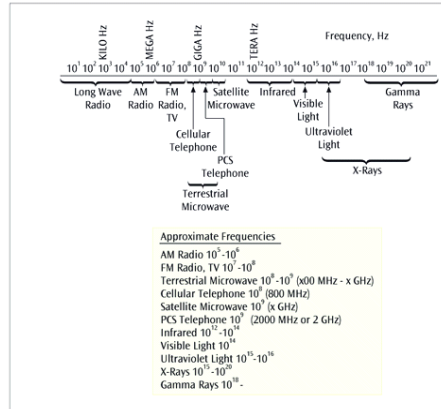


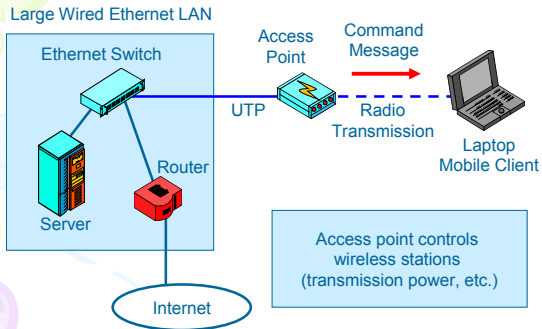
# Chapter 5: Wireless LANs



Figure 3-10  
Electromagnetic wave frequencies



## Wireless LAN (WLAN) Access Point



## Radio Wave Characteristics, Cont'd

- Radio waves are described in terms of frequency
  - Hertz = one cycle per second
  - In increasing orders of 1,000...
    - KiloHertz (kHz)
    - MegaHertz (MHz)
    - GigaHertz (GHz)

## Radio Wave Characteristics, Cont'd

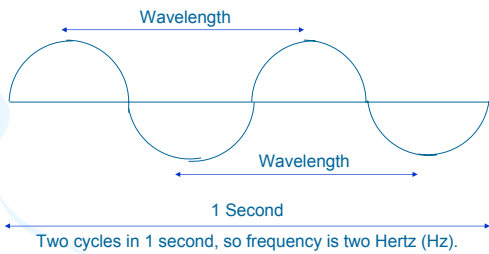


Figure 5-3:

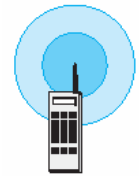
## Omni-directional & Dish Antennas



Dish Antenna

Concentrates incoming and outgoing signals in a narrow range

Must point at receiver  
Good for fixed subscribers



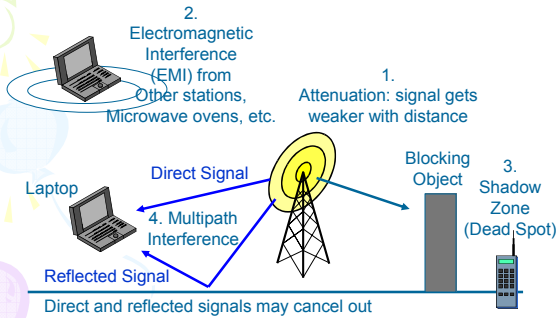
Omnidirectional Antenna

Signal spreads as a sphere  
Rapid signal attenuation

No need to point at receiver  
Good for mobile subscribers

Figure 5-4:

## Wireless Propagation Problems



7  
Figure 5-5:

## Wireless Propagation Problems, Cont'd

- Inverse square law attenuation
  - To compare relative power at two distances
    - Divide the longer distance by the shorter distance
    - Square the result; this is the relative power ratio
- Examples
  - 100 mW (milliwatts) at 10 meters
  - At 20 meters:  $100/(20/10)^2 = 100\text{mW}/4 = 25 \text{ mW}$
  - At 30 meters:  $100/(30/10)^2 = 100\text{mW}/9 = 11 \text{ mW}$

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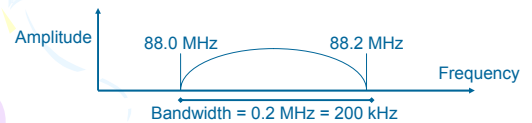
## Wireless Propagation Problems, Cont'd

- Some problems are Frequency-Dependent
  - Higher-frequency signals attenuate faster
    - Absorbed more rapidly by water in the air
  - Higher-frequency signals blocked more by obstacles
    - At lower frequencies, signal refract (bend) around obstacles like an ocean wave hitting a buoy
    - At higher frequencies, signals do not refract; leave a complete shadow behind obstacles

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Figure 5-5

## Channel Bandwidth & Transmission Speed

- Channel Bandwidth
  - An 88.0 MHz to 88.2 MHz channel (FM radio) has a bandwidth of 0.2 MHz (200 kHz)
  - Higher-speed signals need wider bandwidths



10  
Figure 5-7

## Channel Bandwidth & Transmission Speed, Cont'd

### • Shannon Equation

$$C = B \log_2 (1 + S/N)$$

- C = Maximum possible transmission speed in the channel (bps)
- B = Bandwidth (Hz) (Like thickness of a hose)
- S/N = Signal-to-Noise Ratio

- Note that doubling the bandwidth (B) doubles the maximum possible transmission speed
- More generally, increasing the bandwidth by X increases the maximum possible speed by X



11  
Figure 5-7

## Channel Bandwidth & Transmission Speed, Cont'd

### • Broadband and Narrowband Channels

- Broadband means wide channel bandwidth and therefore high speed
- Narrowband means narrow channel bandwidth and therefore low speed
- Narrowband is below 100 kbps
- Broadband is above 100 kbps

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Figure 5-7

## Channel Bandwidth and Transmission Speed, Cont'd

- Channel Bandwidth & Spectrum Scarcity
  - Why not make all channels broadband?
    - There is a limited amount of spectrum in desirable frequencies
    - Making each channel broader than needed would mean having fewer channels or widening the service band
  - Service band design requires trade-offs between speed requirements, channel bandwidth, and service band size

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## Channel Bandwidth and Transmission Speed, Cont'd

- The Golden Zone
  - Most organizational radio technologies operate in the "golden zone"
    - High megahertz to low gigahertz range
  - At higher frequencies, there is more available bandwidth
  - At lower frequencies, signals propagate better
  - Frequencies are high enough for there to be large total bandwidth
  - Frequencies are low enough to allow fairly good propagation characteristics

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## Normal Radio Transmission & Spread Spectrum Transmission

Note: Height of Box Indicates Bandwidth of Channel

Channel Bandwidth Required for Signal Speed



Normal Radio: Bandwidth is No Wider than Required



To conserve spectrum channel, bandwidths usually are set to be only as wide as signals in the service band need based on their speed

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Figure 5-8

## Spread Spectrum Transmission

Note: Height of Box Indicates Bandwidth of Channel

Channel Bandwidth Required for Signal Speed



Spread Spectrum Transmission: Channel Bandwidth is Much Wider than Needed



However, spread spectrum transmission uses much wider channels than the signal requires, which seems wasteful

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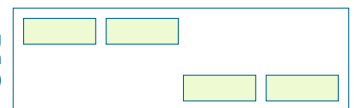
## Normal Radio Transmission & Spread Spectrum Transmission, Cont'd

- Why Spread Spectrum Transmission?
  - Commercial spread spectrum transmission reduces certain propagation effects (multipath interference and narrowband EMI);
    - These typically occur over a narrow range of frequencies
    - With spread spectrum transmission, most of the signal will get through
  - Does *not* provide security as in military spread spectrum systems (common misconception)

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## Figure 5-9: Spread Spectrum Transmission Methods

Frequency Hopping Spread Spectrum (FHSS)



Signal only uses its normal bandwidth, but it jumps around within a much wider channel

If there are propagation problems at specific frequencies, most of the transmission will still get through

Limited to low speeds; used by Bluetooth (later)

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## Figure 5-9: Spread Spectrum Transmission Methods, Cont'd

### Direct Sequence Spread Spectrum (DSSS)

Wideband but Low-Intensity Signal

Signal is spread over the entire bandwidth of the wideband channel

The power per hertz at any frequency is very low

Interference will harm some of the signal, but most of the signal will still get through and will be readable

Used in 802.11b (11 Mbps), which is discussed later

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## Figure 5-9: Spread Spectrum Transmission Methods, Cont'd

### Orthogonal Frequency Division Multiplexing (OFDM)

Subcarrier 1

Subcarrier 2

Subcarrier 3

OFDM divides the broadband channel into subcarriers

Sends part of the signal in each subcarrier

The subcarrier transmissions are redundant so that if some are lost, the entire signal will still get through

Used in 802.11a and g at 54 Mbps (discussed later)

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## 802.11 Wireless LAN Standards

	802.11b	802.11a	802.11g	802.11g if 802.11g access point serves an 802.11b station
<b>Unlicensed Band</b>	2.4 GHz	5 GHz	2.4 GHz	2.4 GHz
<b>Crowded Band?</b>	Yes	No	Yes	Yes
<b>Attenuation</b>	Lower	Higher	Lower	Lower

Note: 802.11b reached market before 802.11a

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Figure 5-14

## 802.11 Wireless LAN Standards (Table)

Source for throughput data: Broadband.com

	802.11b	802.11a	802.11g	802.11g if 802.11g access point serves an 802.11b station
802.11a, operating at a higher frequency, has more attenuation than 802.11b				
<b>Rated Speed</b>	11 Mbps	54 Mbps	54 Mbps	Not Specified
<b>Actual Throughput, 3 m</b>	6 Mbps	25 Mbps	25 Mbps	12 Mbps
<b>Actual Throughput, 30 m</b>	6 Mbps	12 Mbps	20 Mbps	11 Mbps

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## Market Realities

- 802.11b
  - Dominates the installed base but not for sale much longer because of 802.11g
- 802.11g dominates sales today
- 802.11a is not thriving in the market
- 802.11n is under development
  - 100 Mbps or more in the 5 GHz band
  - Fast enough for video

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## Security

- Default is usually set to none
  - Allows for drive by hacking
- Security key is available in new systems but
  - all stations use the same key
- 802.11i Security
  - Products started becoming available in late 2003
- Wireless Protected Access (WPA)
  - Stopgap security method introduced before full 802.11i security could be developed

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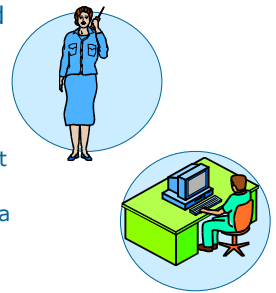
## 802.11 Security, Cont'd

- Rogue Access Points
  - Unauthorized access points set up by department or individual
  - Often have very poor security, leaving a big opening for hackers
  - Often operate at high power, attracting many clients to these access points with weak security

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## Bluetooth

- Wireless standard for personal area networks (PANs)
  - Replace wired connections
  - A few devices that a person carries
  - A few devices on a user's desktop



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## 802.11 Versus Bluetooth

	802.11	Bluetooth
<b>Focus</b>	Local Area Network (LAN)	Personal Area Network (PAN)
<b>Rated Speed (Actual Throughput Will Be Lower)</b>	11 Mbps to 54 Mbps in both directions	722 kbps with back channel of 56 kbps. May increase.
<b>Distance</b>	30 to 100 meters	10 meters
<b>Number of Devices</b>	Limited in practice only by bandwidth and traffic	10 piconets (PANs), each with up to 8 devices

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## 802.11 vs. Bluetooth, Cont'd

	802.11	Bluetooth
<b>Scalability</b>	Good because allows multiple access points	Poor
<b>Cost</b>	Higher	Lower
<b>Battery Drain</b>	Higher	Lower
<b>Application Profiles</b>	No	Yes

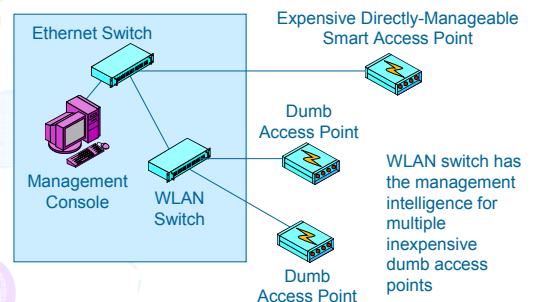
28

## 802.11 vs. Bluetooth, Cont'd

- Bluetooth Application Profiles
  - Devices with compatible application profiles (a printer and PC, for instance) can work together automatically
  - Extremely useful; nothing like it in 802.11
  - However, few application profiles have been designed

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## Access Point Management Alternatives



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Figure 5-20:

## Emerging WLAN Technologies

### • **Wireless LAN Management**

#### – Functions

- Notification of failures
- Constant QoS monitoring
  - Signal strength, etc.
- Support remote access point adjustment
  - Power, channels used, etc.
- Send software updates to all access points
- All of this should be as automatic as possible

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## Emerging WLAN Technologies, Cont'd

### • **Fourth-Generation (4G) Stations**

#### – Stations that can support multiple radio methods

- 802.11a, b, and g
- Bluetooth
- 3G cellular
- Etc.

#### – Choose the best mode for a situation

- E.g., 802.11g when in reach of WLAN (fast & cheap)
- Expensive 3G when nothing else is available

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