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WIRELESS-NETWORK TECHNOLOGIES/PROTOCOLS

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Wireless LAN or WLAN

1. WLAN is a wireless network of computer-based devices or nodes.
2. Advantages of WLAN
 - Easy and fast deployment
 - Nomadic and mobile access
 - Connecting field devices in inaccessible locations.
3. Major Issues with WLAN
 - Noise & interference
 - Interception & eavesdropping
 - Jamming
4. Share of WLANs in LAN-market is increasing fast.

Application Areas of WLAN

1. Extension of wired LANs
2. Interconnection of cross-building wired LANs
3. Nomadic access
4. Mobile access
5. Ad-hoc networking

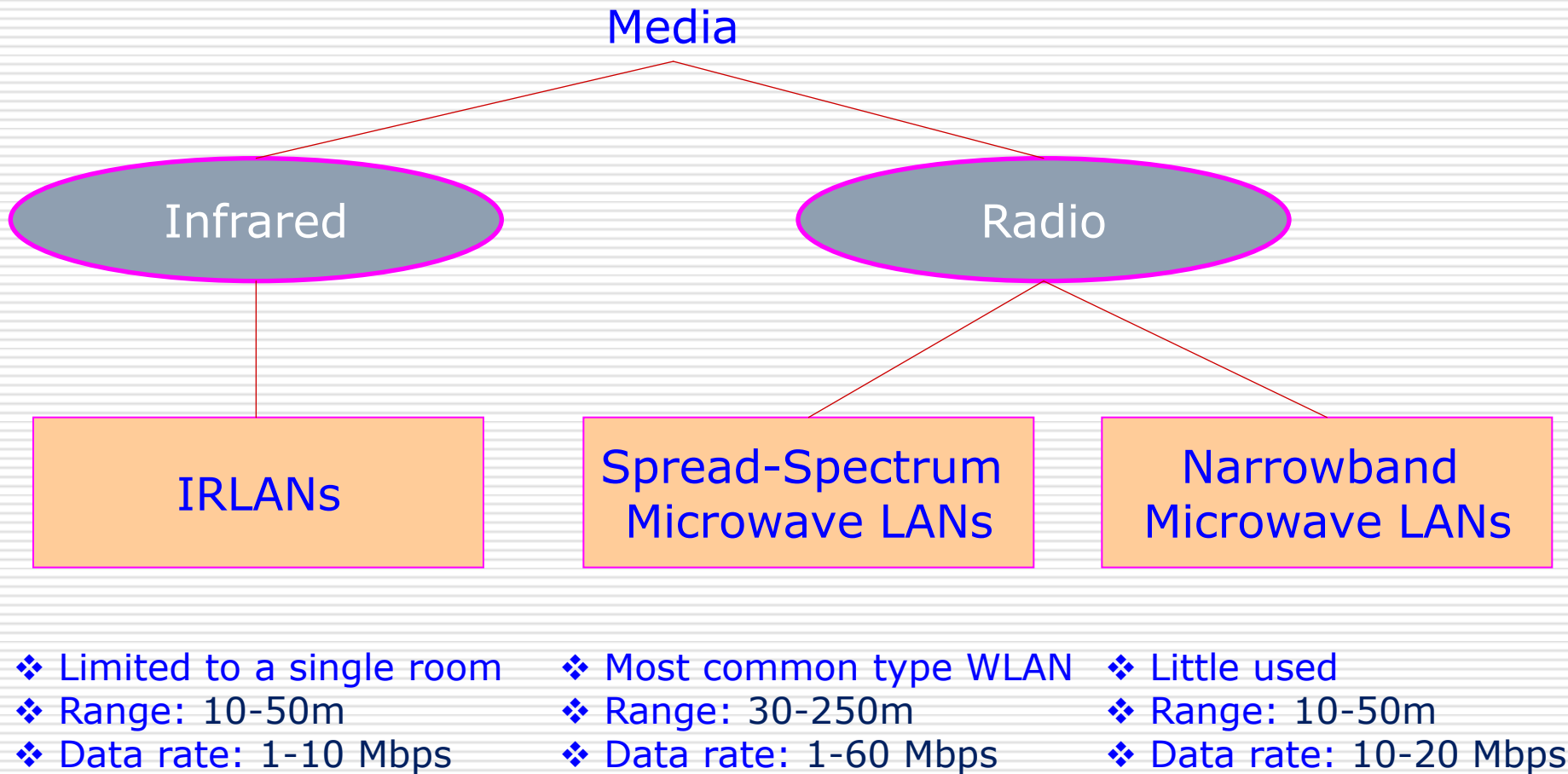
Requirements of WLAN

1. Large number of nodes should be permissible
2. Connection to wired backbone LAN should be easy
3. Adequate range
4. Low power consumption for long battery life
5. Reliability in noisy environment
6. Security from interception and eavesdropping
7. Security against jamming
8. Operation of multiple WLANs in same area without interference
9. License-free operation (using ISM frequency bands)

Requirements of MAC of WLAN

1. Proper MAC for maximized throughput
2. MAC to allow roaming of stations
3. MAC and network management aspects to automatically permit dynamic changes in WLAN configuration (addition/ deletion/ relocation of nodes).

Media for WLAN



IR LANs

- ❖ Infrared portion of spectrum is used
- ❖ Mostly deployed in homes, within a room
- ❖ Common for remote-control devices
- ❖ Transmission techniques
 - **Directed-beam IR**
 - Point-to-point link
 - Ring WLAN
 - **Ominidirectional IR**
 - Broadcasting from ceiling transmitter
 - Radiations in all directions
 - **Diffused IR**
 - Relies on diffusely-reflecting ceiling

Drawbacks of IR LANs

- ❖ Background radiations from sunlight and indoor lighting appear as noise
- ❖ Large power IR transmitter (for high SNR) can lead to:
 - Concerns of eye safety
 - Excessive power consumption

Spread Spectrum LANs

- ❖ "Spread Spectrum" technique is a form of coding for wireless communication
- ❖ Advantages of "Spread Spectrum":
 - Jamming is difficult
 - Interception is difficult
 - Reception quality is good
- ❖ Uses a pseudorandom spreading code
- ❖ Techniques:
 - Frequency-hopping (FHSS)
 - Direct-sequence (DSSS)
- ❖ Topologies: Hub, Peer-to-peer
- ❖ Spectrum: ISM microwave frequency bands

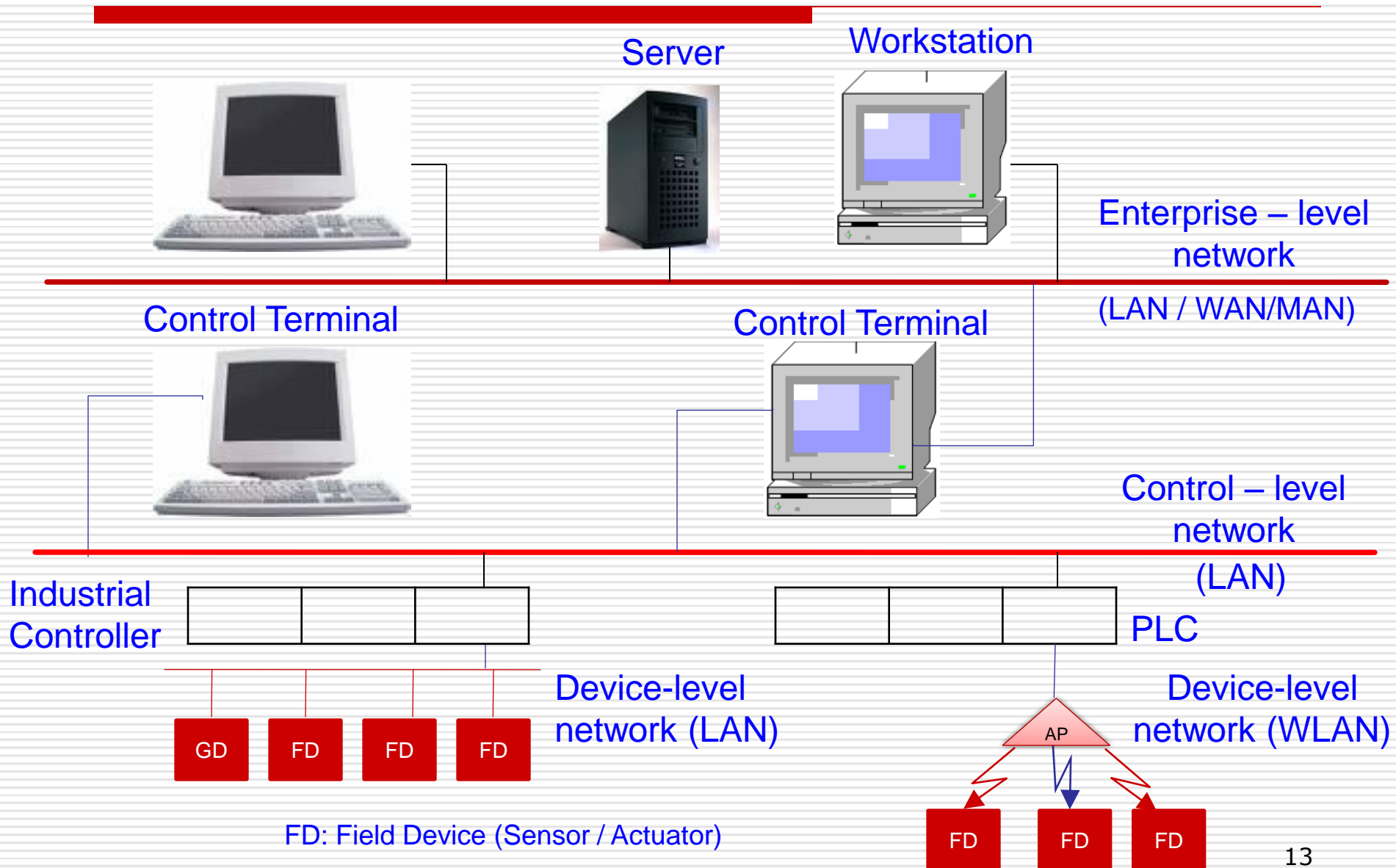
ISM Frequency Bands

- ❖ License-free microwave frequency bands
- ❖ For Industrial, Scientific and Medical purposes
- ❖ Only low-power transmissions (upto 1W) allowed
- ❖ Three ISM bands:
 - ISM-900: A frequency band around 900 MHz
 - ISM-2.4: A frequency band between 2.4 & 2.5 GHz
 - ISM-5: A frequency band a little above 5 GHz
- ❖ ISM-900 Band: 900 MHz devices are least expensive
- ❖ ISM-2.4 Band: Most widely used ISM band
- ❖ ISM-5 Band: Uncluttered as 5GHZ devices are most expensive.

Wireless Sensor Network (WSN)

- ❖ WSN is a radio-frequency (wireless) network of sensor nodes
- ❖ Application areas of WSN:
 - Sensor at inaccessible or difficult-to-access locations
 - Sensors are mobile or nomadic
 - Quick deployment
 - Ad-hoc networking
- ❖ WSN principles also apply to Wireless Sensor and Actuator Networks (WSANs) and other wireless networks of field devices.

Industrial Networks



Important WLAN Technologies/Protocols

Business Network
Protocols

Industrial Network Protocols

1. WiFi/IEEE 802.11
2. Bluetooth
3. Zigbee/IEEE 802.15.4
4. Wireless Fieldbuses

Zigbee/IEEE 802.15.4

- ❖ Zigbee technology addresses needs of industrial measurement and control (automation)
- ❖ Promoted by Zigbee Alliance, a consortium of 150+ companies
- ❖ Includes Honeywell, Motorola, Phillips, Samsung, Mitsubishi
- ❖ Zigbee conforms to IEEE 802.15.4 standard
- ❖ IEEE 802.15.4 is “Low-Rate Wireless PAN Standard”
- ❖ IEEE 802.15.4 defines only Physical and MAC layers
- ❖ Zigbee supports networking of fixed, portable and moving devices.

Zigbee Technology

- ❖ Developed to meet special requirement of wireless sensor and actuator networks, namely
 - Low bandwidth
 - Low latency
 - Long battery life
 - High data security

- ❖ Not attractive for business communication networks because of low data rate.

Main Features of Zigbee

- ❖ Data rates: 20, 40 & 250 Kbps
- ❖ Topologies: Star, Mesh, Cluster tree
- ❖ MAC logic: CSMA/CA
- ❖ Device addressing: Dynamic
- ❖ Frequency bands
 - ISM-900: 2 MHz channel BW, 20 & 40 kbps
 - ISM-2.4: 5 MHz channel BW, 250 kbps
- ❖ Transmission technique: DSSS
- ❖ Transmitter power: 1 mw or more
- ❖ Range: 10 m or more

IEEE 802.15.4 Specified Devices

Standard specifies 2 type of devices:

➤ Full-Function Device (FFD)

- Can talk to any other device
- Can perform job of Network (or PAN) Coordinator
- Can also function as a normal device

➤ Reduced-Function Device (RFD) or Normal Device

- Can function only as an end device (terminal node)
- Can talk only to Network Coordinator
- Can't function as Network Coordinator
- Simpler in design than FFD

Network (PAN) Coordinator

- Initiates all network communications
- Can communicate directly with any device
- Transmits beacon in becoming system for periodic data transfers
- There is only one node in a network functioning as the Network Coordinator

IEEE 802.15.4 MAC Protocol

- ❖ MAC protocol is Carrier Sense Multiple Access/ Collision Avoidance (CSMA/CA)
- ❖ Collision is avoided by a node attempting to transmit on the given channel
- ❖ If the channel is sensed busy, transmission is deferred by the node for a random interval, which reduces probability of collisions
- ❖ MAC protocol supports 2 network topologies:
 - Star topology
 - Mesh (peer-to-peer) topology
- ❖ MAC protocol has flexibility to handle 3 types of data transfers

Types of Data Transfers

1. Periodic Data Transfer

- Beacons system to handle data
- Beacon sent by Network Coordinator periodically
- Period can vary from 15.36 ms to 15.36×2^{14} ms \cong 4 min
- Period is a trade off between message latency and power consumption
- Device wakes up, sends data if any, and then goes back to sleep mode

2. Intermittent Data Transfer

- Network coordinator sends message as and when necessary
- Beaconless mechanism
- Device sleeps most of time, so it is power saving mode

3. Low-Latency Data Transfer

- Guaranteed time slot (GTS) system
- Network coordinator allots certain time to the device to transmit its data without contention

IEEE 802.15.4 MAC Frame

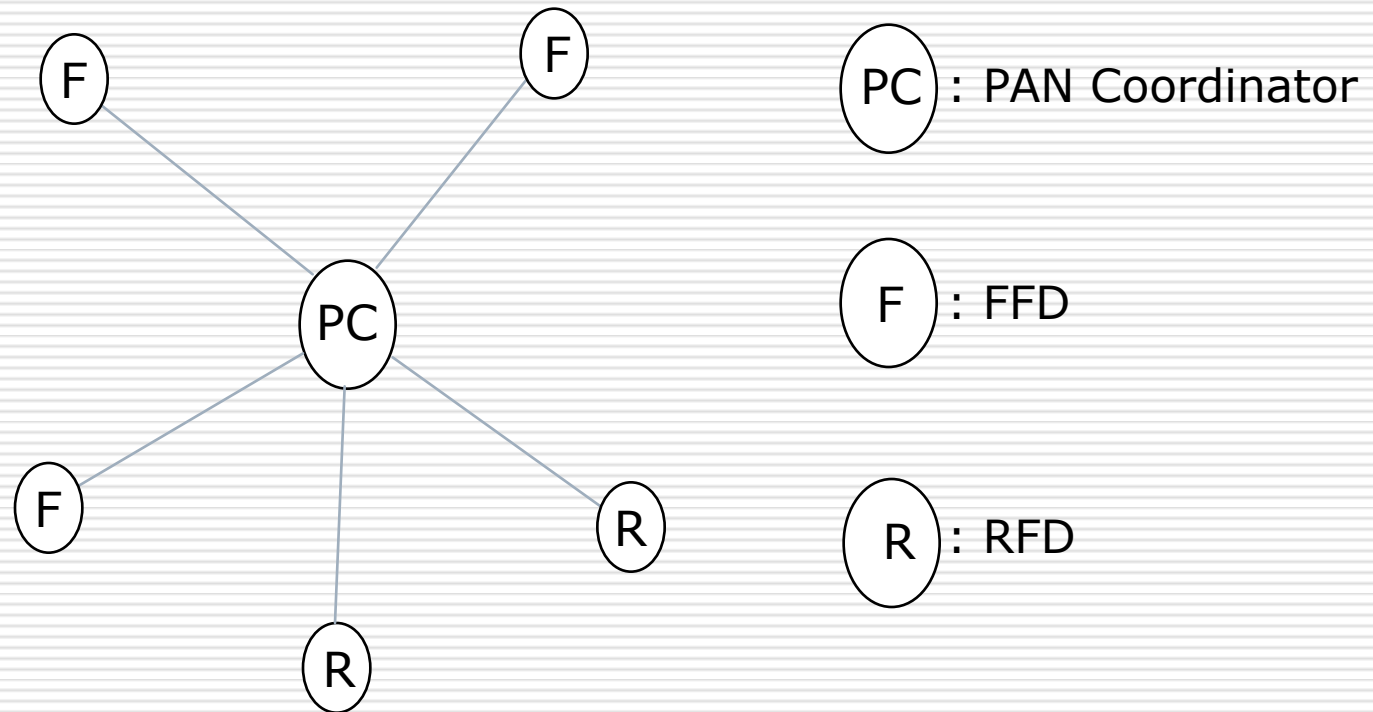
❖ Types of MAC frames:

- Data frame
- Beacon frame
- Acknowledgement frame
- MAC command frame

❖ General format of MAC frame

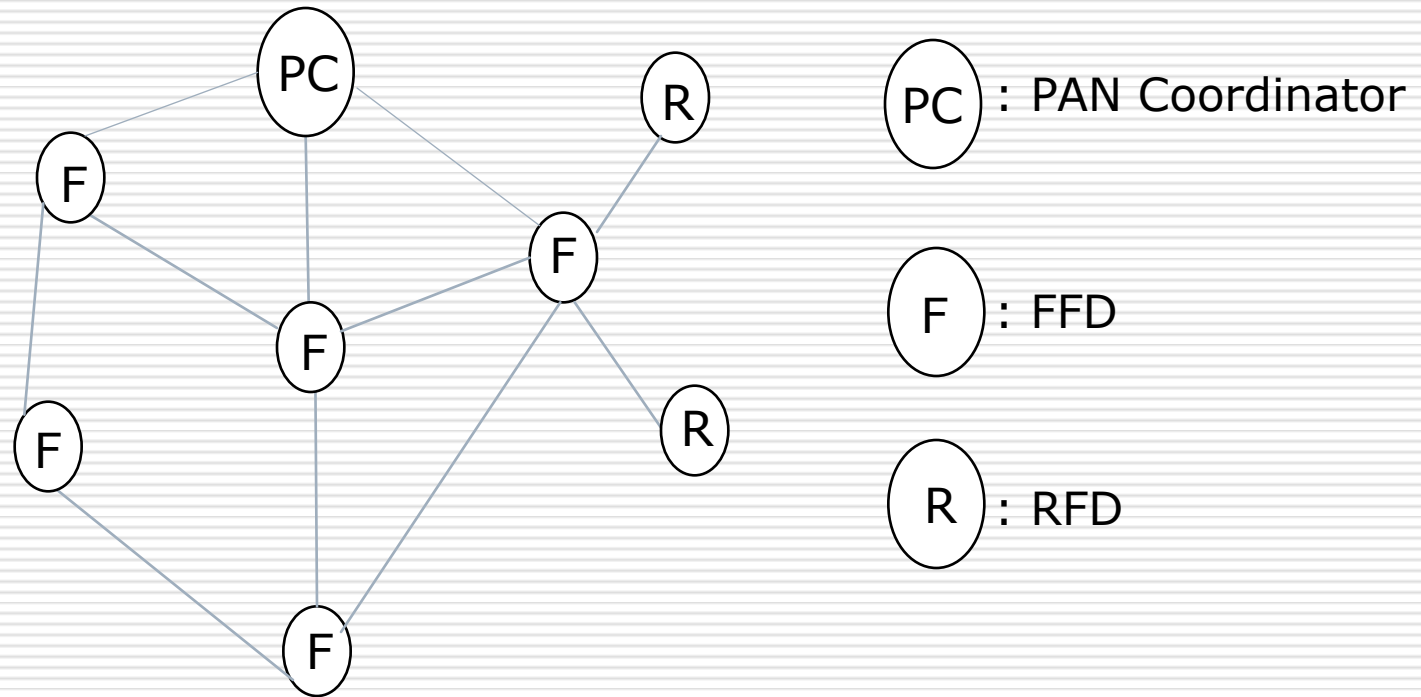


Zigbee Star Topology



- ❖ PAN Coordinator (PC) forms central node
- ❖ Each other node can be either FDD or RFD.

Zigbee Mesh (Peer-to-Peer) Topology



- ❖ Every node in the mesh is connected to each of other nodes
- ❖ All nodes in the mesh are FFDs
- ❖ One of FFDs is configured as PAN Coordinator (PC)
- ❖ RFDs can be connected as end devices to a node in the mesh.

Advantages and Limitations of Zigbee

❖ Advantages of Zigbee

- Low latency
- Low complexity
- Low message overhead
- Low power requirement
- Low cost

❖ Limitations of Zigbee

- Low data rate
- Small range

WiFi/IEEE 802.11

- ❖ WiFi means Wireless Fidelity (Technology/Protocol)
- ❖ WiFi provides wireless internet access in neighbourhood
- ❖ IEEE 802.11 is “Wireless LAN Standard”
- ❖ WiFi Alliance (formed in 1999) promotes IEEE 802.11 standard
- ❖ Earlier called “Wireless Ethernet Compatibility Alliance”
- ❖ It Certifies 802.11 products for interoperability
- ❖ IEEE 802.11-1997 (original)
- ❖ IEEE 802.11a-1999
- ❖ IEEE 802.11b-1999
- ❖ IEEE 802.11g-2002

IEEE 802.11: Scope & Keypoints

↑ MAC layer ↓	Point coordination function (PCF)					
	Distributed coordination function (DCF)					
↑ Physical layer ↓	IR	2.4 GHz	2.4 GHz	5 GHz	2.4 GHz	2.4 GHz
	850-950 nm	FHSS	DSSS	OFDM	DSSS	DSSS/OFDM
	1, 2 Mbps	1, 2 Mbps	1, 2 Mbps	6-54 Mbps	5.5, 11 Mbps	6-54 Mbps
	IEEE 802.11 (original)			IEEE802.11a	IEEE802.11b	IEEE802.11g

IEEE 802.11 MAC

- ❖ MAC algorithm specified is DFWMAC (Distributed Foundation Wireless MAC)
- ❖ DCF sub-layer
 - Uses contention logic (CSMA logic)
 - Provides access service to all users
- ❖ PCF sub-layer
 - Uses contention-less logic (polling by master, called point coordinator)
 - Built on top of DCF
 - Optional (depends on traffic needs)
 - Provides access service to the users with time-critical traffic

IEEE 802.11 MAC Frame

- ❖ General format for data and control frames
- ❖ Contains 9 fields
- ❖ Some fields are optional depending on the context

Octets 2 2 6 6 6 2 6 0-2312 4

Frame control	Duration/ connection ID	Address	Address	Address	Sequence control	Address	Frame body	Frame check sequence
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Bluetooth

- ❖ Bluetooth technology conceived in 1994
- ❖ Developed as robust, secure, short-range wireless communication protocol
- ❖ Industry standard for office and home environments
- ❖ Supported by Bluetooth Special Interest Group (SIG) setup in 1998
- ❖ Bluetooth SIG has 9 members:
 - Ericson, Nokia, IBM, Intel, Microsoft, Lucent, 3 COM, Motorola and Toshiba
- ❖ Now more than 2500 Bluetooth Adopters

Key Features

- ❖ Ad-hoc-network technology
- ❖ Protocol supports both voice and data communication
- ❖ Frequency band: ISM-2.4 GHz
- ❖ Transmission method: FHSS
- ❖ Frequency Hopping: BW split into 79 hops
1600 hops/s
- ❖ Each hopping frequency displaced by 1 MHz
- ❖ Some countries use smaller number of hops
- ❖ Modulation method: GFSK
 - '1' represented by positive frequency deviation of 150 kHz
 - '0' represented by negative frequency deviation of 150 kHz
- ❖ Transmission rate: upto 1 Mbps

Power and Range

- ❖ Three power classes (transmitter powers) specified
 - Class 1: 100 mW or 20 dBm
 - Class 2: 2.5 mW or 4 dBm
 - Class 3: 1 mW or 0 dBm

- ❖ Ranges specified
 - Class 1: 100 m (extended range devices)
 - Class 2: 10 m (normal range devices)
 - Class 3: 10 cm (short range devices)

Message Packet

- ❖ Small packet size
- ❖ Packet has 3 fields



- ❖ Access code
 - For timing synchronization, paging, inquiry etc.
- ❖ Header
 - For packet numbering, packet acknowledgement, slave address, flow control etc.
- ❖ Payload
 - Voice or data or both, includes payload header and payload error check bits

Bluetooth Products

- ❖ Laptops PCs
- ❖ Printers
- ❖ Cellular phones
- ❖ PDAs
- ❖ Watches
- ❖ Wireless headsets
- ❖ Cameras
- ❖ Etc.

Merits & Limitations

❖ Merits

- Low power consumption
- Secure connection
- Low cost
- Ease of use
- Globally acceptable specifications
- Wide range of devices

❖ Limitations

- Low data rate
- Small range (piconets)
- Short packets