

# **CWNA Guide to Wireless LANs, Third Edition**

## *Chapter 13: Other Wireless Networks*

# Objectives

- Define the technologies found in a wireless personal area network
- Explain the uses of a wireless metropolitan area network
- List the technologies of a wireless wide area network
- Describe the IEEE 802.11ac proposed standard

# Wireless Personal Area Networks (IEEE 802.15)

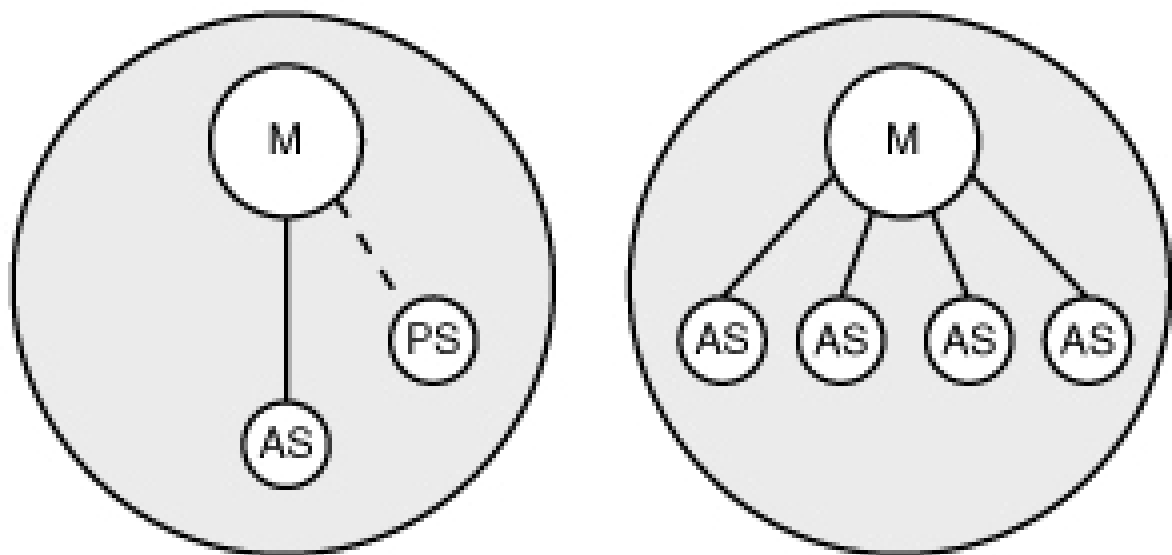
- WPAN technologies:
  - Bluetooth (802.15.1-2005)
  - Ultrawideband (802.15.3c-2009)
  - Low rate technologies (802.15.4)
  - Body Area Networks (802.15.6)
  - Visible Light Communications (802.15.7)

# Bluetooth (802.15.1-2005)

- Bluetooth uses short-range RF transmissions
  - Users can connect wirelessly to wide range of computing and telecommunications devices
  - Rapid and ad hoc connections between devices
- Current version is Bluetooth v4.0
  - Rate of transmission is 1 million bits per second
- Two types of 802.15.1 network topologies
  - Bluetooth Piconet
  - Bluetooth Scatternet

# Bluetooth (802.15.1-2005)

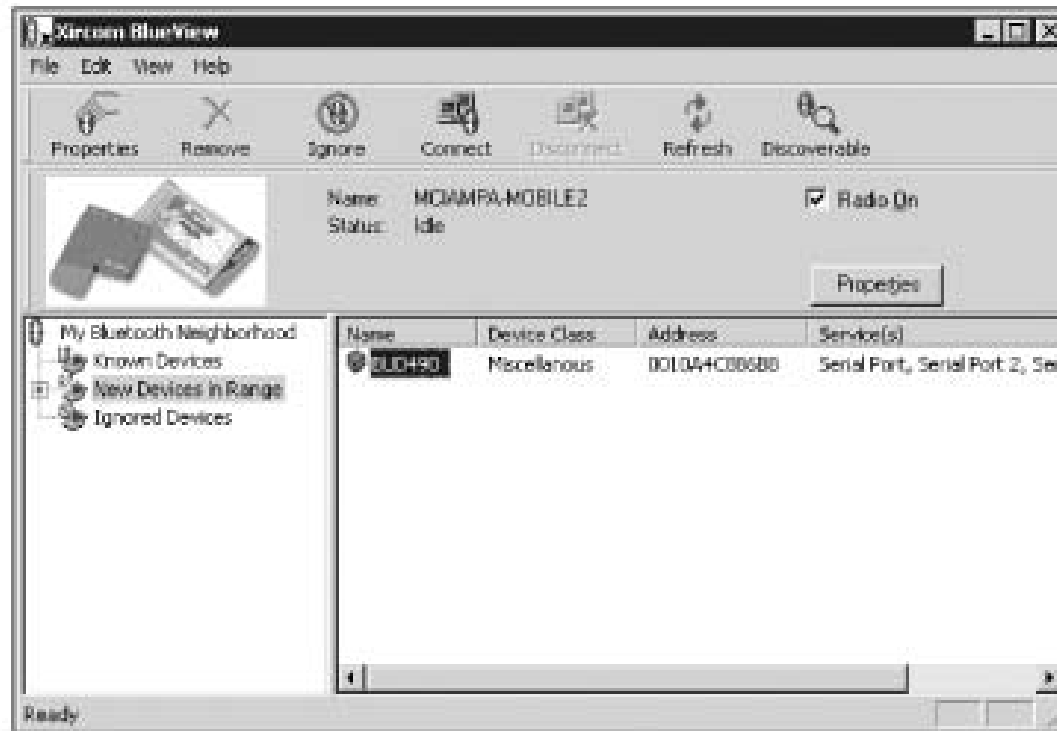
- **Bluetooth piconet:** When two 802.15.1 devices come within range, automatically connect
  - *Master:* Controls wireless traffic
  - *Slave:* Takes commands from master
  - Piconet has one master and at least one slave
- *Active slave:* Connected to piconet and sending transmissions
- *Parked slave:* Connected but not actively participating



M = Master  
AS = Active slave  
PS = Parked slave

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Figure 13-2 Bluetooth piconet



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Figure 13-3: Slave device detected by master

# Bluetooth (802.15.1-2005)

- Devices in piconet can be in one of five modes:
  - *Standby*: Waiting to join a piconet
  - *Inquire*: Device looking for devices to connect to
  - *Page*: Master device asking to connect to specific slave
  - *Connected*: Active slave or master
  - *Park/Hold*: Part of piconet but in low-power state
- **Bluetooth scatternet**: Group of piconets in which connections exist between different piconets
- 802.15.1 uses FHSS



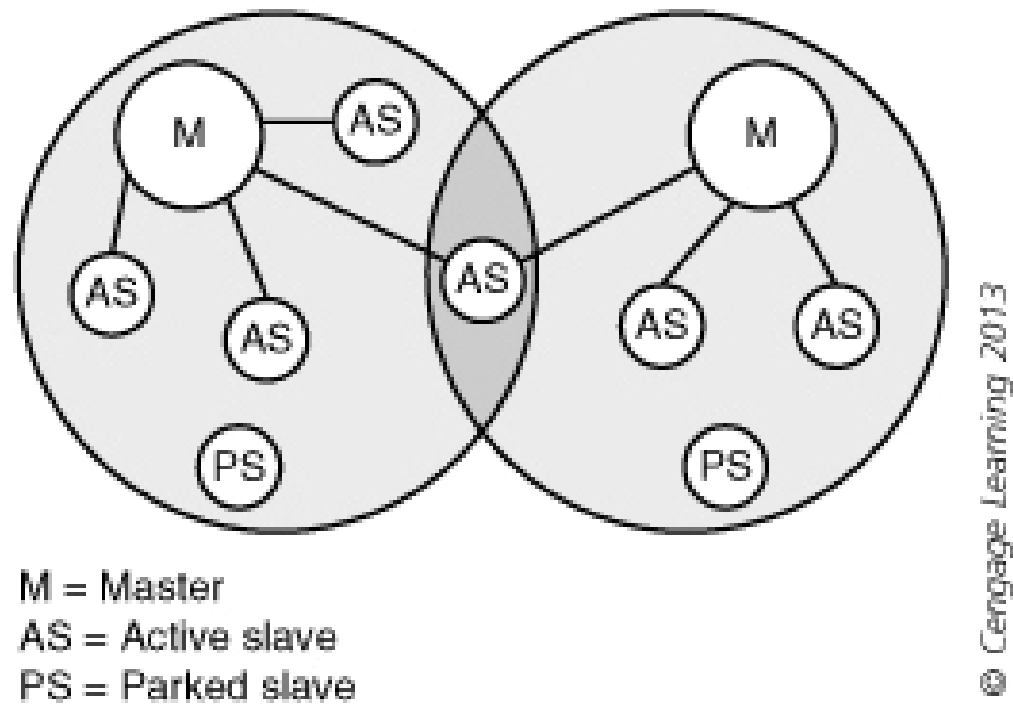


Figure 13-4 Bluetooth scatternet

# Bluetooth (802.15.1-2005)

- A major drawback of Bluetooth is its slow speed
- Attacks on wireless Bluetooth technology is not uncommon
- Two Bluetooth attacks:
  - Bluejacking: an attack that sends unsolicited messages to Bluetooth-enabled devices
  - Bluesnarfing: an attack that accesses unauthorized information from a wireless device through a Bluetooth connection

# Ultra-Wideband (802.15.3c-2009)

- Ultra-wideband (UWB): high-rate WPAN with speeds over 2 Gbps
- Created in response to limitations of 802.15.1
- Two main applications:
  - Video and audio distribution for home entertainment systems
    - High-speed digital video transfer
    - Interactive video gaming
  - Higher-speed data transfer intended for MP3 players, personal home storage devices, printers, scanners, and transfers to and from digital still cameras and kiosks

# Ultra-Wideband (802.15.3c-2009)

- UWB has not been widely implemented
- It distributes a signal across a wide range of spectrum
  - Widespread interference on other transmissions is a concern
  - FAA and other Federal agencies claimed that UWB could interfere with critical safety equipment, such as aircraft radar and communications

<b>UWB Feature</b>	<b>Description</b>
Quality of Service (QoS)	Because UWB was to be used extensively in audio and video applications, it is essential that QoS be implemented.
Security	The security features for the 802.15.3 standard include key distribution and encryption using AES. The standard supports four modes (levels) of security.
High data rates	The standard specifies raw data rates of 11 Mbps, 22 Mbps, 33 Mbps, 44 Mbps and 55 Mbps at distances of 33 feet (10 meters). The highest rate supports low-latency multimedia connections and large file transfers, while 11 Mbps and 22 Mbps rates target long-range connectivity for audio devices.
Spectrum utilization	The UWB standard uses the 2.4 GHz spectrum and supports either three or four nonoverlapping channels 15 MHz wide.
Coexistence	The standard was designed to coexist with IEEE 802.11 WLANs. It causes less interference because it occupied a smaller bandwidth and transmits at a lower power level. It also monitors the channels that are being used by other devices and will dynamically select the best channel available.

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Table 13-2 UWB features

# Low Rate Technologies (802.15.4)

- Sometimes preferable to have low-speed, low-power wireless devices
  - Size can be dramatically reduced
- **IEEE 802.15.4** standard addresses requirements for RF transmissions requiring low power consumption and cost

Data Rate	Frequency
250 Kbps	2.4 GHz
40 Kbps	915 MHz
20 Kbps	868 MHz

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Table 13-3 IEEE 802.15.4 data rates and frequencies

# Low Rate Technologies (802.15.4)

- **ZigBee:** low-power, short-range, and low-data rate specification that is based on 803.15.4 but that includes standards for network configuration, security, and other high-level features
- Typically found in the following applications:
  - Smart lighting
  - Advanced temperature control
  - Medical data collection
  - Smoke and intruder detection

# Low Rate Technologies (802.15.4)

- **Radio Frequency Identification (RFID):** RFID tags are able to receive and respond to queries from an RFID transceiver
- **Passive RFID tags:** No power supply
  - Can be very small
  - Limited amount of information transmitted
- **Active RFID tags:** Must have power source
  - Longer ranges/larger memories than passive tags



# Low Rate Technologies (802.15.4)

- Common applications for RFID tags:
  - Automobile toll booths for electronic toll collection
  - Asset tracking
  - Embedded in tires to ensure tire-tracking capabilities
  - Cards with embedded RFID chips are used in casinos and to pay mass transit fares
  - Smart Keys
  - U.S. passports

# Body Area Networks (802.15.6)

- IEEE 802.15.6 group is currently creating a standard for **body area networks (BAN)**
- BAN is a network system of devices in close proximity to a person's body that cooperate for the benefit of the user
- Commonly used for sports and fitness monitoring
- Sensors can be placed on the body to monitor EKG impulses, blood pressure, glucose, and others
  - Transmitted via computer or smartphone to a physician who can make care decisions
    - Known as a **managed body sensor network (MBSN)**

# Body Area Networks (802.15.6)

- **Autonomous body sensor network (ABSN):** network that introduces actuators in addition to sensors so that immediate effects can be made on the human body
  - Devices take in signals from the human nervous system and then stimulate nerves through electrical charges
    - Causes muscles to contract and limbs to move
    - Bypasses areas of the nervous system that have been impaired by strokes, spinal cord or brain injuries

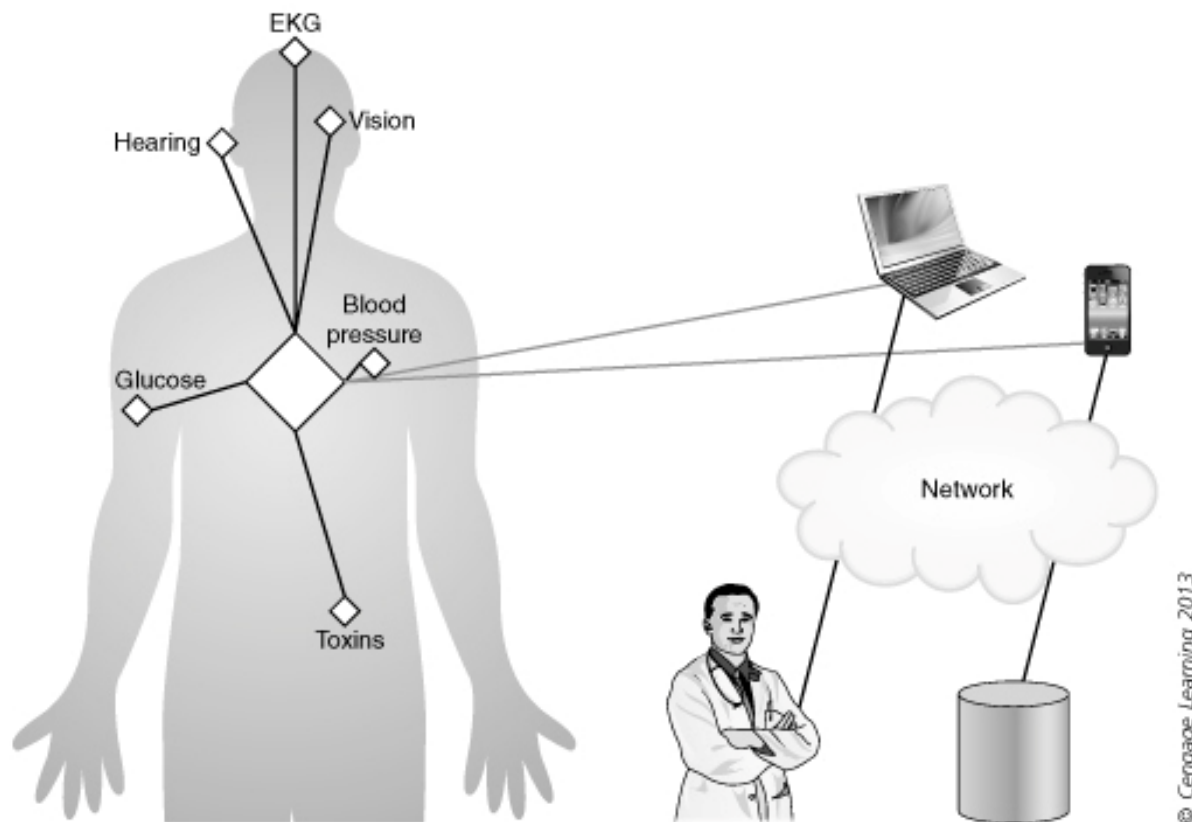


Figure 13-5 Managed body sensor network

# Visible Light Communications (802.15.7)

- Light can be used instead of RF
- One of the first WPAN technologies using light is based on a standard known as IrDA (Infrared Data Association)
- IrDA devices can transmit from 9.6 Kbps - 16 Mbps
- Devices communicate using infrared light-emitting diodes
  - Recessed into device
  - Many design considerations affect IrDA performance

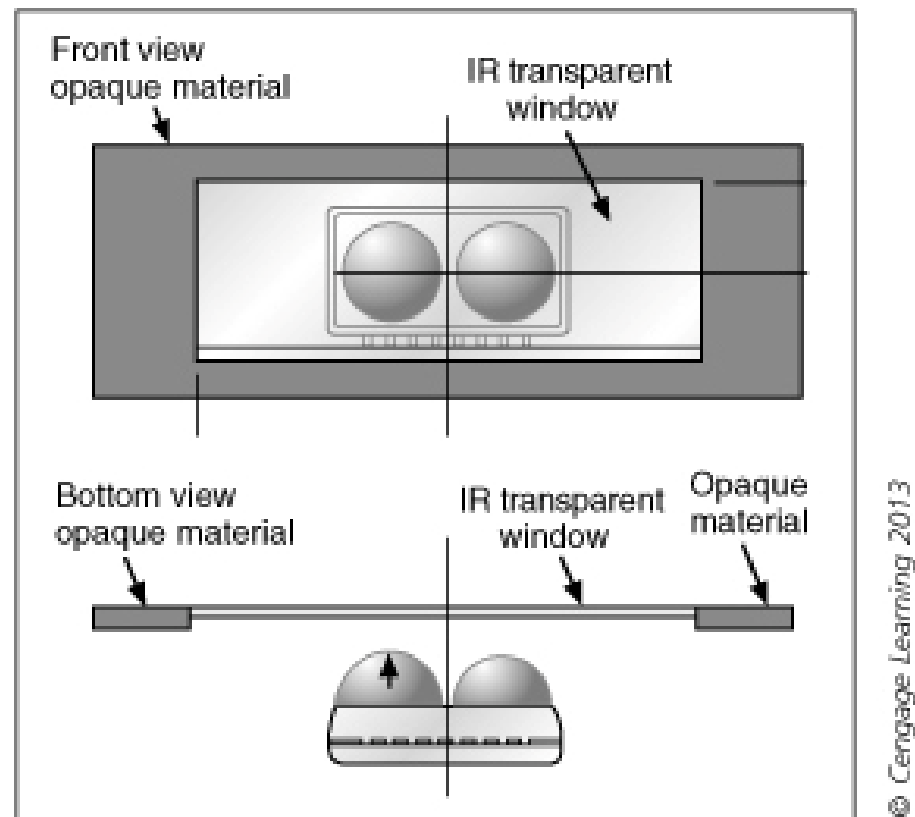


Figure 13-6 IrDA diodes in device

# Visible Light Communications (802.15.7)

- IrDA drawbacks:
  - Designed to work like standard serial port on a personal computer, which is seldom used today
  - Cannot send and receive simultaneously
  - Strong ambient light can negatively impact transmissions
  - Angle and distance limitation between communicating devices

# Visible Light Communications (802.15.7)

- Visible light communications (VLC): based on visible light instead of infrared light is gaining popularity
  - Standards are being developed by the IEEE 802.15.7 committee
- VLC can operate in one of three topologies:
  - Peer-to-peer topology: communication is between only two VLC devices
  - Star topology: all devices communicate with a single central controller, called the coordinator
  - Broadcast topology: device in a broadcast mode can transmit a signal to other devices without forming a network



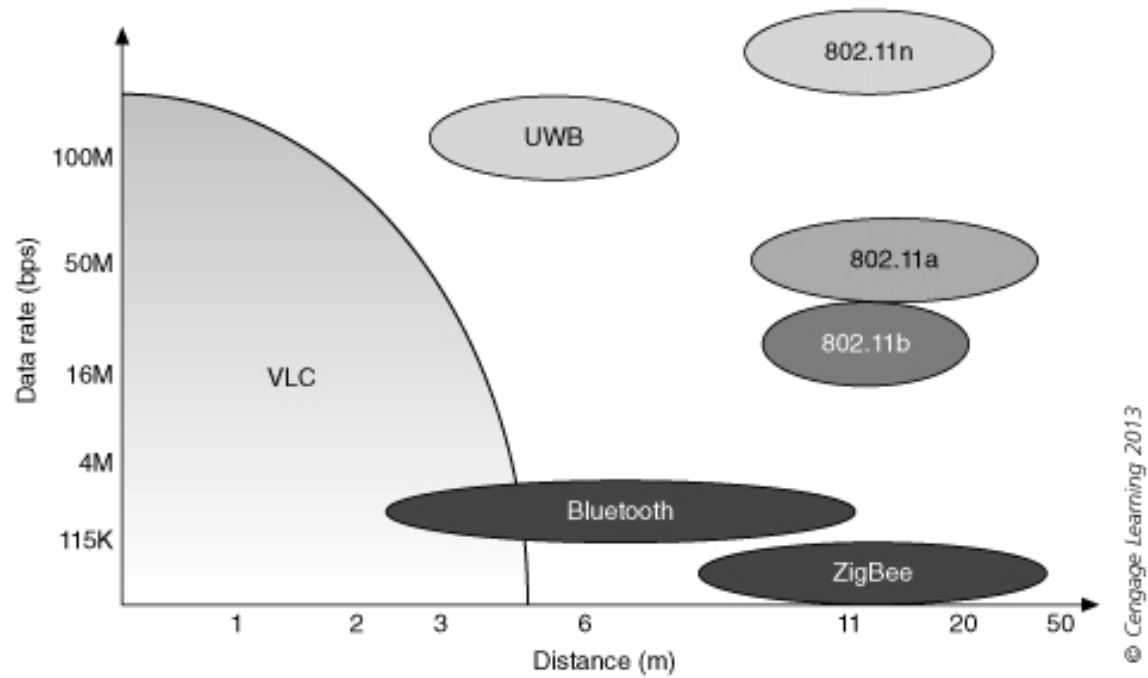


Figure 13-8 VLC data rate comparison

# Visible Light Communications (802.15.7)

- VLC has several advantages:
  - Visible light is harmless to the human body
  - VLC networks can be created to transmit data by adding optical communication devices to the sockets of existing light fixtures
  - No EMI impacts VLC
  - There are no regulations regarding use of light
  - Signals cannot be intercepted

# Wireless Metropolitan Area Networks

- Cover an area of up to 56 kilometers (35 miles)
- WMANs are often used as an alternative to an organization's fiber optic cable connection between two or more remote locations
- Two primary WMAN technologies are:
  - Free space optics
  - Broadband radio service

# Free Space Optics (FSO)

- Optical, wireless, point-to-point, line-of-sight wireless technology
  - Able to transmit at speed comparable to Fiber Optics
  - Transmissions sent by low-powered infrared beams
- Advantages compared to fiber optic and RF:
  - Lower installation costs
  - Faster installation
  - Scaling transmission speed
  - Good security
- Atmospheric conditions can affect transmission



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Figure 13-9 FSO transceiver

# Broadband Radio Service (BRS)

- Broadband Radio Service (BRS): uses microwave frequencies to transmit at distances of up to 35 miles (56 kilometers)
- Formerly known as Multichannel Multipoint Distribution Service (MMDS)
  - In homes, alternative to cable modems and DSL service
  - For businesses, alternative to T1 or fiber optic connections
- BRS hubs are typically located at a very high point
  - On top of building, towers, mountains

# Broadband Radio Service (BRS)

- The hub uses point-to-multipoint architecture
  - Multiplexes communications to multiple users
  - Tower has backhaul connection
- BRS uses cells
  - Single BRS cell can cover over 3,800 square miles
- Advantages:
  - Long transmission range, large cell size, low vulnerability to poor weather conditions
- Still requires line-of-site, not encrypted

# Wireless Wide Area Networks

- Wireless networks that transmit beyond the range of WMANs are generally known as wireless wide area networks (WWANs)
- Primary technologies for WWAN are:
  - WiMAX
  - Long term evolution (LTE)



# WiMAX (IEEE 802.16)

- WiMAX (Worldwide Interoperability for Microwave Access )
  - Uses scheduling system
    - Device competes once for initial network entry
- Fixed WiMAX: based on IEEE 802.16-2004
  - Can serve as a substitute for fiber optic connections between buildings
  - Provides up to 31 miles (50 kilometers) of linear service area range
  - Does not require line-of-sight

# WiMAX (IEEE 802.16)

- Mobile WiMAX: based on IEEE 802.16e-2005
  - Can connect mobile devices over a wide area
  - One mobile WiMAX base station can cover an area of 6 miles (9.6 kilometers)
  - Can support users traveling at vehicular speeds of 70 miles per hour
  - Often promoted as a solution to the last mile connection

# Long Term Evolution (LTE)

- **Mobile telecommunications switching office (MTSO):** link between the cellular network and the wired telephone world
  - controls all of the transmitters and base stations in the cellular network
  - All transmitters and cell phones operate at a low power level so the signal stays confined to the cell and does not interfere with other cells
    - This allows the same frequency to be used in other cells at the same time

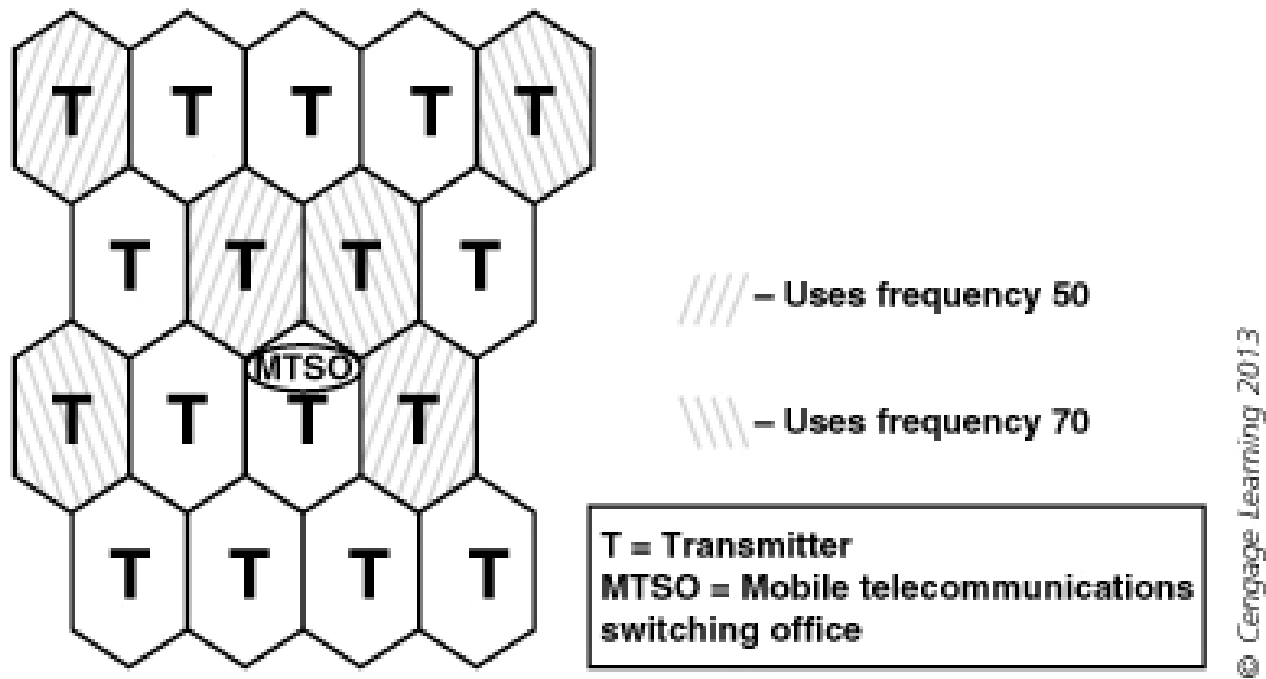


Figure 13-10 Cellular frequency reuse

# Long Term Evolution (LTE)

- By early 2008, the two largest cellular carriers in North America adopted 3<sup>rd</sup> Generation Partnership Project Long Term Evolution (3GPP LTE)
- LTE incorporates several elements found in IEEE 802.11n WLANs
  - Uses orthogonal frequency division multiplexing (OFDM)
  - Breaks down transmission into separate parts to send each part in parallel simultaneously
  - LTE also utilizes Multiple –Input Multiple-Output (MIMO)

# IEEE 802.11ac

- Current IEEE 802.11a/b/g/n technologies often cannot keep up with demands of streaming video
  - Results in deteriorated performance, choppy videos, and slow load times
- First draft of IEEE 802.11ac, known as Very High Throughput <6Ghz, was introduced in January 2011
  - Built upon many of the enhancements introduced in 802.11n
  - Advertised data rates over 1 Gbps

# IEEE 802.11ac

- Some of the 802.11ac technologies include:
  - *Spectrum*: will operate in the less-crowded 5 GHz spectrum and not support 2.4 GHz
  - *Increased channel bandwidth*: uses channel bandwidths up to 80 MHz
  - *MU-MIMO*: Multi-User MIMO enables simultaneous transmission of different data frames to different clients
  - *Error correction coding*
  - *Beam forming*
  - *Improved battery life*

Technology	802.11ac	802.11n
Maximum data rate	3.6 Gbps	600 Mbps
Spectrum	5 GHz	2.4 GHz or 5 GHz
Modulation	256-QAM	16-QAM or 64-QAM
Channel width	80 MHz	40 MHz
Spatial streams	8	4
Primary uses	Video	Data

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Table 13-7 IEEE 802.11ac technologies



# Summary

- Four broad categories of wireless technology: WPANs, WLANs, WMANs, and WWANs
- Bluetooth is a wireless technology that uses short-range RF transmissions
- There are two Bluetooth network topologies: Bluetooth piconet and Bluetooth scatternet
- ZigBee is a low-power, short-range, and low-data rate specification
- RFID is not a standard but is a technology that uses RF tags to transmit information

# Summary

- The IEEE 802.15.6 group is currently creating standards for body area networks (BAN)
- BANs are commonly used for sports and fitness monitoring as well as healthcare applications
- IrDA technology uses infrared transmissions to transmit data
- Visible light communications (VLC) standards are being developed by IEEE 802.15.7
- FSO is an optical, wireless, point-to-point wireless technology for outdoor transmission

# Summary

- Broadband radio service (BRS) is a wireless technology that uses microwave frequencies and is a wireless alternative to cable TV reception
- Fixed WiMAX can serve as a substitute for fiber-optic connections between buildings
- Mobile WiMAX can connect mobile devices over a wide area
- Another WWAN technology is 3<sup>rd</sup> Generation Partnership Project Long Term Evolution (3GPP LTE)

# Summary

- IEEE Task Group for 802.11ac published its first draft of standard known as Very High Throughput <6Ghz to support higher data rates
- IEEE 802.11ac has advertised data rates over 1 Gbps