# **55. Wireless Fundamentals**

## **Wireless LANs and Wi-Fi**

* This section focuses on **Wireless LANs** using **Wi-Fi**, though other types of wireless networks will be briefly covered.
* The **IEEE 802.11** standards define Wireless LANs.
* **Wi-Fi** is a trademark of the **Wi-Fi Alliance** and is not directly connected to IEEE.
* The **Wi-Fi Alliance** tests and certifies equipment for 802.11 standards compliance.
* **Wi-Fi** is commonly used to refer to 802.11 Wireless LANs and will be used throughout the course.

## **Wireless Networks**

Wireless networks have specific challenges that need to be addressed:

### **1) Broadcast Nature of Wireless Networks**

* **All devices** within range receive **all frames**, similar to devices connected to an Ethernet hub.
* **Data privacy** within the LAN is a greater concern.
* **CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance)** facilitates **half-duplex** communication.
* **CSMA/CD (Collision Detection)** is used in wired networks to detect and recover from collisions.
* **CSMA/CA** in wireless networks helps **avoid** collisions.
* When using **CSMA/CA**, a device waits for other devices to **stop transmitting** before it transmits data itself.

### **2) Regulation of Wireless Communications**

* Wireless communications are **regulated** by various **international** and **national** bodies.

### **3) Wireless Signal Coverage Area Considerations**

* **Factors affecting signal range**:
  + **Absorption**: Signal is weakened as it passes through materials.
  + **Reflection**: Signal bounces off surfaces, affecting reception.
  + **Refraction**: Signal bends when entering a medium with different transmission speed.
  + **Diffraction**: Signal bends around obstacles, potentially causing blind spots.
  + **Scattering**: Signal disperses in different directions due to particles or rough surfaces.

### **4) Interference from Other Devices**

* Other devices using the **same frequency channels** can cause **interference**, e.g., a neighbor’s Wi-Fi network.

## **Radio Frequency (RF) Principles**

* Wireless signals are transmitted by applying **alternating current** to an antenna, creating **electromagnetic waves**.
* **Electromagnetic waves** are measured using:
  + **Amplitude**: Maximum strength of electric and magnetic fields.
  + **Frequency**: Number of cycles per second (measured in Hertz, Hz).

**Frequency Units:**

* **Hz (Hertz)** = Cycles per second
* **kHz (Kilohertz)** = 1,000 cycles per second
* **MHz (Megahertz)** = 1,000,000 cycles per second
* **GHz (Gigahertz)** = 1,000,000,000 cycles per second
* **THz (Terahertz)** = 1,000,000,000,000 cycles per second
* **Visible frequency range**: ~400 THz to 790 THz
* **Radio frequency range**: 30 Hz to 300 GHz (used for various wireless applications)

## **Radio Frequency Bands**

### **Wi-Fi Uses Two Main Bands:**

1. **2.4 GHz Band** (2.400 - 2.4835 GHz)
   * Provides **longer range** and **better penetration** through obstacles.
   * More **prone to interference** due to many devices using this band.
2. **5 GHz Band** (5.150 - 5.825 GHz)
   * Divided into four smaller bands:
     + 5.150 - 5.250 GHz
     + 5.250 - 5.350 GHz
     + 5.470 - 5.725 GHz
     + 5.725 - 5.825 GHz
   * **Less interference** due to more available non-overlapping channels.
3. **Wi-Fi 6 (802.11ax)** introduces an **additional band** in the **6 GHz range**.

## **Wireless Channels**

* Each band is divided into **multiple channels**.
* Devices **transmit and receive** on one or more channels.
* **2.4 GHz Band**:
  + Channels have **22 MHz width**.
  + **Recommended channels** to avoid interference: **1, 6, and 11**.
* **5 GHz Band**:
  + Uses **non-overlapping channels**, reducing interference.
* **Channel Planning**:
  + **Larger WLANs** with multiple APs should avoid overlapping channels.
  + **Honeycomb pattern** ensures **full coverage** without interference.

## **Wi-Fi Standards (802.11)**

* **Wi-Fi** operates under **IEEE 802.11** standards, which have evolved over time.
* Different **802.11 versions** provide improved speed, range, and efficiency.

## **Service Sets in 802.11 Networks**

802.11 defines different **Service Sets** (groups of wireless network devices):

1. **Independent (IBSS)**: Devices connect **directly** without an AP (Ad-hoc network).
2. **Infrastructure (BSS)**: Devices connect via an **AP (Access Point)**.
   * APs are identified using **BSSID (Basic Service Set Identifier)**.
   * Clients associate with the **BSS** to communicate.
   * The **Basic Service Area (BSA)** defines the coverage area of an AP.
3. **Extended (ESS)**: **Multiple APs** connected via a **wired network**.
   * Each **BSS** in an ESS:
     + Uses the **same SSID**.
     + Has a **unique BSSID**.
     + Operates on **different channels** to avoid interference.