

Guide to Wireless Communications, Third Edition

Chapter 1
Introduction to Wireless Communications
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Objectives

- Describe how wireless communications technologies are used today
- List various applications of wireless communications technology
- Outline the advantages and disadvantages of wireless communications technology
- List several types of wireless technologies and their purposes

How Wireless Technology is Used

- **Wireless:** describes all types of devices and technologies not connected by a wire
- **Wireless communications:** transmission of digital data without the use of wires
- Various forms of wireless data communications:
 - Bluetooth
 - WirelessHD
 - WiGig
 - Satellite
 - Cellular
 - Wi-Fi-based wireless LANs
 - Fixed broadband wireless communications

A Wireless World

- Wireless devices
 - Distance: up to 330 feet (100 meters)
 - Bandwidth: up to 300 Mbps
 - Can also include Voice over IP (VoIP)
- **Wireless network interface card (Wireless NIC)**
 - Sends and receives data over radio waves
- **Smartphone:** Combination mobile phone and personal digital assistant (PDA)
- **Radio frequency identification (RFID) tags:** small chips containing radio transponders

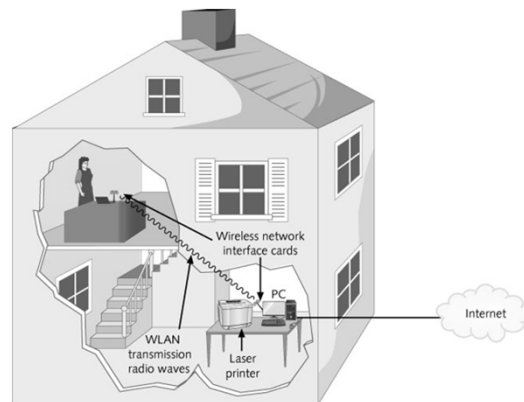


Figure 1-1 Home wireless network (WLAN)

Bluetooth and Other Short-Range Wireless Technologies

- **Bluetooth**
 - Wireless standard designed for very short ranges
 - Typically a few inches to 33 feet (10 meters)
 - Main purpose is to eliminate cables between devices
- Bluetooth communicates using small, low-power transceivers called **radio modules**
- **Link manager**
 - Special software that helps identify other Bluetooth devices, create a link between them, and send and receive digital data



Figure 1-2 Two examples of Bluetooth headsets: mono (left) and stereo (right)

Bluetooth and Other Short-Range Wireless Technologies

- Wireless HD and WiGig
 - Can transfer video and sound at speeds between 7 Gbps and 10 Gbps using Ultra Wide Band (UWB)
 - Distance: up to 10 meters (only in a room with few or no obstacles)
 - Greater the distance, the slower the transmission
- Piconet
 - Wireless personal area network (WPAN)
 - Consists of two or more Bluetooth devices that are exchanging data with each other
 - Up seven devices can belong to a single WPAN

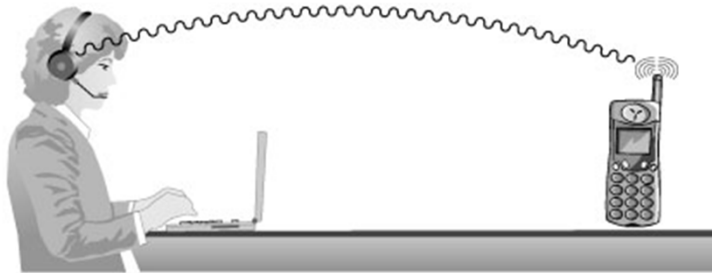


Figure 1-3 Bluetooth network (piconet) or WPAN between a cordless handset and a headset

Satellite Networks

- Used to transmit data over very long distance
- Repeater
 - Located in the satellite itself
 - “Repeats” the same signal to another location down on the surface
 - Used to transmit data from one earth station to another
 - Transmission time can be up to 250 milliseconds

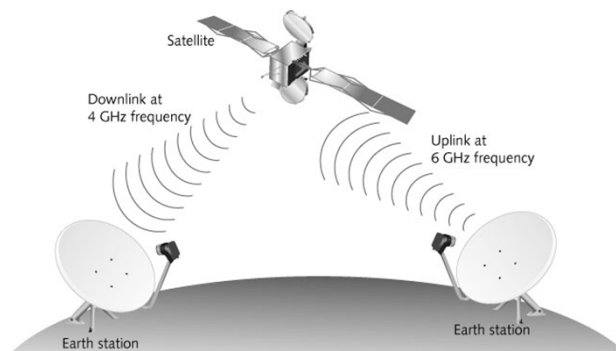


Figure 1-5 Satellite repeating a signal to another Earth station

Cellular Networks

- Modern cellular telephone network
 - Built around the concept of low-power transmitters
 - With each “cell” handling a number of users
 - Transmission towers are spread throughout a geographical area
 - The same radio frequency channels can be reused by another tower
 - Located a few miles away to avoid interference
 - Maximizes the use of a limited range of frequency channels



Figure 1-6 Smartphones - BlackBerry Bold (left) and Apple iPhone (right)

Cellular Networks

- 4G (fourth generation) technology
 - Uses 100% digital transmission for both voice and data
 - Transmission speed
 - Over 150 Mbps when stationary
 - 45 Mbps for slow-moving pedestrians
 - 20 Mbps in a fast moving vehicle
- 3G (third generation) technology
 - Has a theoretical maximum data transmission rate of up to 21 Mbps
 - Realistic speeds are between 3 to 11 Mbps

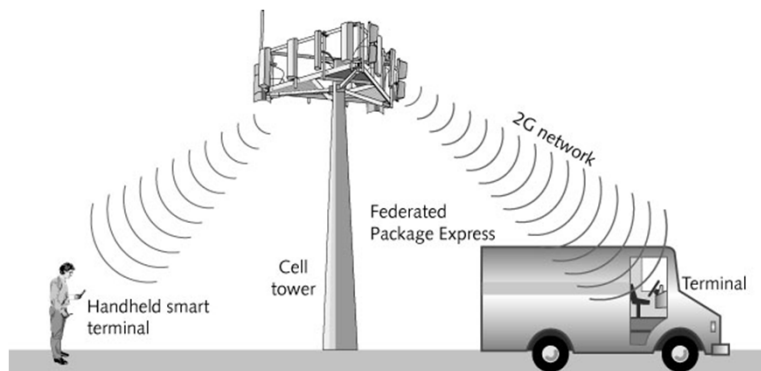


Figure 1-7 Digital cellular network

Wireless Local Area Networks

- Wireless Local Area Network (WLAN)
 - Extension of a wired LAN
 - Connecting to it through a device called a wireless access point
- Access point (AP or wireless AP)
 - Relays data signals among all of the devices on the wired network
- Each computer on the WLAN has a wireless network interface card (NIC)
 - Has an antenna built into it

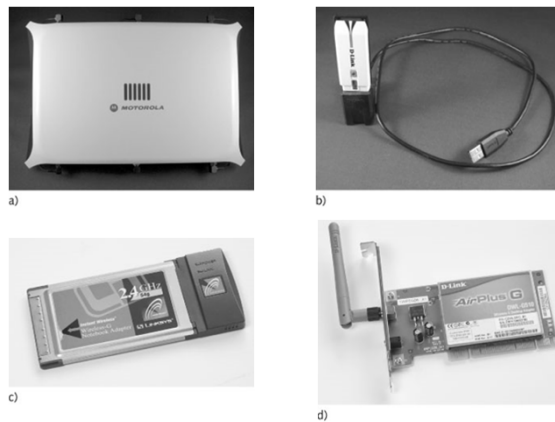


Figure 1-8 Clockwise from top left: a) access point with built-in antennas, b) USB Wireless NIC, c) PCMCIA, and d) PCI Wireless NICs

Wireless Local Area Networks

- Institute of Electrical and Electronic Engineers (IEEE) standards
 - Established a series WLAN standards
 - Most recent IEEE 802.11n-2009 (more commonly known as IEEE 802.11n)
 - Provides for transmission speeds of up to 600 Mbps and covers distances up to 375 feet

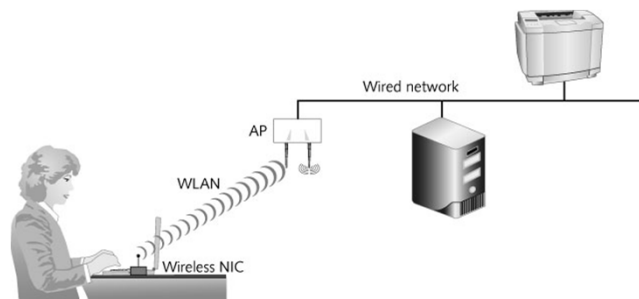


Figure 1-10 Office WLAN

Fixed Broadband Wireless

- Integrated Services Digital Networks (ISDN)
 - Transmits at up to 256 Kbps over regular phone lines
- T1 lines
 - Transmit at 1.544 Mbps
 - Very costly option
- Cable modems
 - Generally only available in residential areas
- Digital subscriber lines (DSL)
 - Use either regular or special telephone lines
 - Speed is dependent on distance between FPE's main office and nearest telephone switching office

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Fixed Broadband Wireless

- Wireless metropolitan area network (WMAN)
 - Covers a distance of up to 25 miles
 - Based on the IEEE 802.16 WIMAX Fixed Broadband Wireless standard
 - Uses radio waves and small custom antennas on the roof of each building in WMAN
 - Transmission speeds
 - 75 Mbps at distances of up to 4 miles (6.4 km)
 - 17 to 50 Mbps at distances over 6 miles (10 km)
 - Newer versions of IEEE 802.16m standard will be able to achieve average speeds up to 100 Mbps

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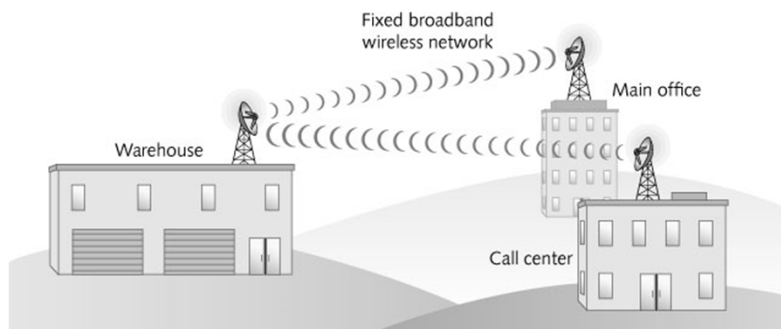


Figure 1-11 IEEE 802.16 wireless metropolitan area network (WMAN)

Wireless Wide Area Network

- Hypertext Markup Language (HTML)
 - Standard language for displaying content from the Internet

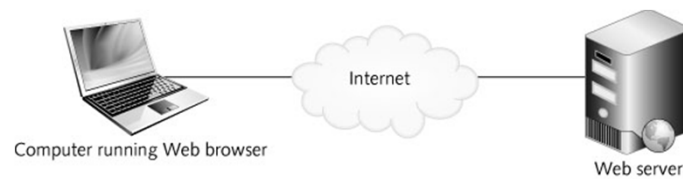


Figure 1-12 Browsing the World Wide Web on a PC

Wireless Wide Area Network

- Microbrowser
 - Miniaturized version of a Web browser
 - May be found on older cellular phones
- Wireless Application Protocol version 2.0 (WAP2)
 - Provides a standard way to transmit, format, and display Internet data
 - For small wireless devices such as cell phones
 - Compatible with HTTP but uses earlier, simpler version (1.1) of HTTP
 - Most smartphones are equipped with WAP2 browsers, which are used when they cannot access high-speed digital cellular services

Wireless Wide Area Network

- J2ME (Java 2 Micro Edition) – programming language that allows most newer cell phones to display text, graphics, and limited animations on small screens
- Wireless Wide Area Network (WWAN)
 - Enables employees to access corporate data and applications from virtually anywhere using cellular phone technologies

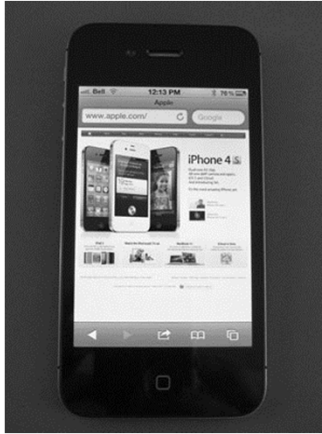


Figure 1-13 Displaying Web content on a smartphone

The Wireless Landscape

- Wireless communications
 - Has become a standard means of communication for people in many occupations and circumstances

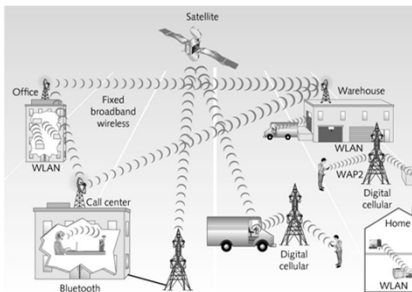


Figure 1-14 Wireless communications

Wireless Technology	Range (Transmission Distance)	Maximum (Average) Speed
RFID	1 inch (2.5 centimeters) to 300 feet (100 meters), depending on frequency and type of tag	A few thousand bits-per-second (Kbps)
Bluetooth version 4	Class 3: 3.3 feet (1 meter) Class 2: 33 feet (10 meters) Class 1: 330 feet (100 meters)	1 Mbps (721.2 Kbps) to 24 Mbps (version 4 only)
WiGig and WirelessHD	150 feet (50 meters)	7–10 Gbps (3–5 Gbps)
WLAN 802.11n	375 feet (114 meters)	300–600 Mbps (140–400 Mbps)
WLAN 802.11g	300 feet (90 meters)	54 Mbps (22–26 Mbps)
WMAN 802.16 WiMAX	35 miles (56 kilometers)	75 Mbps (20–40 Mbps)
WMAN 802.16m WiMAX	35 miles (56 kilometers)	100 Mbps (40–60 Mbps) to 1 Gbps (point-to-point)
3G digital cellular	16 miles (up to 25 kilometers to tower), then anywhere in the world via other networks	21 Mbps (2–11 Mbps)
4G digital cellular	Typically, 16 miles (up to 25 kilometers) to tower, then anywhere in the world via other networks	20 Mbps–150 Mbps (4–25 Mbps)
Satellite	Worldwide	Greatly varying speeds, with each transmission experiencing about a quarter second (250 milliseconds) delay

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Table 1-1 Wireless data communications technologies

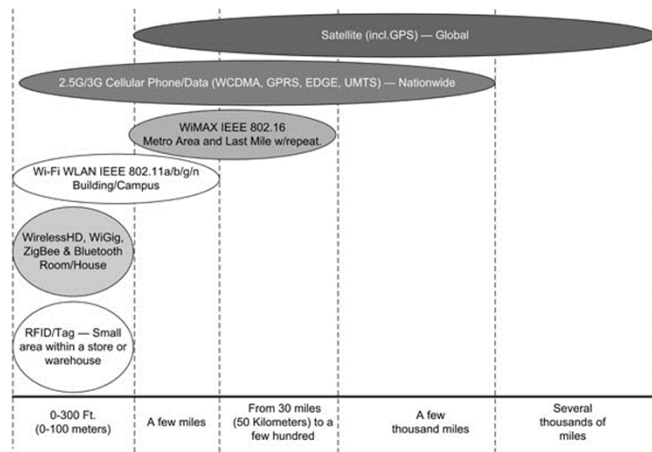


Figure 1-15 Comparing wireless communications technologies

The Wireless Landscape

- Speeds of wireless networks vary greatly depending on:
 - Number of users connected
 - Amount of data traffic
 - Amount of interference present at the time
 - Other factors that will be discussed in later chapters
- Job market will increase for:
 - Wireless engineers
 - Wireless local area network managers
 - Wireless technical support personnel

Digital Convergence

- Digital convergence
 - Refers to the power of digital devices to combine voice, video, and text-processing capabilities
 - As well as to be connected to business and home networks and to the Internet
 - Same concept applies to the development of VoIP networks
 - Use the same protocols and media that once only carried data
 - Wireless technologies are used to fulfill many daily activities

Wireless Applications

- Main areas
 - Education
 - Home entertainment and Home control systems
 - Health Care
 - Government and Military
 - Office environments
 - Event management
 - Travel
 - Construction and warehouse management
 - Environmental research
 - Industrial control

Education

- Ideal application for colleges and schools
- Instructors can create classroom resources in their home or school office and easily connect to campus network in the classroom
- It frees students from having to go to a specific computer lab or the library
 - To get on the school's computer network
- Wireless technology translates into a cost savings for colleges
 - Traditional classrooms become computer labs without the expense of additional wiring

Home Entertainment

- Wireless communication
 - Enables people to download, distribute, and control all forms of digital entertainment from anywhere in the house
 - Examples:
 - Wireless speakers, media players, game consoles, DVD players, televisions, digital video recorders (DVRs), and multimedia personal computers

Home Control Systems

- Manufacturers are creating wireless systems that enable us to:
 - Control lights, heating, ventilation, air conditioning, drapes, alarms, door locks, and home appliances
 - Can control from locations throughout the house or even from smartphones or tablets outside the home
- Several systems use the ZigBee Alliance communications protocols and the IEEE 802.15.4 standard

Health Care

- Administering correct medication in a hospital setting
 - A major concern for the health care industry
- Wireless point-of-care computer systems
 - Allow medical staff to access and update patient records immediately
- Many hospitals use portable devices with barcode scanners or RFID and a wireless connection
- Patients may have a barcoded or RFID-enabled armband that can be scanned to access records
- System immediately verifies correct medication

Government

- Wireless communication
 - Lets residents, city employees, contractors, and utility staff collect and transmit data to central databases
 - Examples:
 - Building inspectors can update permit data while at the construction site
 - City employees can locate and monitor municipal vehicles
 - Delivers broadband connectivity to schools, libraries, and government buildings
 - Provides free Internet access to residents and attracts visitors and businesspeople

Military

- Latest devices allow military personnel in the field to:
 - Use voice and the Internet
 - Receive and transmit full-motion video
 - Maneuver remote control survey drones
 - Use digital battlefield maps
 - Many other applications

Office Environments

- Employees in all lines of work no longer have to be away from the data they need
 - To help them make decisions
- Wireless technologies allow businesses to create an office where the traditional infrastructure doesn't exist
- During office renovations or reorganization
 - Employees can move to another location and be connected immediately

Event Management

- Wireless networks
 - Help identify a stolen or counterfeit ticket
 - Can also give a real-time look at traffic flow
 - Use to determine where staff might be needed
 - In-progress game statistics are available to any fan in the stadium with a wireless device

Travel

- Wireless global positioning systems (GPS)
 - Tie into emergency roadside assistance services
 - OnStar roadside assistance is an example
- Satellite radio
 - Transmits over 150 music and talk stations
- Airport terminals are offering wireless technologies to passengers
- Airplanes themselves are being equipped with wireless data access
- City transit systems are also “going wireless”

Construction

- Wireless communications
 - Send information from the job site to the main office
 - Tardy subcontractor or problems with materials
 - Alert when maintenance operations need to be performed on equipment
 - Bulldozers and earth graders are being turned into “smart” equipment
 - Exact location of dig coordinates can be transmitted to a terminal on the bulldozer
 - Track engine hours and equipment location

Warehouse Management

- Implementing wireless technology is key for many warehouse operations
- Warehouse management system (WMS) software
 - Used to manage all of the activities from receiving through shipping
- In the near future
 - Most of the bar code functions, including inventory counting, will be replaced by RFID tags
 - Will eliminate the need for printing and affixing labels

Environmental Research

- Scientists are now using small, battery- or solar-cell-powered WLAN sensors
 - In places that were previously difficult to access and monitor
 - Considered a major breakthrough in many scientific fields
 - Has helped collect data that used to be very difficult or impossible to collect and record

Industrial Control

- Motes
 - Remote sensors
 - Can connect to a WLAN
 - Then collect data and transmit it to a central location
- Manufacturing managers can monitor equipment from an office
 - Problems can be detected instantly
- Technicians in a control room can monitor status of every machine or device
 - Dispatch a technician when necessary

Wireless Advantages and Disadvantages

- As with any new technology, wireless communications offers both advantages and disadvantages

Advantages of Wireless Networking

- Mobility
 - Freedom to move about without being tethered by wires
 - Permits many industries to shift toward an increasingly mobile workforce
 - Creating “flatter” organizations with fewer management levels between top executives and regular employees
- Easier and less expensive installation
 - Installing network cabling in older buildings can be a difficult, slow, and costly task
 - Makes it easier for any office to be modified with new cubicles or furniture

Advantages of Wireless Networking

- Increased reliability
 - Network cable failures may be the most common source of network problems
- Disaster recovery
 - In the event of a disaster, managers can quickly relocate the office
 - Some planners keep laptop computers with wireless NICs and access points in reserve
- Future Applications
 - Every day, a new application for wireless data transmission is thought of or implemented

Disadvantages of Wireless Networking

- Radio signal interference
 - The potential for two signals to interfere exists
 - Solution: locate source of interference and eliminate it
- Security
 - It is possible for an intruder to be lurking outdoors with a notebook computer and wireless NIC
 - With the intent of intercepting the signals from a nearby wireless network
 - Some wireless technologies can provide added levels of security
 - Network managers can limit access

Disadvantages of Wireless Networking

- Health risks
 - High levels of RF can produce biological damage through heating effects
 - Wireless devices emit low levels of RF while being used
 - No clear picture of the biological effects of this type of radiation has been found to date
 - Science today does not yet permit anyone to draw a definitive conclusion on the safety of wireless mobile devices
 - Be aware of the possibility and monitor ongoing scientific research

Summary

- Wireless communications have become commonplace
- Wireless networks and devices are found in all circles of life today
- Wireless wide area networks will enable companies of all sizes to interconnect their offices
 - Without the high cost charged by telephone carriers for their landline connections
- WLAN applications are found in a wide variety of industries and organizations

Summary

- Remote sensors capable of communicating using wireless technologies
 - Used in large manufacturing facilities to monitor equipment and for scientific research
- Wireless communication advantages
 - Mobility
 - Easier and less expensive installation
 - Increased network reliability
 - Support for disaster recovery

Summary

- Wireless communication disadvantages
 - Radio signal interference
 - Security issues
 - Health risks