SRWC Unit 1- Notes

Short Range Wireless Communication (SRM Institute of Science and Technology)

UNIT - I

Wireless Systems

Syllabus:

Introduction to wireless systems, Reasons for the Spread of wireless applications characteristics of Short-range radio, wireless applications, Elements of wireless communication systems, Transmitter element of wireless communication systems, Receiver, Wireless Local area networks (WLAN), WIFI network architecture, Bluetooth Transceiver, Bluetooth modes, Zigbee architecture, Frame Structure applications and conflicts, Ultra-wideband technology, Bit sequence detection, UWB Block diagram

Introduction to Wireless systems:

Networks:

* Network is a set of devices connected by media links.
* A node can be a computer printer or any other device capable of sending / receiving data generated by other nodes or network.
* Links are called communication channel
* Networks can be classified as wired or wireless
* A wired network uses copper wire cable or

fibre optic cable to form connections between the network devices (nodes)

* Wireless networks tends to use radio signals as their communication medium but could use other wireless methods such as infrared light

Why wireless communication system:

- 1. Primary benefit is mobility
- 2. Offers flexibility and ease of use
- 3. Infrastructure of wireless communication can be easily installed at low cost.
- 4. In emergency situations and remote locations wireless communication is a viable option

Advantages:

* Cost
* mobility
* Ease of installation
* Reliability
* Disaster recovery

Disadvantages

* Interference
* Security
* Health concerns

Reason for the Spread of Wireless applications:

⇒ Higher and higher frequencies can now be employed in the spectrum whose use was previously impossible or very expensive

⇒ In particular, solid state devices has recently been developed to amplify at mm wavelength or tens of GHz.

⇒ Efficient, compact antennas are available such as planar antennas which are often used as in short range devices.

⇒ Digital modulation techniques are replacing the analog methods permitting a multiplication of the number of communication channels that can occupy a given bandwidth.

Short Range wireless communication:

* most relevant-diversified field in wireless communications
* wireless social networks - IoT, car communication
  home and office networking
* wireless grids & personal communication - rely on short range communication
* refers to technology which communicate wirelessly with in a small dia region
* envolve transfer of information from mm to few hundreds of meters

defines technologies used to build service access in local areas

Two main developing directions

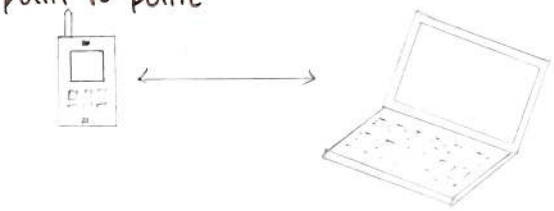
→ maximizing the supported data throughput

→ mobility support.

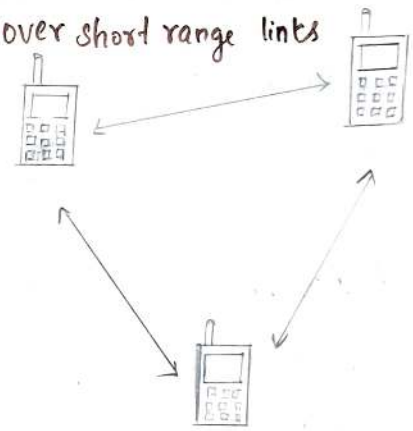
Short range technologies are used in

* Mobile social networks
* wireless sensor networks
* Cooperative wireless network.

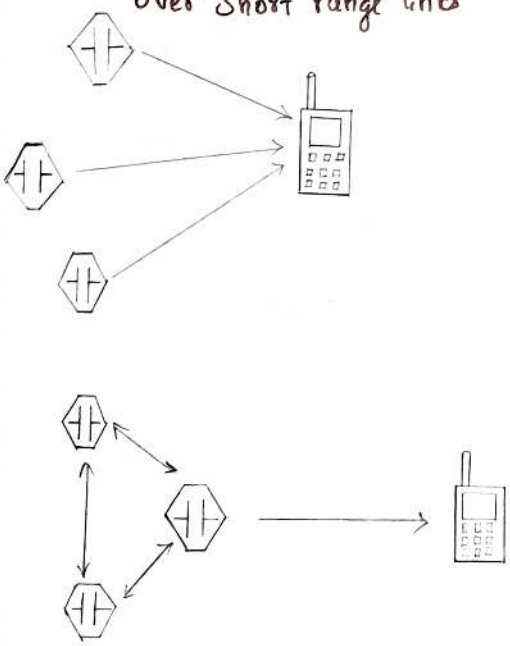
Short range link as point to point



Social mobile networks over short range links



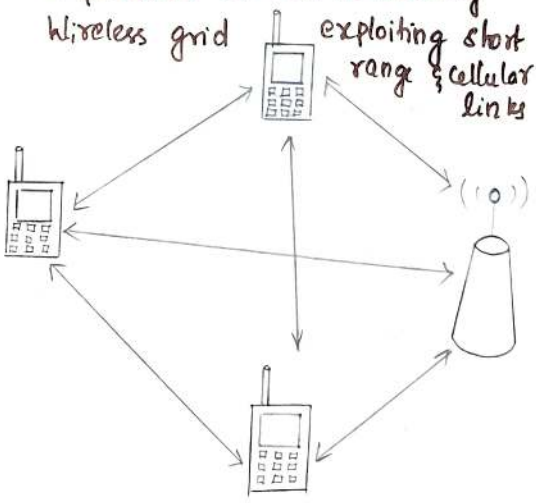
Autonomous sensors & WSN Connected to wireless device over short range links



Cooperative wireless networking

Wireless grid

exploiting short range & cellular links



Mobile Social networks:

* Connect people within each other proximity
* Short range technology → used to discover and connect other mobile phones in range → referred to as mobile peer to peer
* Multiple mobile peer to peer network in some place.

Wireless sensor networks:

* Wireless sensor networks attracted a lot of attention in recent years
* mainly focused on military applications and later in civil environment
* It is composed of a wireless communication facility Sensor elements
* Source of energy is battery
* Different physical phenomena measured by sensors like light, temperature pressure distance and many others.
* Passive sensors such as RFID & UHF devices which dont need battery
* remotely powered by EM waves
* Linking WSN to wireless device → the user can control the network → got access to measured data

* Wireless devices equipped with cellular and short range interfaces

* Flexible too in monitoring and controlling the sensor network. both remotely and locally

eg: water pump in farms

Cooperative Wireless Network.

* Mobile phones connected with other phones in their proximity forming wireless grids

* Uses their capabilities and resources in a much more effecient way than any stand alone device

* It also exploits cellular links of the interacting wireless devices

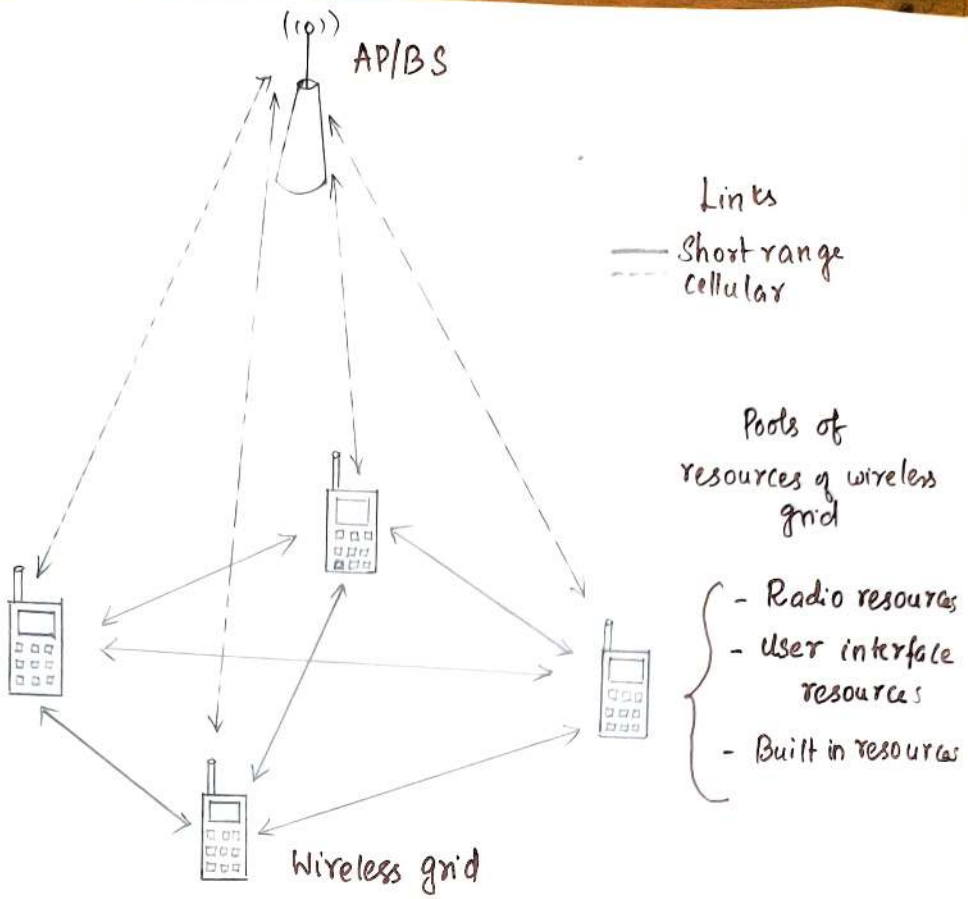
Advantage

⇒ Better utilization of radio and other shared resources

⇒ Enhancement of communication capabilities such as data throughput

⇒ Quality of service

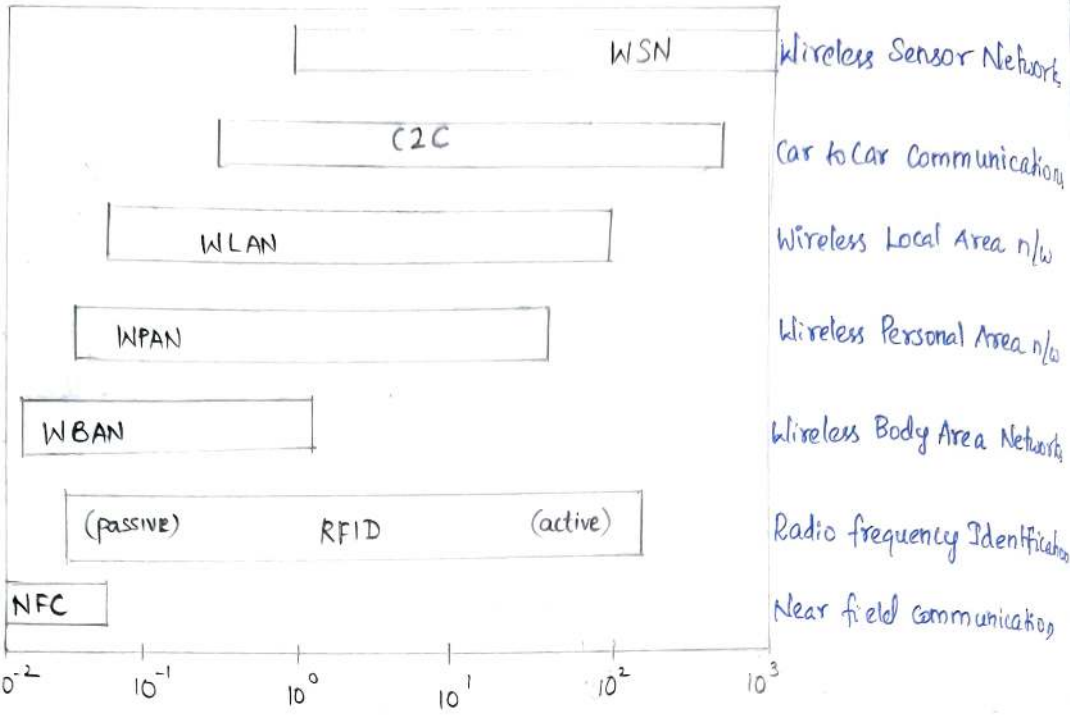
⇒ Natural support



Characteristics of Short range Radio

- RF power output of several μW to 100 mW
- Communication range of several cm upto several 100 m
- Principally indoor operation
- Omnidirectional, built in antennas
- Simple construction and low price
- Unlicensed operation
- Non-critical bandwidth specifications
- UHF operation
- Battery operated transmitter or receiver

Short Range Communication Systems and their typical operating ranges



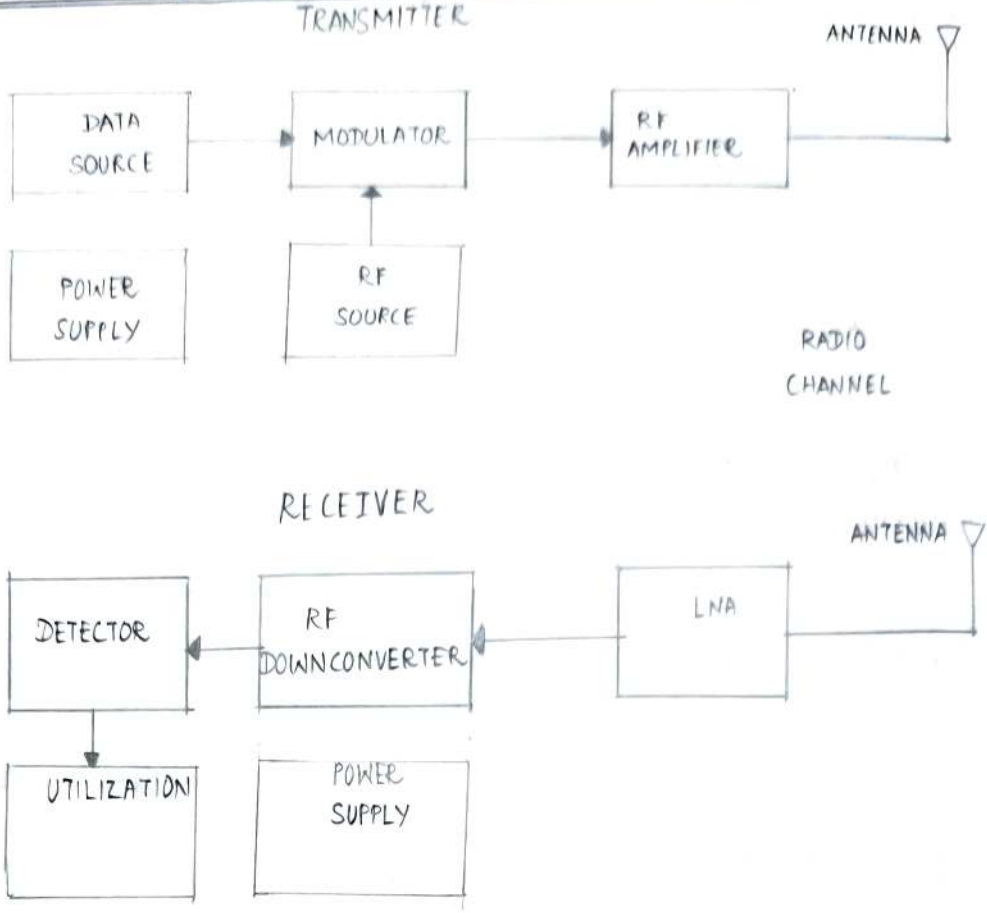
Classification of Short Range Communications

- Short Range wireless Communication
  - Air interface
    - Conventional radio (NBR)
    - ultrawide band (UWB) radio
    - Non-wave communication
    - Optical wireless communication
    - Infrared & visible light
  - Network Topology
    - Centralised (cellular infrastructure)
    - Distributed (adhoc, mesh decentralised infrastructure)
  - Mobility
    - Fixed
    - Nomadic
    - Mobile
  - Data rate
    - low (1bps - 100kbps)
    - moderate (100kbps - 10Mbps)
    - high (10Mbps - 10Gbps)

Short range radio applications

Applications	Frequencies	Characteristics
Security systems	300-500 MHz 800, 900 MHz	Simplicity, easy installation
Emergency medical alarms	300-500 MHz 800 MHz	Convenient carrying long battery life reliable
Computer accessories mouse, keyboard	UHF	High data rate, very short range, low cost
RFID (Radio Frequency Identification)	100 KHz - 2.4 GHz	Very short range active or passive transponder
WLAN (Wireless Local Area network)	900 MHz, 2.4 GHz	High continous data rates, spread spectrum modulation, high price
Wireless microphones Wireless headphones	VHF, UHF	Analog high fidelity voice modulation, moderate price
Key entry - Gate openers	UHF	Miniature transmitter Special coding to prevent duplication
Wireless bar code readers	900 MHz, 2.4 GHz	Industrial use, spread spectrum expensive

Elements of Wireless Communication Systems:



Data Source:

⇒ Information to be conveyed from one side to the other

⇒ Data source can be analog or digital

Message frame:

⇒ An address field identifies the unit that is transmitting and the data field conveys the specific information in on/off form. A parity bit or bits may be appended to allow detecting false messages.

Address bit	Data	Parity

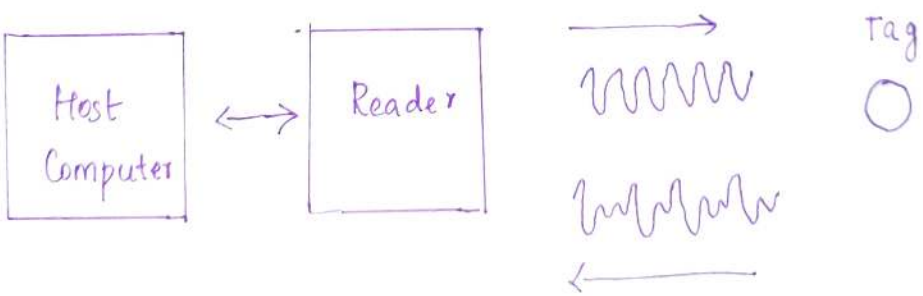
⇒ Computer accessories and WLANs send continous digital data over the short range link These datas are organized according to protocols that include sophisticated error detection and correction techniqus

⇒ Audio devices such as wireless microphones and headset send analog data to the modulator. However these data must be specially processed for best performanc over wireless channel.

Input transducer:

⇒ The message from the information source may or may not be electrical in nature. In case when the message produced by the information source is not electrical in nature, an input transducer is used to convert it into a time varying electrical signal.

⇒ In case, if the data source is RFIDs, the data not available in the transmitter but added to the RF signal in an intermediate receptor called transducer



RFID

Radio frequency generation section:

* This part consists of an RF source (oscillator or synthesizer), a modulator and an amplifier.

* In the simplest short range devices, all three functions may be included in a circuit of only one transmitter.

* RFIDs are different from other application in that the modulation is carried out remotely from the RF source.

RF conduction and radiation:

- All short range devices have built in antennas so their transmission lines are relatively short and simple

- However particularly on the higher frequencies their lengths are high enough percentage of wave length to affect the transmission efficiency of the transmitter.

- Usually omnidirectional for most uses

  must be small and often a fraction of wavelength

Radio channel

* Radio channel for short range application is short
* For a large part of the equipment is used indoors
* Allowed radio frequency power is relatively low.
* Devices are usually operated whicle close or attached to a human/animal body which affects the communication performance.
* Reliable operating range is difficult to predict

Short range devices is often used to replace hard wiring, so similiar performance is expected, but the limitations must be accounted for each applications

Receivers:

* Operation is reversed in comparing with transmitter
* They have an antenna and transmission line, RF amplifiers and use oscillator in their operation.
* Weak signal signals intercepted by the antenna are amplified above the circuit noise by a low noise amplifier (LNA)
* The desired signal is seperated from all other and is shifted lower in frequency in a down convertor where it is effectively amplified to the level required for demodulation

The detector converts the data source which

was implanted in RF wave in the transmitter, back to its original form.

Power supplies:

- In short range devices, at least one side of the wireless link must be completely untethered.
- When size is limited, energy is limited
- The need to change batteries is highly inconvenient and expensive and hence there is a widespread use of radio in place of wires.
- Low current consumption is an important design aim for wireless devices
- Harder to acheive in receivers than transmitter
- Transmitter is kept in standby status until it need to send, the receiver doesn't know when data will be sent so it must be alert all the time.
- Another way to reduce power consumption is to operate in power stand by mode, wherein operation goes to normal when the beginning of signal is detected

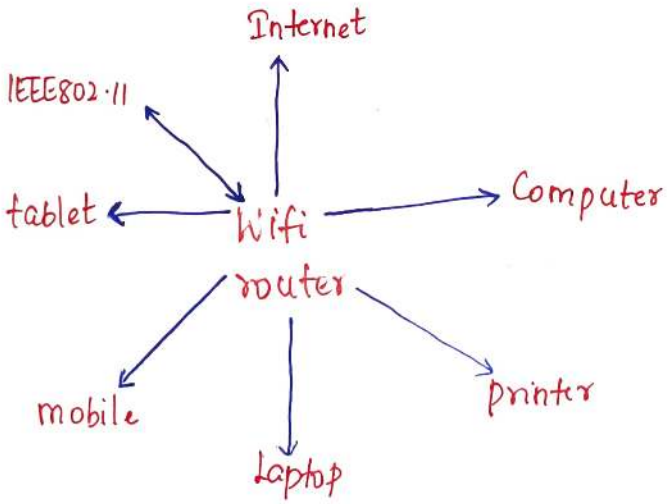
WIRELESS LOCAL AREA NETWORKS (WLAN).

★ A group of colocated computer or other device that form a network based on radio transmission rather than wired connection.

★ WiFi network is a type of WLAN

★ WLAN stands for wireless local area network and it is a type of local area network (LAN) that uses radio transmission to connect device with in the limited or short range area.

★ WLAN are useful because they allow device to without physical cables making it easy to add or remove devices from the networks.



Benefits:

→ Internet connectivity while on node
→ cost effective
→ less hassle for IT and maintanence staff
→ Flexibility for organisation
→ useful in disasters and when physical infrastructure is damaged

WLAN data transmission is implemented by one of the technologies such as

→ FHSS (Frequency Hoping Spread Spectrum)

→ DSSS (Direct Sequence Spread Spectrum)

→ Infrared Technology

Spread spectrum is a system in one in which the transmitted signal is spread over the wide frequency bands much wider than the bandwidth required to transmit the message

* FHSS → Narrow band carrier (Tx & Rx)

* DSSS → produces a redundant bit pattern for each transmitted bit
patterns of bit is known as chip or chipping code
It appears at a low power wideband noise to and inadvertent receiver

* U-Infrared IR WLAN does not pass through opaque object.

Types of WLAN:

1. Infrastructure
2. Ad-hoc
3. Bridge
4. Wireless distribution system

Wi-Fi: Wireless Fidelity

* Wi-Fi is the generic name for all devices based on the specification 802.11 and its derivatives

* 802.11 covers the data link layer of lower level software, the physical layer hardware definition and the interfaces between them. The connection between the application and software and the wireless hardware is MAC.

* The basic specification defines three types of wireless communication techniques

  → DSSS (Direct Sequence Spread Spectrum)
  → FSSS (Frequency Hoping Spread Spectrum)
  → IR (Infra-red)

* Application software doesn't know that a wireless connection is being used, the MAC interface firmware take care of that.

* Frequency band for wireless communication according to 802.11 is 2.400 to 2.4835 GHz.

* Supplement 802.11a specifies the higher rate operation in band of frequencies 5.2 and 5.8 GHz.

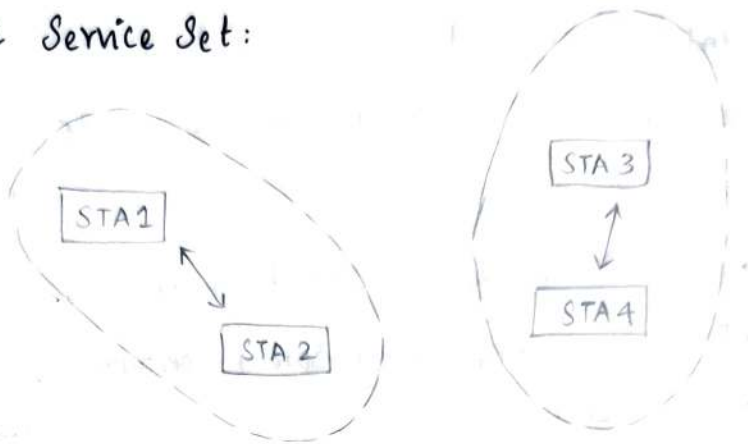
* Supplement 802.11b adds increased data rates and other features using DSSS physical layer.

NETWORK ARCHITECTURE:

- Wi-Fi architecture is very flexible, allowing considerably mobility of stations and transparent integration with wired IEEE networks

WiFi network Configuration:

Basic Service Set:



Basic Service Set

⇒ The figure shows two unattached basic service set (BSS) each with two stations (STA).

⇒ The BSS is the basic building block of an 802.11 WLAN

⇒ A station can make ad-hoc connections with other stations within its wireless communication range but not in those with another BSS that is outside of this range.

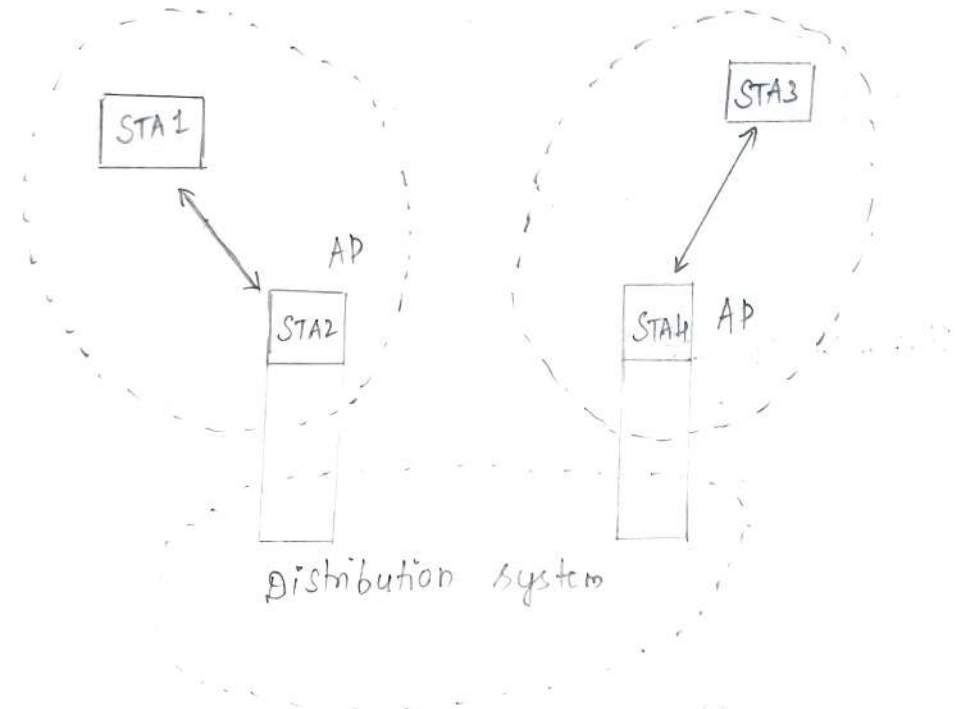
Distributed System and Access Points:

* Distributed system is needed inorder to interconnect terminals that are not in range (direct range) one with other.

* Here terminals that are in range of a station designated as AP can communicate with other terminals not in direct range but associated with same or other AP.

* Two or more APs communicate among themselves either by wired or wireless medium and hence the data exchange between all terminals in the network is supported.

* The media connecting the STA's and AP's, and those connecting AP's among themselves are completely independent.

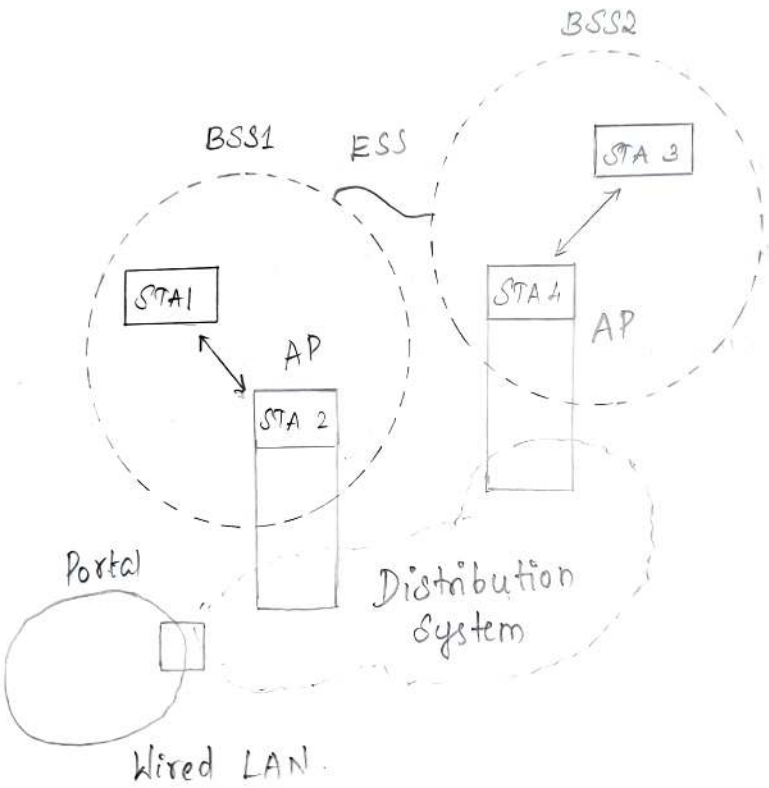


Distribution system and Access points

Extended Service Set:

→ STAs have full mobility and may move from one BSS to another while remaining in the network.

→ Portal is a gateway between the WLAN and wired LAN. It connects the medium over which the APs communicate to the medium of the wired LAN.



Extended Service Set.

Functions of WiFi

1. Distribution of data throughout the network
2. Authentication:
3. Encryption.

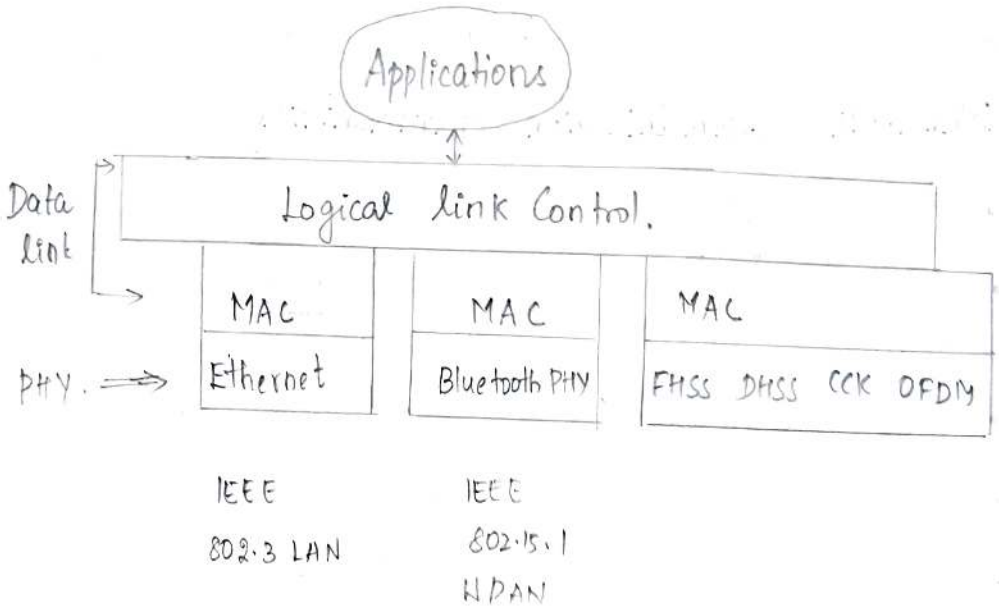
* The operational specifics of WLAN are described in IEEE 802.11 in terms of defined protocols between lower level software layers.

* IEEE 802.11 prescribes the protocols between the MAC sublayer of the data link layer and physical layer as well as the electrical specifications of the physical layer. of several types of networks with upper layer application software interfaced through a Logical Link Control (LLC) layer.

* Protocol of LLC is same for both wired and wireless networks.

* MAC is implemented by high level logic digital circuits or combination of logic and microcontroller or a digital signal processor.

* The PHY describes wireless signal characteristics such as data rates and modulation techniques (DSSS, CCK, OFDM).



Data link and Physical layers

BLUETOOTH:

* Bluetooth wireless technology is a short range radio technology which is developed for WPAN.

* It is an ad-hoc type network operable over a small area such as room.

* Bluetooth wireless technology makes it possible to transmit signal over short range or distance between telephones, computers and other devices thereby simplify communication and synchronization between the devices in the vicinity of 10 meters.

* Facilitates both voice and data transmission.

* Bluetooth device in a network have the function of master or slave.

* All communication between a master and one or more slaves, never directly between slaves.

Blue tooth communication characteristics

- 1. Frequency band - 2.4 to 2.483 GHz
- 2. FHSS - 79 1-MHz channel from 2402 to 2480 MHz
- 3. Hop rate - 1600 hops per second
- 4. Channel bandwidth - 1MHz
- 5. Modulation - Guassian FSK (GFSK)

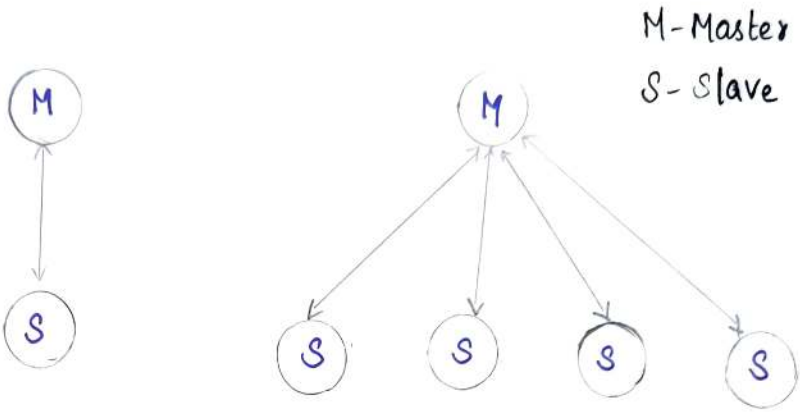
Topology:

1. Piconet 2. Scatternet

Piconet:

⇒ Basic bluetooth network

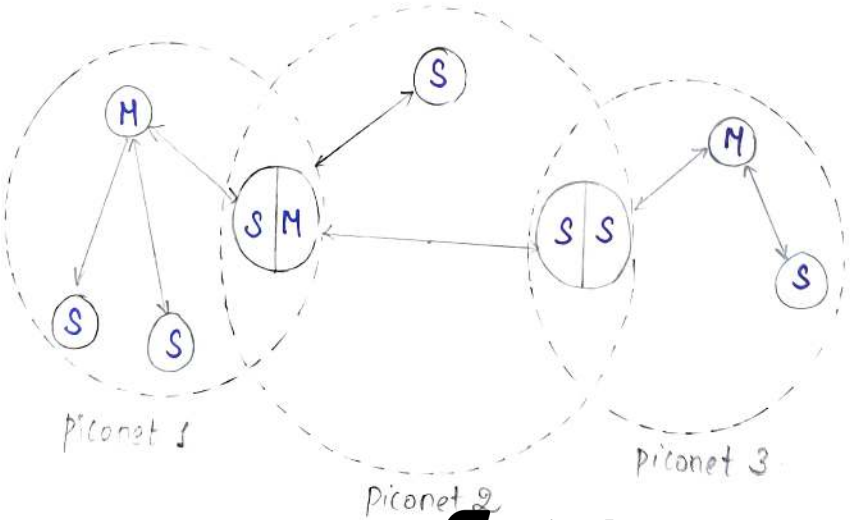
⇒ It has one master and from one to seven slaves.



Scatternet:

⇒ Scatternet is an interelated network of piconets where any member of a piconet may also belong to the adjacent piconet.

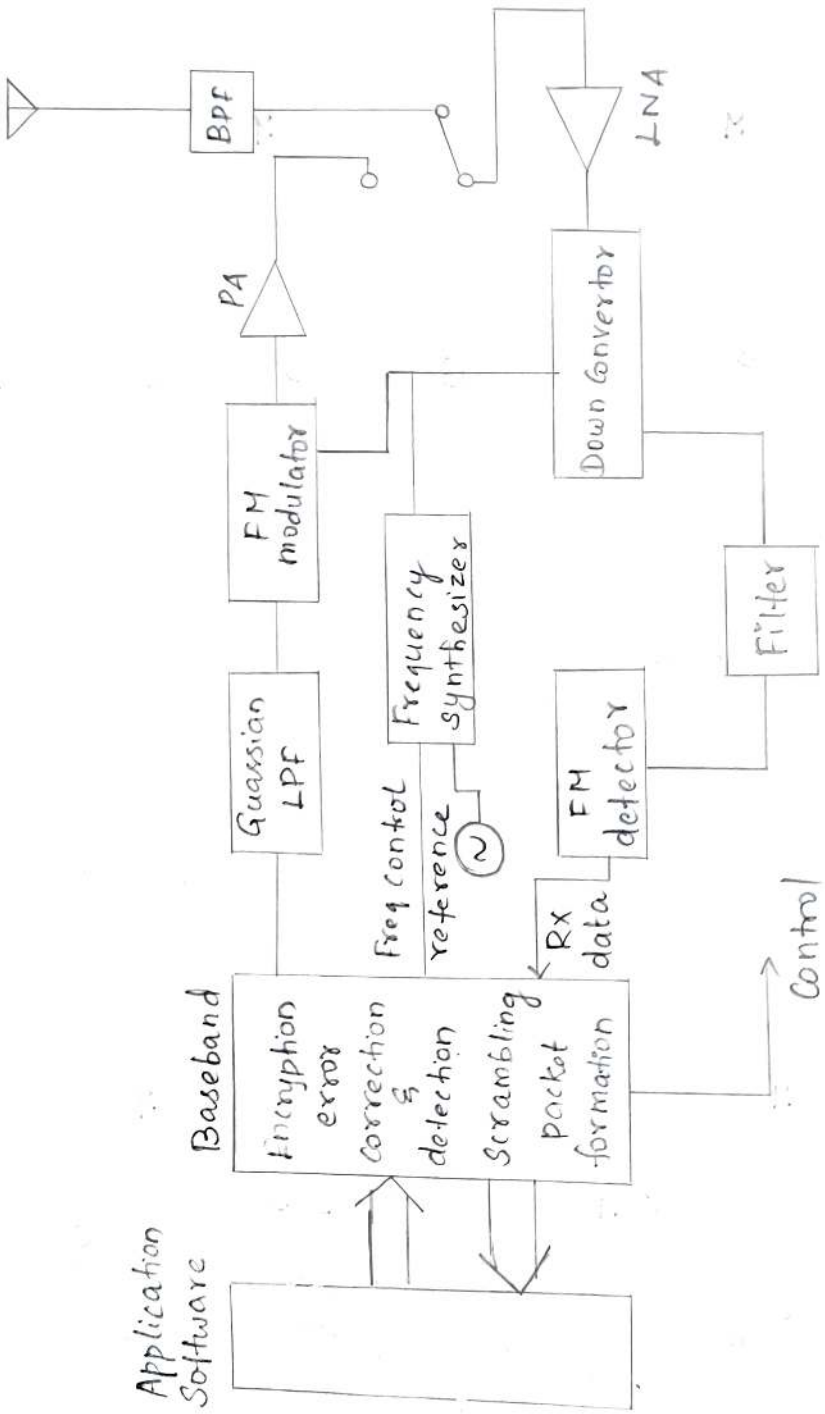
⇒ A node may be a slave in one piconet and master in another. A device may be master in one piconet only.



Bluetooth Transceiver:

Bluetooth transceiver is divided into three basic parts

RF
Baseband
Application software.



Bluetooth Transceiver:

A bluetooth chip set will usually include the RF and baseband parts, with the application software being contained in system's computer or controller.

Application Software:

The user data stream originates and terminates in the application software.

Baseband Section:

The baseband section manipulates the data and forms frames or data bursts for transmission.

It also controls the frequency synthesizer according to the bluetooth frequency hopping protocol.

The main functions in baseband section are

Encryption:

Encryption is the processes of transforming readable plaintext into unreadable cipher text to mask sensitive information from unauthorized users

Error detection & Correction:

Error detection is the detection of errors caused by noise or other impairments during transmission from the transmitter to the receiver.

Error correction is the detection of errors and reconstruction of the original, error free data.

Scrambling:

Technique that randomizes the order of bi data in a randomized order. It is used to improve the security and reliability of data transmission.

Packet formation:

Packet is a smaller segment of a larger message. The data sent at the transmitter is divided into packets and recombined at the device that receives them.

RF Section : Transmitter:

Guassian Low pass filter:

A guassian low pass filter is a filter that reduces noises and in the data by removing high frequency components.

FM modulator:

The output from the guassian low pass filter is fed as an input signal to the modulator.

The frequency synthesizer is an electronic circuit that uses an oscillator to generate the carrier signal and the output from the frequency synthesizer is fed to FM modulator. The carrier signal generated is typically a high frequency range than the message signal. The modulated signal is fed to the power amplifier.

Power Amplifier:

Power amplifier is a type of electronic amplifier that converts a low power RF signal into a higher power signal.

Typically RF power amplifier is used in the final stage of the radio transmitter their output driving the antenna.

Switch: The single pole Double throw (SPDT) switch used here determines whether the transceiver acts in transmitter mode or receiver mode based on the input given.

RF Section: Receiver:

Band Pass filter:

Band pass filter allows the specific range of frequencies to pass through while eliminating the frequencies outside the range.

Low Noise Amplifier

Low noise amplifier is a device that boosts a received signal above the noise floor so it can be processed further

Down Conversion:

Down conversion is the process of shifting a signal from a higher frequency to lower frequency and sent to the filter

Filter:

The filter circuit removes the undesired signals

FM detector:

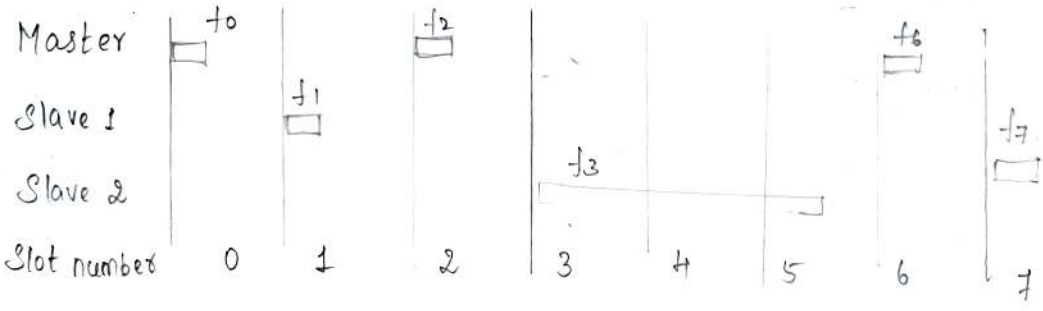
FM demodulation retreives the original signal from the modulated signal by using the reference coherent carrier signal.

The detector reproduces the signal that is given as input to the FM transmitter

Bluetooth Timing:

A transmission burst may occur within a duration of one, three or five consecutive slots on one hop channel

All slaves in the piconet have internal time synchronized to the master device timer.



Slots are numbered according to the state or phase of the master clock which are copied by each slave joining the piconet.

Master transmission takes place during even numbered clock phases and slaves during odd numbered clock phases

Types of wireless links associated with Bluetooth:

There are two different types of wireless links associated with bluetooth connection

1. Asynchronous Connection Link (ACL) (used for packet transfer)
2. Synchronous Connection Oriented (SCO) (used for voice)

When SCO link is established between master and slave on dedicated slots with a constant interval.

ACL uses handshaking protocol to regulate transmission

Bluetooth modes:

Active mode: Normal mode when connections are established between the devices and are actively performing data transfer.

Sniff mode: Power saving mode operation

Sniff mode is application dependent and slave only responds to the master at particular set of intervals so it will be in sleep state for reducing power consumption

Hold mode: Power saving mode. Slave may request to be placed in HOLD mode by master or master unit When the HOLD state is released, it moves to active state. The hold is used for temporary period to manage low power devices

Park mode: Deepest power saving mode. In this mode, the master can command the slaves to park itself to an inactive state and when the master again changes the command to normal it will switch to an active state.

It remains synchronized to the piconet even when it is not in any traffic and it also listens to the devices around.

ZIGBEE:

IEEE Specification 802.15.4 is associated with Zigbee

Low data rate WPAN which describes the physical and data link layers that address remote monitoring and control applications.

Features of IEEE 802.15.4

Low data rates - between 20 to 250 kbps

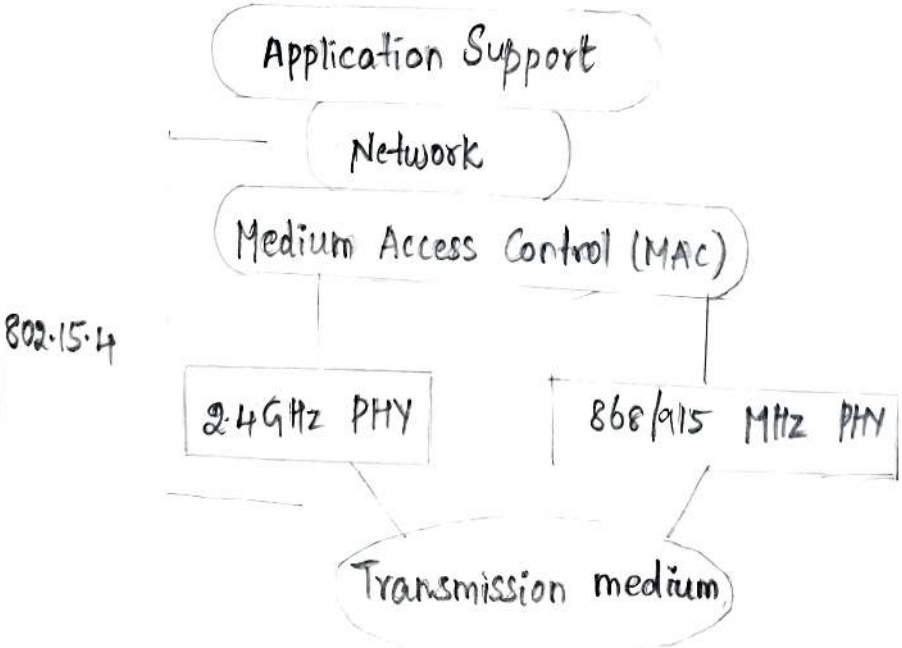
Low power consumption - Several months upto two years on standard batteries

Network topology appropriate for multisensor monitoring and control applications.

Low complexity for low cost and ease of use

High reliability and security.

Zigbee Architecture:



Physical layer:

Physical layer shows two alternative options for the RF transceiver functions

Both options are not expected to exist in single device as their frequencies data rates and modulation system are quiet different.

Medium Access Control Layer

MAC Layer is responsible for management of the physical layer and delivering data to and from the applications through the layer about it.

Functions of MAC : *1: Channel access

*2: Keeping track of slot times

*3. Message delivery acknowledgement

Network Layer:

The principle function of network layer are forming a network, managing association and disassociation from the network and routing.

Application Support Layer:

Not a part of IEEE 802.15.4

The Zigbee alliance prepares the guidelines and requirement for various functional classes that assure product interoperability and vendor independence.

These defines network formation, security and application requirement

Communication Characteristics:

Operation of Zigbee is specified for three unlicensed band - 2.4 GHz, 915 MHz and 868 MHz.

Zigbee defines 28 transmitting channels.

Channel number	Center frequency range	Channel width
0	868.3 MHz	600 KHz
1 to 10	906 - 924 MHz	2 MHz
11 to 27	2405 - 2480 MHz	5 MHz.

Output power and Receiver Sensitivity

The devices must be capable of radiating at least 3dBm output power

Output power may be reduced to the minimum necessary in order to limit interference to other users.

Maximum power is determined by the regulatory authorities.

Minimum receiver sensitivity for the 868/915 MHz physical layer is specified as -92 dBm and -85 dBm on 2.4 GHz

Device Types and Topologies:

Two types of devices are defined

→ Full function device (FFD)

→ Reduced function device (RFD)

Full Function Device:

Implement the full protocol set and can act as a network coordinator

Reduced Function Device:

Capable of minimal protocol implementation

Topologies:

Two types of topologies are widely used

1. Star
2. Peer to peer.

A network may have as many as 255 members one of which is a PAN (Personal Area Network) coordinator.

Function of the PAN Coordinator:

- Initiate, terminate and/or route communication around the network.

- provides synchronization services

Star network:

* Each device communicates directly with the Coordinator
* Coordinator must be FFD
* Others can be FFDs or RFDs
* simple application uses star topology

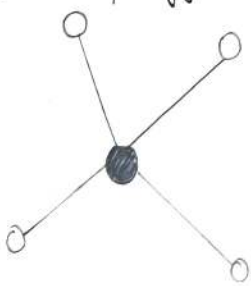
Peer to Peer topology:

* Any device can communicate with any other device as long as it is in range
* RFDs cannot participate

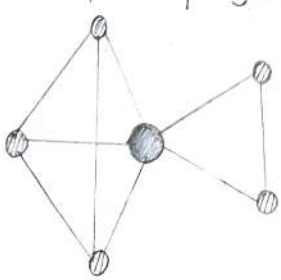
Cluster Tree network:

* Combination of peer to peer groups and
* star configuration
* Just one PAN Coordinator in the whole network.

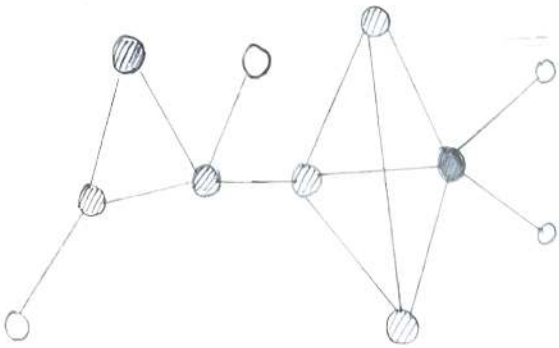
Star Topology



Peer to peer topology



Cluster Topology



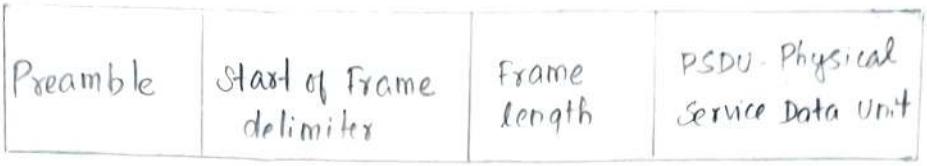
— Two way communication link

● - PAN coordinator, FFD

◍ — FFD

○ — RFD or FFD

FRAME STRUCTURE:



* Preamble is to permit acquisition of chip and symbol timing.

* The PHY header, notifies the length of the subsequent data

* PSDU (phy service data unit) is the message that has been pass down through the higher protocol layers

* Size of PSDU ⇒ maximum of 127 bytes.

* PSDU contains
  - ⇒ Information on the format of the message frame
  - ⇒ a sequence number
  - ⇒ address information
  - ⇒ the data payload
  - ⇒ frame check sequence

* The receiver performs an independent calculation of this frame check sequence and compares it with the number received.

* If any bits have been changed by interference or noise, the numbers will not match.

* Only if a match occurs, the receiver side returns an acknowledgement to the originator of the msg.

Collision Avoidance:

* To avoid two or more stations trying to transmit at the same time, a carrier sense multiple access with collision avoidance (CSMA-CA) is employed.

* Zigbee transceiver monitors the channel

⇒ If channel is idle it may initiate transmission

⇒ If channel is occupied it must wait for a period of time before attempting access again

Zigbee applications:

Personal health: patient monitoring
fitness monitoring

Building automation: Security HVAC AMR lighting control access control

Industrial control: asset management, process control, environmental energy management.

Consumer electronics: TV/VCR, DVD/CD remote

PC & Peripherals: mouse, Keyboard, Joystick

Residential light commercial control: Security, lighting control lawn & garden irrigation.

Difference between Bluetooth and Zigbee:

Parameters	Bluetooth	Zigbee
Transmission Scheme	FHSS (Frequency hopping spread spectrum)	DSSS (Direct Sequence spread spectrum
Modulation	GFSK, Guassian frequency shift keying, $\pi/4$ Quadrature & 8 angle phase shift keying	O-QPSK (offset quadrature phase shift keying) or BPSK (Binary Phase Shift Keying)
Frequency Band	2.4 GHz	2.4 GHz, 915
Raw data bit	1, 2, 3 Mbps	250, 100, 40, or 20 kbps
Power output	Maximum 100, 2.5 or 1mW depending on class	Minimum capability 0.5 mW, maximum as allowed by local regulations
Minimum sensitivity	-70 dBm for 0.1% BER	-85 dBm (2.4 GHz) or -92 dBm (915/868 MHz) for packet error rate <1%
Network Topology	Master - Slave 8 active nodes no fixed limit for LE	Star or peer to peer upto 64 K active nodes

Ultra Wide Band:

* Ultrawide Band based on transmission of very narrow electromagnetic pulses at low repetition rate.

* Radio spectrum - spread over a wide bandwidth

* ⇒ much wider than bandwidth used in Spread spectrum.

Advantages:

* Very low spectral density
* High immunity to interference
* low probability of interception
* High multipath immunity
* many high data rate ultra-wideband channels
* fine large resolution
* relatively simple, low cost construction

UWB has two basic signal generating technologies for UWB devices

⇒ Impulse Radio (IR)

⇒ Multiband OFDM.

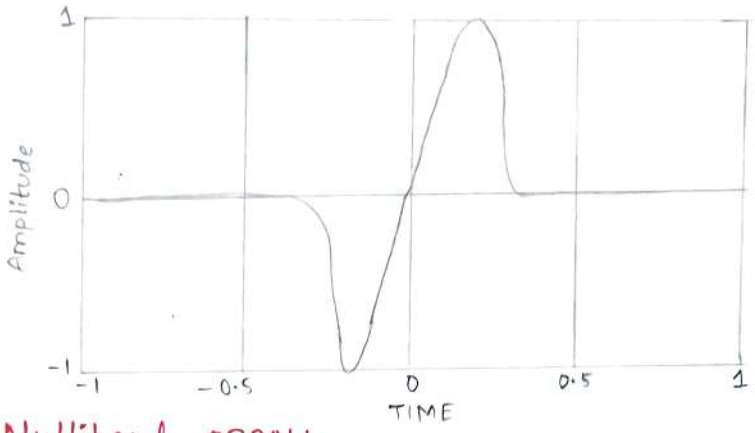
Impulse radio:

* Impulse radio is the legacy method of acheiving wide bandwidth

* It is based on creating a sequence of short pulses, modulated by pulse amplitude modulation or pulse position modulation.

- Eg: Guassian monopulse

Monopulse: * A pulse can be generated by applying an impulse, or perhaps more conveniently a step voltage or current, to a linear band limited network.

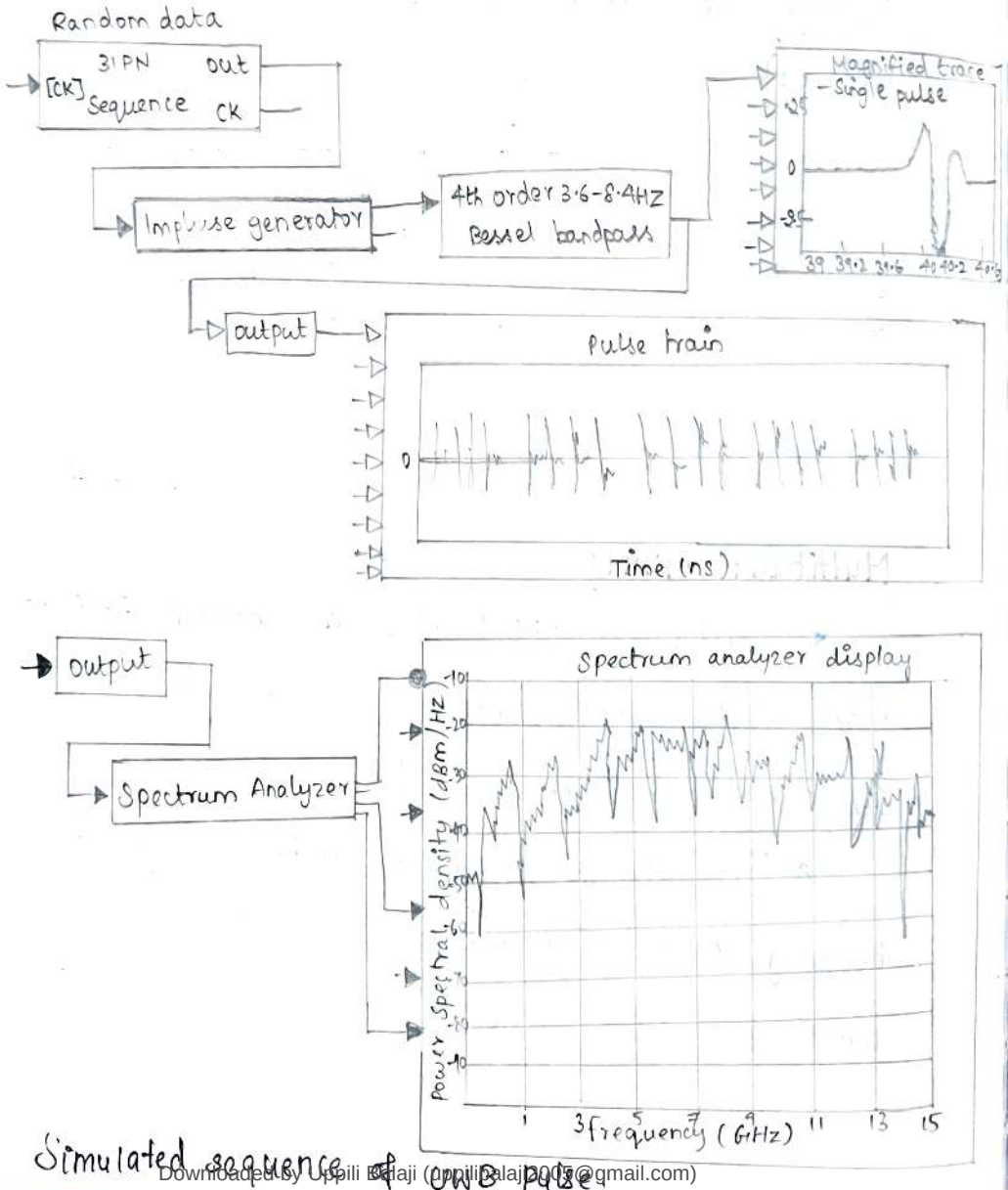


Multiband OFDM:

* Multiband OFDM uses an inverse FFT to place data in optimally spaced discrete subchannels to create a flap-topped wideband spectrum

* Further widening is acheived by frequency hopping over a number of consecutive OFDM bands.

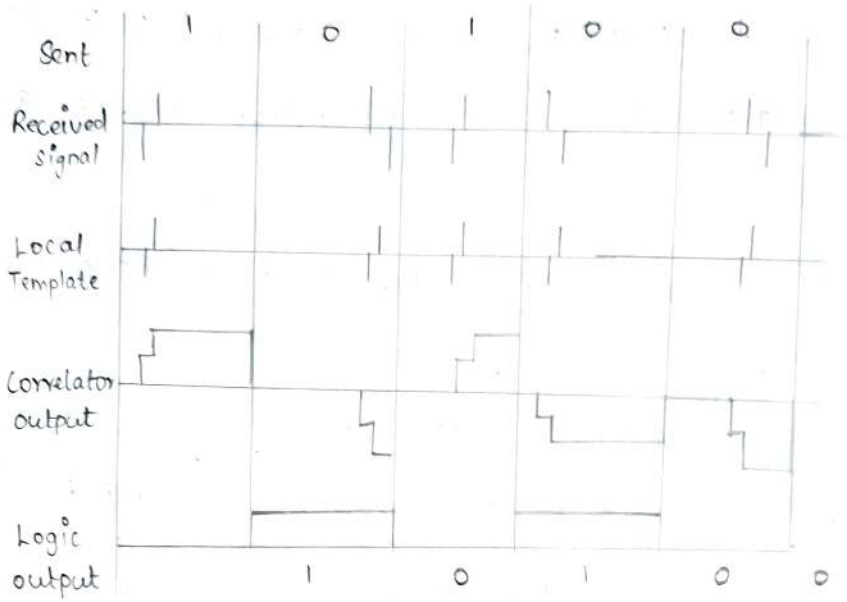
- UWB signal generation and detection uses baseband technique.
- Train of pulses are transmitted with the characteristics of pulse or group of pulse inorder to dishinguish between 0 and 1.
- The time between consecutive pulses should be determined by in a pseudo random inorder to smooth the energy spikes in the frequency spectrum.



Simulated sequence of UWB pulse

- UWB is created by Band Pass Filter with pseudo random spread sequence of impulses
- The network that creates individual UWB includes transmitter antenna, the propogation channel and the receiving antenna
- There are several ways to represent a UWB pulse as '1' or "0"
- One method is to advance or retard the transmitted pulse in the receiver according to the agreed pseudo random time sequence. This is PPM.
- Another method is to send the pulse with or without inversion, which is BPSK.
- Third method is ON-OFF Keying (OOK) where a pulse is transmitted for a 1 level and no pulse for '0' level.
- In first two methods the correlation of the received pulse with a "template" pulse generated in the receiver will result in different polarity which depends on whether a '0' or '1' is transmitted
- In third case, a data bit level should be represented by a sequence of two bits of opposing level inorder to preserve a constant average zero pulse stream level.

Detection of UWB bit sequence:



* A '1' monopulse is represented by a negative line followed by a positive line and

* '0' monopulse a neg positive line followed by negative line.

* The synchronized sequence generated in the receiver is drawn on the second line and below it the result of corelation operation

$$\int f(t)\, g(t)\, dt$$

Where $f(t)$ is received signal

$g(t) \rightarrow$ locally generated sequence.

* The positives are the line that go up and negatives are lines that goes down.

UWB Block diagram:

* A key to the generation of UWB pulses is the ability to create short pulse or step function.

* We can expect high data rate from this system.

* The pulse generator block creates short impulse or step functions with rise time on the order of tens or at the most hundreds of picosecond which are conditioned in the shaping network to produce the required output spectrum.

* High speed IC or special circuit elements such as tunnel diodes are employed in pulse generator

* The receiver produces the replica of the known transmitted pulse sequence which is synchronized with the incoming pulse stream in acquisition & tracking block.

* The baseband mixer (multiplier), integrator and sample and hold blocks perform the corelation function and data is the output.