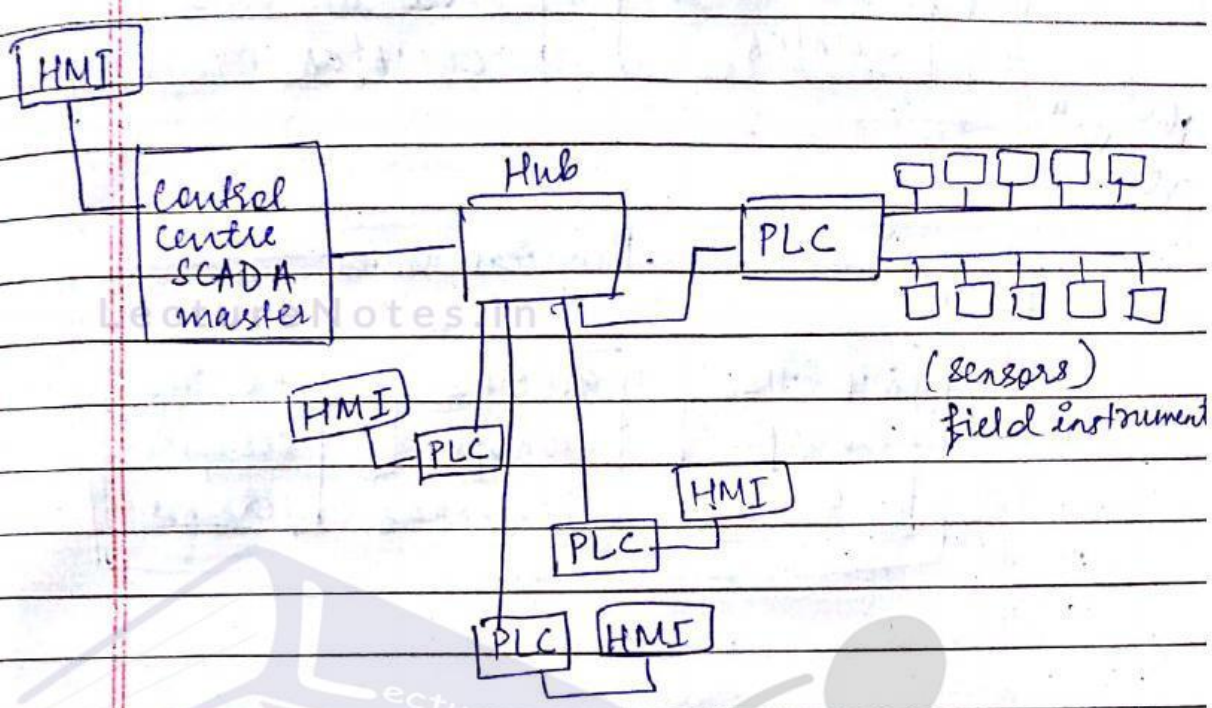
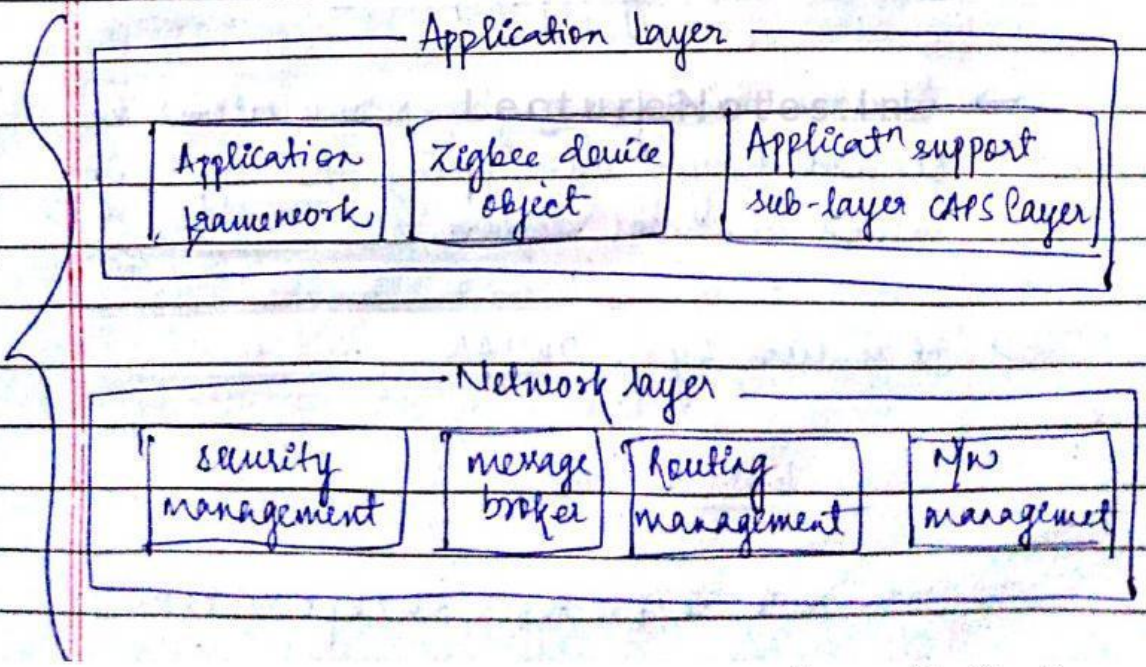
Eg:-

Industrial control system



Industrial control system used to monitor & remotely control ~~ckt~~ critical industrial processe

Ieee 802.15.4 :-



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Beacon → signal thrown by the coordinator node
↳ contains data for all the end devices & other info. and addresses.

IEEE 802.15.4

Medium access control (MAC) layer

beacon enabled	Non beacon enabled
mode slotted	mode unslotted
CSMA/CA	CSMA/CA

Physical layer

2.4 GHZ	915 MHZ	868 MHZ
250 Kbps	40 Kbps	20 Kbps
16 Channels	10 channels	1 channel

→ It is a technical standard which defines the operation of low rate WPAN (LRWPAN)

→ It specifies the physical layer & media access control in the MAC layer for LRWPAN & is maintained by IEEE 802.15 working group.

→ It is the chassis for zigbee which extends the standard by developing the upper layers which are not defined.

→ It is used by 6LOWPAN

Characteristics :-

→ Data rate is 250 Kbps, 20 Kbps, 40 Kbps

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Ieee 802.15.4 device types :-

2 types:-
1. Fully functn device (FFD)
2. Reduced functn device (RFD)

FFD

→ It can be used in any topology.
→ It has network coordinator capability.
→ Talk to any other device.

RFD

→ Limited to star topology.
→ It cannot become network coordinator.
→ It can only talk to network coordinator.

Ieee 802.15.4 Physical Layer :-

It has the following functionalities :-

1. Activatn and Deactivatn of radio transciever.
2. Energy detectn within the current channel.
3. Link quality indicatn for recieved packets.
4. Channel frequency selection.
5. Data transmission and reception.

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Ieee 802.15.4 MAC Layer

→ It provides channel access mechanism

Two types of channel access mechanism are there:

① Beacon enabled network. -

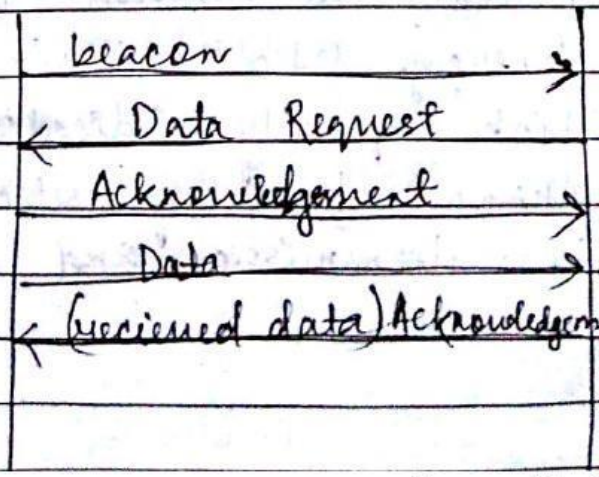
It uses slotted CSMA/CA channel access mechanism

② Unslotted CSMA/CA channel access mechanism

It is used in Non-Beacon enabled networks.

→ Carrier sense multiple access with collision avoidance

Data transfer from coordinator to device in a beacon enabled network



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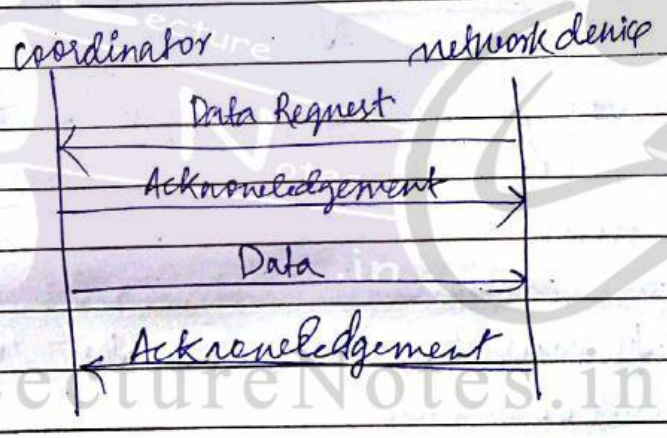
The coordinator node indicates in the beacon that some data is pending. A device periodically listens to the beacon and transmit a Data request using slotted CSMA/CA

Then coordinator sends acknowledgement to the device. device sends acknowledgement back to the coordinator.

Data transfer from coordinator to device in a non-beacon enabled network



→ The device transmits a request using unslotted CSMA/CA
→ If the coordinator have its pending data, an acknowledgement is ~~recd~~ replied.

→ Then the coordinator transmits data using unslotted CSMA/CA

→ If there is no pending data, a data frame with 0 length payload is transmitted.

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Zigbee Network layer

Zigbee network layer provides reliable and secure transmission among devices.

Three kinds of devices used in ZNL.

1. Zigbee coordinator (Master Node)
2. " Router
3. " end devices

(1) It is responsible for initialization, maintainance and controlling the network.

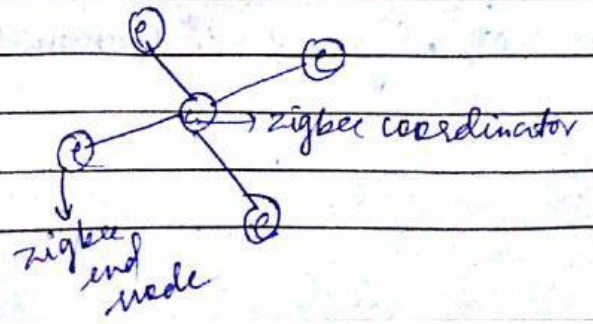
(2) It forms the network backbone by connecting the end devices and coordinator node

(3) It must be connected to routers or coordinators

Three types of Networks are used in Zigbee such as

- Star topology network
- tree " "
- Mesh " "

Star Topology :-



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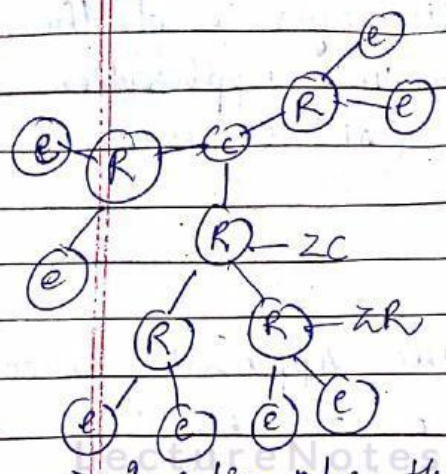
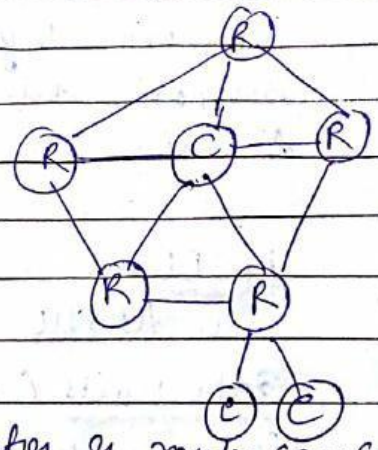
Tree



Mesh



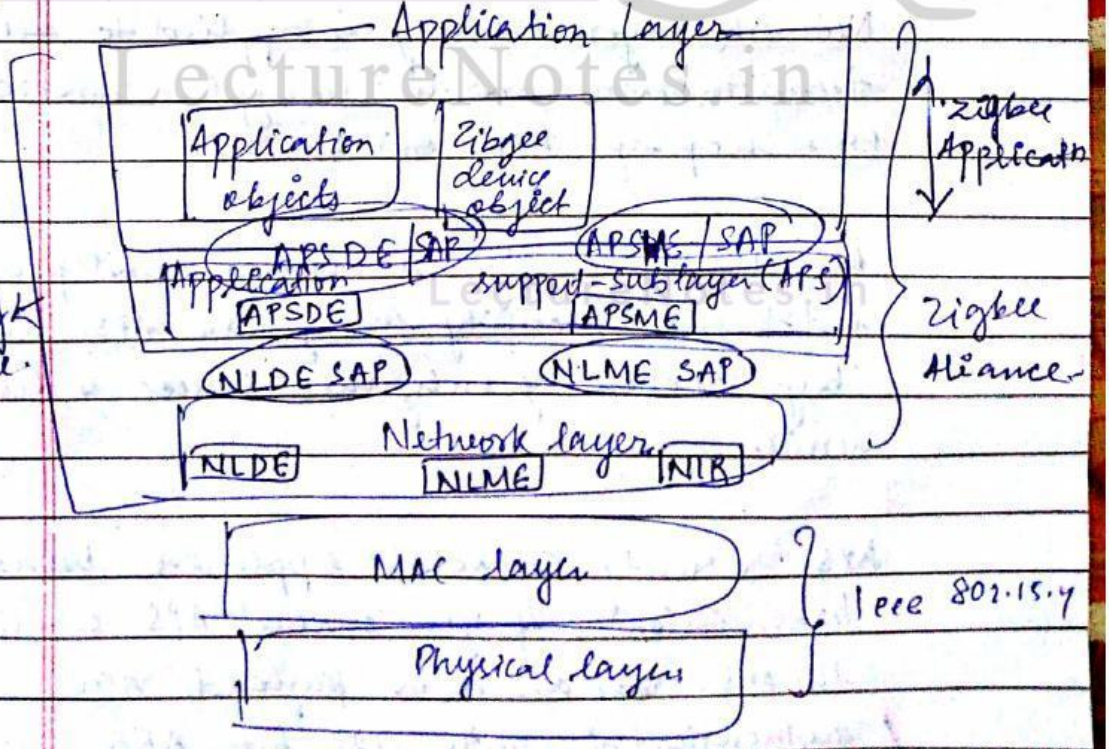
→ In a tree n/w, the coordinator & router can announce beacons.

→ In a mesh regular beacons are not allowed

→ Devices in a MN network can only communicate with each other by peer to peer transmission of routers

Zigbee Application support sublayer (APS layer)

3/9/18.



APSDE → Application Support Data Entity.
APSME → Application Support Managment entity.

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The Applicatn support sub-layer (APS) provides services to the applicatn layer and the network layer through the application support data entity (APSDE) and APSME.

APSDE :-

The APSDE access the Applicatn protocol data units (APDU) from the applicatn layer adds its hidden information to the APDU and transfers the resulting frame to the network layer.

APS layer Security :-

APS layer security can be used to encrypt applicatn data using a key that is shared b/w source & destinatn devices.

Network layer security is applied to all data transmission and is decrypted and reencrypted on a hop by hop basis.

APS layer security is optional and provides end to end security using an APS link key known by only the source & destination device.

APS security cannot be applied to broadcast transmission. If you enable APS security, the APS mdor and data payload are authenticated with 128 bit. AES

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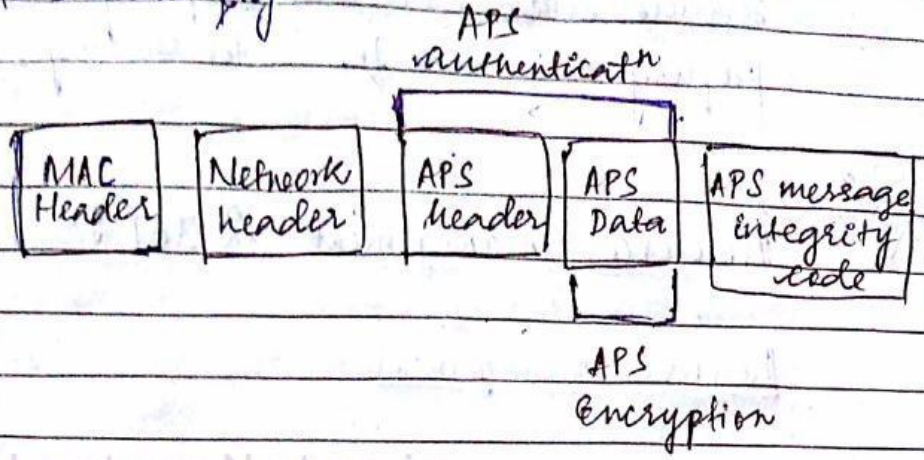
As shown in fig :-



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BACNET protocol (Building Automatn and Control Network)

It is a standard communicatn protocol for building automatn and management of building through a single application. It was developed by the consortium ASHRAE (American society of Heating, Refrigerating and Air conditioning engineers)

The main goal of BACNET is to create a protocol enabling multiple systems integration from different manufacturers primarily designed for building automation.

BACNET defines a no. of services that are used to communicate b/w building devices.

The protocol services include :-

who-is
I-AM
Who-Has
I-have

These are used for device or object discovery.

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services such as read property and write property are used for data sharing.

4/9/18

Resource management in IoT :-

Resource management

Techniques

1. Clustering
2. Software agent
3. Synchronization

Resource Management

→ IoT system has constraint resources that need to be managed efficiently.

→ IoT aims to use adhoc networks to connect things.

→ Connecting the adhoc network of things to the IoT infrastructure is not always possible.

→ Several techniques are used to manage the resources of IoT.

The techniques are mentioned above.

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Adhoc Network

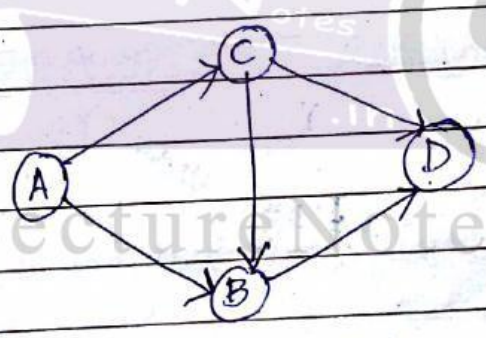
It is a local area network that is built spontaneously as devices connect each other. Instead of relying on a base station to coordinate the flow of messages to each other, the individual network nodes forward packets to and from each other.

There is no fixed access point in Adhoc Network.

Each node can act as a router.

Multihop communicatn takes place.

Mobile Adhoc Network (MANET)



Wireless Sensor Network (WSN)

Types of nodes :-

- end nodes (Sensor node)

- Router node (Sink node)
  collects data from end nodes and forwards them to the coordinator.

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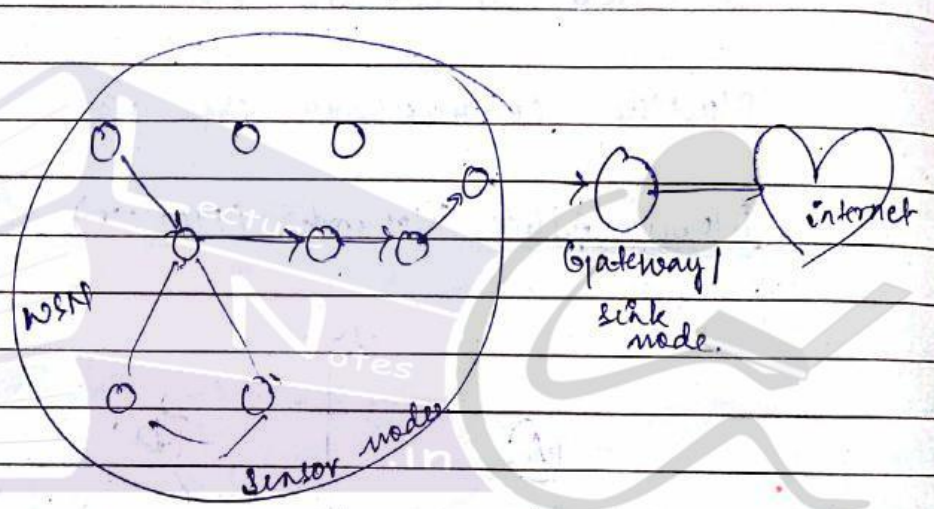
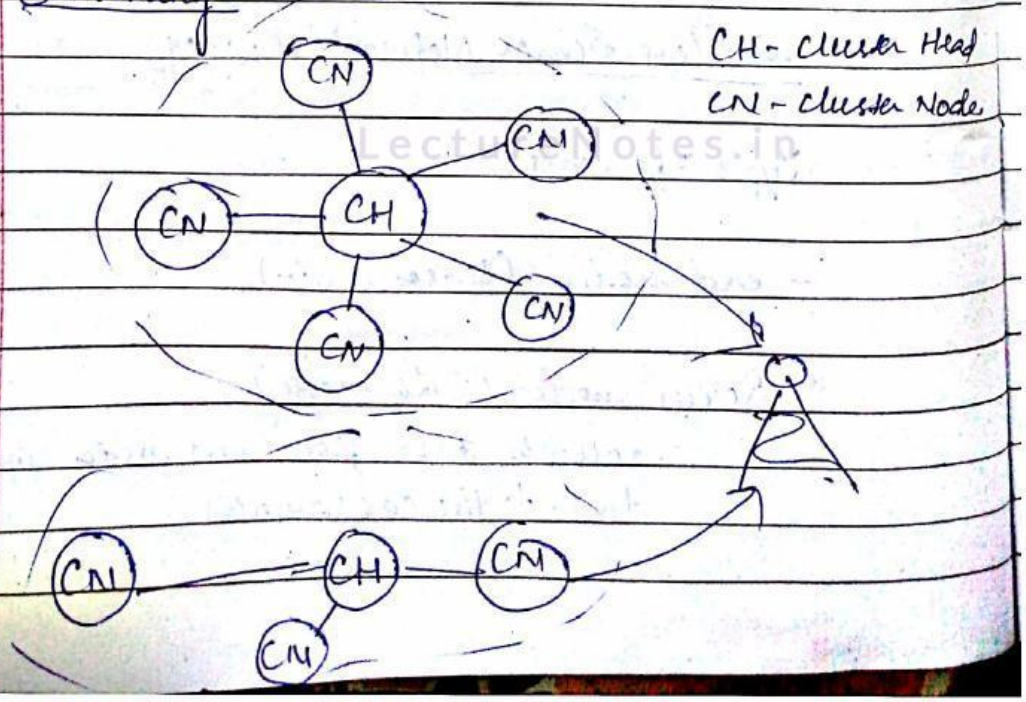
- Coordinator nodes (Base station / sink) connected to internet, it is also known as gateway.

WSN comprises of distributed devices with sensors which are used to monitor the env. and physical condition.

3 types of nodes :-
end, Router & Coordinator nodes



Clustering :-



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Clustering is a popular method of organizing wireless network topologies in which a few nodes and the cluster head (CH) are elected as representatives to route the traffic data originated in the entire network.

Clustering is beneficial to reduce the energy expenditure and improve the scalability and robustness of the object network.

Diff. clustering methods are there in the field of Mobile Adhoc network (MANET) and wireless sensor network (WSN) with diff. objectives. Clustering in MANET and WSN is done based on some criteria such as mobility and energy efficiency (residual energy).

Properties of Clustering :-

1 → Type
2 → controlled variable CH Period
3 → CH. election acc. to node conditions.
4 → synchronizatn
5 → Global cluster info.
6 → multihop routing
7 → CH election complexity.

Type :-
i) MANET
ii) WSN

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(2) ~~Cluster~~ Controlled variable CH Period :-

Cluster head elected for periodic or aperiodic time interval.

(3) ~~Rel~~ Residual energy, mobility.

(4) Synchronizatn :- It is costly and should be avoided.

(5) GCI :- Info. about the cluster members

(6) Multihop Routing :- Leach. Protocal for WSN.

(7) CH electn complexity :- - - - -

Software Agent :-

It is a s/w pgm. that can process human characteristics such as autonomy, adaptability, ~~sociability~~ sociality, judicousness, mobility, and reactivity.

S/w agents are used in agent based systems.

& Types :-

1) Intelligent agent
2) Autonomous agent

Intelligent A :-

This is a s/w pgm. that continously perform

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3 functions :-

i) Percepth of dynamic condith in the env.

ii) Reasoning to interpret perceptions, solved problems and draw inferences.

iii) Determine actions

Autonomous A :-

It is a computational system that inhibit some complex, dynamic env.

Sense and act autonomously in this env.

Realize a set of goals for which they are designed.

MUS

KA N

S/w agent should maintain following properties :-

1. Autonomy.

It suggest that agents should operate without the direct intervention of external forces. and control over there actions & internal state.

2. A description of the current state of env..

It helps to percieve the state it is in.

3. Reactivity

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It should respond to changes in the env. and exhibit goal directed behaviour by taking the initiative and planning to reach its goal.

4. Knowledge of how the agents actions affects its env.

It is reqd. for reactivity and proactivity to happen.

1/9/18 Data Synchronization :-

The data distributed in the ~~the~~ IoT can be stored in the objects themselves or in heterogeneous online repositories. and might exist in connected / disconnected env.

The synchronizatn of data across the arch. components is necessary in order to maintain coherent, cross infrastructure view of the object info.

Becoz of the inc. complexity of IoT systems data sync. is a big challenge so services such as data access on demand and data consistency are essential.

Bell & Gronsen described that data is stored in distributed database which is physically distributed across the nodes.
B&G outlined the following requirements for

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distributed dB.

1. Data Handling
2. Query optimisatn
3. Concurrency control
4. Recovery
5. Integrity & security.

& additional reqts. suggested by OSZDU such as:-

Transaction management
Replication Protocol

IoT assumption & definitn:-

some manufactured object in IoT may not have info. capability.

Electronics h/w & s/w are embedded with the manufacture to enable them to produce & process the info.

Assumption :-

It is assumed that participating objects in IOT have following capability

1. A unique identity
2. ability to sense and store their condition
3. ability to make their info. available to external nodes.

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4) ability to communicate with other objects.
5) ability to take decisions about their selves and their interaction with other objects.

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A clustering design for IOT requires the use of ad hoc networking to create collaborative, multihop and always dynamic interactions among objects which are equipped with intelligent embedded devices.
This strategy extends the paradigm on object info. gathering.

(4) ability to communicate with other objects.
(5) ability to take decisions about their selves and their interaction with other objects.

14/9/18 Clustering Principles in IOT arch. :-
- sensor nodes are embedded with IOT object.
- WSN is used in IOT arch. to monitor the env.

Features of WSN

- Multihop communicatn
- cooperative applicatns and events triggered inside the network.
- WSN devices use power for
  (1) sensing
  (2) using wireless transceiver

we need to use ethernet protocols to manage node communicatn & networking.

→ Clustering can be used to manage the power of devices that represents the objects in the IoT network.

→ Clustering extends the network lifetime by electing a representative network member i.e cluster Head (CH)

→ Cluster Head consumes more energy than the rest of the network.

→ So cluster Head role must be periodically rotated inorder to avoid premature exhaustion of the battery power.

→ The state of each CH is realized through an election process, which computes the best candidates for the next period.

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→ Hidden nodes problem is solved by the infrastructure gateway by sending advertisements to announce their presence.

Parameter used CH election

(1) Nodes residual energy.
(2) Nodes presence within the range of infrastructure gateway.

→ During CH election nodes with less residual energy and hidden nodes are avoided.
→ only the CH that receives the advertisement would participate in the CH election process.

CH election Process :-

Once the CH role is decided, each

$$TCH = C \times \text{Residual energy}$$

where C → const. value
TCH → Cluster Head duration.

Then the members send their proposal to rest of the cluster member along with the TCH value.

A concensus decision would be made and the node with highest TCH value would be selected as new CH for the duration of TCH.

3 For the CH election process the node should be present within the range of infrastructure gateway.

TCH election Process should start when any of the following situation occurs:-

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~~CH election process~~

Association in clusters :-

→ **Associatn request reception algo.**

i/p : list of associatn requests,
o/p : Association response, update to local network/ cluster.

```
if (list of request not null)
    if (I am in HAL)
        HAL: list of requests from
             networks with highest no.
             of nodes.
        # nodes = # nodes + # nodes in the
                  list of associatn requests
        • initiate CH( cluster head) electn
        • send associatn response to the
          list of associatn requests
        • update
    end
end
```

→ **Associatn response receptn algo.**

i/p : associatn response
o/p : update to the local network acc. to the associatn response

- change my network id
- Change my addr
- update no. of nodes (# nodes)
- update my network.

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Clustering design guidelines:-

includes →

(1) cluster head (CH) election process (discussed in previous page)

(2) suitable addressing principle

(3) An effective routing procedure.

(2) Addressing and Routing

Dynamic addressing is used in IOT clustering because nodes dynamically enter the cluster and leave the cluster because of node mobility.

Requirements for IOT addressing schemes:-

(1) address must be unique inside a network

(2) address must be reused when objects leave.

(3) addressing must be dynamic & address assignment should be fully distributed.

(4) addressing must be scalable

(5) support for network merge and split should be provided

(6) In protocol overhead must be minimised.

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18/9/18

Hierarchical addressing :-

→ Tree structured address is used.
→ senders of associatn request are children
→ senders of associatn response are parent
→ parent node computer address.

Routing :-

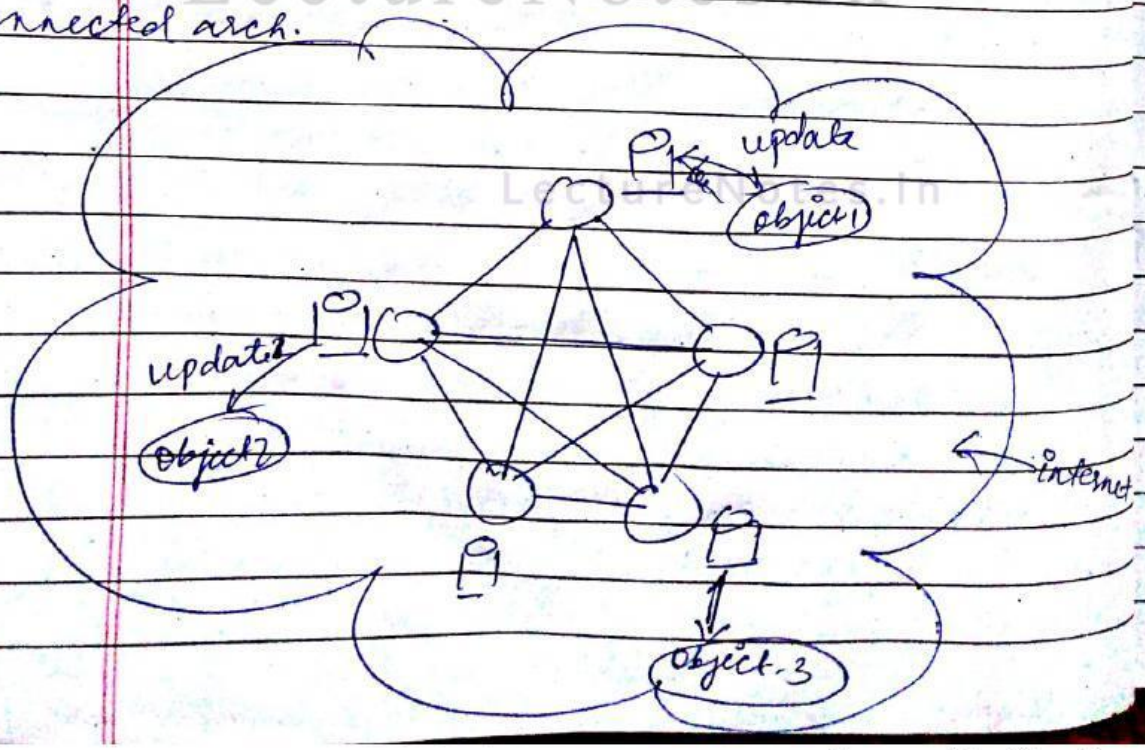
Finding the path from source node to destinatn node to forward data through that path.

Types of network arch :-

3 types :-

1. connected arch. (internet based)
2. Partitioned arch. (Internet & extranet based)
3. Disconnected arch.

Connected arch.



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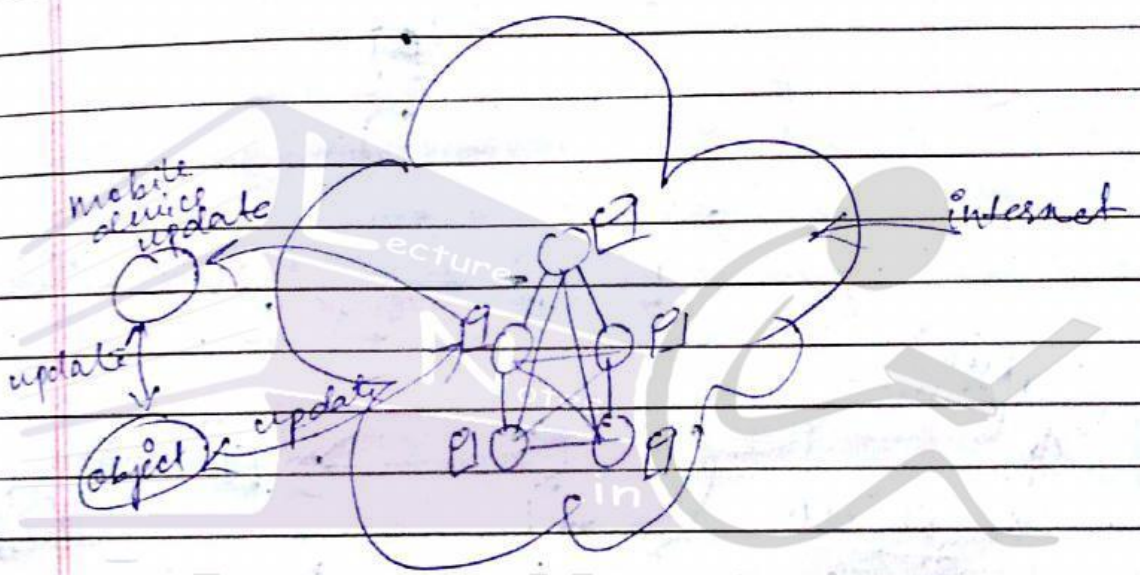
In connected arch., resources are always connected to share & update info.

Objects moving in a connected arch. do not need a special synchronizat^n method because object info. can be updated at any place inside the network.

Partitioned arch. :-



In PA, intranet & extranet can be used. They are based on same technology as internet but they are only reachable inside a closed area (intranet) or with a special authenticat^n in extranet.

These are partially disconnected devices such as mobile devices which are disconnected while updating info.

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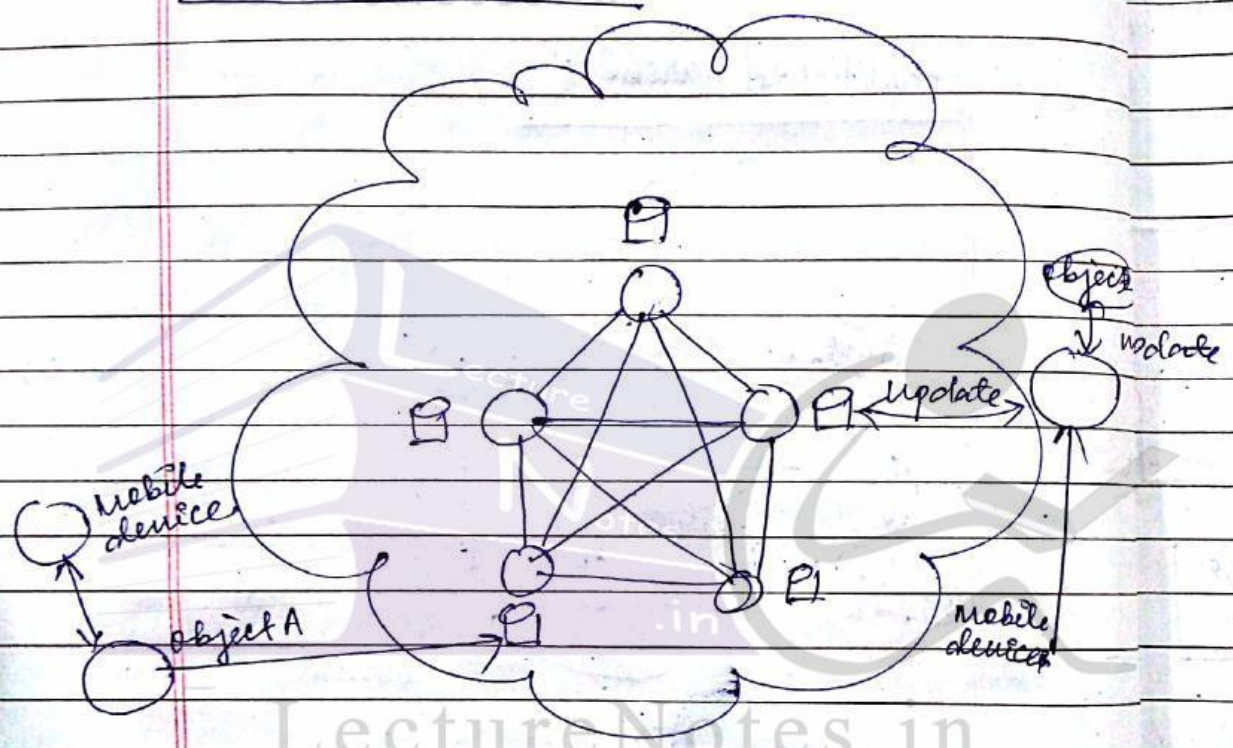
- Data will be updated at the mobile devices first and has to be sync. to related network info. resource when the mobile device will be connected again.

Disconnected Arch. :-



- Things that interact with IOT, may not have permanent reliable connectivity with the communication networks.

- A permanent disconnected arch. has to distinguish between objects and other resources without network availability

- mobile devices could be used to exchange info. between disconnected objects & other network resources.

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Fundamental concepts of Agility & Autonomy

Agility :-

- Ability to move quickly and early.
- Ability to think and understand quickly.

Market oriented view of Agility in manufacturing

Defn :-

Agility in manufacturing involves being able to respond quickly and effectively to the current configuration of market demand & also to be proactive in developing and retaining markets in the face of extensive competitive forces (Bessant et al).

* Agility relates to the interface between the company and the market. Essentially, it is a set of abilities for meeting widely varied customer requirement in terms of price, specification, quality, quantity and delivery. (By Kathayama and Bennett).

* Agility is the successful exploration of competitive bases through the integratn of reconfigurable resources and best practises in a knowledge rich environment to provide customer driven products and service in a fast changing market env.

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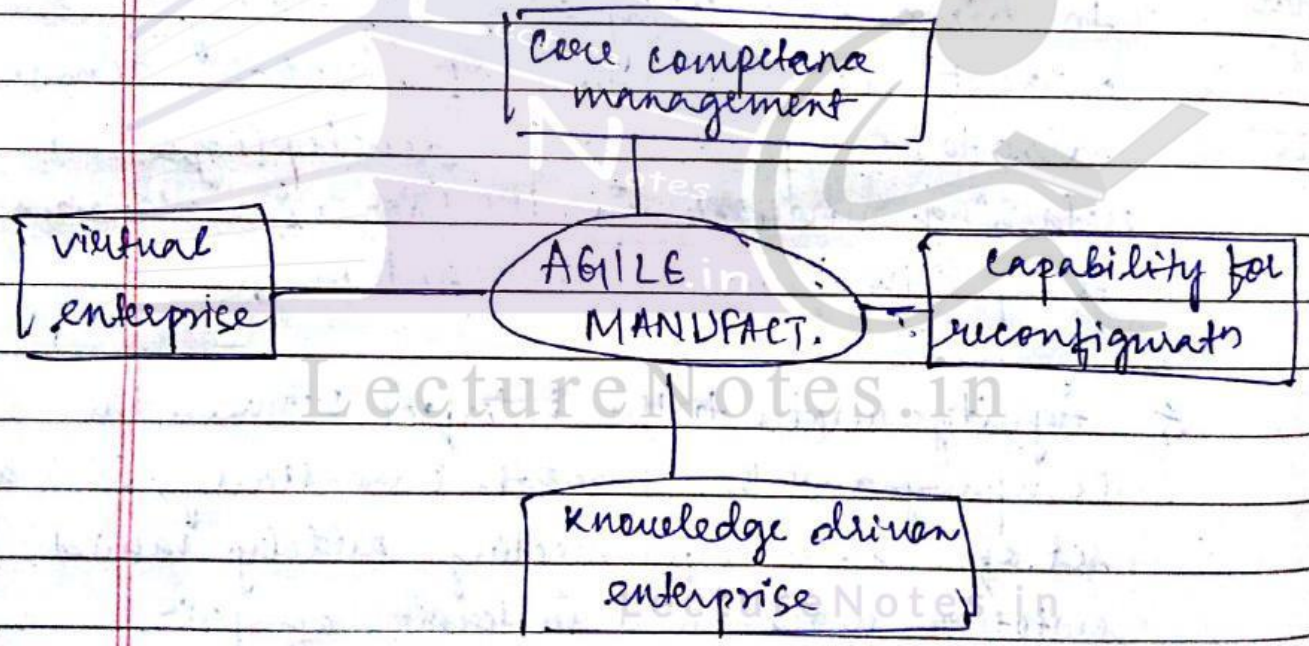
Core concepts of Agility manufacturing :-

In order to develop the systematic capability of agility, an org. has to percieve the four core concepts of agile manufacturing.

4 core concepts of agile manufacturing :-

1. Core competance management
2. virtual enterprise
3. Knowledge driven enterprise
4. capability for reconfiguration.



1. **Core competance management :-**
Skills that enable a ~~fundamental customer~~ firm to deliver a fundamental customer benefit.

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capability of reconfiguratn:-

contains the structural and operational flexibility to shift the enterprise's focus and realign its business to the changed market env.

Knowledge driven enterprise :-

Based on the inc. acceptance of inimitable knowledge and info. as the source of corporate success.

virtual enterprise :-

Detailed understanding of the core competences enables org. to interact in a virtual enterprise.

Agility enablers :-

1. virtual enterprise formation tools / metrics
2. physically distributed teams and manufacturing
3. rapid partnership formation tools / metrics
4. concurrent engg.
5. integrated product / productn / business info. system
6. rapid prototyping tools.
7. electronics commerce

Autonomous control :-

Autonomous control describes processes of decentralized decision making in hierarchical structures.

It presumes interacting elements in non-deterministic

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systems; which posses the capability and possibility to render decision independently.

24/9

* The objective of autonomous control is the achievement of increased robustness and +ve emergence of the total system due to distribution and flexible coping with dynamics and complexity.

Characteristics of autonomous control

1. Autonomy
2. Heterarchy
3. Decentralized
4. Decision making
5. interaction
6. non-deterministic system behaviour

Objective of autonomous control:-

- increased robustness
- positive emergence

Agility diagram →

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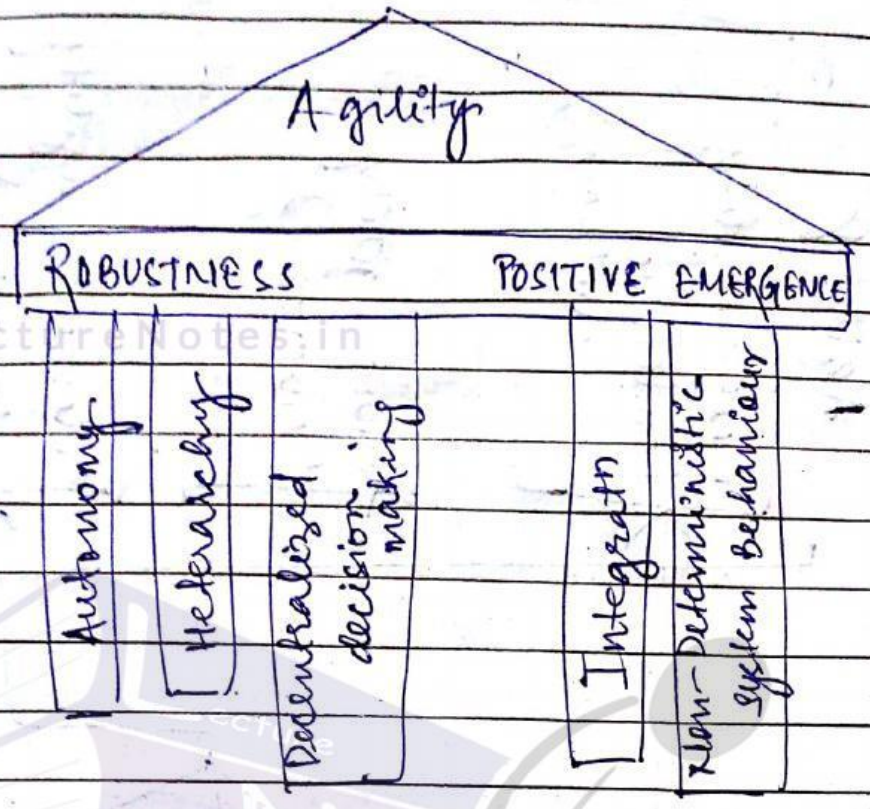
Correlation b/w characteristics and objectives of autonomous control :-



Prerequisite for autonomous object :-

It should be intelligent.
Intelligent object has following properties :-

1. It posses a unique indentification
2. It is capable of communicating effectively within its env.
3. Can retain or store data about itself.
4. Deploy a lang. to display its features, product^n, requirements.
5. It is capable of participating in or making decisions relevant to its own destiny.

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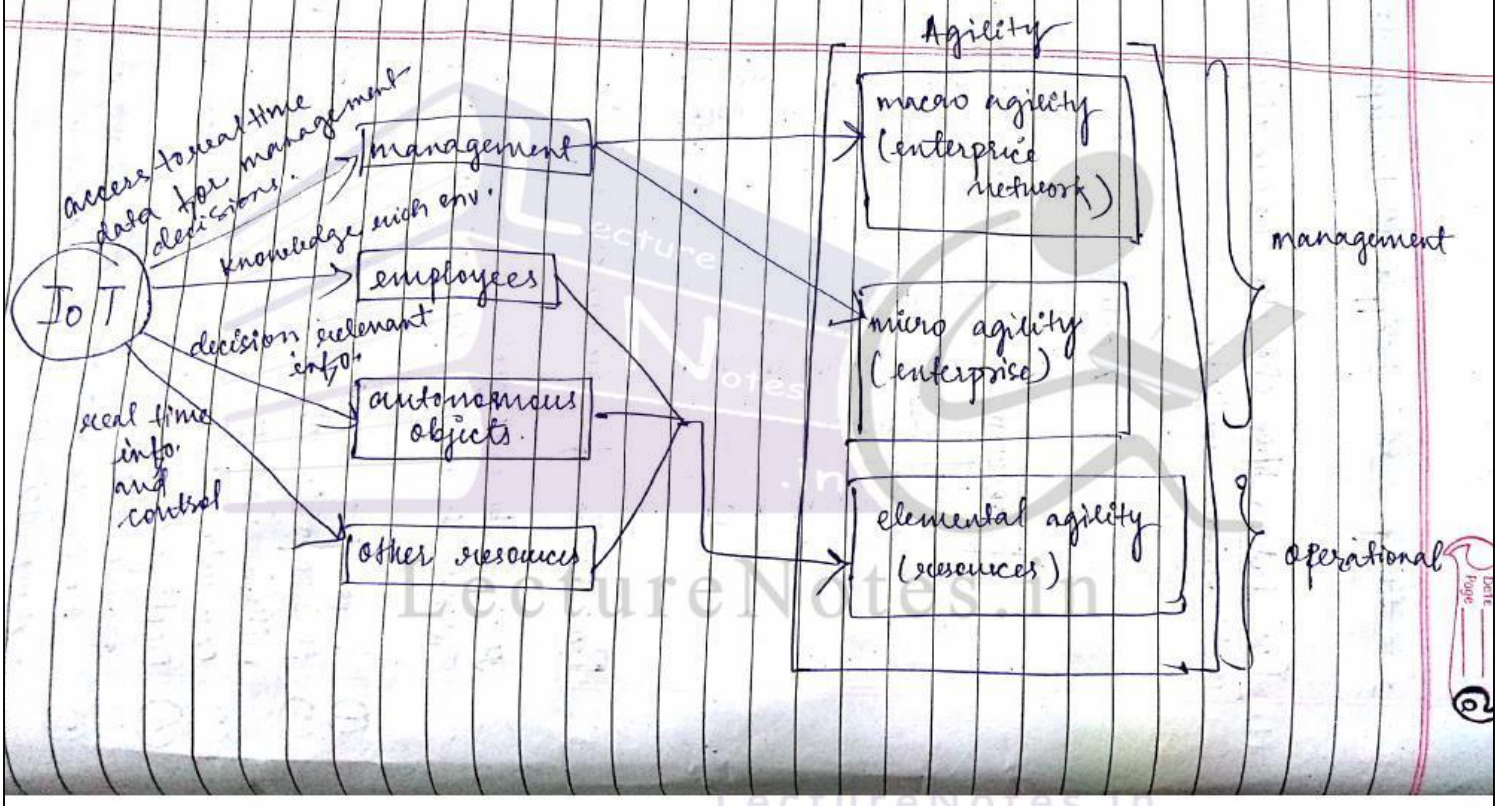
Enabling Autonomy and agility by IoT :-



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24/9/18

The evolution from the RFID based EPC Network to an agent based IoT :-

EPC = Electronic Product code

Requirements :

1. Energy supply for embedded devices
2. sensors for collecting info.
3. communication
4. Task specific degrees of object capabilities.

Hardware Tasks, necessary improvements and development

	Available Technologies	Necessary improvements	Technologies in development
Energy supply.			
identification	Barcode, OCR, RFID	RFID needs suitability for daily use	Polymer electronics (RFID)
Short distance communicatn	Zigbee, bluetooth, WLAN, UWB, RFID	reducing energy consumption, simplify communicatn protocol	Bluetooth, low energy, 6LOWPAN.
Long distance communicatn	copper wires, fibre optics, GSM UMTs	expand the availability of broad band access	LTE, smart grids.
CPU	Standard silicon technology, ex- ARM low voltage CPUs	reducing energy consumption improving environmental friendliness	Photonic computing polymer electronics

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	available technology	necessary improvements	Technologies in development
Energy supply.	batteries (lithium) capacitors	Higher energy density improving environmental friendlyness, extending lifetime, fast battery charging.	energy harvesting
sensors	small variety of miniaturized sensor types ex) temperature acceleration	Developing more different sensors integrated in to embedded systems	miniatured sensors for gases & enzymes.

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5/9/18 S/w agents for the behaviour of objects

Locatn of agents

(1) central IT system
(2) Local IoT Informatn system
(3) Embedded system

For inc. the IoT with colaborative Productn env. with inc. autonomy & agility it is necessary to go beyond standart centralized arch.

Agents technology offers promising approach to attend the above challenge.

different agent platforms are available for programming the agents such as
i) Java agent development framework (JADE)
ii) Open services Gateway Interative Framework (OSGI)

For realizatn of agents following ques need to be answered

(1) where the s/w agent will work?
Such as central IT system, Local IoT info. system or embedded system.

(2) who will be responsible for the agents on the organizational level. (Manufacturer will be responsible on the org. level)

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Comparision of Hosting Locatn in the IoT

Locatn of process capability	Technical Reqd. at the obj	PROS	CONS.
central IT system	object should have a unique id	• no computational power at the object needed. • permanent access to agents. cheap tag sufficient	no offline decision possible, increased network traffic.
local IoT IS	object should have unique id	• same • same • Agent is near by the object	Agent has to transfer itself to the next IoT IS's
Embedded system.	object should have microcontroller, sensors and network connection	• offline decisions are possible • Low network traffic	• complex embedded hardware is needed • synchronizatn with agent replics.

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Big Data

→ Big Data analytics
→ Big Data visualization

Properties of Big Data :-

1. volume - big volume of data is generated
2. velocity -
3. variety - different types of data generated text data etc.

Steps in Big Data Analytics :-

→ data cleaning
→ data merging
→ data processing
→ data visualization

Big data Analytics :-

Big Data is defined as collection of data sets where volume, velocity and variety is so large that it is difficult to store, manage, process and analyse the data using traditional dB and data processing data.

Big Data Analytics involve several steps namely :- data cleaning, data merging, data processing and data visualizatn.

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Examples of Big Data generated by IoT systems are :-

a) sensor data generated by IoT systems such as weather monitoring stations.

b) m/c - sensor data collected from sensors, embedded in industrial and energy systems for monitoring their health and detecting failure.

Big Data visualization :-

It refers to the implementatn of more contemporary visualizatn technique to illustrate the relationships with data.

Visualization tactics include :-

→ applicatn that can display real time changes and more illustrative graphics. Thus, going beyond pi, bar and other chats.

→ These illustratn shift from the use of hundreds of rows, columns and attributes towards a more artistic visual representatn of the data.

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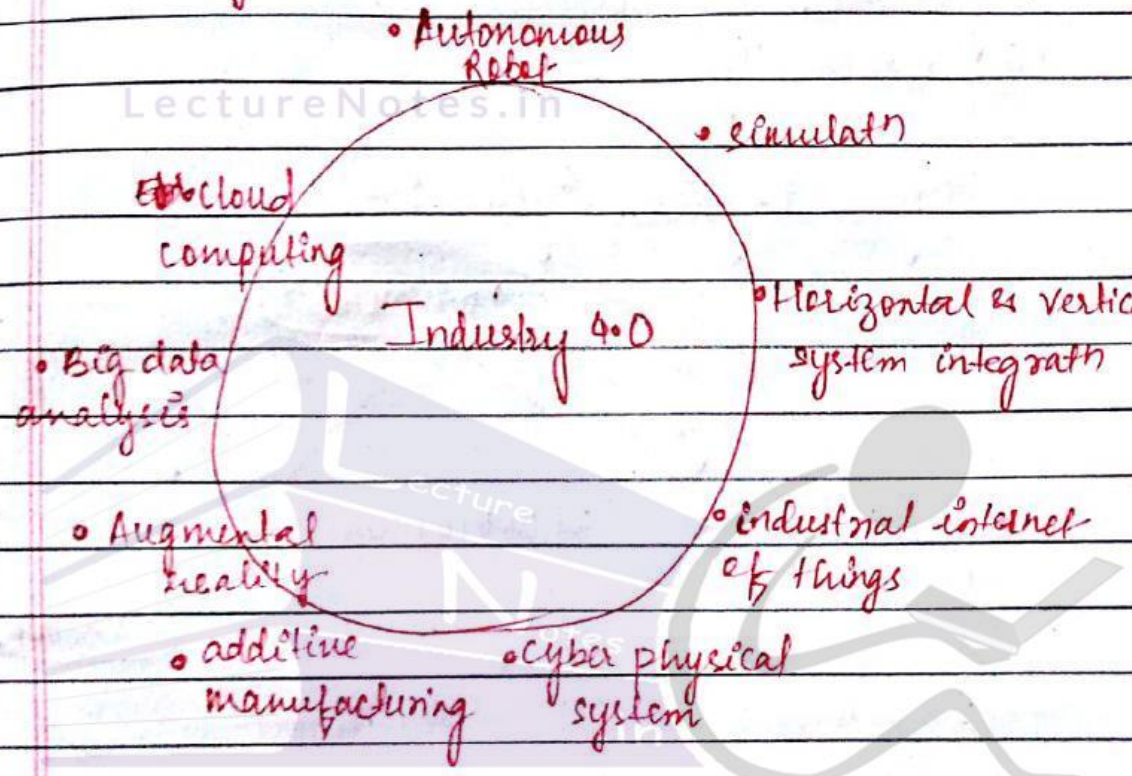
Industry 4.0

current trends of automatn and data exchange in manufacturing technology.

Building Block of industry 4.0



→ It is a name given to the current trend of automatn and data exchange in manufacturing technology.

→ It includes cyber physical system, IoT, cloud computing cognitive computing, autonomous robots, big data analysis, augmental reality etc.

→ Industry 4.0 is commonly referred as 4th Industrial Revolution.

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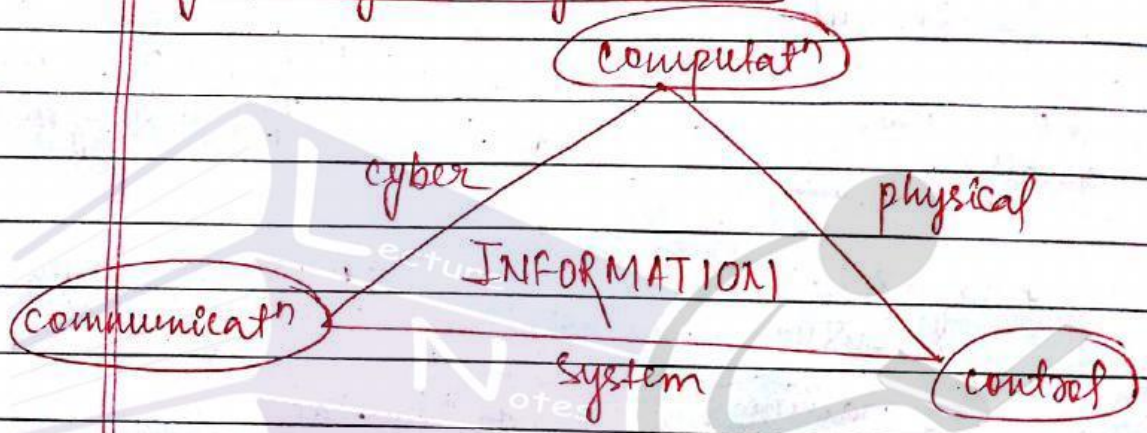
Six design Principles of Industry 4.0

1. Interopeability
2. Virtualization
3. Decentralizatn
4. Real time capability
5. Service orientatn
6. Modularity.

Cyber Physical System :-



→ Cyber Physical system (CPS) is a system of collaborating computational elements controlling physical element.

→ CPS is a physical & engineer system whose operations are monitored, co-ordinated, controlled & integrated by a computing and communicatn core.

→ They allow us to add capabilities to physical systems by merging computing and communicatn with physical processes.

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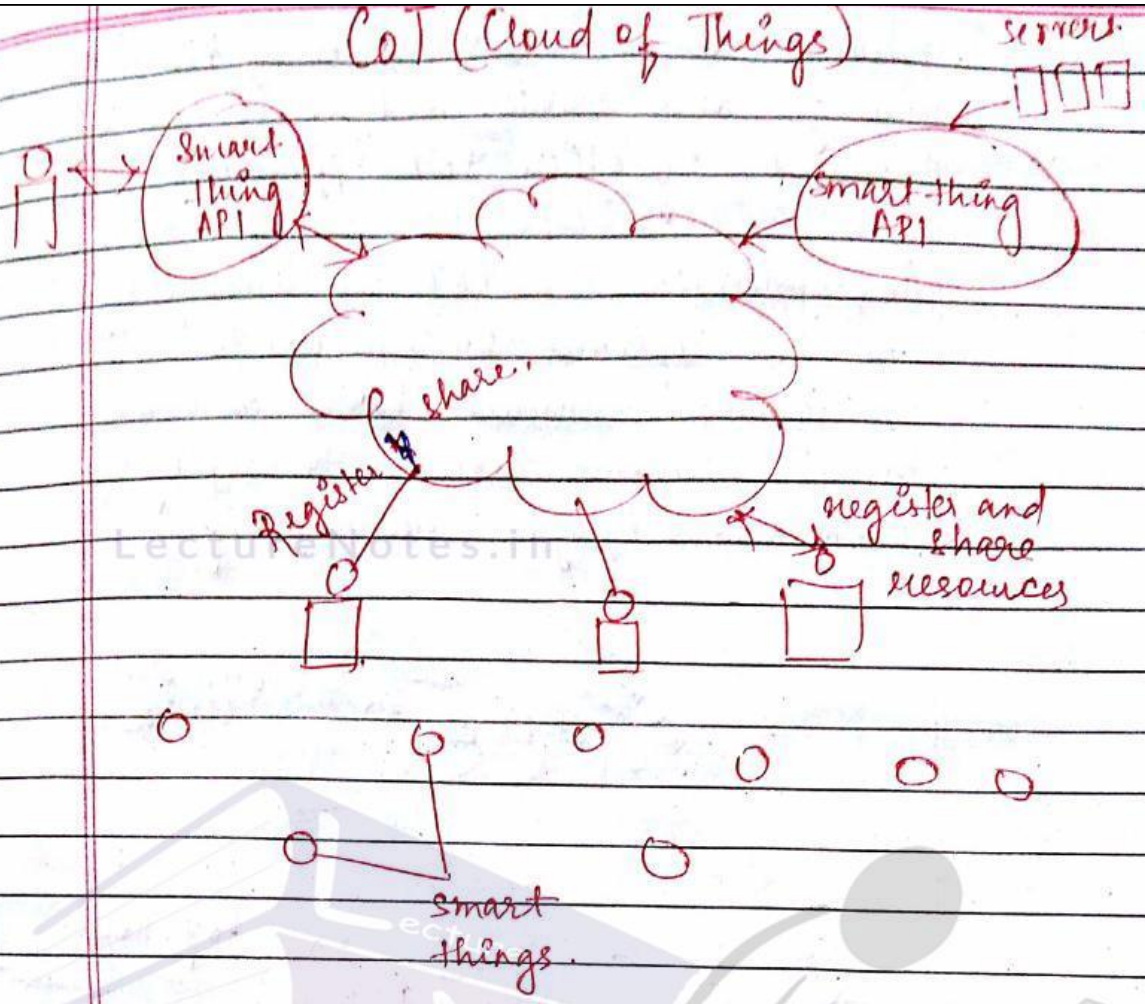
CoT (Cloud of Things)



Concept of CoT

CoT is a concept that provides smart things functn as a service allows them to be used by multiple applicatn.

In CoT, a single smart thing instance should efficiently host multiple application called multi-ownership.

The CoT is different from cloud computing where simultaneous access to smart things should be restricted in some cases to resolve resource conflicts, because controlling smart things influence not just usages of computing resources like memory, CPU etc.

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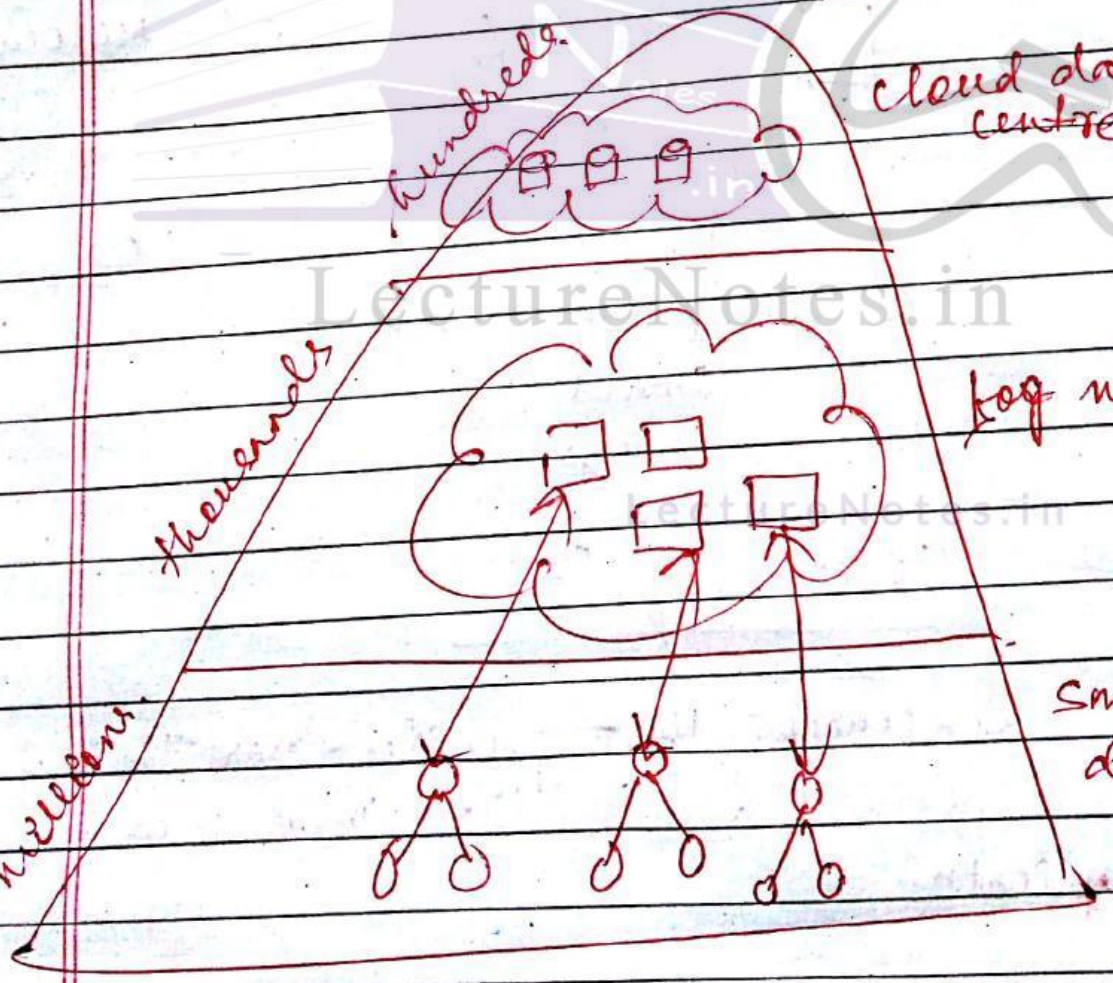
Aim of CoT is to expose a set of API's of smart things as a service and allow them to be shared by other IoT application.

Any applications in CoT can leverage smart things deployed by any one to build integrated services based on smart things without having to deploy their own smart things redundantly.



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Web of Things

Web of Things describe approaches, s/w arch. styles and programming patterns that allow real world objects to be part of the w.w.w. The Web of Things provide an app. layer that simplifies the creat^n of internet of things app.

The WOT re-use existing and well-known web standards used in programmable web such as REST, HTTP, JSON, semantic web such as JSON-LD, microdata, the real time web such as web socket and social web such as OAUTH.

WOT concept is becoming more popular becoz of following:-

i) It leverage web standard and technology to interconnect all types of devices.

ii) expose functionality using REST full API making them easier to access and use.

iii) Provides truly open, flexible, scalable and interoperable services.

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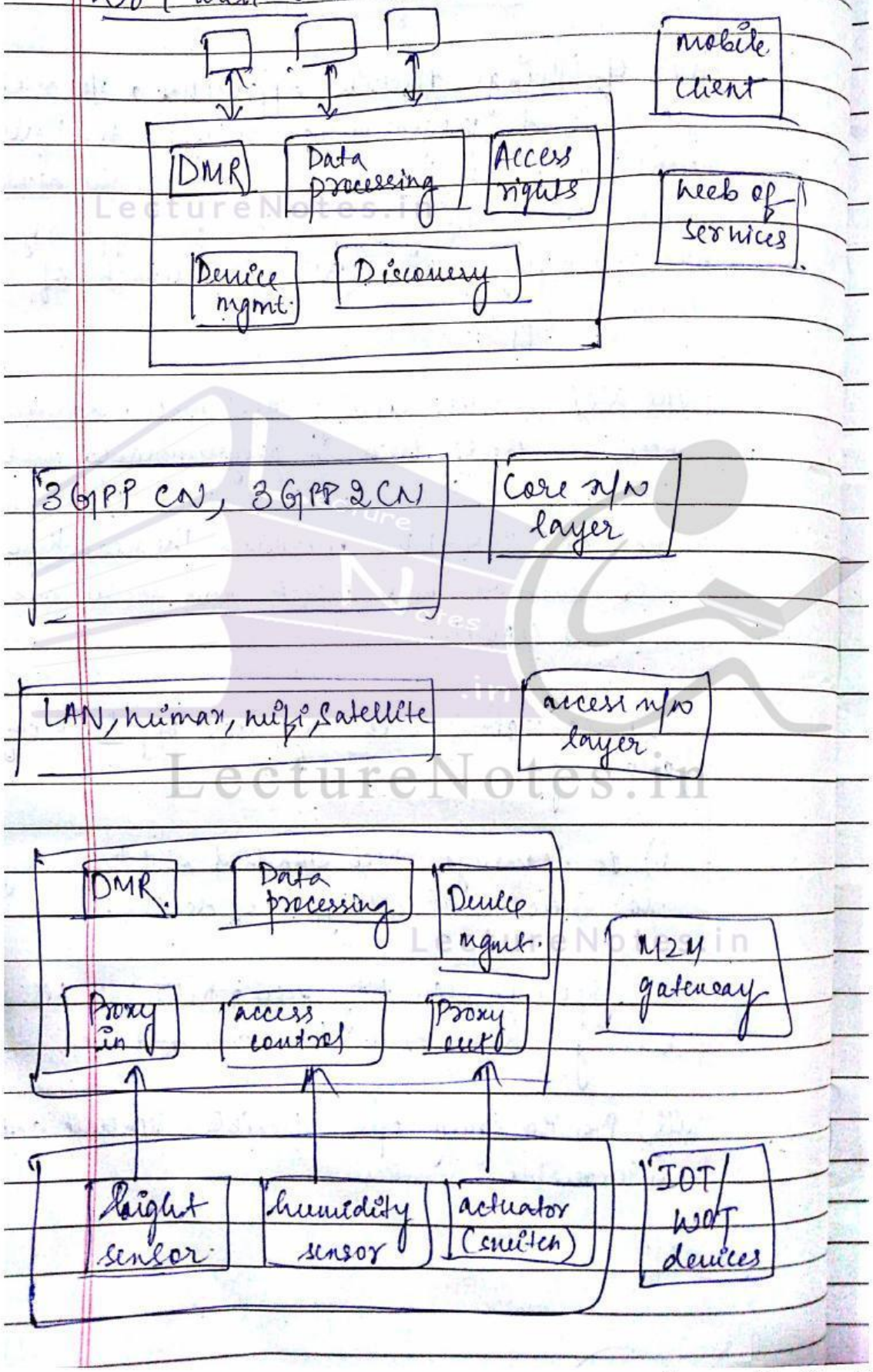
WoT arch :-



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Requirements of WoT :-

→ uniform descriptn of devices / things
→ Discovery.
  - → local discovery
  - → Remote discovery
  - → P2P discovery.

Management of devices :-

  - → automatic management
  - → provisioning maintainance (config. & update)
  - → end user access control.

→ binding to HTTP, COAP and MQTT.
→ security, privacy & trust
→ Data management & repository (DMR)
→ Data processing.
  - → utilisatn of web technology
  - → result in high level abstractn
  - → actionable intelligence
  - → uniform treatment of data coming from heterogeneous source.

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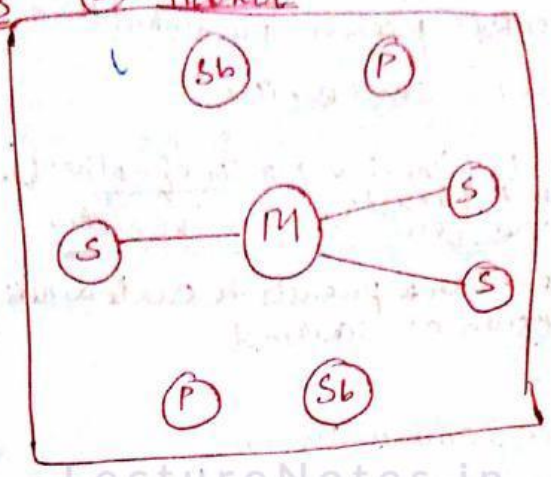
18/18 (1) Piconet



PN - Not active, but can be made active when reqd.
↓
parked node

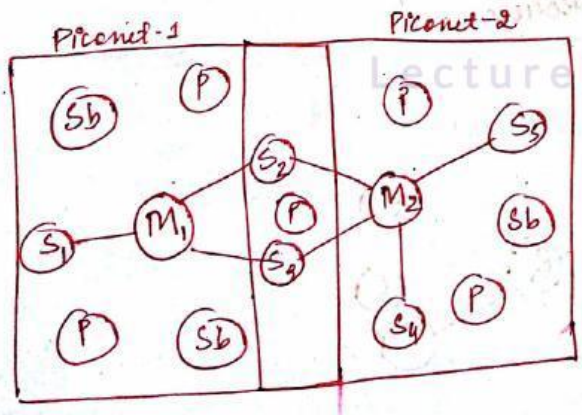
→ It is a collectⁿ of devices connected in Adhoc fashion. One device acts as master node and others as slave nodes for the lifetime of piconet.

→ MN determines hopping pattern. SN have to synchronize with the hopping pattern.

→ Each piconet have unique hopping pattern

→ Each piconet has one Master & upto 7 simultaneous slaves and more than 200 parked nodes.

(2) Scatternet



→ Piconets are combined & interconnected
→ They share some nodes as they overlap eachother.
→ The shared nodes can be MN or SN

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⇒ In scatternet multiple colocated piconets are linked through the sharing of common master or slave devices.

→ Devices can be slave in one piconet & master of other but can't be a master in more than 1 piconet.

→ Devices can jump back and forth b/w the piconets.

⇒ A common node connects more than 1 piconets to create a new communicatn architecture known as scatternet.

Zigbee

{ Low power, low cost device communication.
{ Low computatn
{ Low range

→ Its a WPAN standard

→ It works with IEEE 802.15.4 standard

→ Data rate is 250 kbps.

→ 2.4 GHz, 868 MHz, 902 - 928 MHz used

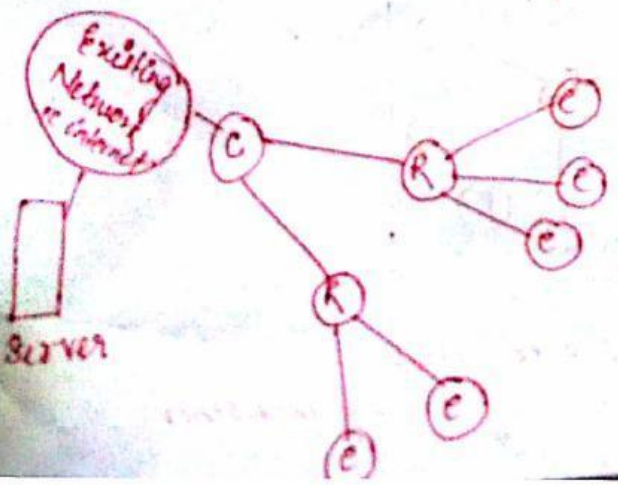
→ Range is from 10 to 20 meters

→ Less expensive & simpler than the other proprietary short-range wireless sensor networks like wi-fi or bluetooth.

Types of nodes in zigbee :-

① End nodes
② Route nodes
③ Coordinator node.

Zigbee Network Architecture



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ZMB

ZigBee is a low cost, low power wireless standard targeted at battery power devices in wireless control & monitoring applications.

It is specifically deal for control & sensor networks on IEEE 802.15.4 standard for WPAN

It defines ~~and~~ physical & media access control (MAC) layers to handle many devices at low rates.

Layers of ZigBee :-

Layer 7	Applicat^n layer	ZigBee
Layer 3	Network layer	
Layer 2	MAC / link layer	802.15.4
Layer 1	Physical layer	

Types of ZigBee Devices :-

1. ZigBee Co-ordinator (ZC) :

→ Forms the root of the network tree & might bridge to other networks

→ Exactly 1 zigbee coordinator in each n/w since it is the device that started the n/w originally

→ Stores info. about the n/w, including acting as the Trust Center & repository for security keys.

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(2) Zigbee Router (ZR):

→ As well as running an applicatn functn, a Router can acts as an intermediate router, passing on data from other devices.

(3) Zigbee End Devices (ZED):

→ contains just enough functionality to talk to the parent node (either the coordinator or the router)

→ Cannot relay data from other devices.

→ Allows the node to be asleep a significant amount of time thereby giving long battery life.

→ Requires the least amt. of memory.

→ less expensive to manufacture than a ZR or ZC.

How Zigbee Works??

1. States of operation:
   - Active
   - Sleep
2. Devices:
   - Full Functn Devices
   - Reduced Function Devices
3. Modes of operation:
   - Beacon
   - Non-Beacon

Beacon

ZC & ZR continously monitor active state of incoming data. hence more power is consumed.

The R & C do not sleep because at any time any node can wake up and communicate. However, it requires more power supply & its overall power consumption is low bcoz

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for most of the devices are in an inactive state for over longer periods in the n/w.

Non-Beacon

when there is no data communicatn from end devices, then the ZR & ZC enter into sleep state.

These non-beacon n/w works for time slots which means they operate when the communicatn needed results in lower duty cycles & long battery usage

Adv. of zigbee :-

→ Reliable
→ Support large no. of nodes
→ Easy to deploy
→ very long battery life
→ Secure
→ Low cost
→ can be used globally
→ Mobility
→ Simplicity
→ flexibility

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piconet:-

→ point to point communicatn occur b/w the master & 1 slave

→ The device that initializ the establishment of the piconet becomes the master

→ The master is responsible for transmission control by dividing the n/w into a series of time.

→ There is no direct communicatn b/w the slaves & all the connectn are b/w master to slave or slave to master.

→ Slaves are allowed to transmit data using poll command by the master

Barcode Technology	RFID
→ requires the use of an optical barcode reader or scanner.	→ reads info by using radio frequencies. RFID inventory managment requires tags & an RFID reader
→ The scanner must have an unobstructed view of the barcode which referred to as the line of sight. without a clear LOS, the scanner may be unable to read the barcode.	→ does not require a line of sight
→ Takes more time	→ Takes less time as when a business uses RFID tracking s/w, potentially hundreds of tags may be read per second as tags are activated

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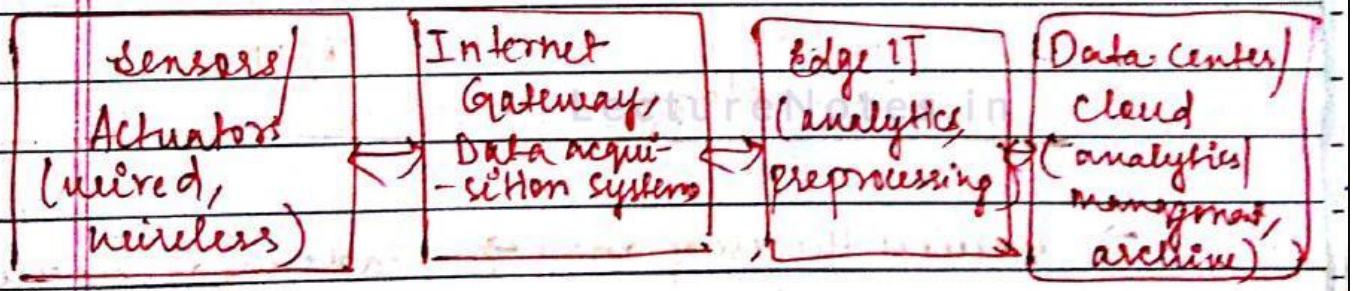
as it requires ~~a lot~~ ~~of~~ human labor to scan each label separately.	by radio signals from the reader.
→ cheaper.	→ can be read from as far as 50 feet away
→ ~~happen~~ hampers scaning due to dirt, torn out or obstructed labels.	→ Not ~~bag~~ hampered by these things.

4 Stage arch. of an IOT system:-



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IOT Protocol stack

App. layer	COAP
Transport layer	UDP
Network layer	6 LOWPAN
Data link layer	IEEE 802.15.4 MAC
Physical layer	IEEE 802.15.4 PHY

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