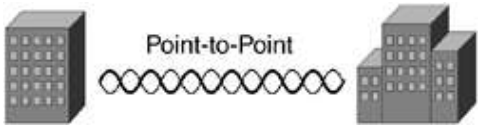
Wireless MAN Systems

Wireless MANs offer connections between buildings and users within a city or campus area through several system configurations. In most cases, the wireless MAN beams RF or infrared light from one point to another using directive antennae.

Point-to-Point Systems

A point-to-point solution uses RF or infrared signals that utilize either semidirectional or highly directional antennae to extend range across metropolitan areas, such as college campuses and cities. Range can be as high as 30 miles for RF systems using highly directional antennae. Figure 6-5 illustrates a point-to-point wireless MAN system.

Figure 6-5. Point-to-Point Wireless MAN Directly Connects Two Points in the Network



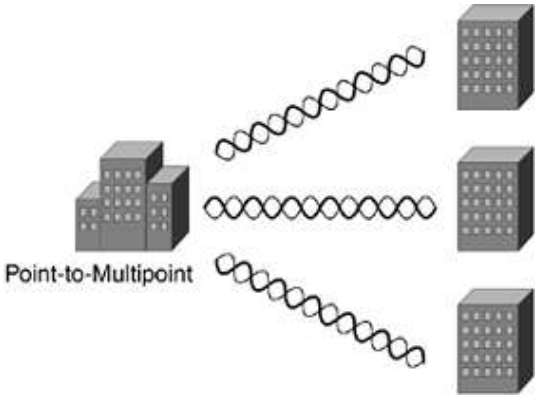
A medical center, for example, can use a point-to-point wireless MAN to provide a communications link between the main hospital and a remote clinic within the same city. This resulting system, however, does not provide as much flexibility as point-to-multipoint solutions. However, if there is a need to connect only a couple sites, the cost of implementing a **point-to-point system** is less compared to a point-to-multipoint system.

Exhibit 1010
Page 192 of 292

Point-to-Multipoint System

A typical point-to-multipoint link (see **Figure 6-6**) utilizes a centralized omnidirectional antenna that provides a single transceiver point for tying together multiple remote stations. For example, a building within the center of a city can host the omnidirectional antenna, and other nearby metropolitan-area buildings can point directional antennae at the centralized location. The central transceiver receives and retransmits the signals.

Figure 6-6. Point-to-Multipoint Wireless MAN Interconnects Users Through a Common, Centralized Transceiver



A strong advantage of the point-to-multipoint wireless MAN is that it makes the addition of new connections easy. In fact, this approach can be less expensive compared to point-to-point systems when there are multiple sites to interconnect or connect to a central location. For example, a company headquarters having many remote warehouses and manufacturing plants within the same city or rural area would benefit from a **point-to-multipoint system**.

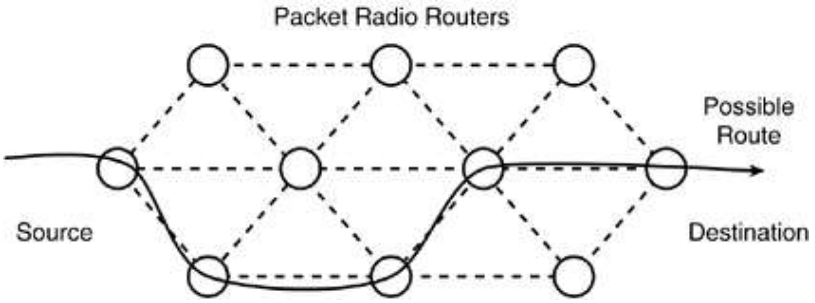
Packet Radio Systems

A packet radio system (see **Figure 6-7**) utilizes special wireless routers that forward data contained within packets to the destination. Each

Exhibit 1010
Page 193 of 292

user has a packet radio NIC that transmits data to the nearest wireless router. This router then retransmits the data to the next router. This hopping from router to router occurs until the packet reaches the destination. This mesh type networking is not new. Amateur Ham radio operators have used it for decades, and companies such as Metricom have been deploying these types of systems in cities for nearly 10 years.

Figure 6-7. Packet Radio System Hops Data Packets from the Source to Destination



A city government might want to deploy a packet radio system to offer wireless connectivity for supporting applications through the entire city area. The installation of routers in strategic places through the city provides the necessary infrastructure. There's no need for wires for interconnecting the routers. Each router is capable of receiving and retransmitting—hopping— the packets to their destination.

This form of networking is also survivable. If one router becomes inoperative, perhaps because of a lightning strike or sabotage, adaptive routing protocols automatically update routing tables in each router so that data packets will avoid traversing the inoperative router.

Exhibit 1010
Page 194 of 292

Wireless MAN Technologies

Many of the wireless MAN installations utilize proprietary technologies operating in licensed bands. The licensing avoids potential RF interference by ensuring that nearby systems are using different frequencies. Even though end users follow a process of obtaining a license, it isn't time consuming because it is only done once. The problem, however, is that licensed band components are expensive.

As a result, companies prefer to utilize equipment based on standards, which generally results in fewer initial costs and lower support costs. If a manufacturer no longer supports a particular product, the company can go to a different manufacturer when modifying the network. Standards certainly improve the longevity of the system.

802.11 and Wi-Fi

Many companies deploy wireless MANs using wireless LAN standards, such as 802.11 and Wi-Fi. **Chapter 5**, "Wireless LANs: Networks for Buildings and Campuses," gives details on these standards. The difference is that a wireless MAN utilizes directional antennae to establish a point-to-point link between fixed points in the system. The hardware includes a wireless bridge that implements wireless LAN standards.

The use of wireless LAN hardware for metropolitan-sized networks decreases costs, but 802.11 has performance limitations when supporting larger numbers of users needing guaranteed bandwidth. In addition, RF interference is often a significant problem with 802.11 when covering large areas because of license-free operation. A competitor might install an 802.11 network that interferes with yours, and users

will suffer due to sporadic performance. There is no solution because there are no legal grounds to remedy the situation.

802.16

The IEEE 802 group initiated the IEEE 802.16 working group to create standards for broadband wireless access in order to offer a high-speed, high-capacity, low-cost, scalable solution to extend fiber-optic backbones. The first IEEE **802.16** standard, published in April 2002, defines the Wireless MAN Air Interface for wireless MANs. These systems are meant to provide network access to homes, small businesses, and commercial buildings as an alternative to traditional wired connections.

With wireless base station equipment targeted at under $20,000, 802.16 can economically serve up to 60 customers with T-1 (1.5 Mbps) speed connections. That's really attractive to the typical WISP that's short on cash. In addition, 802.16 can provide a feasible backhaul for connecting wireless LAN hotspots together.

802.16 supports point-to-multipoint architecture in the 10–66 GHz range, transmitting at data rates up to 120 Mbps. At those frequencies, transmission requires line of site, and roofs provide the best mounting locations for base and subscriber stations. The base station connects to a wired backbone and can transmit wirelessly up to 30 miles to a large number of stationary subscriber stations, possibly hundreds.

To accommodate non-line-of-site access over lower frequencies for locations without line of site, IEEE published 802.16a in January 2003, which includes support for mesh architecture. 802.16a operates in the licensed and unlicensed frequencies between 2–11 GHz using Orthogonal Frequency Division Multiplexing (OFDM).

The 802.16 MAC layer supports many different physical layer specifications, both licensed and unlicensed. Through the 802.16 MAC, every base station dynamically distributes uplink and downlink bandwidth

to subscriber stations using time-division multiple access (TDMA). This is a dramatic difference from the 802.11 MAC, with current implementations operating through the use of carrier sensing mechanisms that don't provide effective bandwidth control over the radio link.

The next step for the IEEE 802.16 working group is to add portability and mobility to the standard. In March 2002, the group began the 802.16e study group on Mobile Broadband Wireless Access. This group will address many different mobility issues, including providing connectivity to moving vehicles within a base station's sector.

Exhibit 1010
Page 197 of 292

Chapter Summary

Wireless MANs primarily use bridges with directional antennae to interconnect two or more networks over a metropolitan area. Point-to-point systems directly connect two sites; and point-to-multipoint enables multiple sites to connect through a central transceiver. Many companies utilize proprietary technologies for wireless MANs. Standards such as 802.11 and Wi-Fi enable less-expensive solutions, but potential RF interference persists. The 802.16 standard, however, promises to offer effective standards-based wireless MANs.

Exhibit 1010
Page 198 of 292

Chapter Review Questions

You can find the answers to the following questions in **Appendix A**, "Answers to Chapter Review Questions."

1: Why does a wireless MAN offer good return on investment?

2: A learning bridge forwards all packets. True or false?

3: What is the primary difference between a bridge and an access point?

4: What are examples of semidirectional antennae?

5: In regards to beamwidth, what is the primary difference between a semidirectional and highly directional antenna?

6: What is an example of a highly directional antenna?

7: What polarization would be most effective at a receiver if the transmitter were using vertical polarization?

8: What are the advantages of using point-to-multipoint systems versus point-to-point for interconnecting multiple sites?

9: What are the advantages of using packet radio for wireless MANs?

Exhibit 1010
Page 199 of 292

10: Which standards do wireless MANs employ?

Exhibit 1010
Page 200 of 292

Chapter 7. Wireless WANs: Networks for Worldwide Connections

What You Will Learn

After reading this chapter, you should be able to

- Recognize specific wireless WAN applications
- **Understand wireless WAN components and standards**
- **Realize the various wireless WAN systems**

Wireless WANs satisfy needs for networking over vast distances, such as countries and continents. In most cases, wireless WANs offer connections while away from the office, home, and the indoor public wireless LANs. Wireless WANs do provide coverage inside buildings, but performance in these areas is often much less than when operating outside.

The advantage of wireless WANs is wide coverage and economies-of-scale that result in low prices for subscribers. The disadvantage is that the limited availability of frequency spectrum results in low performance and limited security. Wireless WANs, however, are more practical than wireless LANs to deploy in large areas. Some performance is better than none.

For example, a wireless WAN enables someone to check her e-mail on her PDA while visiting a customer in a different city. This allows users to react quicker to situations, rather than wait to check their e-mail from the hotel room. The relatively low performance of wireless WANs adequately supports this type of application.

Exhibit 1010
Page 201 of 292

Wireless WANs can also provide Internet access from a stationary location. A camper, for example, can aim a satellite dish mounted on a recreational vehicle and have access to the Internet. This makes it possible to stay in touch with family, and enjoy the benefits of the web, while staying in remote areas.

This chapter offers examples of wireless WAN components, describes how these components interconnect to form a variety of systems, and explores the various technologies.

Exhibit 1010
Page 202 of 292

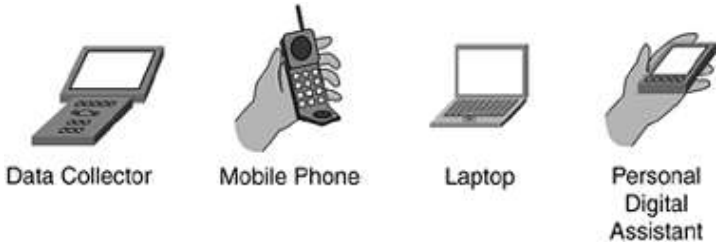
Wireless WAN Components

Wireless WANs satisfy both mobile and stationary applications. Components, therefore, vary depending on the technology and configuration of the wireless WAN. A satellite-based wireless WAN, for example, has different components than a cellular-based system.

Wireless WAN User Devices

Users of wireless WANs operate small and portable devices. This is because access to the network is available over much wider areas, and the users must carry their devices with them. For example, a business traveler can easily carry a small PDA or mobile phone and access e-mail while riding in a taxi from the airport to a hotel. **Figure 7-1** illustrates the types of user devices most common to wireless WANs.

Figure 7-1. Wireless WAN User Devices Are Small for Easy Mobility



The use of wireless WANs to network stationary PCs is not common; however, some applications do exist. The need to set up a portable point-of-sale (POS) register at a remote area, such as a makeshift concert site, could prompt the use of a wireless WAN. A vendor selling t-

Exhibit 1010
Page 203 of 292

shirts can process credit cards over the wireless WAN to an Internet-based processing center.

Radio NICs

Some mobile phones have integrated wireless WAN radios. Telecommunication companies, such as Verizon and Sprint, offer wireless WAN connections with voice services. The problem, however, is that several different types of wireless WANs exist, making it a challenge for users to find a mobile phone that interfaces with the type of wireless WAN they want to use.

To interface a laptop or PDA to a wireless WAN, you need to purchase an applicable wireless WAN radio NIC. **Figure 7-2** shows a radio NIC available for wireless WANs. These cards can look like ones for wireless PANs and LANs; however, the card might contain one of several incompatible technologies.

Figure 7-2. Wireless Radio NICs Exist for Laptops and PDAs



Along with the purchase of hardware, the vendor generally sells access to the service that the card is designed to interface with.

Exhibit 1010
Page 204 of 292

Telecommunications companies spend significant amounts of money to secure frequency spectrum and install hardware over vast areas. As a result, all wireless WAN providers charge for the service. This is different than wireless LAN hotspots, where many hotels and airports are finding it advantageous to offer free Internet access to wireless LAN users. This is made possible because wireless LAN deployment doesn't require much capital.

note



Be certain to purchase a wireless WAN radio NIC that interfaces with a type of wireless WAN that's available in the areas you need. Consider the coverage area, just as you would with a mobile phone, before deciding on which NIC and service to use.

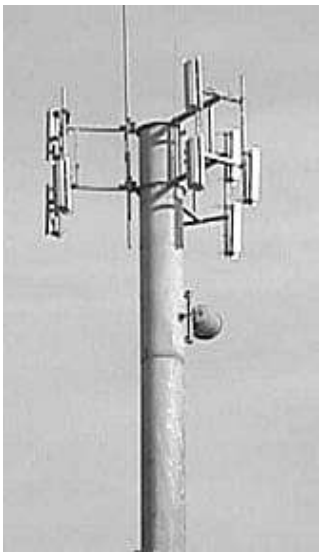
In the case of using a satellite-based wireless WAN, the purchase of satellite terminal hardware becomes necessary. Mobile versions of satellite terminals have a small-parabolic (dish) reflector antenna and electronics that can fit within a medium-sized briefcase. This type of wireless WAN interface is relatively expensive. Satellite terminals are also available for more permanent installations, such as home or recreational vehicles.

Base Stations

Base stations for wireless WANs typically appear outdoors. In fact, the familiar cell towers shown in **Figure 7-3** are seen scattered around cities and country areas. Similar to wireless LANs, these base stations rely on wires to connect to a distribution system that provides switching and an interface to the Internet. In most cases, the towers reside outdoors to provide maximum coverage. However, some large public facilities—such as shopping malls and airports— install cellular base stations indoors to handle larger numbers of subscribers.

Exhibit 1010
Page 205 of 292

Figure 7-3. Cell Towers Are Common Wireless WAN Base Stations



Another form of wireless WAN base station is a **satellite** in orbit, which is actually a repeater in the sky. On the ground, a user aims a dish antenna at the satellite, and the satellite receives the signal and retransmits the signal back to an Earth station. (See **Figure 7-4**.) A strong advantage of this approach is that less infrastructure is necessary on the ground. The problem, however, is that operators must spend millions of dollars to establish a satellite system for computer traffic. This equates to expensive service charges for users.

Figure 7-4. Satellites Have Signal Transponders That Send and Receive RF Signals and Solar Cells That Provide Electricity

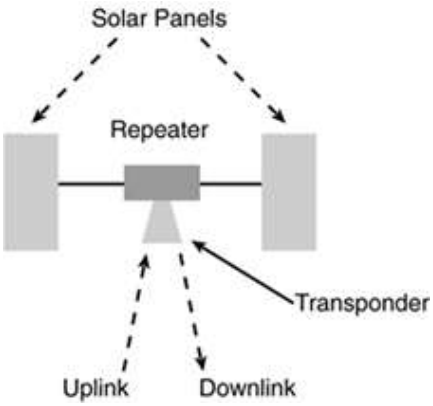


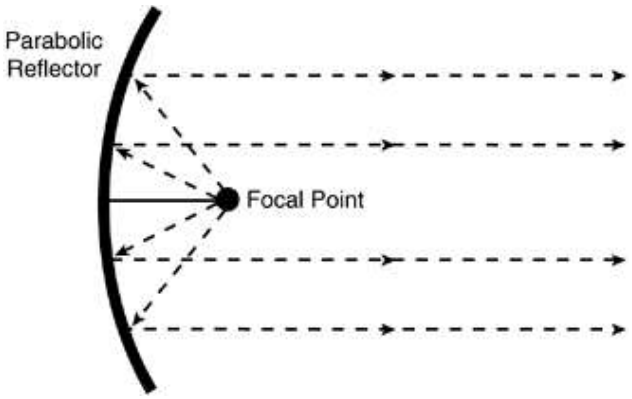
Exhibit 1010
Page 206 of 292

Antennae

Wireless WAN base stations and user devices use a variety of antennae depending on the type of wireless LAN. For cellular systems, the antenna on the user device is generally omnidirectional. Cell towers generally have multiple directional antennae, however, that cover vast distances.

A satellite user has a dish antenna with characteristics as shown in **Figure 7-5**. The transceiver, located at the focal point, transmits and receives the radio frequency (RF) signal. For example, the RF signal leaves the transmitter side of the transceiver, and the shape of the dish focuses the RF signals in one direction.

Figure 7-5. Dish antennae Have Parabolic Reflectors That Focus the Signal Power in a Beneficial Way



No matter how the RF signal hits the dish, the signals leave the dish in the same direction because of its parabolic shape. In fact, the opposite is also true. When the dish receives RF signals, the shape of the dish focuses the RF signals at the receiver, which is at the focal point.

note

Exhibit 1010
Page 207 of 292



A snow sled disk is the shape of a parabolic reflector.

Exhibit 1010
Page 208 of 292

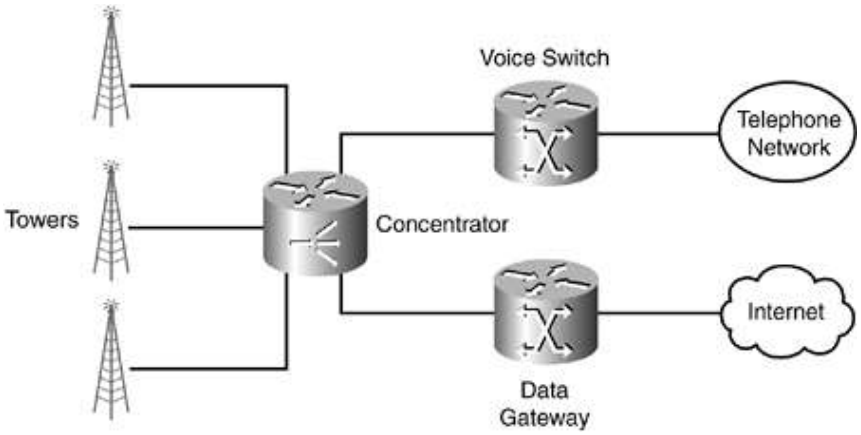
Wireless WAN Systems

Most wireless WANs are cellular based, but some make use of space. Take a closer look at both of these.

Cellular-Based Wireless WANs

As shown in **Figure 7-6**, a cellular system consists of cell towers, concentrators, voice switches, and data gateways. The cell tower receives signals from user devices and transmits information back to the user. The voice switch connects the user device to another wireless, or wired, user through the telephone distribution system. This part of the system supports customary phones calls between users.

Figure 7-6. Cellular Systems Include Data Gateways to Augment Traditional Voice Services with Wireless Network Connections



The component that makes the system a wireless WAN is the data gateway. In this case, the gateway is able to interface with data protocols in

Exhibit 1010
Page 209 of 292

a way that makes it possible for users to surf the Internet, send and receive e-mails, and utilize corporate applications.

Text messaging is a popular application of cellular-based wireless WANs. Users converse by typing in short text messages and sending them to other users, similar to instant-messenger applications available for PCs. With smaller wireless WAN devices, however, it's important that users can save canned messages such as, “I'm traveling today and I'll call you later,” which can be sent at the press of single button. Some wireless WAN devices also capture digital pictures and video that is sent across the network.

First-Generation Cellular

When mobile phones first became available, wireless communications used only analog signals. This initial cell phone system is known as first-generation cellular (**1G cellular**). When someone speaks through a 1G system, his voice is sent using frequency modulation (FM), which merely changes the frequency of carrier wave according to the audio signal. 1G systems make use of a limited number of channels that use FSK to send control signals necessary to set up and maintain the calls.

1G systems work well for voice phone calls, despite occasional crackles and pops, but they are not sufficient for sending computer data. As with the voice, analog signals must represent data. Users must interface PCs to the cellular system using a modem that converts the digital signals from the computing device into an analog form (such as FSK or PSK) that is suitable for transmission through a small, 4-KHz voice channel. This results in slow 20- to 30-kbps data rates.

1G systems also lack capacity to support an authentication and encryption mechanism. The digital FSK control channel only has enough capacity to support telephone calls. There is not enough room for sending usernames and passwords to an authentication service or co-

Exhibit 1010
Page 210 of 292