CHAPTER 11

Antenna Fundamentals

September 4, 2014

This part of the CVD discusses antennas, which are a fundamental part of any WLAN deployment since selecting the right type of antenna for deployment greatly enhances not just coverage, but also location readiness.

An antenna gives the wireless system three fundamental properties—gain, direction, and polarization. Gain is a measure of increase in power. Direction is the shape of the transmission pattern. A good analogy for an antenna is the reflector in a flashlight. The reflector concentrates and intensifies the light beam in a particular direction similar to what a parabolic dish antenna would do to a RF source in a radio system.

Antenna Gain

Antenna gain is measured in decibels, which is a ratio between two values. The gain of a specific antenna is compared to the gain of an isotropic antenna. An isotropic antenna is a theoretical antenna with a uniform three-dimensional radiation pattern (similar to a light bulb with no reflector). dBi is used to compare the power level of a given antenna to the theoretical isotropic antenna. The U.S. FCC uses dBi in its calculations. An isotropic antenna is said to have a power rating of 0 dB, meaning that it has zero gain/loss when compared to itself.

Unlike isotropic antennas, dipole antennas are real antennas. Dipole antennas have a different radiation pattern compared to isotropic antennas. The dipole radiation pattern is 360 degrees in the horizontal plane and 75 degrees in the vertical plane (assuming the dipole antenna is standing vertically) and resembles a donut in shape. Because the beam is “slightly” concentrated, dipole antennas have a gain over isotropic antennas of 2.14 dB in the horizontal plane. Dipole antennas are said to have a gain of 2.14 dBi (in comparison to an isotropic antenna).

Some antennas are rated in comparison to dipole antennas, which is denoted by the suffix dBd. Hence dipole antennas have a gain of 0 dBd (= 2.14 dBi).

Note Majority of documentation refers to dipole antennas as having a gain of 2.2 dBi. The actual figure is 2.14 dBi, but is often rounded up.

You can also use the dB abbreviation to describe the power level rating of antennas:

- dBi—For use with isotropic antennas.
- dBd—With reference to dipole antennas.

The power rating difference between dBd and dBi is approximately 2.2—that is, 0 dBd = 2.2 dBi.

Therefore an antenna that is rated at 3 dBd is rated by the FCC (and Cisco) as 5.2 dBi.

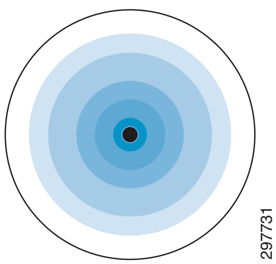
Antenna Types

Cisco offers several different styles of antennas for use with access points and bridges in both 2.4-GHz and 5-GHz products. Every antenna offered for sale has been FCC approved. Each type of antenna offers different coverage capabilities. As the gain of an antenna increases, there is some tradeoff to its coverage area. Usually high-gain antennas offer longer coverage distances, but only in a certain direction. The radiation patterns below help to show the coverage areas of the styles of antennas that Cisco offers: omnidirectional, Yagi, and patch antennas.

Omnidirectional Antenna

An omnidirectional antenna (Figure 11-1) is designed to provide a 360 degree radiation pattern. This type of antenna is used when coverage in all directions from the antenna is required. The standard 2.14-dBi "Rubber Duck" is one style of omnidirectional antenna.

Figure 11-1 Omnidirectional Antennas



Directional Antennas

Directional antennas come in many different styles and shapes. An antenna does not offer any added power to the signal; it simply redirects the energy it receives from the transmitter. By redirecting this energy, it has the effect of providing more energy in one direction and less energy in all other directions. As the gain of a directional antenna increases, the angle of radiation usually decreases, providing a greater coverage distance, but with a reduced coverage angle. Directional antennas include patch antennas (Figure 11-2), Yagi antennas (Figure 11-3), and parabolic dishes. Parabolic dishes have a very narrow RF energy path and the installer must be accurate in aiming these types of antennas these at each other.

Figure 11-2 Directional Antenna

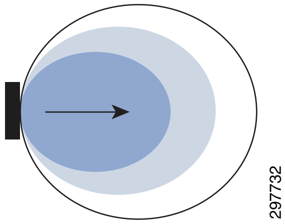
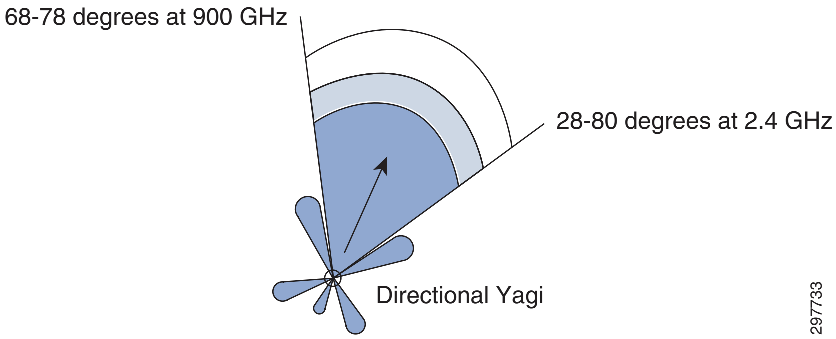


Figure 11-3 Yagi Antenna



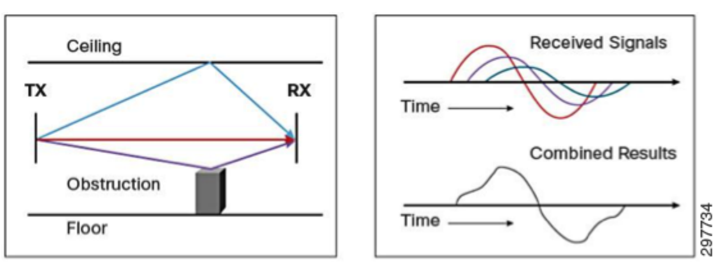
Multipath Distortion

Multipath interference occurs when an RF signal has more than one path between a receiver and a transmitter. This occurs in sites that have a large amount of metallic or other RF reflective surfaces.

Just as light and sound bounce off of objects, so does RF. This means there can be more than one path that RF takes when going from a transmit (TX) and receive (RX) antenna. These multiple signals combine in the RX antenna and receiver to cause distortion of the signal.

Multipath interference can cause the RF energy of an antenna to be very high, but the data would be unrecoverable. Changing the type of antenna and location of the antenna can eliminate multipath distortion (Figure 4).

Figure 11-4 Multipath Distortion



You can relate multipath distortion to a common occurrence in your car. As you pull up to a stop, you may notice static on the radio. But as you move forward a few inches or feet, the station starts to come in more clearly. By rolling forward, you move the antenna slightly, out of the point where the multiple signals converge.

Diversity Antenna Systems and Multipath Distortion

A diversity antenna system can be compared to a switch that selects one antenna or another, but never both at the same time. The radio in receive mode continually switches between antennas listening for a valid radio packet. After the beginning synchronization if a valid packet is heard, the radio evaluates the synchronization signal of the packet on one antenna and then switches to the other antenna and evaluates. Then the radio selects the best antenna and uses only that antenna for the remaining portion of that packet.

On Transmit, the radio selects the same antenna it used the last time it communicated with that given radio. If a packet fails, it switches to the other antenna and retries the packet.

Diversity antenna systems are used to overcome a phenomenon known as multipath distortion or multipath interference. A diversity antenna system uses two identical antennas located a small distance apart to provide coverage to the same physical area.

One caution with diversity antenna systems is that they are not designed for using two antennas covering two different coverage cells. The problem in using it this way is that if antenna number 1 is communicating to device number 1 while device number 2 (which is in the antenna number 2 cell) tries to communicate, antenna number 2 is not connected (due to the position of the switch) and the communication fails. Diversity antennas should cover the same area from only a slightly different location.

With the introduction of the latest direct-spread spectrum physical layer chips and the use of diversity antenna systems, direct-spread spectrum systems have equaled or surpassed frequency-hopping systems in handling multipath interference. While the introduction of Wide Band Frequency Hopping does increase the bandwidth of frequency-hopping systems, it drastically affects the ability to handle multipath issues, further reducing its range compared to present direct-spread systems in sites that are highly RF reflective.

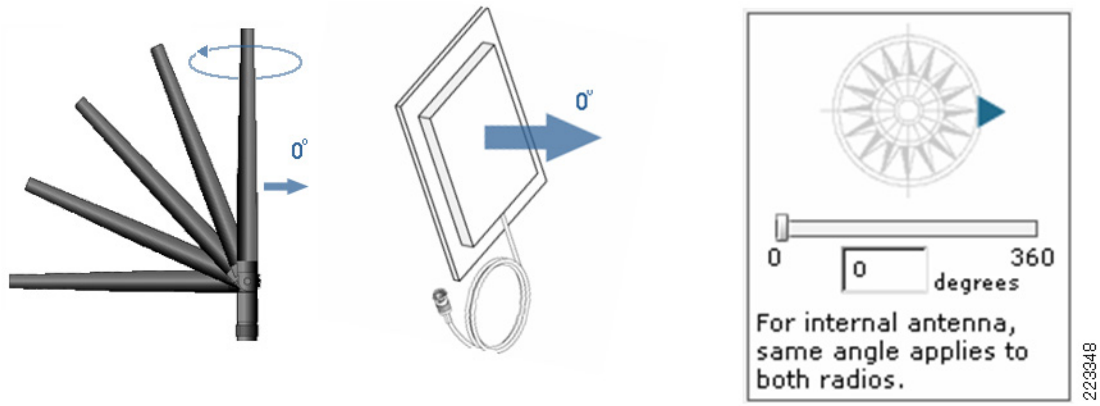
Antenna Orientation and Access Point Placement

When installing access points using either internal or external antennas, it is highly recommended that both the placement of the access point as well as the orientation selected for the access point antennas in Cisco Prime Infrastructure match the actual physical access point placement and antenna orientation. This helps to ensure accuracy and precision in both location tracking as well as the display of predictive heat maps.

The typical Cisco Aironet access point is installed using antenna diversity. Antenna diversity helps ensure optimal range and throughput in high multipath environments. With few exceptions, it is recommended that antenna diversity always be enabled. The location-aware Cisco UWN is designed to take RSSI information from both access point antennas into account when localizing tracked devices. For good accuracy, ensure that antennas are physically present on all enabled access point antenna ports. Failure to do so may cause inordinately low RSSI readings to be reported on enabled antenna ports that do not have an attached antenna. The use of abnormally low RSSI from antenna ports without antennas is not conducive to good location accuracy and should be avoided.

Antenna Orientation (Figure 11-5) illustrates how the configuration of the antenna's azimuth orientation within Cisco Prime Infrastructure is mapped to the actual physical orientation of the antenna. The blue triangle in the azimuth compass rose shown at the right of the figure indicates how the actual antenna should be physically positioned during deployment (notice that each of the antenna graphics contains a blue arrow as well). For omni-directional antennas, use unique identifying factors that are associated with the antenna (such as the right angled flexible antenna connector shown at the bottom of the 2.2dBi black whip antenna in Figure 11-5) to assist in proper positioning. For directional antennas, use unique physical characteristics of the antenna such as the exit location of the cable (for example, cable exiting up or cable exiting down) or other unique marks and construction characteristics.

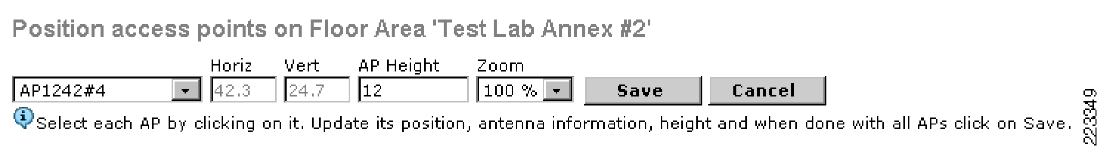
Figure 11-5 Antenna Orientation



In software Release 7.0 and above of the location aware Cisco UWN, the ability to specify installed access point and antenna characteristics has been enhanced. CUWN provides the ability to account for antenna installations at varying heights for individual APs. This capability allows the Mobility Services Engine (MSE) to incorporate varied access point antenna heights in its lateration calculations, an approach that more realistically approximates installations, especially in non-carpeted office type environments. Note that the individual height specified for an access point antennas cannot exceed the height of the floor.

Defining Individual Access Point Heights

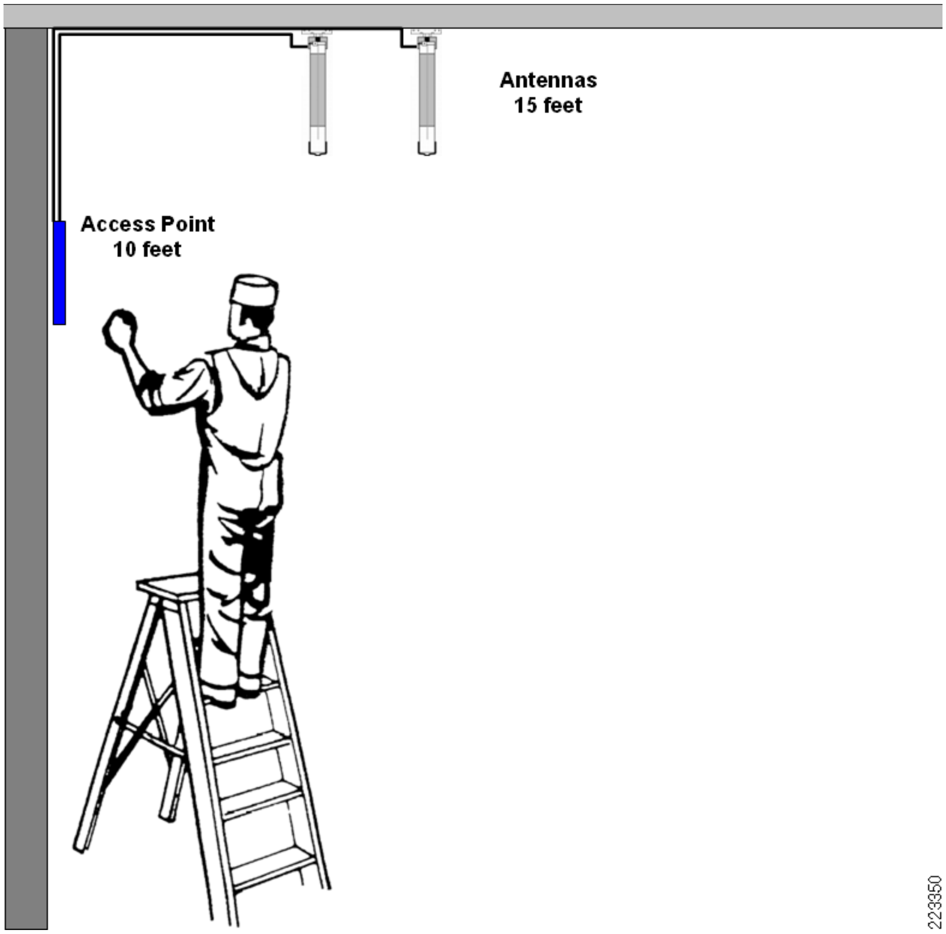
Figure 11-6 Access Point Heights



The antenna propagation characteristics of the AP3700 access point are optimal along its azimuth plane when ceiling mounted. For optimal location performance when using the AP3700, it is preferred that the access point be ceiling mounted rather than wall mounted.

In some cases, it is desirable to separate access points from antennas using a short length (less than 10 feet) of low-loss antenna cable. Reasons for this might include avoidance of obstacles or simply the desire to position access points and other active electronic infrastructure components within easy reach of local employees using commonly available ladders and stepladders. This facilitates easy removal and installation of these components should they require replacement. An example of this is shown in Figure 11-7. In this case, a nationwide retailer has mandated that all electronic infrastructure components be accessible to store employees using the ten foot step-ladders commonly available at each store location. Here we see that the access point is mounted at 10 feet (for easy access) while the antennas are mounted at 15 feet. In cases such as this, the value specified for "AP Height" in Figure 11-6 should reflect the height of the antennas and not the height of the access point.

Figure 11-7 Example of Different AP Heights



Note For a more detailed discussion of antennas, see: http://www.cisco.com/c/en/us/products/collateral/wireless/aironet-antennas-accessories/product_data_sheet09186a008008883b.pdf.