Mobile and Wireless Technology

CT090-3-2-MWT Version VD01

Radio Frequency (RF) Fundamentals for WLAN

Topic & Structure of The Lesson

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- Radio Frequency (RF) Fundamentals for Wireless LAN Technology
- Frequencies Used for Wireless LANs
- Coverage and Capacity
- Basic Units of RF Measurement
- RF Range and Speed
- Environment: RF Behavior

Learning Outcomes

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At the end of this topic, You should be able to:

- Know the basic characteristics or properties of radio frequency.
- Be familiar with the frequencies used for wireless networks.
- Understand wireless network coverage and capacity.
- Know what RF factors will affect the range and speed of wireless networks.
- Identify basic RF units of measurement.

Key Terms You Must Be Able To Use

- **If you have mastered this topic, you should be able to use the following terms correctly in your assignments and exams:**

Radio Frequency (RF)
Coverage
Capacity
Line of sight
Interference
Reflection
Refraction
Diffraction
Scattering
Absorption

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Radio Frequency Fundamentals for Wireless LAN

Radio frequency (RF) plays an **essential role in wireless LAN technology.**

What is Radio Frequency?

RF is a Radio Frequency, a electromagnetic wave.

Radio waves/Radio Frequency waves/Electromagnetic waves are passed through the air (which is the medium) and are used to get information from one wireless device to another.

Radio Frequency Fundamentals for Wireless LAN

How these Radio waves/Radio Frequency waves/Electromagnetic waves are generated?

High frequency alternating current (AC) signals passing over a copper cable connected to an antenna.

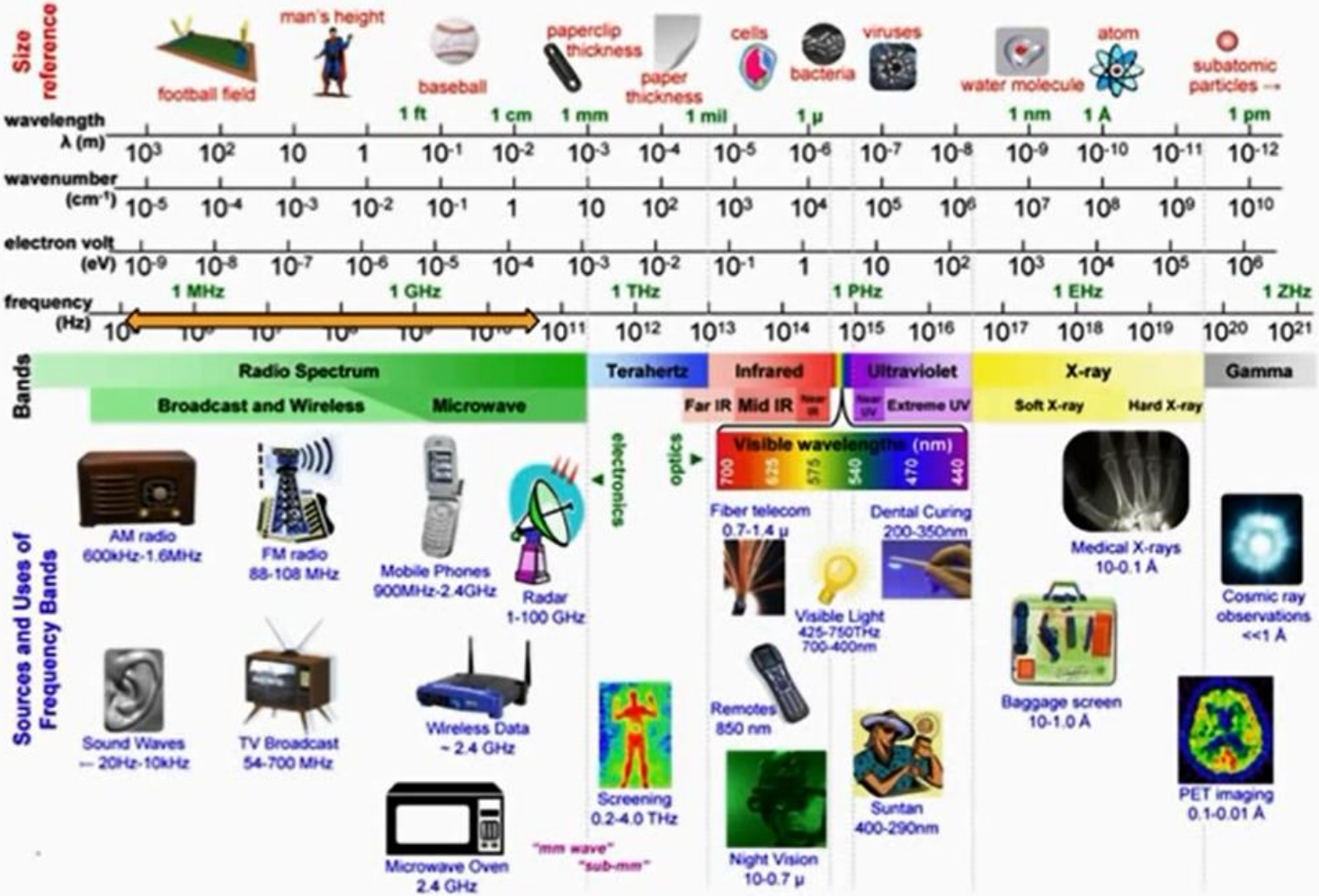
The antenna then transforms the signal into radio waves that propagate through the air from a transmitter to a receiver.

Radio Frequency Fundamentals for Wireless LAN

Radio frequency (RF) waves are used in a wide range of communications, including:

- Radio
- Television
- Cordless phones
- **Wireless LANs**, and
- Satellite communication.

RF is around everyone and everything, and comes in many forms. Radio waves range from 3Khz to 300 Ghz.


Size reference
football field
man's height
baseball
paperclip thickness
paper thickness
cells
bacteria
viruses
water molecule
atom
subatomic particles
wavelength λ (m)
wavenumber (cm-1)
electron volt (eV)
frequency (Hz)
1 ft
1 cm
1 mm
1 mil
1 µ
1 nm
1 Å
1 pm
1 MHz
1 GHz
1 THz
1 PHz
1 EHz
1 ZHz
Bands
Radio Spectrum
Broadcast and Wireless
Microwave
Terahertz
Infrared
Far IR
Mid IR
Ultraviolet
Extreme UV
X-ray
Soft X-ray
Hard X-ray
Gamma
Visible wavelengths (nm)
700
625
575
540
470
440
electronics
optics
Sources and Uses of Frequency Bands
AM radio
600kHz-1.6MHz
FM radio
88-108 MHz
Mobile Phones
900MHz-2.4GHz
Radar
1-100 GHz
Fiber telecom
0.7-1.4 µ
Dental Curing
200-350nm
Medical X-rays
10-0.1 Å
Cosmic ray observations
<<1 Å
Visible Light
425-750THz
700-400nm
Sound Waves
~ 20Hz-10kHz
TV Broadcast
54-700 MHz
Wireless Data
~ 2.4 GHz
Remotes
850 nm
Baggage screen
10-1.0 Å
Screening
0.2-4.0 THz
Suntan
400-290nm
PET imaging
0.1-0.01 Å
Microwave Oven
2.4 GHz
"mm wave"
"sub-mm"
Night Vision
10-0.7 µ

Radio Frequency Fundamentals for Wireless LAN

RF spectrum is governed by local regulatory bodies.

Location	Regulation
Malaysia and Multimedia	**Malaysian Communications Commission(MCMC)**
Canada	ISC RSS-210
China	RRL/MIC Notice 2003-13
Europe	(ETSI) ETS 300.328
	ETS 301.893
Israel	MOC
Japan (MKK)	TELEC 33B
	TELEC ARIB STD-T71
Singapore	IDA/TS SSS Issue 1
Taiwan	PDT
USA	FCC (47 CFR) Part 15C, Section 15.247
FCC	FCC (47 CFR) Part 15C, Section 15.407

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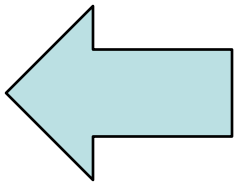
- **Frequencies Used for Wireless LANs**
- Coverage and Capacity
- Basic Units of RF Measurement
- RF Range and Speed



Frequencies used for Wireless LAN

The **Wireless LAN (IEEE 802.11)** standard addresses the 2.4 GHz ISM band and the 5 GHz UNII bands.

The 2.4 GHz ISM band allows for 11 of 14 channels to be used for wireless LAN communications.

The 5 GHz UNII band consists of three bands utilizing four frequency ranges.

The three bands are:

- UNII-1, the lower band;
- UNII-2 and
- UNII-2e

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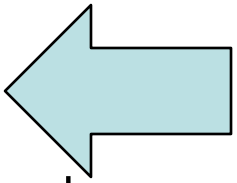

Coverage and Capacity

Coverage and capacity are two key factors to take into consideration when designing and implementing an IEEE 802.11 wireless LAN.

During the design phase of an IEEE 802.3 Ethernet wired network, the design engineer will take capacity into consideration, verifying and validating that there are enough capacity switches, ports, etc., for the user base of the network.

Coverage and Capacity

The term *coverage* has different meanings depending on the context in which it used.

For example, if you buy a gallon of paint, the label will specify the approximate coverage area in square feet.

If one gallon of paint covers 300 square feet and the room you wish to paint is 900 square feet, simple math shows at least three gallons of paint would be needed to effectively cover the room.

Coverage and Capacity

The concept is similar in IEEE 802.11 wireless networks.

However, unlike with paint, there is no simple rule that determines how much space an access point will cover with the RF energy it is transmitting.

This coverage will depend on many factors, some of which include:

- Size of area
- Number of users
- Applications in use
- Obstacles, propagation and Radio Frequency Range
- WLAN Hardware and Output Power

Coverage and Capacity

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1. Size of area –

- The amount of area an access point will cover.
- Manufacturer (ASUS/TPLINK) of wireless LAN hardware will not commit to the amount of area an access point will cover.
- A site survey of the area will help determine the coverage area of an access point.

2. Number of users –

- The number of users in an area will also affect the RF coverage.
- Too many users using powerful applications will overload the access point, adding to the poor performance issues.

Coverage and Capacity

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3. Applications in Use –

- The **application types in use** - either software or **hardware - can affect the bandwidth of an access point.**

- If the users connected to an access point use bandwidth-intensive applications such as the Computer Aided Design and Manufacturing (CAD/CAM) application, this could result in poor throughput for all users connected to that access point.

Coverage and Capacity

4. Obstacles, Propagation and Radio Frequency Range

- Obstacles in an area, such as **walls, doors, windows, and furnishings**, as well as the physical properties of these **obstacles - thickness of the walls and doors, density of the windows, and type of furnishings - can also affect coverage.**

- The radio frequency used - either 2.4 GHz or 5 GHz - will determine how well a signal will propagate and handle an obstacle.

Coverage and Capacity

5. WLAN Hardware and Output Power

- The wireless LAN hardware in use can also have an impact on the coverage area.
- Examples include the antenna type, antenna orientation, and gain of the antenna.
- The higher the gain of an antenna, the greater the coverage area; conversely, the lower the gain of an antenna, the smaller the coverage area.
- The polarization of an antenna (horizontal vs. vertical) will also have an effect on the coverage area because of the different shapes of the radiation patterns.

Coverage and Capacity

5. WLAN Hardware and Output Power

- The output power of the transmitter or access point will also have an effect on coverage. The higher the output power, the greater distance a signal will propagate.
- A higher power signal will provide more coverage.

Coverage and Capacity

Just as an elevator or a restaurant has a limited number of people they can accommodate comfortably, wireless access points also have a capacity.

The capacity of an access point is how many users the AP can service effectively, offering the best performance.

This capacity depends on several factors, including:

- **Software applications in use**
- **Number of users**

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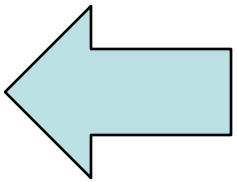

Basic Units of RF Measurement

A wireless access point may be set to an output of 30 mW (milliwatts) of power.

A milliwatt is 1/1000 of a watt.

Watts and milliwatts are measurements of RF power.

Other units of measurement for RF are dB, dBi, dBd, and dBm.

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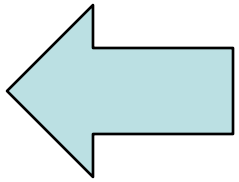

RF Range and Speed

How far and fast an RF signal can travel depends on a variety of factors, including

1. **line of sight,**
2. **interference,**
3. **Environment: RF Behavior**

RF communication between devices in 802.11 wireless networking requires a line of sight.

There are **two types of line of sight** to take into consideration: **visual and RF.**

RF Range and Speed – Line of Sight

RF communication between devices in 802.11 wireless networking requires a line of sight.

There are **two types of line of sight** to take into consideration: **visual and RF.**

RF Range and Speed – Line of Sight

***Visual line of sight* is the ability of the transmitter and receiver to see each other.**

In order for **wireless networking direct link communication to be successful** there **should be a clear, unobstructed view between the transmitter and receiver**.

An unobstructed line of sight means few or no obstacles blocking the RF signal between these devices.

RF Range and Speed – Line of Sight

The ***RF line of sight,*** **or the radio transmissions between a transmitter and receiver, could be affected if the total area of radio frequency transmissions(the Fresnel zone)is blocked by more than 40 percent.**

This blockage could be from a variety of sources **such as trees, buildings, terrain, or other obstacles,** including the curvature of the earth.

RF Range and Speed - Interference

Interference from a radio frequency point of view occurs when a receiver hears two different signals on the same or similar frequencies.

Interference causes distortion.

In wireless LANs, this interference can have a severe impact on the quality of signal received by the wireless device.

RF Range and Speed - Interference

IEEE 802.11 wireless network may use the unlicensed 2.4 GHz industrial, scientific, and medical (ISM) band. This band is also used for many other devices, including:

- Cordless phones
- Microwave ovens
- Medical devices
- Industrial devices
- Baby monitors

RF Range and Speed –Interference

a) Co-channel and Adjacent Channel Interference

Co-channel or adjacent channel interference occurs when two devices in the same physical area are tuned to a close or same radio frequency channel.

For example, an access point on channel 1 and another access point on channel 2 in close or hearing range of each other will experience adjacent channel interference.

RF Range and Speed - Interference

b) WLAN/WPAN Interference

The performance of IEEE 802.11 wireless networks can be affected when they are co located with IEEE 802.15 wireless personal area networks or WPANs.

Bluetooth is an example of a personal area network. Like 802.11, Bluetooth devices operate in the 2.4 GHz frequency range and use frequency hopping spread spectrum (FHSS).

RF Range and Speed - Interference

c) Bright Sunlight Interference

Bright sunlight will not affect wireless LAN communications that use the 2.4 GHz ISM and 5 GHz UNII bands;

RF Range and Speed - Environment

Environment: RF Behavior

RF behavior is the result of environmental conditions including:

1. Reflection
2. Refraction
3. Diffraction
4. Scattering
5. Absorption
6. Diffusion

RF Range and Speed - Environment

1. Reflection –

***Reflection* occurs when an RF signal bounces off a smooth, non absorptive surface such as a table top and changes direction.**

Reflections can affect indoor wireless LAN installations fairly significantly in certain cases. Depending on the interior of the **building—such as the type of walls, floors, or furnishings—there could be a large number of reflected signals.**

If not properly handled, reflections **could cause a decrease in throughput and poor network performance.**

RF Range and Speed - Environment

2. Refraction

When an RF signal passes between mediums of different densities, it may change speeds and also bend. This behavior of RF is called *refraction*. **Glass is an example of material that may cause refraction.**

When an RF signal comes in contact with an obstacle such as glass, the signal is refracted (bent) as it passes through and some of the signal is lost.

RF Range and Speed - Environment

3. Diffraction

When an RF signal passes an obstacle, the wave changes direction by bending around the obstacle. This RF behavior is called *diffraction*. A building or other tall structure could cause diffraction, as could a column in a large open area or conference hall.

When the signal bends around a column, building, or other obstacle, the signal weakens, resulting in some level of loss.

RF Range and Speed - Environment

4.Scattering

When an RF signal strikes an uneven surface, wave fronts of the signal will reflect off the uneven surface in several directions. This is known as *scattering*.

Scattering is another form of loss that may severely degrade the RF signal.

RF Range and Speed - Environment

5.Absorption

When material absorbs an RF signal, no signal penetrates through the material. An example of *absorption* is the human body.

The human body has a high water content and will absorb RF signals. This type of absorption can be a problem for wireless network deployments in certain environments.

Densely populated areas such as airports and conference halls need to consider absorption when designing a wireless LAN deployment.

Quick Review Question

- Coverage and capacity will depend on many factors. What are they? Explain each of them.

- How far and fast an RF signal can travel depends on a variety of factors. What are they? Explain each of them.

Summary of Main Teaching Points

This chapter looked at radio frequency basics and the essential role RF plays in the world of IEEE 802.11 wireless LANs. This chapter also looked at correct channel reuse to minimize interference from co-location of access points.

Coverage and capacity are two important areas that should be closely looked at in order to ensure a wireless deployment will offer reliable connectivity and perform well for the user base.

Finally, we discussed RF units of measure, including watt, milliwatt, dB, and dBi. We also looked at RF behaviors such as reflection, refraction, and absorption, and the impact of propagation on radio waves.

Question and Answer Session

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Q & A

What we will cover next

WLAN Terminology and Technology