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Key Terms You Should Know

Key terms in this chapter include

voltage, amperage, wattage, frequency, modulation, frequency modulation, carrier frequency, interference, coax, twisted pair, NEXT, FEXT, plenum, MTU, bus topology, CSMA/CD, star topology, repeater, punch-down tool, crossover, PoE, fiber optics, acceptance cone, wavelength, WDM, multimode, single-mode, attenuation, decibels, dispersion, WDM/D, OADM, ROADM, LC connector, ST connector, SC connector, FC connector, MPO connector, UPC, APC, pluggable interface, GBIC, SFP

Concepts and Actions

Review the concepts considered in this chapter using Table 7-7. You can cover the right side of this table and describe each concept or action in your own words to verify your understanding.

Table 7-7 Concepts and Actions for Review

Inductive reactance	The formation of a magnetic field as a signal travels through a wire, and the creation of an electrical signal when a wire is in a changing magnetic field
Two ways to reduce interference	Twisted pairs, shielding
FEXT	Far-end crosstalk; interference measured at the far end of the cable
NEXT	Near-end crosstalk; the amount of interference a cable can reject
Bus topology	All hosts are connected to a single long wire, generally coax
Star topology	Each host has a separate wire connecting to a central point, such as a hub, switch, or router
CSMA/CD	Carrier Sense Multiple Access with Collision Detection; method used by Ethernet to allow multiple hosts to share a single segment
RJ-45	Most common Ethernet twisted-pair connector
Wavelength	Length of a single cycle in a signal; related to the color of light
Single mode	Higher-powered light source and a smaller core
Multimode	Lower-powered light source and a larger core
OADM	Optical add/drop multiplexer, used to drop and add data channels at specific wavelengths or colors of light
LC connector	Little connector, used for high-density fiber-optic installations
ST	Straight tip fiber-optic connector
SC	Square connector, fiber-optic connector
FC	Ferrule connector, fiber-optic connector with a screw-down mechanical connection
UPC	Ultra physical connect, a flat optical connector that optimizes light transmission and reduces reflections
APC	Angled physical connect, an angled optical connector that directs reflected light away from the light source
SFP	Small form-factor pluggable router and switch interface
GBIC	Gigabit interface convertor, a larger form-factor pluggable interface

CHAPTER 8

Wireless Networks

This chapter covers the following exam topics:

3. Endpoints and Media Types

3.2 Differentiate between Wi-Fi, cellular, and wired network technologies.

Copper, including sources of interference; fiber; wireless, including 802.11 (unlicensed, 2.4GHz, 5GHz, 6GHz), cellular (licensed), sources of interference

While wired connectivity was the standard in the early years of computer networking, wireless connectivity is now how the majority of individual users connect their devices to the Internet. This chapter begins by exploring wireless transmission concepts. We then consider Wi-Fi, cellular, and satellite communications at a high level.

"Do I Know This Already?" Quiz

Take the quiz (either here or use the PTP software) if you want to use the score to help you decide how much time to spend on this chapter. Appendix A, "Answers to the 'Do I Know This Already?' Quizzes," found at the end of the book, includes both the answers and explanations. You can also find answers in the PTP testing software.

Table 8-1 "Do I Know This Already?" Foundation Topics Section-to-Question Mapping

Section	Questions
Free Space Concepts	1, 2, 3
Wi-Fi	4, 5, 6
Cellular	7, 8
Satellite	9

CAUTION The goal of self-assessment is to gauge your mastery of the topics in this chapter. If you do not know the answer to a question or are only partially sure of the answer, you should mark that question as wrong for purposes of the self-assessment. Giving yourself credit for an answer you incorrectly guess skews your self-assessment results and might provide you with a false sense of security.

1. How does beam forming create a directional signal?
   a. By physically blocking a wireless signal from traveling in some directions
   b. By turning the signal on and off in a specific pattern so the beam goes in only one direction

c. By combining signals from multiple antennas as they pass through the air

d. By bouncing signals off solid objects in the room to create a narrow pattern

2. What two characteristics of noise will cause greater interference when mixed with a signal?

a. Lower power and a frequency close to the signal's frequency

b. Higher power and a frequency farther away from the signal's frequency

c. Higher power and a frequency close to the signal's frequency

d. Lower power and a frequency farther away from the signal's frequency

3. What is the carrier of an electromagnetic signal?

a. The center frequency, or the frequency onto which the signal is modulated

b. The physical medium through which the signal is carried

c. The signaling mechanism carrying the data being pushed through the network

d. The physical wire carrying the signal

4. What organization defines and supports the Wi-Fi standards?

a. The Internet Engineering Task Force

b. The International Telecommunications Union

c. The World Wide Web Consortium

d. The Institute of Electrical and Electronics Engineers

5. What Wi-Fi device can extend the range of a Wi-Fi network signal?

a. Access point

b. Repeater

c. Backhaul network

d. Longer cables

6. What are the primary advantages of Wi-Fi for a network operator? (Select all that apply.)

a. It does not require configuration of any kind.

b. It operates in unlicensed spectrum.

c. It allows for centralized billing based on data usage.

d. It does not require extensive infrastructure.

7. What is the radio access network (RAN)?

a. The antenna and transmitter in a Wi-Fi network

b. The antenna and software on a cellular telephone or other cellular-connected device

c. A group of cellular towers and the transmitters, and the network connecting those cellular towers

d. The network connecting a cellular radio tower to the mobile core

8. What is the mobile core?

a. A set of cellular radio transmitters and towers that can be moved to improve reception when needed

b. A set of servers and software that authorize users, track user locations, and track cellular network usage

c. The network connecting the RAN to the Internet

d. The network connecting multiple MANs

9. What is the key advantage of a low Earth orbit (LEO) satellite system?

a. Shorter delay because the satellites are closer to the Earth

b. Shorter delay because the satellites forward traffic more quickly

c. Each satellite covers a larger part of the Earth than geosynchronous systems

d. Each satellite can transmit larger amounts of data than geosynchronous systems

Foundation Topics

Free Space Concepts

Transmitting signals through the air uses the same principles as transmitting signals through wires or optical fibers: there is still a carrier, and data is still modulated onto this carrier. The power levels and frequencies differ, but the ideas are the same.

To carry these ideas into the wireless space, we need to look at two additional concepts: wave propagation and wireless interference. The section on wave propagation below also includes a high-level description of a critical technology in the wireless space—beam forming.

Wave Propagation and Beam Forming

In most electrical circuits, we create a path for power to return to the transmitter, as Figure 8-1 shows.

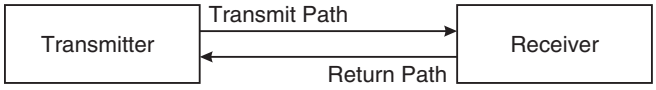

Figure 8-1 *Transmit and Return Paths in a Circuit*

What happens if you remove the return path, increase the power, and remove all the shielding? The wire turns into an antenna. Figure 8-2 illustrates the circuit path with free space radiation.

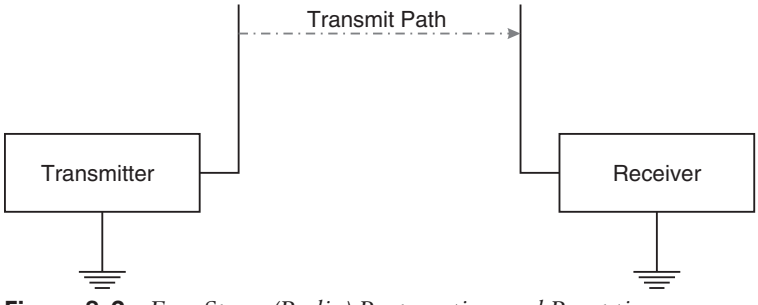

Figure 8-2 *Free Space (Radio) Propagation and Reception*

The signal power now flows from the transmitter through the antenna, into the air (or any other free space, including water and…space), and to the receiver's antenna. The signal causes small currents to flow in the receiver's antenna, which are then translated into the same kind of modulated signal transmitted through wired circuits.

What about the return path? In a way, the Earth itself is the return circuit. Both the transmitter and receiver are connected to the Earth as a ground, which acts like a big "sink," absorbing the return power from the transmission.

Signals dissipate as they pass through the air in various ways. Just traveling through the air uses up energy from the electromagnetic wave, but there are also objects like walls and raindrops to pass through.

Electromagnetic signals lose roughly half of their power for every wavelength they travel through the air, and more as they travel through various solids. Shorter wavelength, or higher frequency, signals lose power more quickly than longer wavelength, or lower frequency, signals.

The signal transmitted by an antenna is not uniform in space; it forms a wave. Figure 8-3 illustrates.

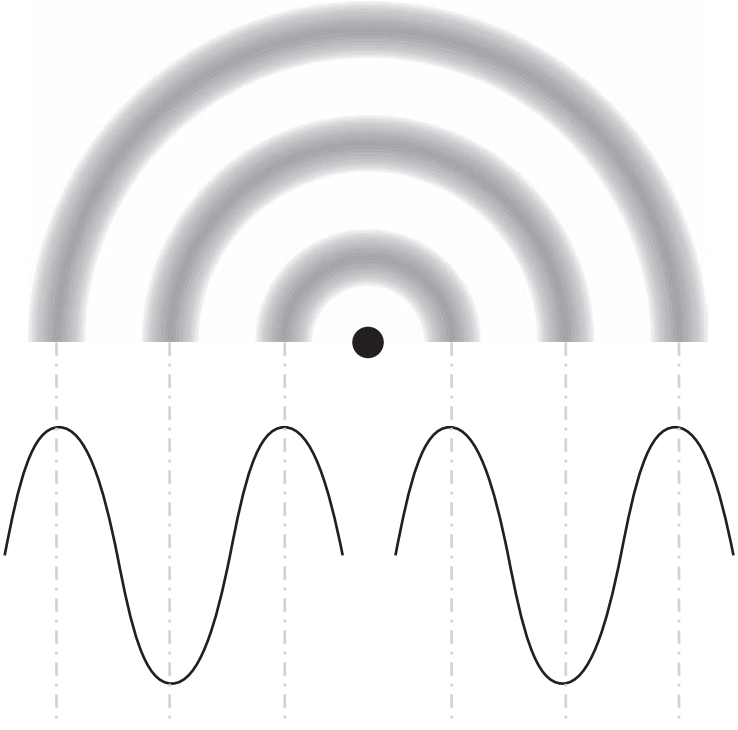

Figure 8-3 *Free Wave Propagation*

Figure 8-3 is what you would see if you

- Look down the antenna wire from the top (the black dot in the center of the image is the antenna wire).
- Cut out half of the signal (to create a space to show the wave). The signal would normally be a complete set of circles.
- Increase the darkness of the color as the signal becomes stronger.

The wave under the propagation illustration shows how the signal strength correlates with the changing power level. The electromagnetic wave is not fixed in space (it is not a *standing wave*), but the signal flows out from the antenna in waves, much like ripples in water. As the signal "washes over" a receiver's antenna, it creates small electrical currents the receiver then cleans up, amplifies, and finally turns into the signal the transmitter originally sent.

The white spaces in the signal are points where there is no power. If you put an antenna in one of the white spaces at just the right moment, it would not pick up any signal—at least until the following wave peak passes.

NOTE You can shape the signal by bending the wire into more complex shapes, but antenna theory is beyond the scope of this book.

Beam forming works by combining the signal from two (or more) different antennas, called a *phased array*, as shown in Figure 8-4.

Key Topic

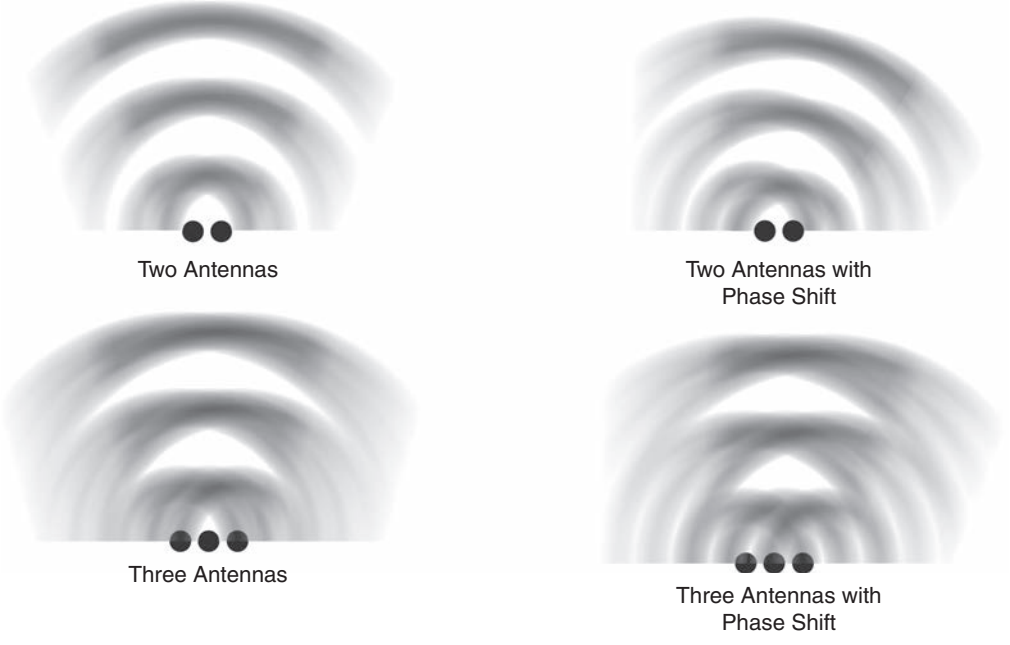

Figure 8-4 *Beam Formation with an Antenna Array*

On the upper left, you can see the darker spots directly above the antennas where the highest power points of the signals are added together, creating a single stronger signal. To either side of the two antennas, the signal is weaker.

Adding more antennas, as shown on the bottom left, increases this effect, allowing the antenna designer to create a narrow range of powerful signals with lower-powered signals on either side. With two antennas in the array, the effect is pronounced. Adding a third antenna increases the strength of the center beam and weakens the strength of the areas outside the beam.