Unit - 3

① IEEE - 802.15.4 → Institute of Electrical and electronics engineers.
→ LR-WPAN

Evolving Standards:-

↳ operation under Unlicensed freq. band.
↳ low data rate sol^{n}.
↳ Multi-year battery life with very low complexity.

Appl^{n}s → Home automation
→ Remote Control.

Features

→ It's main aim of standard is defining of Phy/Mac layer specification
→ low power Consumption, reduced transmission rate, because on limited bandwidth we will maximize the data transmission.

power efficient modulation techniques.

(11) Zigbee

→ Zigbee is developed by Zigbee Alliance, Zigbee is a Competitor of 6LOWPAN.

→ Zigbee Uses IEEE 802.15.4 at MAC and physical layer.

→ Zigbee is designed for low-cost and low-power wireless IoT Networks.

→ It is used in low data rate application that requires long battery life & Secure Networking.

→ Zigbee is Simpler and less expensive than other WPAN such as Bluetooth and Wi-fi.

→ It operates Short range around 10m to 20m and using Mesh topologies it can be extended upto 500m.

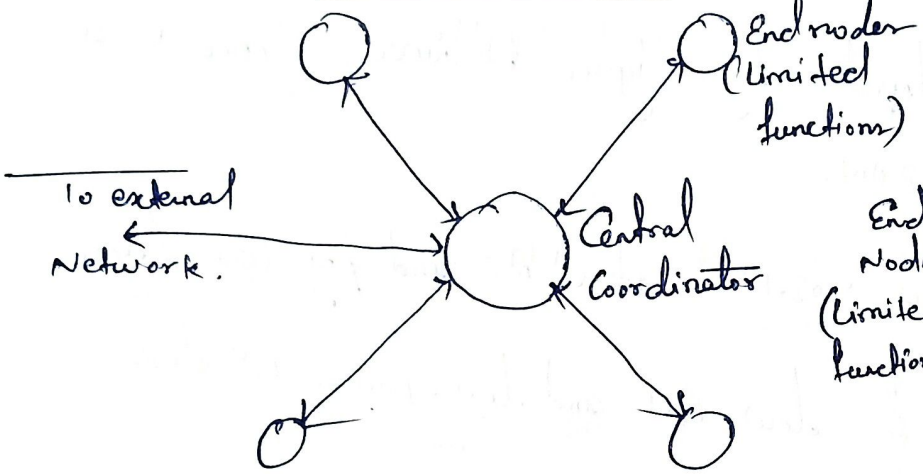
→ It operates 2.4GHz unlicensed Band & max data rate 250 kbps. (It comes under ISM band).

Protocol Stack of Zigbee

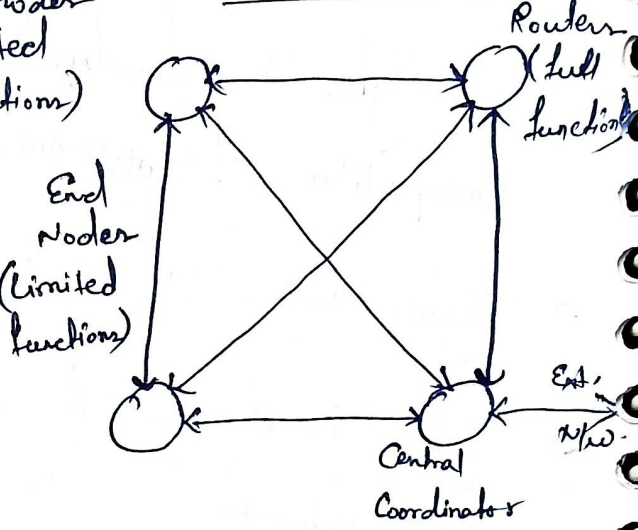
Application layer	Zigbee
N/W layer (routing/Network)	Zigbee
DLL (MAC - CSMA/CA)	IEEE 802.15.4
Physical layer (2.4GHz, 250kbps)	IEEE 802.15.4

Zigbee Support different Network topologies like:-

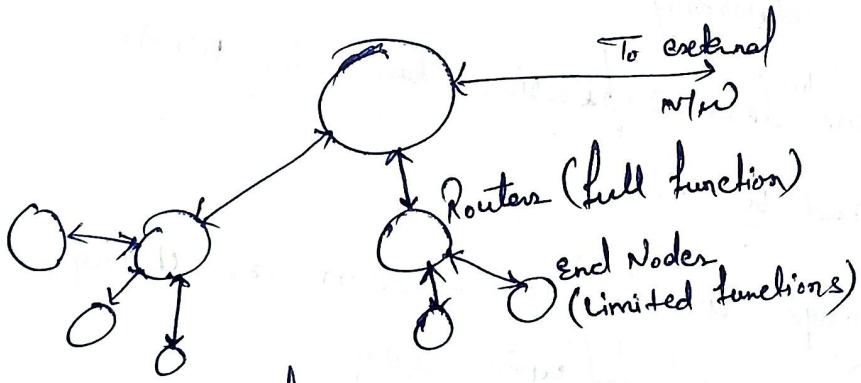
(i) STAR topology



(ii) Mesh Topology



(iii) Cluster tree topology



Zigbee devices

(1) Zigbee Coordinator:- (i) It has one coordinator node, that can store information.
(ii) This Node can control a complete N/w, that can communicate with an external N/w.
(iii) ZCs & ZRs require high power, so it cannot be battery powered.

(2.) Zigbee Router:- (i) It can route the data with interconnected nodes.
(ii) It needs less memory than ZCs. (iii) It can also acts as a Coordinator in the network.

(3.) Zigbee end devices:-
→ It has a minimum power requirements. So it can operate with the battery powered.
→ It can only communicate with connected ZR or ZC.
→ It communicater periodically for effectively battery utilization.

Z-wave

→ Z-wave is a wireless communication protocol used by automatic or automotive appliances for the purpose of connection and communication.

→ It is invented in 1999 by Zensys a Danish-American company

→ Like Zigbee, Z-wave is optimized for low-power, low-latency, short range communication, but it uses different frequency bands.

Z-wave protocol Stack :-

Z-wave protocol stack contains five layers physical layer, MAC layer, transport layer, network layer and application layer.

(i) **Physical layer** :- This layer has many functions but the important one is modulation and coding.

(ii) **MAC layer** :- MAC layer takes care of medium access control among slave nodes based on collision avoidance and backoff algorithm.

(iii) **Transport layer** :- Z-wave transport layer is mainly responsible for retransmission, packet acknowledgement, and packet origin authentication. the Z-wave layer consist of four basic frame types :-

(i) Single Cast frame
(ii) ACK frame
(iii) Multicast frame
(iv) Broadcast frame

(v) Network layer:- Z-wave n/w layer controls the frame routing from one node to another node.

(vi) Application layer:- This layer is responsible for decoding & execution of Commands in the Z-wave network.

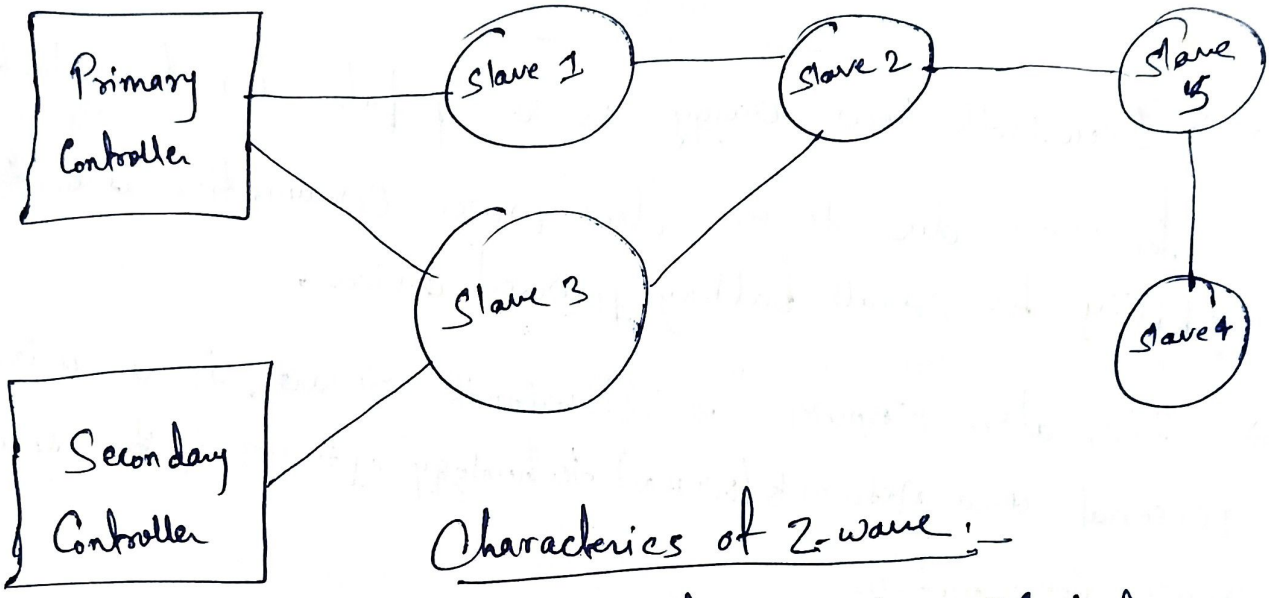
Z-wave Components

(i) Controllers:- A Controller is a unit that has the ability to Compile a routing table of the network and can calculate routes to the different nodes. There are 2 types of Controller

* primary Controller:- It is the device that Contains a description of the Z-wave network and Controls the output. It assigns network ID, HomeID or NodeID to the Z-wave during the enrollment process.

* Secondary Controller:- It also has a Network ID and it remains constant to maintain routing tables.

(ii) Slave nodes:- Slave nodes are the nodes that do not Contain routing tables but may Contain a network map. Slave nodes have the ability to receive frames & respond to them if necessary.



Characteries of Z-wave :-

- → User RF for signaling & Control.
- → Frequency :- 900 MHz (ISM)
- → Range :- 30 meter
- → Data Rate :- Upto 100 kbps
- → FSK Modulation.

Application :-

- → Home automation
- → Water management using flood sensors.
- → Fingerprint sensors/scanner.

BLE

→ Bluetooth low energy is a popular wireless technology for IoT due to its low power consumption and suitability for small, battery-powered devices.

→ BLE, also known as Bluetooth Smart, is a wireless personal area network (WPAN) technology optimized for low power consumption.

→ It operates in 2.4 GHz ISM band and is maintained by the Bluetooth SIG.

Why BLE important for IoT?

(i) Low power consumption :- It is specially designed for IoT devices that requires long battery life such as wearable sensors, remote sensors and smart home devices.

(ii) Small data transmission :- It is optimized for transmitting small amounts of data, which is common for IoT sensors that need to send state data or updates.

(iii) Ubiquitous Support :- It is supported by a vast ecosystem of smartphones and other devices, making it easy to connect and interact with IoT device.

(iv) Cost Effective :- BLE chips and modules are generally low-cost, making them accessible for various IoT applications.

(v) Versatile :- It can be used in a wide range of applications including health and fitness, home automation, asset tracking and industrial monitoring.

How does BLE Compare to other IoT technologies?

(i) **Bluetooth Classic:-** Classic Bluetooth is designed for higher data transfer rates and consumes more power than BLE, making it less suitable for many IoT applications.

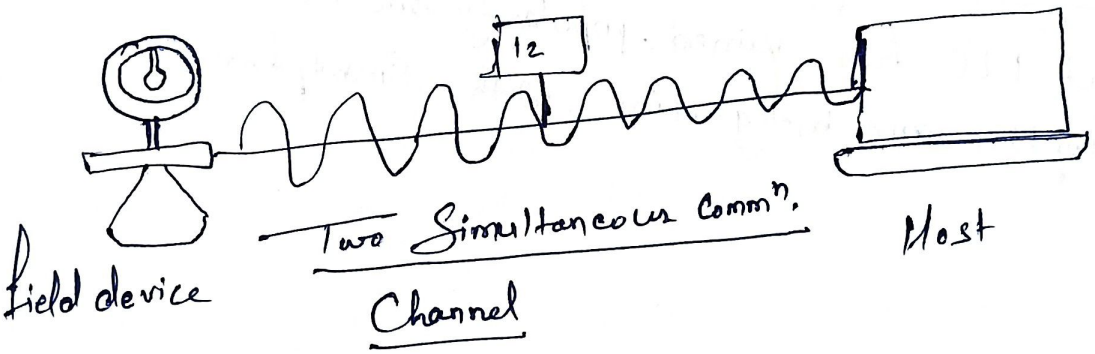
(ii) **Wi-Fi:-** Wifi offers higher bandwidth, it consumes more power than BLE and is often used for high-throughput data transfer in home.

(iii) **Zigbee:-** Zigbee is another low-power wireless technology, but BLE has gained popularity due to its widespread adoption and integration with Smartphones.

HART

→ HART is a bi-directional communication protocol that provides data access between intelligent field instruments and host systems.

→ A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety or other system using any control platform.



→ HART provides two simultaneous communication channels, one analog, the other digital.

* A 4-20 mA signal communicates the primary measured value (PV) as an analog value of current using the wiring that provides power to the instrument.
* The host system then converts the current value to a physical value according to parameters defined by HART software. for example, 7 mA = 80 degrees F.

→ Digital device information is communicated by encoding a digital signal, generally using a technique known as frequency shift keying on the same 4-20 mA wiring used for analog communications.

→ Together, the two Communication Channels provide a complete field Communications Solution that is easy to design, Simple to use, low Cost & extremely reliable.

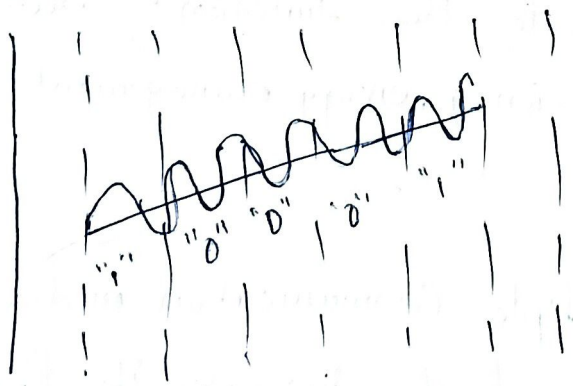
HOW HART Works

→ "HART" is an acronym for Highway addressable Remote Transducer.

→ The HART protocol makes use of the frequency Shift keying (FSK) Standard to Superimpose digital communication signals at a low level on top of the 4-20mA.

→ The hart protocol Communicates at 1200 bps without interrupting the 4-20mA Signal and allows a host application (master) to get two or more digital updates per second from a Smart field device.

→ As the digital FSK Signal is phase continuous, there is no interference with the 4-20mA Signal.



FSK

→ The 4-20mA Signal Communicates the primary measured value (in Case of a field instrument) using the 4-20mA current loop - the fastest and most reliable industry Standard.

→ Additional device information is Communicated using a digital Signal that is Superimposed on the analog Signal.

~~NFA~~

BACnet and Modbus

BACnet

→ BACnet Stands for Building Automation and Control Network, is a Communication protocol primarily used in building automation Systems.

→ The primary goal of BACnet is to enable integration and efficient management of various building System such as heating, Ventilation and Air Conditioning (HVAC), lighting Control, access Control, fire detection & Security.

→ BACnet allows devices & Systems within a building ~~System~~ to share data and Coordinate their functions effectively, enhancing operational efficiency, energy management and occupant Comfort.

→ It Supports for multiple Communication media including Ethernet, IP and Rs-485 further increases its flexibility.

→ It is a Widely adopted protocol in Commercial and industrial building automation projects.

Features of BACnet

Feature	Description
Protocol Type	open, interoperable
Standard	ANSI / ASHRAE Standard 135
Communication layers	Support several transport layers: ethernet, ARCNET, MSTP (RS-485, IP and LonTalk)
Data Model	Object-oriented (Devices modeled as objects with properties).
Network Topology	Star, Bus, Ring and mesh topologies
Services	Read/Write operations, alarms, scheduling, trending, device management.
Device types	Sensors, Actuators, Controllers, gateways.
Interoperability	Enables devices from multiple Vendors to work together

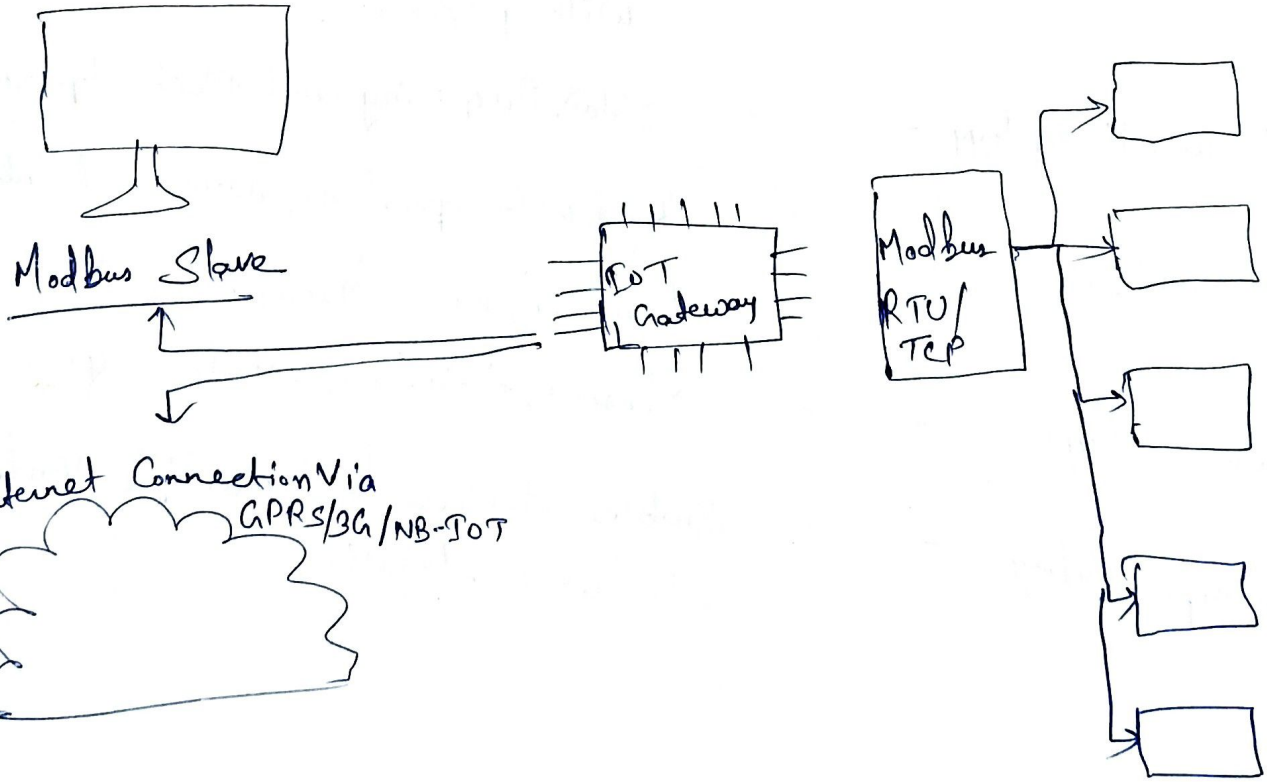
Modbus

→ Modbus is a simple and widely used industrial communication protocol for connecting various industrial devices, including sensors, PLCs and HMI systems.

→ It allowing exchange data between these devices, enabling real-time monitoring, control and automation in industrial environments.

→ It is primarily used for supervisory control and data acquisition (SCADA) systems, connecting sensors, actuators, meters and other field devices to centralized controllers and monitoring stations.

→ Modbus operates on a master-slave architecture, where the master device (PLC, PC, SCADA) initiates communication with one (or) more slave devices (sensors, actuators).



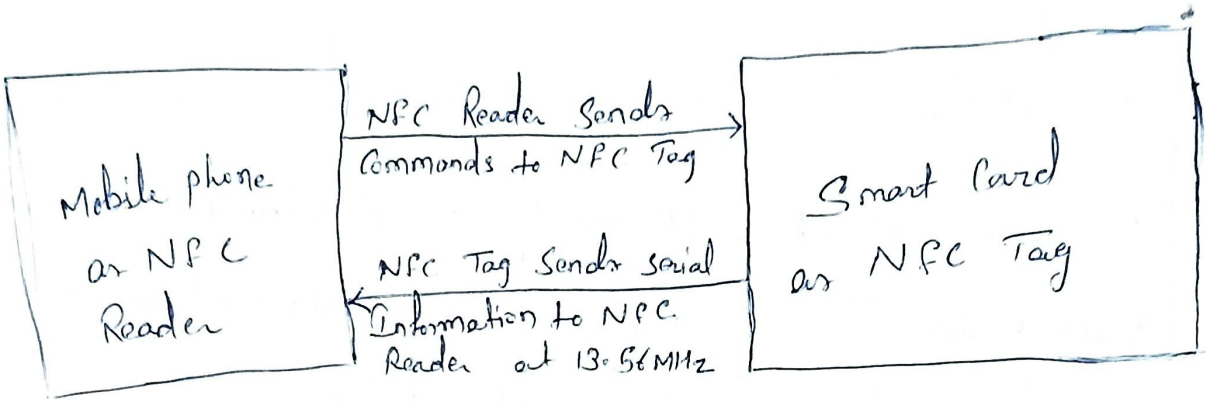
Features of Modbus

Feature	Description
Protocol Type	Serial and ethernet Communication Protocol.
Communication Modes	Modbus RTU (binary), Modbus ASCII, Modbus TCP/IP
Data Model	Registers and Coils (Discret bits and analog values)
Transport Media	RS-232, RS-485, Ethernet
Network Topology	Master-slave (client-server)
Simple Messaging	Read/write registers and coils
Device limit	Upto 247 slaves in serial mode.

NFC

→ NFC Stands for Near field Communication.
→ NFC is used to have Contactless data transfer
→ NFC Can Communicate at a lower distance of around 4cm.
→ NFC is working at 13.56 MHz of ISM band
→ NFC can Communicate with the data rate of 106 kbps to 848 kbps
→ NFC is based on inductive coupling between two antennas.
→ Today in 2023, NFC is available in almost all mobile, which enables many IoT applications.
→ RFID helps to track inventory before the sale, while NFC is aimed at becoming part of a product utility after the sale.
→ NFC-enabled devices can be readers or cards.
→ NFC tags can't act as readers, they are passive (no power source) it always act as information sources.

Working of NFC



→ NFC reader initiates RF Communication by commands.

→ NFC Tag responds to commands by Tag information.

→ Then, NFC reader reads the Tag information and Validates the Smart Card.

→ This Communication happens at 13.56 MHz ISM band.

→ NFC reader Can also act as NFC Tag.

→ Two NFC readers Can transfer data in full duplex mode.

Application of NFC

(i) Data Exchange between two mobiles

(ii) Contactless payment

(iii) Ticketing

(iv) Parking Access Management

(v) Access Control.

(vi) Transport Cards.

Advantage of NFC

(i) Secure Communication
(ii) No Special Software is required
(iii) No manual Configuration is required.
(iv) No Search and pairing is required.

Disadvantage of NFC

(i) Short Distance Communication.
(ii) Low Data rate (106 Kbps, 212 Kbps and 424 Kbps).