UNIVERSITAS KOMPUTER INDONESIA

Wireless and Mobile Communication

Chap 5 Antennas

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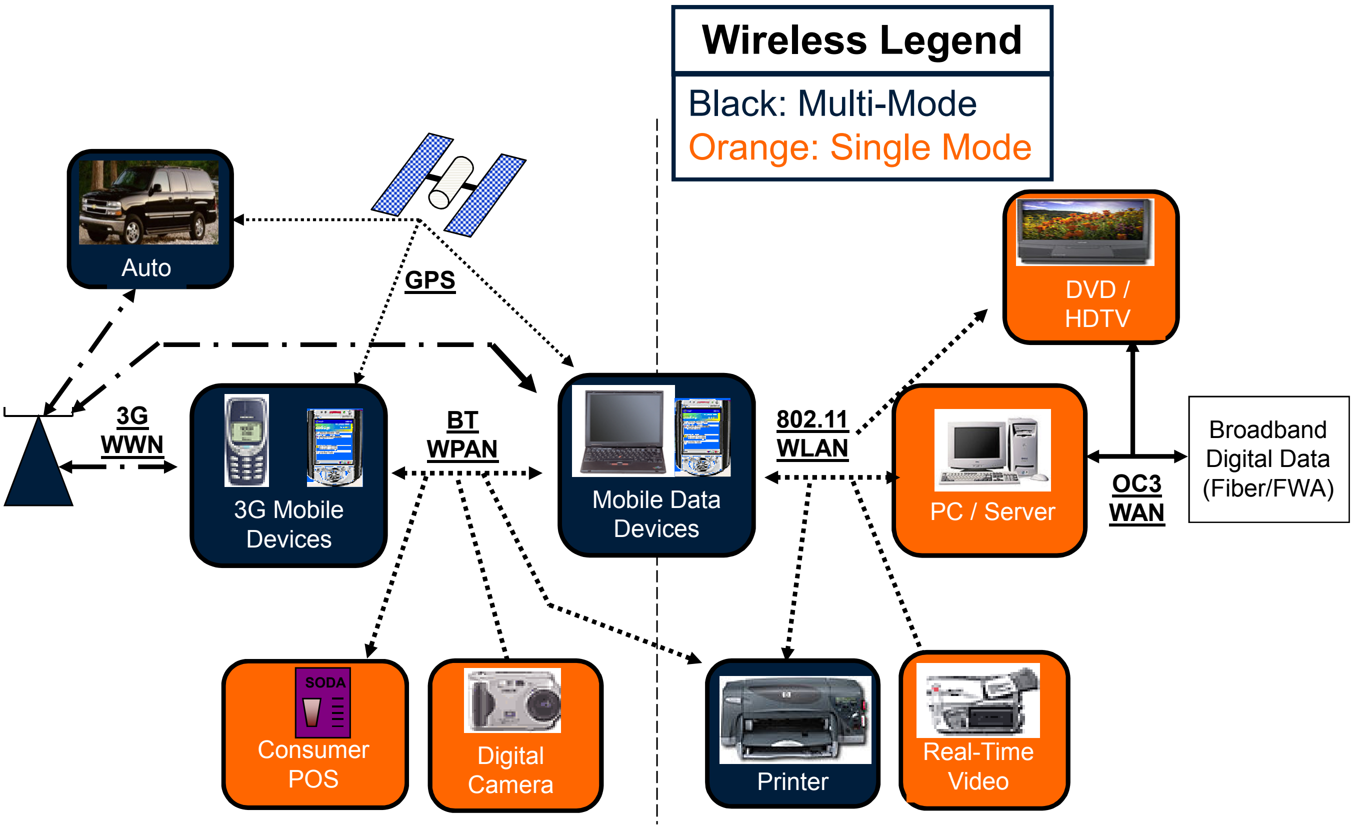
Introduction

- An antenna is an electrical conductor or system of conductors
  - Transmission - radiates electromagnetic energy into space
  - Reception - collects electromagnetic energy from space
- In two-way communication, the same antenna can be used for transmission and reception

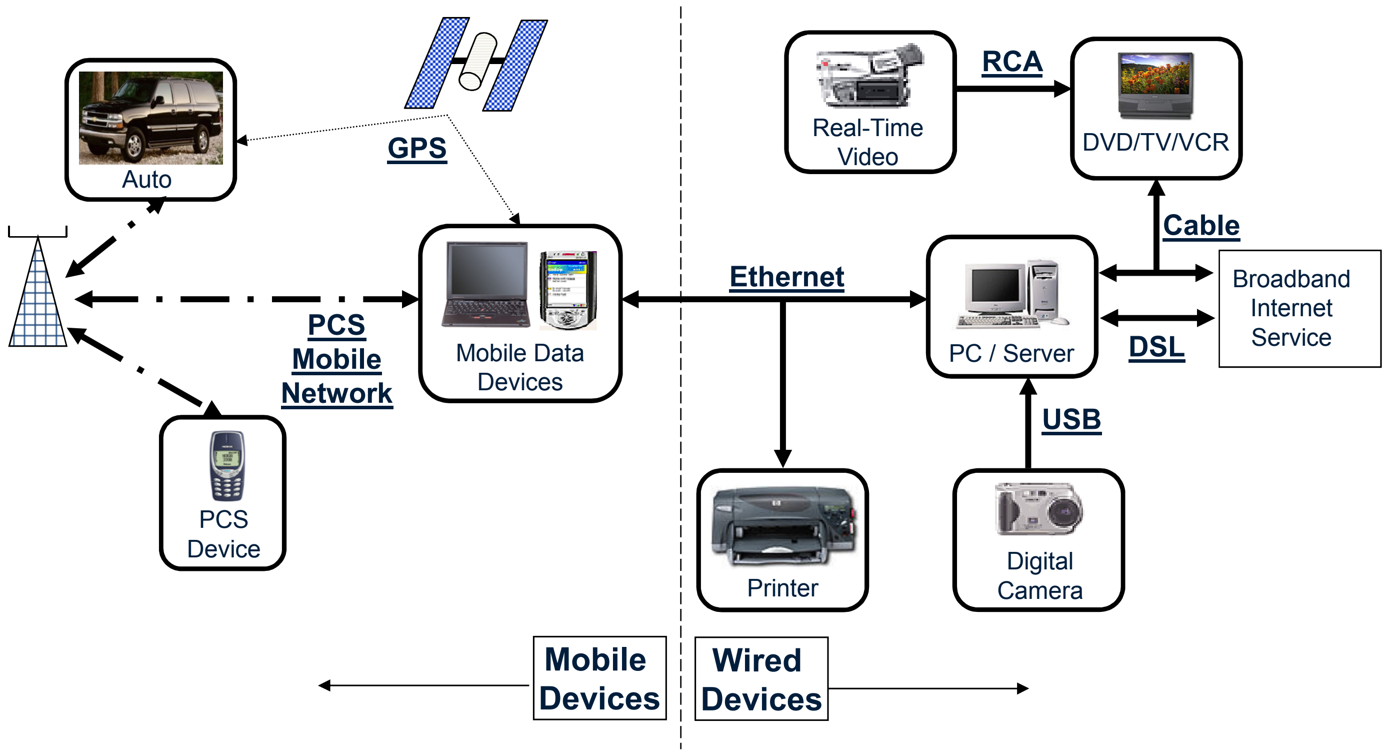
Antenna Evolution

- Antennas Have Always Been the Part That Makes a Wireless Device ***Wireless***
- Have Traditionally Been External, Connectorized Components
  - Misunderstood, considered "*black magic*"
  - Gangly, obtrusive
  - Added on at the end of the design
- Antennas for Mobile Devices Have Evolved Since Their Introduction
  - Whips → Retractables → Stubbies → Embedded

Future of the Wired/Wireless World

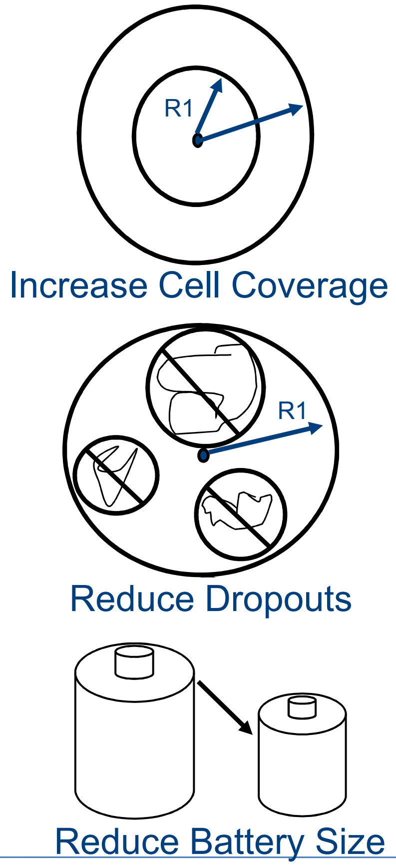


Wired/Wireless Networks of Today



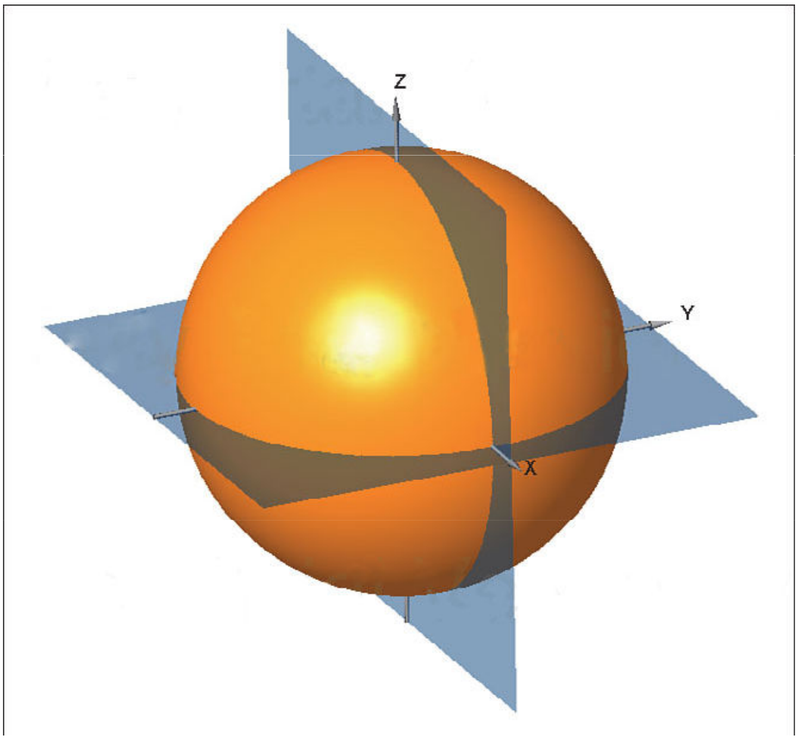
Antenna Performance

- Better Performance is Usually Achieved by Increased S/N in the Wireless Link
  - Performance improvements can be realized by higher gain antenna (if beam is properly focused)
    - Example: Want horizontal beam for cell phone, zenith beam for GPS
- Increased Gain Can be Used in Different Ways
  - Better cell coverage area
    - Increase cell size / range
    - Given all mobiles at max power, then less dropouts
  - Less battery power
    - Given strong signal area, then reduced Tx Battery
    - Especially critical in CDMA networks
  - Some combination of above



THEORY OF ANTENNA

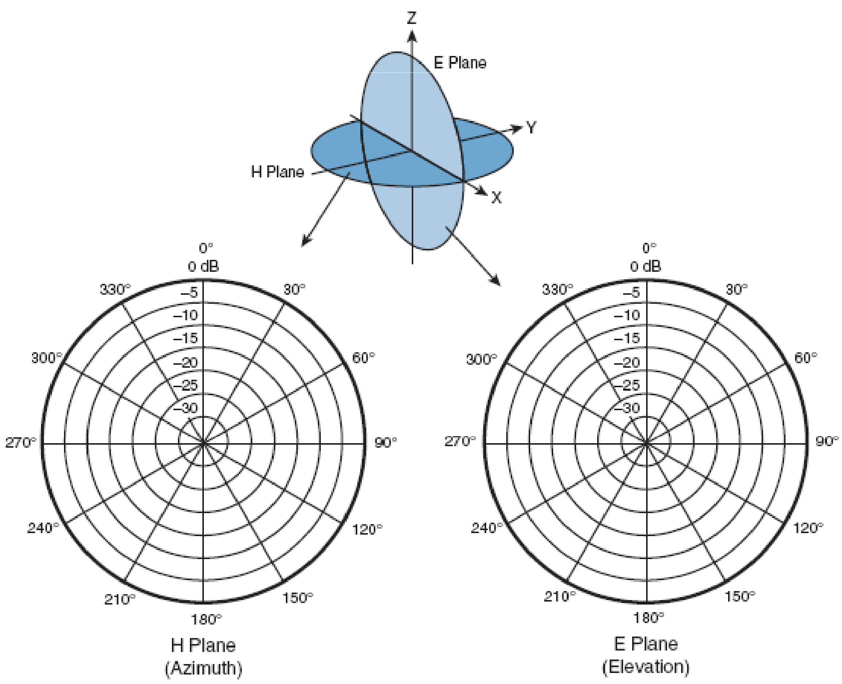
Isotropic Antenna



Radiation Patterns

- Radiation pattern
  - Graphical representation of radiation properties of an antenna
  - Depicted as two-dimensional cross section
- Beam width (or half-power beam width)
  - Measure of directivity of antenna
  - Angle within which power radiated is at least half of that in most preferred direction
- Reception pattern
  - Receiving antenna's equivalent to radiation pattern
- Omnidirectional vs. directional antenna

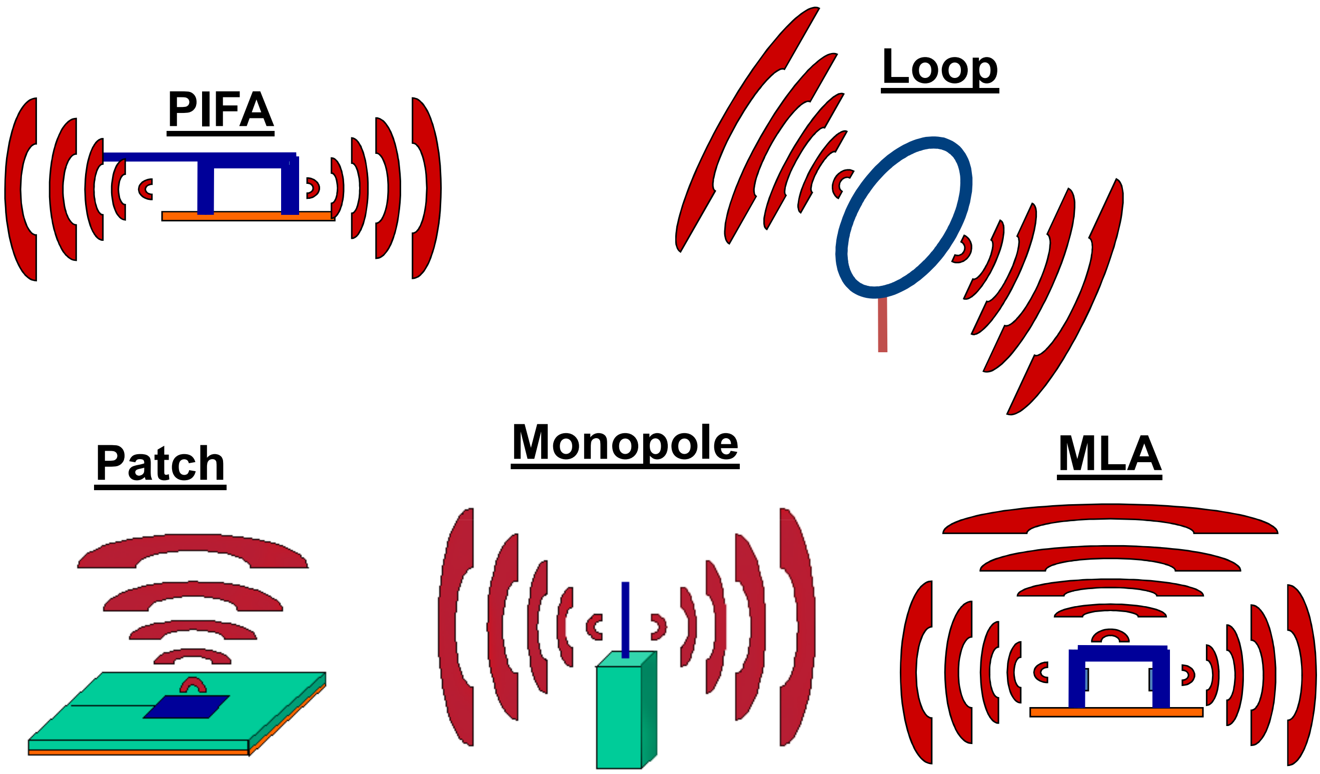
Azimuth (H) Plane and Elevation (E) Plane



Types of Antennas

- Isotropic antenna (idealized)
  – Radiates power equally in all directions
- Dipole antennas
  – Half-wave dipole antenna (or Hertz antenna)
  – Quarter-wave vertical antenna (or Marconi antenna)
- Parabolic Reflective Antenna
  – Used for terrestrial microwave and satellite applications
  – Larger the diameter, the more tightly directional is the beam

Wireless Device Antenna Choices

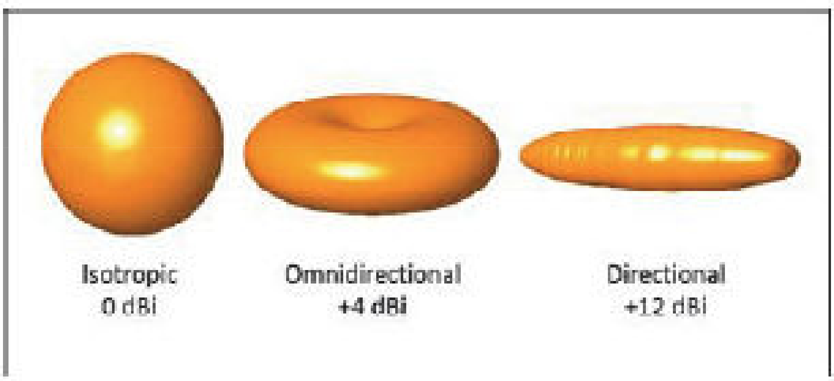


Antenna - Real

- Not isotropic radiators, but always have directive effects (vertically and/or horizontally)
- A well defined radiation pattern measured around an antenna
- Patterns are visualised by drawing the set of constant-intensity surfaces

Antenna Gain

- Antenna gain
  - Power output, in a particular direction, compared to that produced in any direction by a perfect omnidirectional antenna (isotropic antenna)
- Expressed in terms of effective area
  - Related to physical size and shape of antenna



Antenna Gain

- Relationship between antenna gain and effective area

$$G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi f^2 A_e}{c^2}$$

- G = antenna gain
- A_e = effective area
- f = carrier frequency
- c = speed of light (≈ 3 x 10^8 m/s)
- λ = carrier wavelength

Antenna - Ideal - *contd.*

- The power density of an ideal loss-less antenna at a distance *d* away from the transmitting antenna:

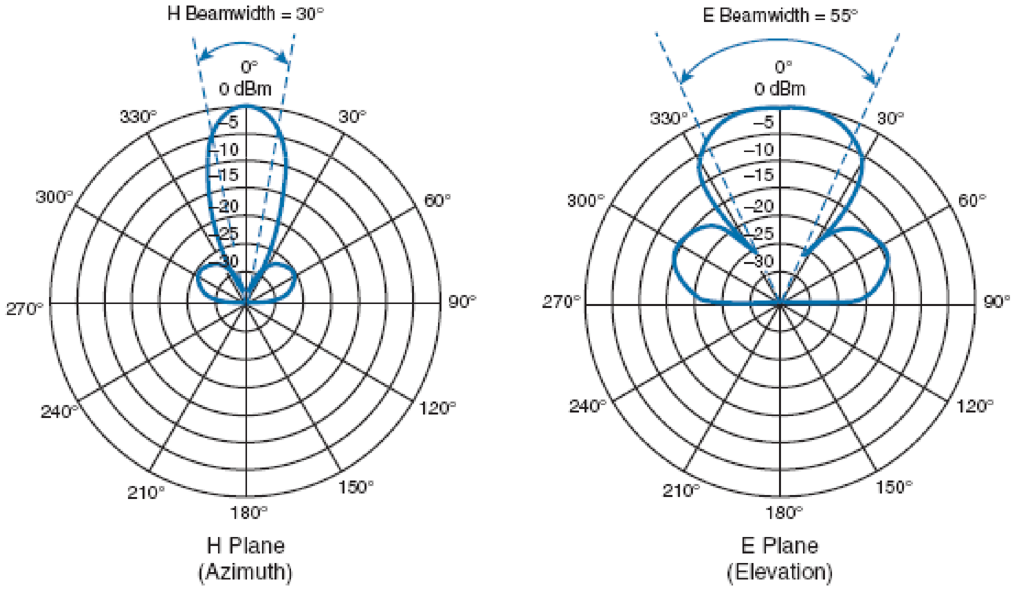
$$P_a = \frac{P_t G_t}{4\pi d^2} \quad \text{W/m}^2$$

Note: the area is for a sphere.

- G_t is the transmitting antenna gain
- The product $P_t G_t$: **Equivalent Isotropic Radiation Power (EIRP)**

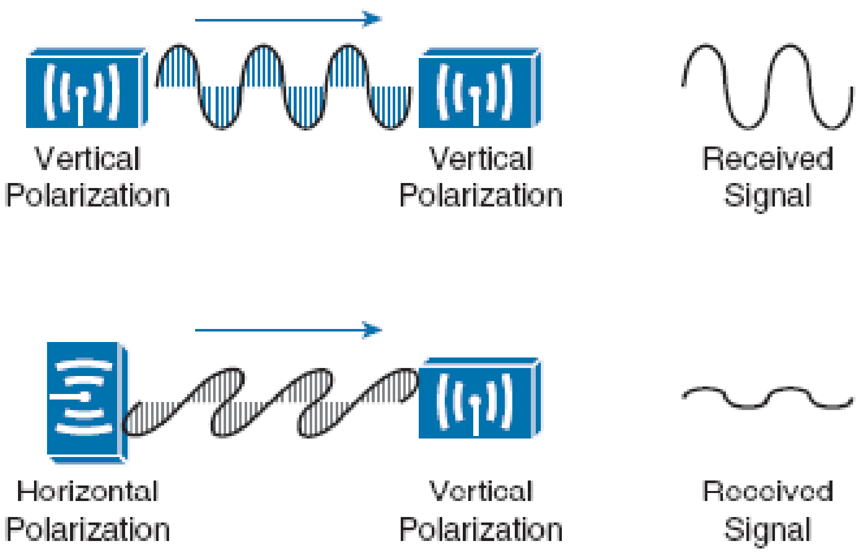
which is the power fed to a perfect isotropic antenna to get the same output power of the practical antenna in hand.

Beam Width



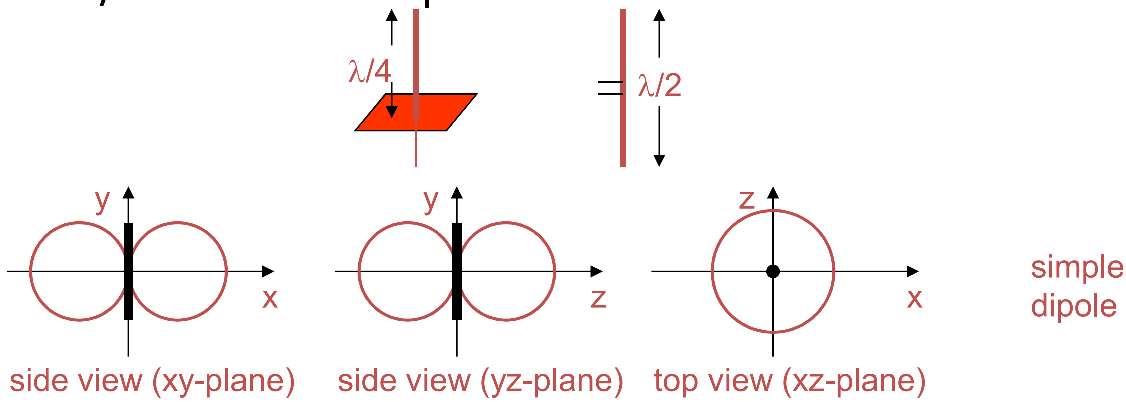
The beamwidth is determined by finding the strongest point on the plot, which is usually somewhere on the outer circle. Next, the plot is followed in either direction until the value decreases by 3 dB, indicating the point where the signal is one-half the strongest power.

Polarization



Antenna – Real - Simple Dipoles

- Not isotropic radiators, e.g., dipoles with lengths $\lambda/4$ on car roofs or $\lambda/2$ as Hertzian dipole

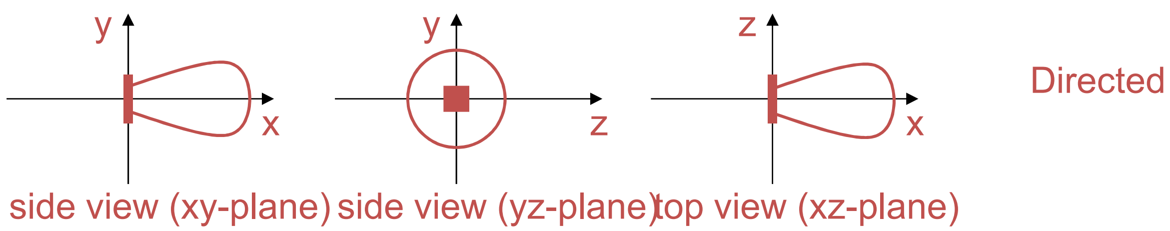


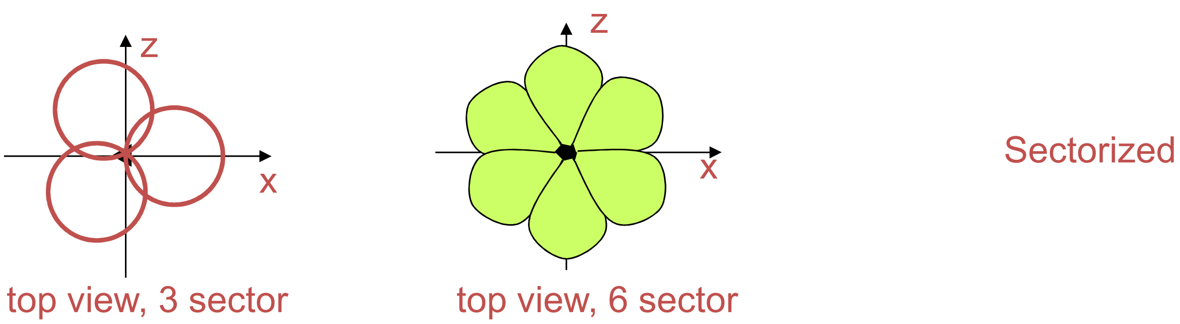
- Example: Radiation pattern of a simple Hertzian dipole

shape of antenna is proportional to the wavelength

Antenna – Real - Sdirected and Sectorized

- Used for microwave or base stations for mobile phones (e.g., radio coverage of a valley)





Antenna - Ideal - *contd.*

- The receiving antenna is characterized by its effective aperture A_e, which describes how well an antenna can pick up power from an incoming electromagnetic wave
- The effective aperture A_e is related to the gain G_r as follows:

$$A_e = P_r / P_a \Rightarrow \qquad A_e = G_r\lambda^2/4\pi$$

which is the equivalent power absorbing area of the antenna.
G_r is the receiving antenna gain and $\lambda = c/f$

Antenna Type

Type	Style	Beamwidth		Gain (dBi)	
		H Plane	E Plane	2.4 GHz	5 GHz
Omnidirectional	Dipole	360°	65°	2.2	3.5
	Monopole	360°	50°	2.2	2.2
	Integrated	360°	150°	2	5
Directional	Patch	50°	50°	6–8	7–10
	Yagi	30°	25°	10–14	—
	Parabolic dish	5°	5°	20–30	20–30

Omni directional Antenna

gain of around +2 to +5 dBi.

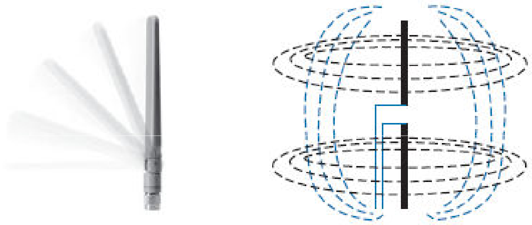
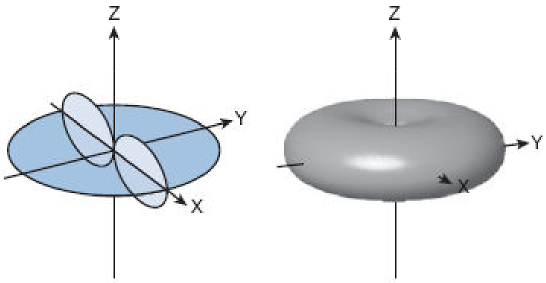


Figure 4-7 *A Cisco Dipole Antenna.*



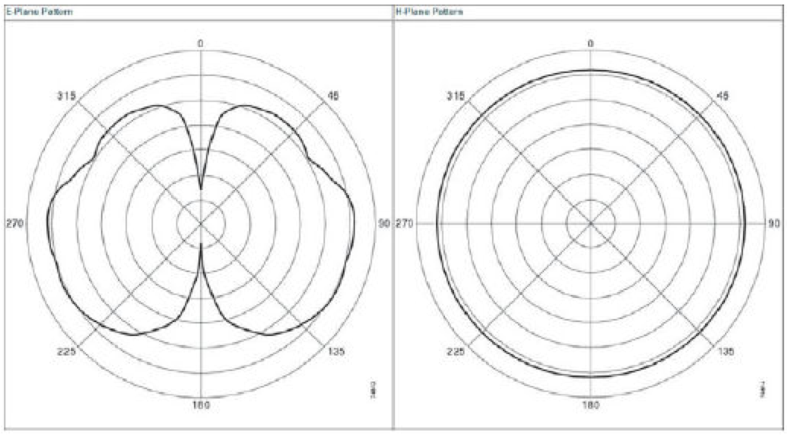


Figure 4-8 *E and H Radiation Patterns for a Typical Dipole Antenna.*

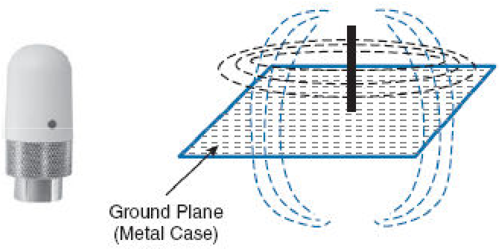
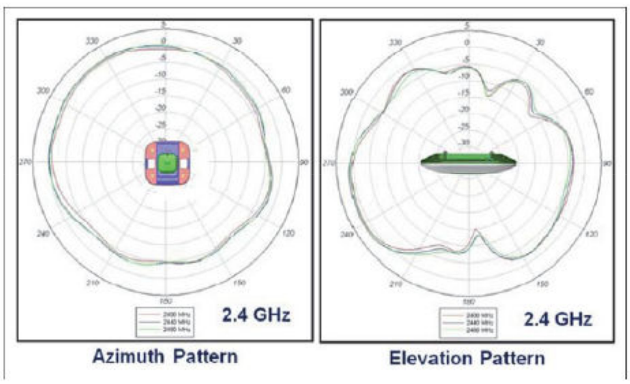


Figure 4-10 *A Cisco Monopole Antenna.*

Figure 4-11 *A Cisco Wireless Access Point with Integrated Omnidirectional Antennas.*



Directional Antennas

mounted on a wall.

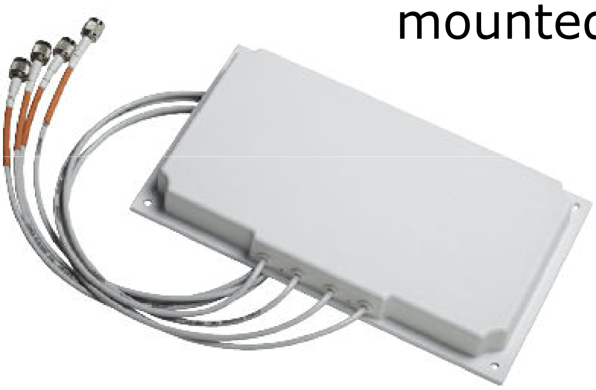
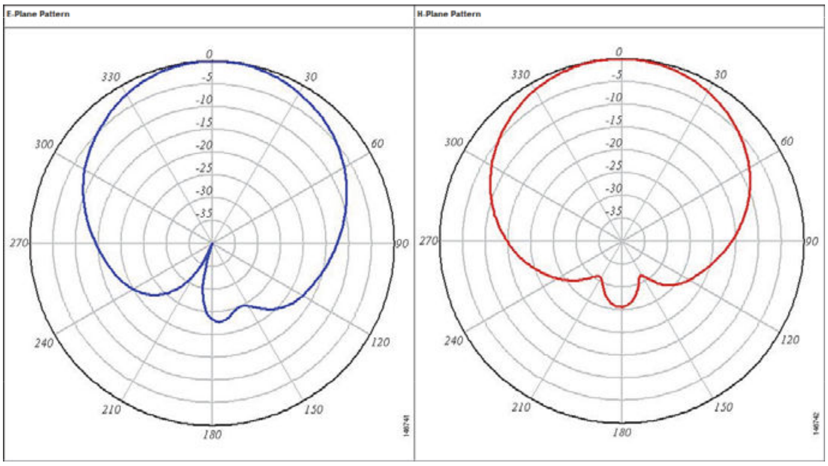


Figure 4-14 *A Typical Cisco Patch Antenna.*



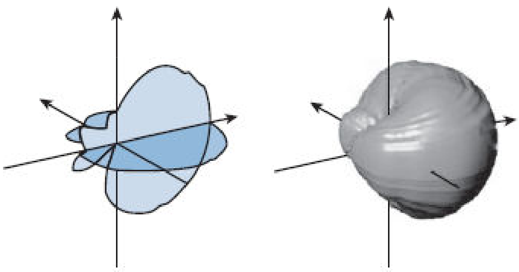
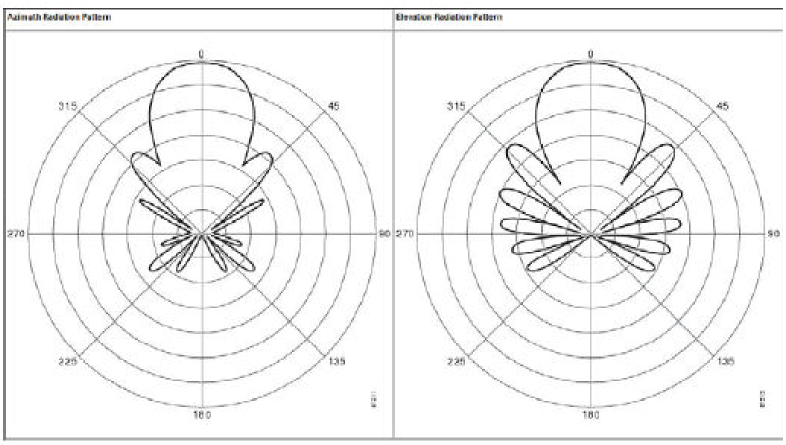


Figure 4-16 *A Patch Antenna Radiation Pattern in Three Dimensions.*

Directional Antennas

gain of about 10-14 dBi in the 2.4-GHz band. Cisco does not offer a 5-GHz Yagi.

Figure 4-17 *A Cisco Yagi Antenna.*



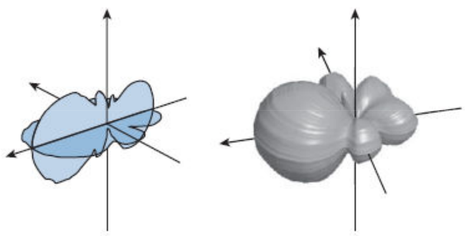
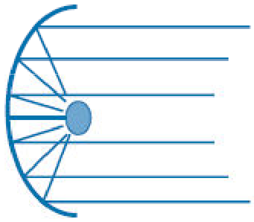


Figure 4-19 *A Yagi Antenna Radiation Pattern in Three Dimensions.*

Directional Antennas



antenna a gain of between 20 and 30 dBi—the highest gain of all the wireless LAN antennas.

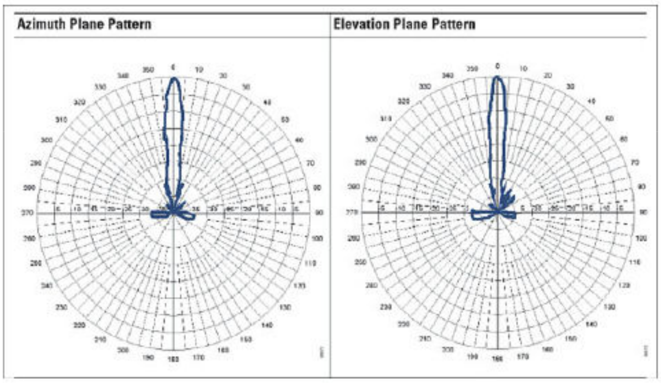


Figure 4-21 *E and H Radiation Patterns for a Parabolic Dish Antenna.*

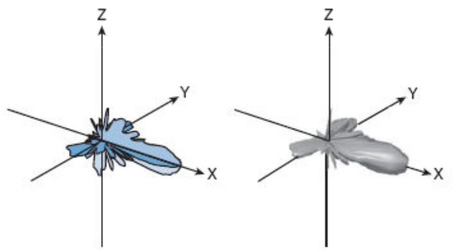


Figure 4-22 *A Parabolic Dish Antenna Radiation Pattern in Three Dimensions.*

Adding Antenna Accessories

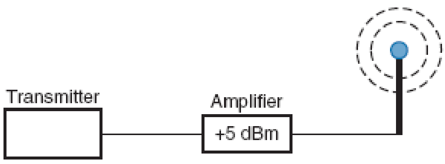


Figure 4-23 *Using an Amplifier to Add 5-dBm Gain.*

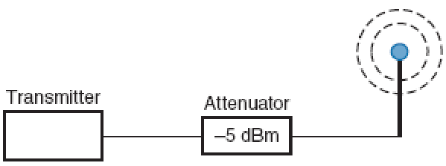


Figure 4-24 *Using an Attenuator to Add 5-dBm Loss.*

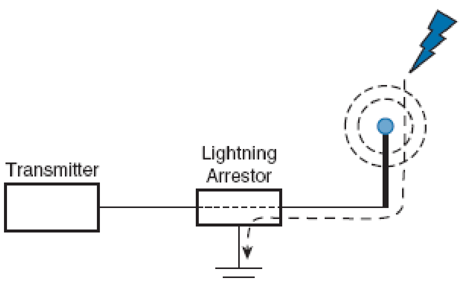


Figure 4-25 *Using a Lightning Arrestor to Protect Sensitive Wireless LAN Equipment.*