Wireless & Mobile Computing

First Semester 3rd Class

Lecture Two

2025/2024

Introduction

- The **electromagnetic spectrum** is the full range of electromagnetic radiation,
- organized by frequency or wavelength.
- The spectrum is divided into separate bands, with different names for the electromagnetic waves within each band.
- From low to high frequency these are:
- radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays. The electromagnetic waves in each of these bands have different characteristics.

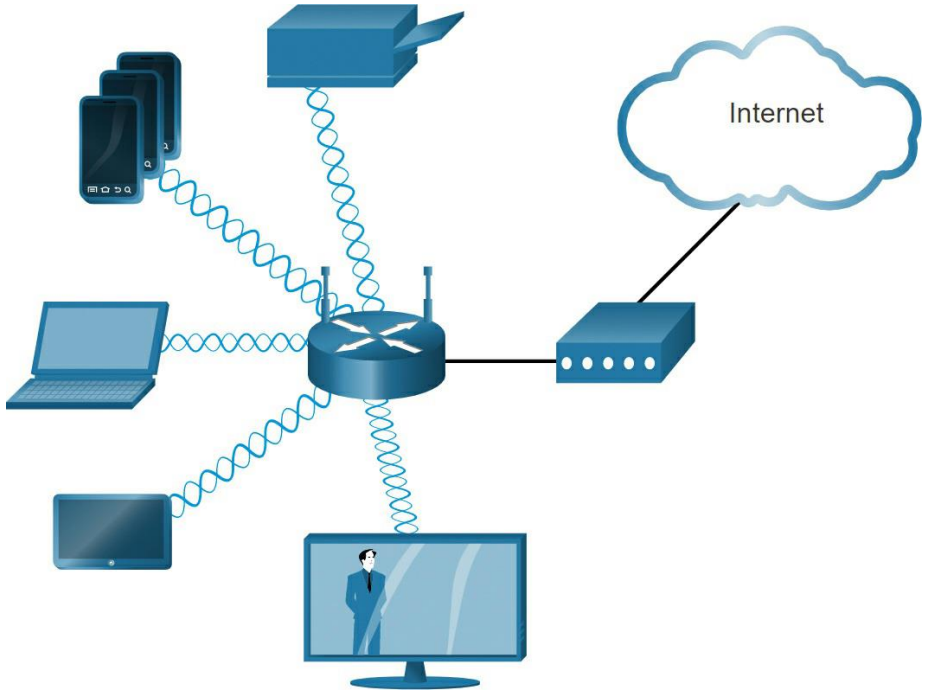
Introduction

- Types of Wireless Networks:
- Wireless networks are based on the Institute of Electrical and Electronics Engineers (IEEE) standards (*is an American 501 professional association for electronics engineering, electrical engineering, and other related disciplines*) and can be classified broadly into four main types:
- WPAN, Wireless Personal-Area Networks
- WLAN, Wireless LANs
- WMAN, and Wireless MANs (WMAN)
- WWAN Wireless Wide-Area Networks

Wireless Personal-Area Networks (WPAN): Uses low-powered transmitters for a short-range network, usually 20 to 30 ft. (6 to 9meters). Bluetooth and ZigBee based devices are commonly used in WPANs. WPANs are based on the 802.15 standard and a 2.4-GHz radio frequency.

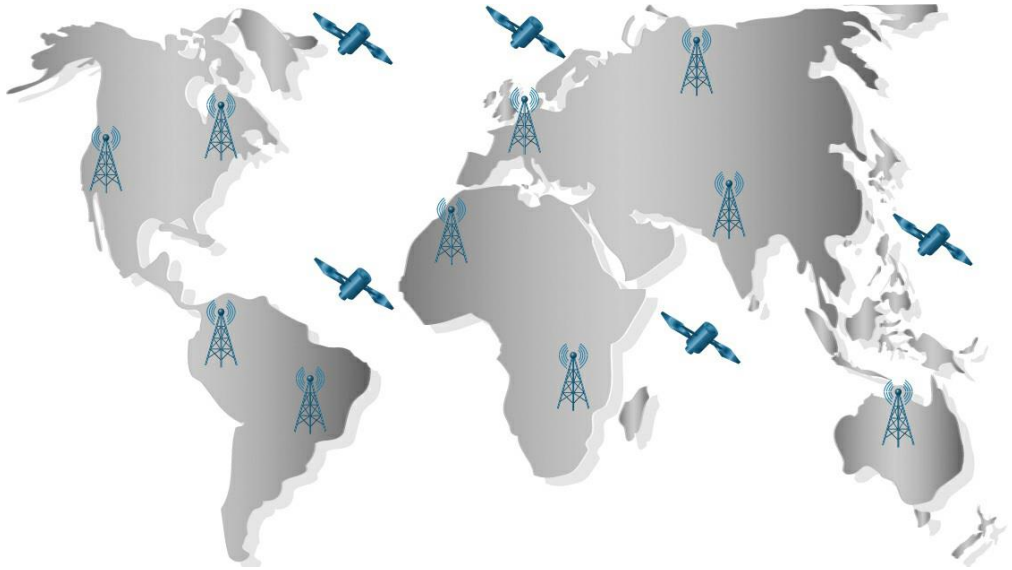
Introduction

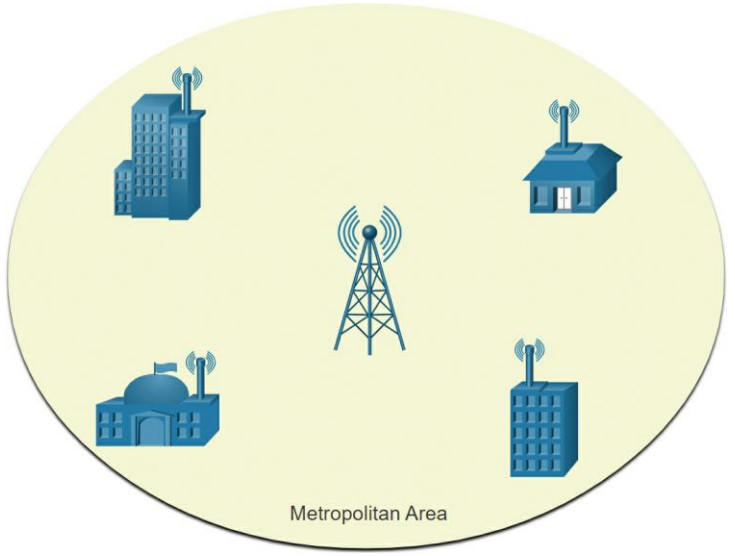
Wireless LANs (WLAN): Uses transmitters to cover a medium sized network (Figure), usually up to 300 feet. WLANs are suitable for use in a home, office, and even a campus environment.
WLANs are based on the 802.11 standard and a 2.4-GHz or 5-GHz radio frequency.



Introduction

- Wireless MANs (WMAN): Uses transmitters to provide wireless service over a larger geographic area. WMANs are suitable for providing wireless access to a metropolitan city or specific district. WMANs use specific licensed frequencies.
- Wireless Wide-Area Networks (WWANs): Uses transmitters to provide coverage over an extensive geographic area. WWANs are suitable for national and global communications. WWANs also use specific licensed frequencies.





Wireless Technologies

- Wireless technology uses the unlicensed radio spectrum to send and receive data. The unlicensed spectrum is accessible to anyone who has a wireless router and wireless technology in the device they are using.
- As devices become more interconnected, more data is transferred in between them via radio waves, and it is important to ensure that this does not cause interference.
- Licensed spectrum is a part of the electromagnetic spectrum assigned exclusively to mobile network operators (MNOs) for independent usage.
- Unlicensed spectrum is a part of the electromagnetic spectrum that can be assigned to or shared with anyone for non-exclusive usage, and it is subject to some regulatory constraints.

Wireless Technologies

- The amount of available data is increasing on a daily basis, and devices are becoming increasingly interconnected in an Internet of Things (IoT).
- These devices communicate with each other over wireless networks via radio waves, a type of electromagnetic radiation which transmits data from one location to another.
- Radio waves are measured via wavelength--the distance between two points in a wave--and frequency--the number of waves that pass a given point per second. The optimal frequency for most modern data communication is between 300 MHz and 6GHz.

Wireless Technologies

- All wireless technologies use radio waves to transmit and receive information, so frequency bands are needed in order for different technologies to use the airwaves at the same time.

Wireless Technologies

- The following describes some common wireless technologies:
- *1. Bluetooth:* An IEEE 802.15 WPAN standard that uses a device pairing process to communicate over distances up to 300 ft. (100m).
- It can be found in smart home devices, audio connections, automobiles, and other devices that require a short distance connection.
- There are two types of Bluetooth radios:

Wireless Technologies

- **Bluetooth Low Energy (BLE):**
- This supports multiple network technologies, including mesh topology to large scale network devices.
- **Bluetooth Basic Rate/Enhanced Rate (BR/EDR):**
- This supports point-to-point topologies and is optimized for audio streaming.
- *2. WiMAX (Worldwide Interoperability for Microwave Access):*
- WiMAX is an alternative to broadband wired Internet connections, competing with DSL and cable. However, it is typically used in areas that are not yet connected to a DSL or cable provider.
- It is an IEEE 802.16 WWAN standard that provides high-speed wireless broadband access of up to 30 miles (50 km).
- WiMAX operates in a similar way to Wi-Fi, but at higher speeds, over greater distances, and for a greater number of users. It uses a network of WiMAX towers that are similar to cell phone towers.
- WiMAX transmitters and cellular transmitters may share space on the same tower.
- In telecommunications, broadband or high speed is the wide-bandwidth data transmission.

Wireless Technologies

- *3. Cellular Broadband:* Cellular *4G/5G* are wireless mobile networks primarily used by cellular phones but can be used in automobiles, tablets, and laptops.
- Cellular networks are multiaccess networks carrying both data and voice communications.
- A cell site is created by a cellular tower transmitting signals in a given area.
- Interconnecting cell sites form the cellular network.
- The two types of cellular networks are
- Global System for Mobile (GSM) and
- Code Division Multiple Access (CDMA).
- GSM is internationally recognized, whereas CDMA is primarily used in the United States.

Wireless Technologies

- *4. The 4th Generation GSM network (4G):*
- is the current mobile network. 4G delivers speeds that are 10 times the previous 3G networks.
- The new *5G* holds the promise of delivering 100 times faster speeds than 4G and connecting more devices to the network than ever before.
- *5. Satellite Broadband:*
- Provides network access to remote sites through the use of a directional satellite dish that is aligned with a specific geostationary Earth orbit satellite.
- It is usually more expensive and requires a clear line of sight.
- Typically, it is used by rural homeowners and businesses where cable and DSL are not available.

802.11 Standards

- The 802.11 standards are defined by the Institute of Electrical and Electronics Engineers (IEEE) for implementing wireless local area network (WLAN) communication in various frequency bands.
- These standards include several versions, each providing improvements in speed, range, and efficiency.

802.11 Standards

- These standards define how radio frequencies are used for wireless links.
- Most of the standards specify that wireless devices have one antenna to transmit and receive wireless signals on the specified radio frequency (2.4 GHz or 5 GHz).
- Some of the newer standards that transmit and receive at higher speeds require wireless access points (APs) and wireless clients to have multiple antennas using the multiple-input and multiple-output (MIMO) technology.

802.11 Standards

- *multiple-input and multiple-output (MIMO)* technology. MIMO uses multiple antennas as both the transmitter and receiver to improve communication performance.
- Up to eight transmit and receive antennas can be used to increase throughput.

•Radio Frequencies

- All wireless devices operate in the radio waves range of the electromagnetic spectrum.
- WLAN networks operate in the 2.4 GHz frequency band and the 5 GHz band.
- Wireless LAN devices have transmitters and receivers tuned to specific frequencies of the radio waves range

802.11 Standards

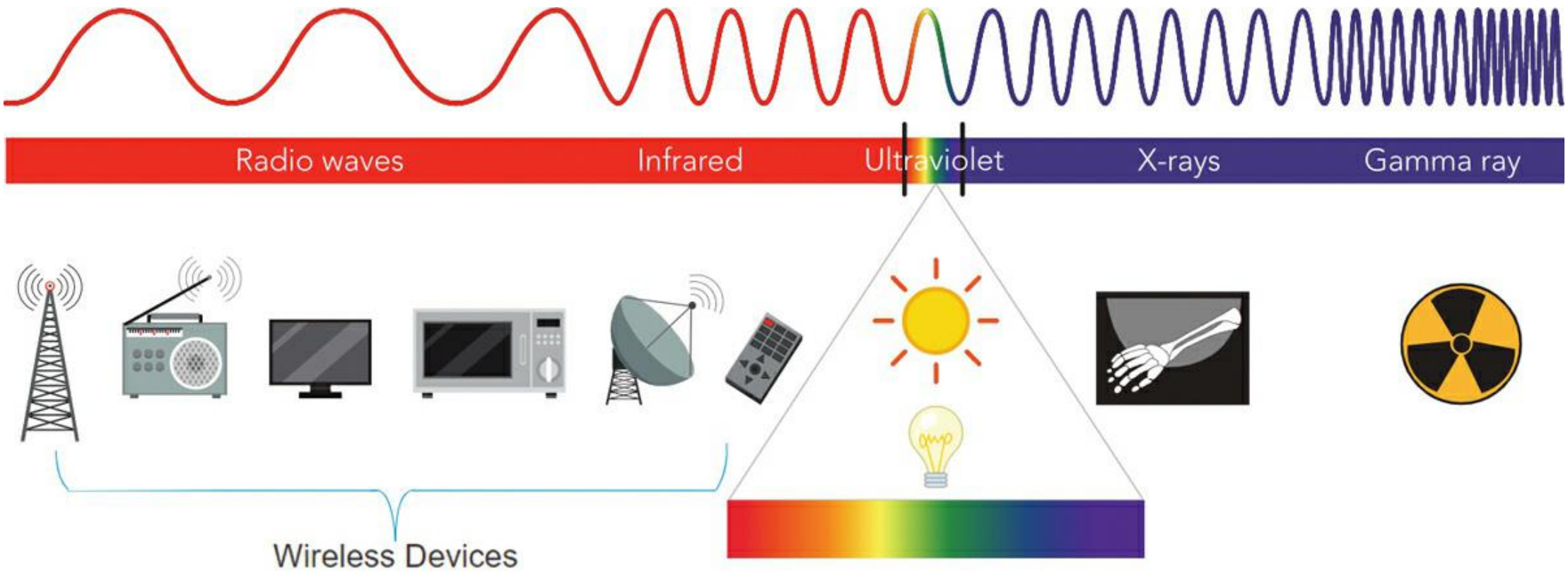
- Specifically, the
- following frequency bands are allocated to 802.11 wireless
- LANs:
- 2.4 GHz (UHF) - 802.11b/g/n/ax
- The 2.4 GHz frequency band, which falls under the Ultra High Frequency (UHF) range, is widely used for various wireless communication technologies.
- This includes Wi-Fi, Bluetooth.
- It's popular due to its ability to provide a good balance between range and data throughput.

1. License-Free
2. Ease of Setup.
3. Cost.

802.11 Standards

- 5 GHz (SHF) - 802.11a/n/ac/ax
- The 5 GHz frequency band falls under the Super High Frequency (SHF) range, which spans from 3 to 30 GHz.
- This band is often referred to as the centimeter band due to its wavelength being measurable in centimeters.
- The 5 GHz band is widely used for wireless communication technologies, including Wi-Fi, radar, and satellite communication.
- Compared to the 2.4 GHz band, the 5 GHz band offers higher data rates and less interference, but it has a shorter range.

802.11 Standards



Wireless Standards Organizations

- Standards ensure interoperability between devices that are made by different manufacturers.
- Internationally, the three organizations influencing WLAN standards are

1. The ITU-R,
2. The IEEE, and
3. The Wi-Fi Alliance

- The *International Telecommunication Union (ITU)* is a specialized agency of the United Nations responsible for many aspects of information and communication technologies (ICTs).
- It regulates the allocation of the radio frequency spectrum and satellite orbits through the ITU-R.
- ITU-R stands for the ITU Radiocommunication Sector.
- *The ITU-R (International Telecommunication Union Radiocommunication Sector) is one of the three sectors of the ITU, alongside ITU-T (Telecommunication Standardization Sector) and ITU-D (Telecommunication Development Sector).*
- *ITU-R is responsible for managing the international radio-frequency spectrum and satellite orbits to ensure interference-free operation of radiocommunication systems.*