Understanding Wireless Antennas - Part 1 & 2

by Lisa Phifer, VP, Core Competence
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Many WLAN users take antennas for granted. They just use the antenna supplied with their 802.11 PC card or router and quietly curse the manufacturer when speed drops and signal fades. But they don't know what WLAN designers do: upgraded antennas can improve performance, reach and security.

Types of antennas
Wireless radios generate signal on a given frequency. Antennas distribute (propagate) that signal through the air in a particular pattern.

The antennas commonly included with 802.11 products are **omni-directional** antennas that radiate signal in all directions around the antenna's axis. After-market **directional antennas** focus transmissions more narrowly by radiating in a certain direction.

How does that help?
Picture a 6" water-filled balloon. Put the balloon on a table. The bottom flattens and the circumference expands slightly. Squash the balloon with your hand. By concentrating the same volume of water in the horizontal direction, the balloon can now touch objects 8" apart. Squeeze the balloon into a 4x10" shoebox. By losing its shape and shrinking in one dimension (width,) the balloon is able to reach even further in the other dimension (length.)

The same principal applies to antennas. They take a given power output and make it reach further by reducing direction(s) along which signal is radiated. This is useful because buildings are not spherical - they're like that shoebox. Concentrating signal on your workspace makes better use of your AP's power output. Stations *inside* your workspace get stronger coverage and therefore higher speed. Directing signal where you want it also means less signal where you don't want it. Stations *outside* your workspace - i.e., war drivers - get little or no coverage.

What kind of antenna do you have?
An omni-directional **monopole** would radiate signal in a uniform sphere. But that's not your average 802.11 AP antenna.

Most APs come with omni-directional **dipole** antennas - those flexible black plastic sticks commonly called rubber duckies. Dipole coverage looks like a squashed donut, with the antenna sticking through the center. Power does not radiate out of the top (or bottom) of the antenna; it radiates horizontally.

If you put an AP with a dipole on a table at the center of the second floor, stations on that floor will get the strongest signal. Stations on the first and third floors will get some signal, depending upon the AP's output and the antenna's gain (i.e., how flat the donut is.) You can often improve results by repositioning the AP. For example, in a two-story home, try mounting the AP on the first floor ceiling.

When viewed from the top, dipole coverage is circular. When the AP is centrally-located, stations in distant corners will have the weakest coverage. Multiple APs may therefore be required to provide adequate coverage for the entire floor - in other words, overlapping circles. Speed is higher for stations closer to the AP, so you may be tempted to add APs to boost performance - more overlapping circles. But as APs are positioned closer to exterior walls, the more signal is going to leak outside.

Directional antennas can improve performance without increasing risk and waste.

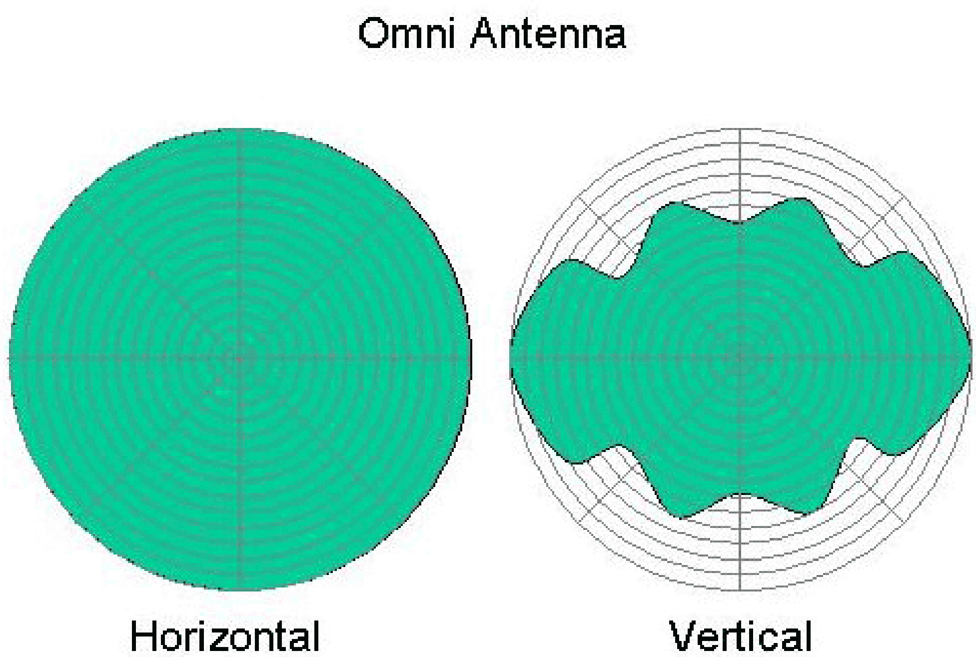
Part 2

Upgraded antennas can improve WLAN performance, reach and security. As explained in the first part of this tip, dipole antennas included with 802.11 products radiate signal 360 degrees around the antenna's axis. After-market antennas focus transmission more narrowly, boosting power where you need it by decreasing signal where you don't.

Types of antennas

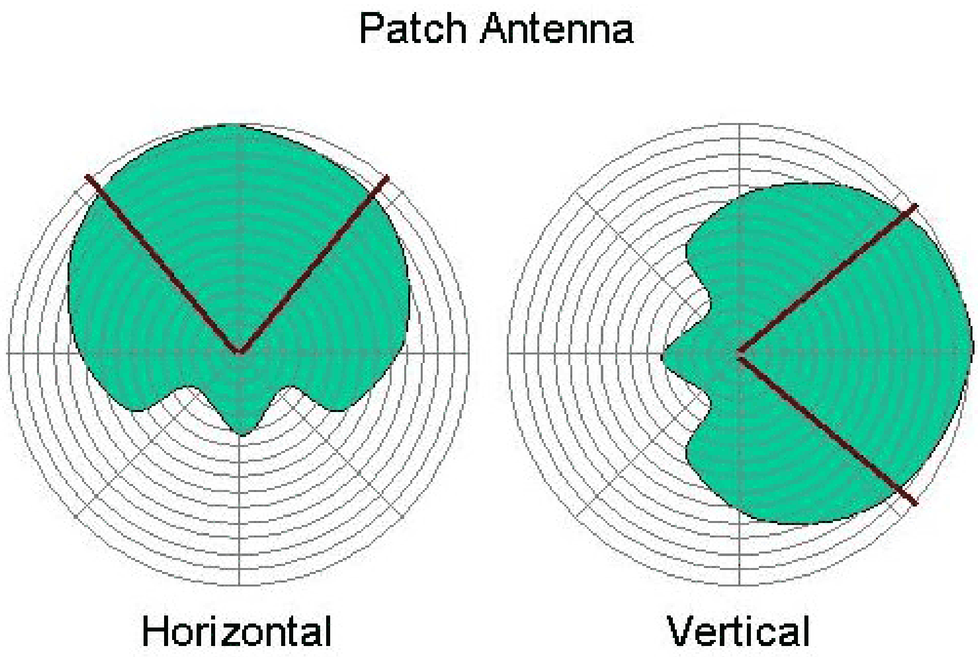
Like dipoles, **Omni** antennas radiate signal 360 degrees horizontally. But they increase gain by flattening the signal, producing a vertical beam between 80 degrees (modest gain) and 7 degrees (high gain) – see Figure 1. Recall that gain makes signal travel further. For example, Cisco's 5.2dBi Ceiling Omni has a 40 degree vertical beam and indoor range up to 397 feet.

Figure 1



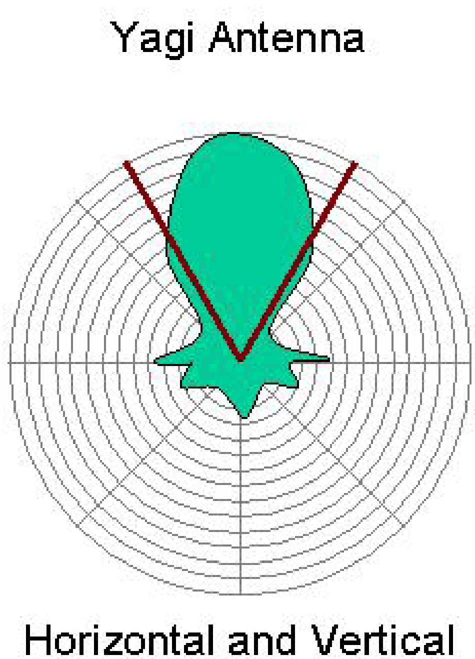
Directional antennas focus signal in both planes. **Patch** antennas are flat directional antennas, mounted flush on walls or ceilings. They produce hemispherical coverage, spreading away from the mount point (Figure 2) at a width of 30 to 180 degrees. Concentrating signal on this smaller area further increases range. For example, Cisco's 9.5 dBi Patch has a 50H/43V beam with indoor range up to 1030 feet. HyperGain's 14 dBi Patch has a narrower 30H/30V beam.

Figure 2



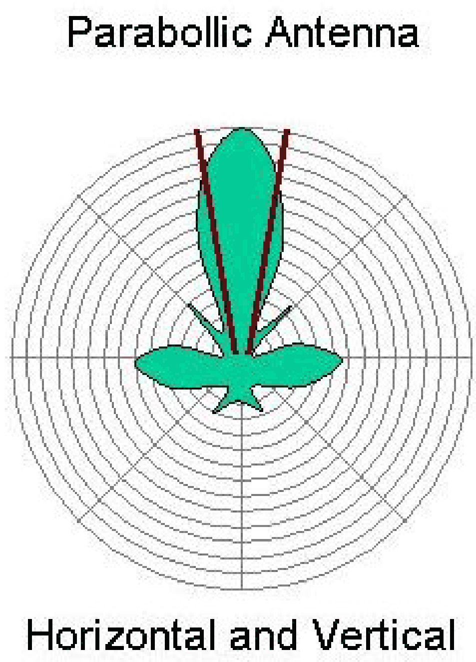
Yagis are higher-gain directional antennas. These cylinders contain a boom supporting thin vertical rods. Signal propagates off the front of the boom somewhat like blown bubble gum (Figure 3). Note that some signal (back lobes) fall behind the boom. Yagis create higher gain by producing narrower beams (20-80H, 14-64V). Examples include HyperGain's 14.5 dBi Yagi (30H/30V) and Cisco's 13.5 dBi Yagi (30H/25V, outdoor range up to 18 miles.)

Figure 3



Parabolic dish or grid antennas are concave panels or bowls that produce an extremely narrow beam (4-25 degrees horizontal/vertical), like a rocket with exhaust spreading from the base (Figure 4). Examples include HyperGain's 24 dBi Grid (8H/V) and Cisco's 21dBi Dish (12.4H/V, outdoor range up to 26 miles.)

Figure 4



Where they can be helpful

Now that we know what they look like, where should we use these antennas?

Standard-equipment **Dipoles** are ok in densely-populated office floors, including cubicle bullpens where stations are centered around the AP. But dipoles waste (leak) signal when the AP is located near an outside wall or corner or when you need to cover just one floor.

After-market **Omnis** are better for high-ceiling industrial and retail environments – factory floors, warehouses, or "big box" stores where antennas can be suspended from the ceiling at the center of large open areas. But Omnis are not good in long, narrow workspaces where antennas cannot be centrally located.

Patch antennas are better for covering single-floor small offices, small stores, and other indoor locations where APs cannot be placed centrally. For example, mount patch antennas unobtrusively on the back wall of a store. Back lobes do create some leakage, but far less than an omni-directional antenna would in the same situation.

Yagi antennas are better for corridors, hallways, tunnels, long narrow building, and point-to-point medium range connections between outdoor bridges (for example, connecting two buildings in an office park or campus). Be wary of back lobes, but the Yagi's narrow beam will reduce unwanted peripheral exposure in the focal direction.

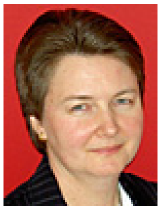
Parabolic antennas are better for long-range outdoor point-to-point connections – for example bridges that are miles apart. They require more precise installation to aim signal where you want it, but have the very high gain necessary to reach such distances.

Today, many 802.11a/b/g products can transmit over the better of two antennas. This Diversity Antenna technique is used to compensate for Multipath, an RF phenomenon caused by wave reflection. New 802.11n products will leverage Multipath to increase bandwidth by transmitting simultaneously through several antennas, recombining signals at the receiver. Products using this technique, called Multiple Input Multiple Output (MIMO), may apply existing antenna types in new ways. For example, some MIMO APs may have 3 or more factory-installed dipole antennas (e.g., NetGear RangeMax 240). Others may aim several high-gain antennas in different directions to create omni coverage (e.g., BeamFlex). Visit the IEEE 802.11 TGn page or browse 802.11n at Wikipedia to learn more.

Conclusion

I hope these descriptions help you to visualize what after-market antennas can do, and how they might benefit your WLAN. Within each category, you'll find a variety of products with a wide range of beam widths and signal gains, so shop carefully to find the antenna that's best for your workspace. With the right antenna, you don't have to sacrifice performance for security - by focusing signal, you can improve both at once.

About the author: Lisa Phifer is vice president of Core Competence Inc., a consulting firm specializing in network security and management technology. Phifer has been involved in the design, implementation, and evaluation of data communications, internetworking, security, and network management products for nearly 20 years. She teaches about wireless LANs and virtual private networking at industry conferences and has written extensively about network infrastructure and security technologies for numerous publications. She is also a site expert to SearchMobileComputing.com and SearchNetworking.com.



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