6.1 WiFi: 802.11 Wireless LANs

📌 Definition

WiFi is a **wireless networking technology** that allows devices to connect to the internet without cables using **radio waves**.

◆ Key Points

- Based on **IEEE 802.11 standard**
- Works in **2.4 GHz and 5 GHz bands**
- Used in homes, offices, cafes, airports
- Provides **Wireless LAN (WLAN)**

◆ Real-Life Example

- Connecting your phone or laptop to **home WiFi router**

◆ Simple Diagram

```
[Internet] → [Router/AP] → ((( Wireless Signals ))) → [Laptop / Mobile]
```

📊 Important Table

Feature	WiFi (802.11)
Type	Wireless LAN
Range	~20–100 meters
Frequency	2.4 GHz / 5 GHz
Speed	High (varies by version)

📌 Summary

WiFi enables **wireless internet access** using radio signals within a limited range.

❓ Exam Questions

1. What is WiFi and how does it work?
2. What is IEEE 802.11 standard?
3. List advantages of WiFi.
4. Explain WiFi architecture briefly.
5. Where is WiFi used in real life?

◆ 6.1.1 The 802.11 Wireless LAN Architecture

📌 Components

- **Station (STA)** → Devices (mobile, laptop)
- **Access Point (AP)** → Connects wireless devices to network
- **Basic Service Set (BSS)** → Group of devices connected to one AP
- **Extended Service Set (ESS)** → Multiple APs connected together

---

◆ Types of Architecture

1. Infrastructure Mode

- Uses Access Point
- Most common

```
[Mobile] → AP → Internet
```

2. Ad-hoc Mode

- No AP
- Devices connect directly

```
[Device] ↔ [Device]
```

📌 Summary

Architecture defines how **devices connect and communicate** in WiFi networks.

❓ Exam Questions

1. What is BSS and ESS?
2. Difference between Infrastructure and Ad-hoc mode
3. Role of Access Point
4. Define Station (STA)
5. Explain WiFi architecture with diagram

◆ 6.1.2 The 802.11 MAC Protocol

📌 Definition

MAC protocol controls how devices **share wireless channel**.

◆ Key Concept: CSMA/CA

(Carrier Sense Multiple Access with Collision Avoidance)

Steps:

1. Device listens to channel
2. If free → send data
3. If busy → wait
4. Use random backoff time

◆ Why needed?

- Wireless cannot detect collision easily
- So it **avoids collision instead of detecting**

📌 Simple Diagram

```
Device → Check Channel → Send / Wait → Random Delay → Send
```

📌 Summary

MAC protocol ensures **efficient and fair data transmission** in wireless networks.

❓ Exam Questions

1. What is CSMA/CA?
2. Why collision detection is difficult in wireless?
3. Steps of MAC protocol
4. What is backoff time?
5. Difference between CSMA/CD and CSMA/CA

◆ 6.1.3 The IEEE 802.11 Frame

📌 Definition

A frame is a **data packet structure** used in WiFi communication.

◆ Frame Structure

```
| Frame Control | Duration | Address | Data | CRC |
```

◆ Important Fields

- **Frame Control** → Type of frame
- **Address** → Source & destination
- **Data** → Actual message

- **CRC** → Error checking

📌 Summary

802.11 frame carries **data + control information** for communication.

❓ Exam Questions

1. What is a frame?
2. Explain 802.11 frame structure
3. What is CRC?
4. Role of frame control field
5. Types of frames in WiFi

◆ 6.1.4 Mobility in the Same IP Subnet

📌 Concept

Device can **move within same network** without changing IP address.

◆ Example

- Moving inside a university campus
- Switching between different WiFi access points

◆ Process (Handoff)

1. Device detects weak signal
2. Connects to new AP
3. Keeps same IP address

📌 Diagram

```
AP1 ---- AP2 ---- AP3
  ↑       ↑
Mobile moves without IP change
```

📌 Summary

Mobility allows **continuous connection** while moving in same network.

❓ Exam Questions

1. What is mobility?
2. What is handoff?
3. Explain mobility in same subnet
4. Why IP does not change?
5. Give real-life example

🔷 6.1.5 Personal Area Networks: Bluetooth

📌 Definition

Bluetooth is a **short-range wireless technology** used for device-to-device communication.

🔷 Features

- Range: **~10 meters**
- Low power consumption
- Used for small devices

◆ Uses

- Wireless headphones
- File sharing
- Smart devices

📊 Table

Feature	Bluetooth
Range	Short (~10 m)
Speed	Low
Power Usage	Very Low
Type	PAN

📌 Summary

Bluetooth is used for **short-distance communication between devices**.

❓ Exam Questions

1. What is Bluetooth?
2. Advantages of Bluetooth
3. Difference between WiFi and Bluetooth
4. Applications of Bluetooth
5. What is PAN?

◆ 6.2 Cellular Networks: 4G and 5G

📌 Definition

Cellular networks provide **mobile communication over large areas** using cell towers.

◆ 4G vs 5G Comparison

Feature	4G	5G
Speed	10–100 Mbps	100 Mbps–1 Gbps+
Latency	30–50 ms	1–10 ms
Devices	Limited	Massive (IoT support)
Technology	LTE	Beamforming, mmWave
Coverage	Wide	Limited (high frequency)

◆ Real-Life Example

- 4G → Normal mobile internet
- 5G → Self-driving cars, smart cities

📌 Summary

5G is faster, smarter, and supports **future technologies**, while 4G is still widely used.

❓ Exam Questions

1. What is cellular network?
2. Difference between 4G and 5G
3. What is latency?
4. Applications of 5G
5. Why 5G is better than 4G?

🎯 FINAL QUICK REVISION POINTS

- WiFi → Local wireless network
- 802.11 → WiFi standard
- MAC → Controls channel access
- Frame → Data structure
- Mobility → Move without disconnect
- Bluetooth → Short-range PAN

- 4G vs 5G → Speed + latency improvement

6.1 WiFi: 802.11 Wireless LANs

📌 Definition

WiFi (Wireless Fidelity) is a **wireless communication technology** that allows devices to connect to a network or the internet using **radio waves** instead of cables.

◆ Key Features

- Based on **IEEE 802.11 standards**
- Operates in **2.4 GHz and 5 GHz frequency bands**
- Provides **Wireless Local Area Network (WLAN)**
- Supports mobility and flexibility
- Easy installation (no wiring needed)

◆ Advantages

- Mobility (use anywhere within range)
- Cost-effective (no cables)
- Easy to install and expand

◆ Limitations

- Limited range (~20–100 m)
- Security risks (hacking if not secured)
- Interference from other devices

◆ Real-Life Example

- Using WiFi at home, office, café, airport

📌 Summary

WiFi enables **wireless internet access within a limited area** using radio signals.

◆ 6.1.1 The 802.11 Wireless LAN Architecture

📌 Basic Components

1. **Station (STA)**
   - Any wireless device (mobile, laptop)
2. **Access Point (AP)**
   - Connects wireless devices to wired network/internet
3. **Basic Service Set (BSS)**
   - Group of devices connected to one AP
4. **Extended Service Set (ESS)**
   - Multiple APs connected together (large network)

◆ Types of Architecture

1. Infrastructure Mode (Most Common)

- Uses Access Point
- Centralized communication

```
[Mobile] → AP → Internet
```

---

2. Ad-hoc Mode

- No Access Point
- Devices communicate directly

```
Device ↔ Device
```

📌 Key Concept

- ESS allows **seamless movement between APs**

📌 Summary

802.11 architecture defines how **devices connect and communicate in a wireless network**.

◆ 6.1.2 The 802.11 MAC Protocol

📌 Definition

MAC (Medium Access Control) protocol controls how devices **share the wireless channel**.

◆ Main Technique: CSMA/CA

(Carrier Sense Multiple Access with Collision Avoidance)

◆ Working Steps

1. Device listens to channel
2. If idle → transmit data
3. If busy → wait
4. Random backoff time applied
5. Send data

◆ Why CSMA/CA (not CSMA/CD)?

- Wireless cannot detect collision easily
- So it **avoids collisions instead of detecting them**

◆ Additional Mechanisms

- **ACK (Acknowledgement)** → confirms data received
- **RTS/CTS (Request to Send / Clear to Send)** → reduces collision

---

📌 Simple Flow

```
Check Channel → Wait → Random Delay → Send → ACK
```

📌 Summary

MAC protocol ensures **efficient, fair, and collision-free communication** in wireless networks.

◆ 6.1.3 The IEEE 802.11 Frame

📌 Definition

A frame is the **data packet format used in WiFi communication**.

◆ Frame Structure

```
| Frame Control | Duration | Address | Data | CRC |
```

◆ Important Fields

- **Frame Control** → type (data/control/management)
- **Duration** → channel reservation time
- **Address Fields** → source, destination, AP

- **Data** → actual payload
- **CRC (Cyclic Redundancy Check)** → error detection

◆ Types of Frames

1. **Data Frames** → carry user data
2. **Control Frames** → manage communication (ACK, RTS, CTS)
3. **Management Frames** → connection setup (beacon, authentication)

📌 Summary

802.11 frames carry **data + control information** to ensure reliable communication.

◆ 6.1.4 Mobility in the Same IP Subnet

📌 Concept

Mobility allows a device to **move within the same network without changing its IP address**.

◆ Key Process: Handoff (Roaming)

Steps:

1. Device detects weak signal from current AP
2. Scans for new AP
3. Connects to stronger AP
4. Keeps same IP address

◆ Types of Handoff

- **Passive scanning** → listen to AP signals

- **Active scanning** → send probe request

◆ Example

- Moving in a university or office building with continuous WiFi

---

📌 Diagram

```
AP1 ---- AP2 ---- AP3
   ↑       ↑
Device moves smoothly
```

📌 Summary

Mobility ensures **continuous connection while moving inside the same network**.

◆ 6.1.5 Personal Area Networks: Bluetooth

📌 Definition

Bluetooth is a **short-range wireless communication technology** used for connecting personal devices.

◆ Features

- Range: **~10 meters**
- Low power consumption
- Low cost
- Works in **2.4 GHz band**

◆ Types of Networks

- **Piconet** → one master + multiple slaves
- **Scatternet** → multiple interconnected piconets

◆ Applications

- Wireless headphones
- File sharing
- Smart watches
- Car systems

📊 Comparison: WiFi vs Bluetooth

Feature	WiFi	Bluetooth
Range	20–100 m	~10 m
Speed	High	Low
Power Usage	High	Very Low
Use	Internet access	Device connection
Network Type	WLAN	PAN