ANTENNA SELECTION AND POSITIONING

7SIGNAL®

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INTRODUCTION

After all the effort invested in selecting a WLAN vendor and planning an Enterprise wireless LAN, many customers underestimate the importance of antenna selection and careful placement. They end up settling for lower performance than they were expecting.

The purpose of this guide is to give you a straightforward and not overly technical overview of antenna design, to provide guidance on choosing the right antenna and maximizing coverage and capacity, and to identify common antenna deployment mistakes to be avoided.

ANTENNAS 101

The world of antennas is full of technical jargon for a range of related features that together result in a wireless signal being radiated at different levels in many directions. It can be quite difficult to grasp how the various factors interplay.

Before we move on to the true star of our show, let's quickly review how an antenna system works.

HOW ANTENNAS WORK

Whether it is for Wi-Fi, Bluetooth, 5G, or other wireless technologies, an antenna is basically an extension of a wireless radio.

The principles are the same for all wireless systems. The range of a wireless product is the result of several factors.

1. The first of which is the amount of energy entering the antenna, which is known as the radio transmit (TX) power.
2. As the radio energy passes through connectors and cables to the antenna, some of it is lost. This is known as cable loss.
3. Finally the remaining energy is concentrated in a certain radiation pattern, depending on the design and polarity of the antenna.

Different antenna materials and design features result in different antenna gain. The gain of the antenna defines how concentrated the energy is. For this reason, the combination of Tx power, cable loss, and antenna gain impact the wireless products range. The antenna radiation pattern, that is the 3D shape of the gain of the antenna, also varies according to the type of antenna.

ADDITIONAL IMPORTANT CONCEPTS TO UNDERSTAND BEFORE MOVING FORWARD

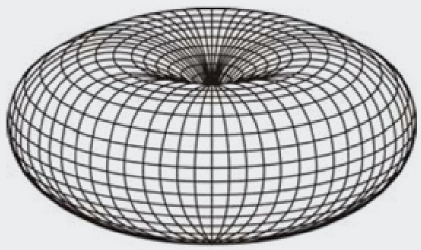
DECIBELS

RF signal level is measured relatively in decibels (dB), which are on a logarithmic scale. Consider the fact that earthquakes or sound can be almost imperceptible or ear splittingly loud, tens of thousands of times louder than "almost imperceptible", yet the human ear can cope with both ends of that continuum. Because of the logarithmic scale, every 3 dB increase represents a doubling of power.

Absolute power levels are often represented in dBm, where 0 dBm equals 1 mW. Use of decibels makes a lot of sense when handling large power level differences. Typical indoor access points operate with a maximum conducted output power per path of 20 dBm (or 100 milliwatts). For optimum coverage, the recommended cell edge received power is -67dBm.

POLARIZATION

This term refers to the orientation of the electromagnetic field of the antenna's radiating element. The simplest vertically-mounted dipole or "rubber duck" antenna has a strong vertical polarization and generally has a uniform radiation pattern (omnidirectional) in the horizontal plane. Antennas are typically designed to be linearly polarized (vertical/horizontal), circularly polarized, or a mixture of polarizations.



3D Polar Pattern

In an ideal world you would want the transmitting and receiving antennas to have the same polarization. In fact, for point-to-point radio connections this is critical. However, due to reflections in typical wireless network environments, polarization may vary and the antennas in mobile devices are designed to work with any polarity. This is because they can be held at any angle. Polarization can have less impact than antenna gain pattern in typical Wi-Fi networks.

ANTENNA GAIN

It is a common misunderstanding that antenna gain is active amplification of the signal. In reality, it is a measure of how concentrated or strong the signal is in the direction of its maximum signal. Increasing the signal concentration in one plane generally reduces it in another plane. This will become clearer when you read about omnidirectional antenna gain below.

Antenna gain is represented as dBi, which stands for dB gain relative to an isotropic radiator which has a uniform pattern. Total antenna gain includes another lesser-known component– efficiency. An antenna may possess certain directional characteristics, but it might still attenuate the signal from the main lobe direction. This is most often the case for electrically small integrated antennas where compromises have to be made between size, performance, as well as cost.

ATTENUATION

When an RF signal travels through a medium, it is attenuated to some degree. This could be anything from a brick wall, to a door, to a cubicle partition. That means the power of the signal diminishes. As an example, let's pretend the input signal on one side of a wall is 10 milliwatts but it is only 5 milliwatts on the other side. This represents 3 dB of attenuation. Remember, the dB log scale and the 3 dB rule noted earlier in the decibels section.

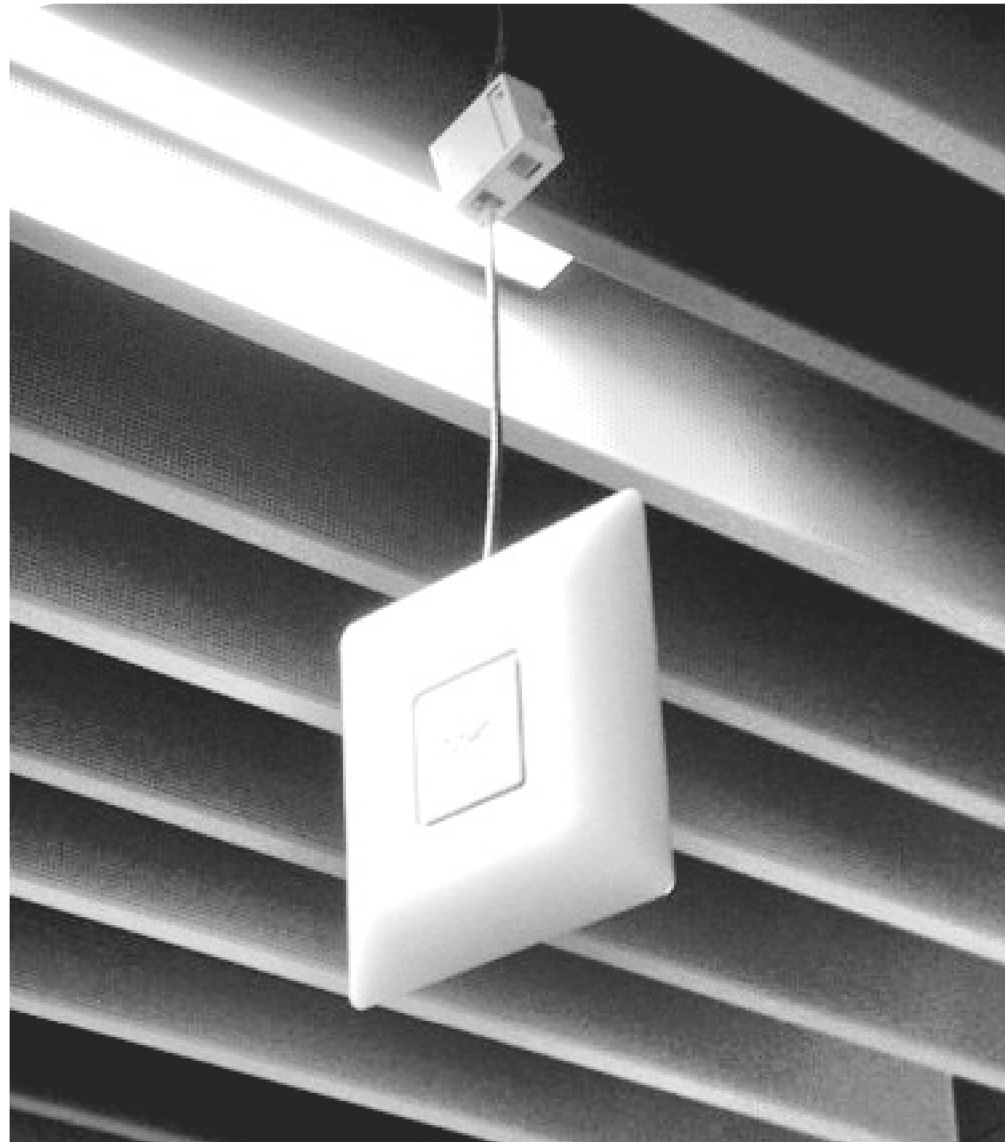
SELECTING ANTENNA TYPES

Omnidirectional Antennas

Omnidirectional antennas are the most common type you find on enterprise access points (APs) for indoor use. They are designed to provide general coverage in all directions in the horizontal plane. For indoor APs, this is an obvious default. If it is unknown where the AP will be placed, most likely it will be in the middle of an indoor area and not its perimeter. Many vendors integrate the antenna within the access point housing to prevent tampering, and improve aesthetics, but this means the AP must be mounted in the correct plane.

DON'T mount APs with integrated antennas vertically, they must be mounted horizontally.

If you mount a dipole antenna with a horizontal donut shaped gain pattern in a vertical orientation, most of the antenna gain now radiates vertically to floors both above and below. Too much signal going to the adjacent floors increases interference on those floors, while clients on the floor the antenna is on get hardly any signal at all.



AP “mounted” in wrong orientation

Extending Coverage with External Antennas

Integrated omnidirectional antennas generally offer low gain in the 2.5 – 5 dBi range. At the same time, the AP radios offer a maximum transmit power in the 16 – 20 dBm range. Together, this gives them a radius of 100-300 meters (328-984 ft.) in open space and 10-30 meters (30-100 ft.) in most office environments, depending on the exact building construction and internal furnishings. This makes typical integrated antennas ideal for most office deployments, where access points and client devices are generally rather close to each other. This is because the main priority is not coverage but capacity, which we will delve further into later in the section on Coverage vs Capacity.

Integrated antennas are not as suitable for large open spaces such as warehouses and distribution centers with relatively low user densities, low bandwidth application requirements, and very high ceilings. External directional antennas with higher gain come in a variety of shapes and sizes, making them more or less suitable for different applications. They limit co-channel interference and provide better floor coverage from high ceilings.

DIPOLE OR DIPOLE ARRAY

An external dipole antenna is a tubular antenna usually enclosed in a fiberglass casing. It looks like a lightsaber, except it doesn't glow or hum like the weapon Luke Skywalker swings around. Essentially this is the same type of technology found in paddle antennas fitted to an AP, only externalized. Sometimes, two or more dipoles are placed one above the other to increase gain and narrow down the vertical beam width. The only visual difference is the tube length.

Dipole antenna or Dipole array

CEILING BLISTER OR DOME ANTENNA

This is not substantially different from mounting an access point with an integrated antenna directly on the ceiling, except they are more attractive, less conspicuous, and easily mistaken for security cameras or smoke detectors. Additionally, you can choose an antenna with slightly higher gain than those on the AP.

Ceiling blister / dome antenna

***Above images: Different external high-gain omnidirectional or hemispherical antennas**

Directional Antennas

Although directional antennas are used for long range point-to-point and point-to-multipoint connections for bridging and mesh, they also have applications for indoor and outdoor client access.

In a warehouse for example, instead of using an omnidirectional antenna in the middle of the building, you should use sector and panel antennas around its perimeter. This could include panel antennas on the sides and narrower sector antennas in the corners facing inward. Long hallways represent an ideal use case for panel antennas too. Similarly, for outdoor areas such as courtyards, the same principles apply.

Another common use for panel and sector antennas is in buildings with high ceilings and locations such as auditoriums where you have an equally high density of users at the edge of the room as you do in the middle. Also, many hotels, museums, and other venues are concerned about building aesthetics. In these cases, they would prefer to use discreetly-mounted panel antennas on walls rather than having ceiling mounted objects.

PATCH ANTENNA

A patch antenna is a wafer-like antenna which comprises two metallic plates, one larger than the other, with a dielectric sheet in the middle. They are suitable for a single floor, small offices or a store. They produce hemispherical coverage, with a 30°-180° spread from the mount point. Because they are flat, thin, and lightweight, they make for inconspicuous mounting on ceilings.

PANEL ANTENNAS

These are designed to be mounted flat on a wall or other vertical surface, and to radiate all their energy directionally away from the wall. Most of the radiation is to the front, with a little to the sides. They usually have gain greater than 8 dBi. Panel antenna are usually implemented by grouping several patch antennas with carefully defined gaps between them. An example would be having four patch elements in a symmetric 2x2 configuration producing an hemispherical pattern. There is very little vertical radiation, so they are only suitable for serving one floor at a time, such as a long room or hallway.

A well shielded panel has a minimal rear lobe, which allows you to place two panel antennas back to back either side of a wall, each radiating signal only into its respective area.

SECTOR ANTENNAS

Sector antennas come with a variety of beam widths. This could be 45°, 90° and 120° or anything in between. They come in various form factors, such as a corner radiator, a dish, or panel with an asymmetric 1x4 element configuration. They can be used indoors or outdoors, wherever there is a need for coverage in a well specified area. If it is important to prevent signal bleeding into another area, this is another time this solution is recommended. They usually have gain in the 10 dBi to 15 dBi range.

Point-to-Point

PARABOLIC GRID ANTENNAS

These are highly directional and have a very high gain. They usually comprise a dipole element in the middle which generates the energy. Then, the parabolic reflector focuses the energy in a narrow beam. This is much like a focused flashlight. They are used in long-range outdoor point-to-point connections. A parabolic antenna with 15-30 dBi can reach up to 12.5 Km, or about 7.8 miles. Grid antennas have superior wind tolerance to a solid dish. This allows for placement in windy areas, a larger size, and higher gain.

YAGI ANTENNAS

In contrast to parabolic antennas, Yagi-Uda (or Yagi for short) antennas look like a fishbone, when not encased in a protective enclosure, and comprise a series of rods perpendicular to a main rod which is pointed in the target direction. These are also used for point-to-point and point-to-multipoint connections but for shorter distances. They usually have a gain of 9-20 dBi. They are very light, easily mounted on a pole, and because of a wider beam width, are easier to align than parabolic dish antennas.

Parabolic Grid

Yagi-Uda

*Above: High-gain outdoor antennas for point-to-point connections

EXTERNAL ANTENNA CONSIDERATIONS

Remember: Antenna gain trumps Tx power.

Once you opt for using external antennas, everything gets a bit more interesting.

In general, to increase coverage, it is best to improve antenna gain, not crank up the transmit power.

DON'T just crank up transmit power to increase range, use antennas with higher gain.

The reason for this is that increasing the transmit power on the AP does nothing for receive sensitivity. In fact, increasing Antenna dBi improves both transmit and receive. This is because a law of reciprocity applies. Basically, Tx and Rx gain are the same.

The job of the antenna is to transmit from the AP and receive from the client. Clients rarely have a problem hearing the AP, but they have comparatively feeble radios (less power) and low gain antennas, so they have a problem being heard by the AP. An antenna with higher dBi is better able to hear low power laptops and even lower powered transmissions from mobile devices, at longer distances.

Switching from an integrated 3 dBi antenna to an external antenna with 9 dBi, which is a jump of 6 dB, would quadruple the power, resulting in double the cell radius in open space. Also, unlike increasing transmit power alone, it is less likely to result in asymmetric data rates between clients and APs.

DO remember the 3 dB rule. Each 3 dBi increase in antenna gain doubles its power.

Antenna gain and wireless range in unobstructed air

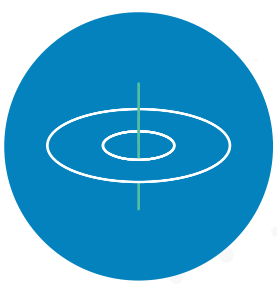
Atenna Gain	0dB	4dB	7dB	10dB	13dB	16dB	20dB	24dB
Wireless Range	200m	440m	620m	1.2km	2.8km	5.0km	12.5km	31km

Going Too Far with High Gain Antennas

Imagine the radiation pattern of an omnidirectional antenna as being like a donut with the antenna sticking up through the center. In the horizontal plane (the Azimuth) it has a diameter, which is its range, but it also has a vertical dimension (the Elevation). As the antenna's gain [dBi] increases, the diameter increases, giving you greater range sideways. At the same time, the vertical dimension shrinks becoming less like a donut and more like a CD disk, resulting in a smaller vertical target area in which clients are able to receive a signal. Therefore, the height at which a high-gain omnidirectional antenna is positioned becomes more important.

DO carefully review antenna gain charts and follow the manufacturer's height recommendations when using high gain antennas, as vertical positioning is critical.

DON'T place high-gain dipole antennas on ceilings in large open spaces. In the absence of reflections, most antenna gain points to other APs, not client devices.



Choosing External Antennas for Each Band

A lot of high-gain external antennas are optimized for 2.4 GHz or 5 GHz, but do not support both bands. That means you may need two or three antennas for each radio, depending on the MIMO configuration. Dual band antennas are available and in most cases, especially for indoor use, they are the better choice. However, since enterprises generally need more 5 GHz cells than 2.4 GHz, single band antennas can make sense in a few locations. Some special venues, like stadiums and outdoor deployments, may be an exception where it makes sense to use single band APs or antennas.

Bear in mind that usually both radios are active in all or most of your APs. Choosing single band antennas carries a risk if your needs change. A dual band capability allows more reconfiguration flexibility.

DON'T assume external antennas are dual band. Many are optimized for a single band.

There are three reasons for having more 5 GHz cells. The first is that 5 GHz attenuates more rapidly and therefore has less range than 2.4 GHz. The second is that with more channels available, it is possible to have much higher cell density without using overlapping channels. By utilizing its 40 MHz channel bonding capabilities 5 GHz can provide superior throughput. In 2020, the FCC freed up an additional 1200 MHz in the 6 GHz band, which will allow 80 MHz channel widths to be used in the many enterprise environments for the first time.

DO focus on 5 GHz as your performance band, and 2.4 GHz for legacy devices and IoT.

Minimizing Cable Length and Connectors

The 50 Ohm coaxial cable needed to connect the antenna to your AP has inherent attenuation (signal loss), and there are several different grades of cable. The longer the cable, the more it is important to select high-grade, low-loss cable.

In addition, in many of the APs which have integrated antennas and also provide connectors for external antennas, there is often an RF interconnect attenuation, sometimes as much as 1 dB, between the radios and the connectors.

When using external antennas, keep the cable length as short as possible. It is extremely important to use high grade cables with the right impedance, the right length, and the right connectors. This is done to avoid extra adapter transitions. The right length means no longer than necessary, and definitely not shorter. Joining multiple cables is a gain-killer as it adds more connectors.

*Below: Cable loss rates for different grades of coaxial cable

100 Series — Ø.105 in. (2.7mm) Nominal — 50 Ohm Impedance

NOMINAL ATTENUATION		
MHz	db/100ft	db/100m
900	22.8	74.8
1800	33.2	108.8
2500	39.8	130.6

195 Series — Ø.195 in. (5.0mm) Nominal — 50 Ohm Impedance

NOMINAL ATTENUATION		
MHz	db/100ft	db/100m
900	11.1	36.5
1800	16.0	52.5
2500	19.0	62.4
5800	29.9	98.1

200 Series — Ø.195 in. (5.0mm) Nominal — 50 Ohm Impedance

NOMINAL ATTENUATION		
MHz	db/100ft	db/100m
900	9.9	32.6
1800	14.2	46.6
2500	16.9	55.4
5800	26.4	86.5

240 Series — Ø.240 in. (6.1mm) Nominal — 50 Ohm Impedance

NOMINAL ATTENUATION		
MHz	db/100ft	db/100m
900	7.6	24.8
1800	10.9	35.6
2500	12.9	45.4
5800	20.4	66.8

400 Series — Ø.405 in. (10.3mm) Nominal — 50 Ohm Impedance

NOMINAL ATTENUATION		
MHz	db/100ft	db/100m
900	3.9	12.8
1800	5.7	18.6
2500	6.8	22.2
5800	10.8	35.5

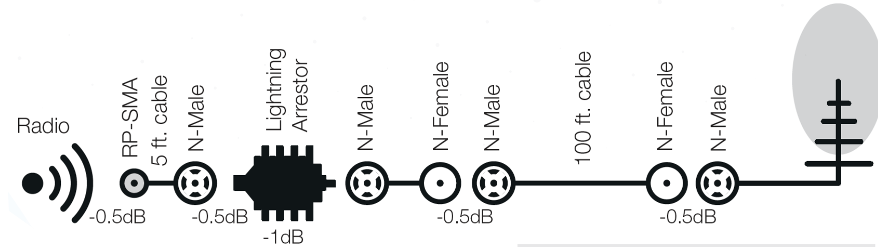
600 Series — Ø.590 in. (15.0mm) Nominal — 50 Ohm Impedance

NOMINAL ATTENUATION		
MHz	db/100ft	db/100m
900	2.5	8.2
1800	3.7	12.1
2500	4.4	14.5
5800	7.3	23.8

900 Series — Ø.900 in. (22.9mm) Nominal — 50 Ohm Impedance

NOMINAL ATTENUATION		
MHz	db/100ft	db/100m
900	1.7	5.6
1800	2.5	8.2
2500	2.9	9.8
5800	4.9	16.0

DON'T use cables any longer than necessary or join short cables together.



Total Signal Loss Calculation	
Connectors (4) =	-2.0 dB
Lightning Arrestor =	-1.0 dB
Cable (105 ft) =	-4.095 dB
Total =	**-7.095 dB**

*Above/right: Calculating total signal loss for an antenna cable

DON'T use cheap cables for long runs, as you'll waste a lot of signal strength in cable loss.

Next, check the connectors. There are a variety of different types and vendors vary them from one product to the next. Often you need different connectors at each end of the cable. You want to be particularly careful making sure the connector at each end of the cable matches the antenna or AP you will attach it to.

DON'T forget to double check cable connectors will match the AP and antenna.

ANTENNA PLACEMENT BEST PRACTICES

If you designed your Wi-Fi network for the ultimate performance, you would have thousands of tiny cells each serving a few hundred square feet, with antennas really close to the users. Sadly, that is a budget-blowing daydream.

In the real world, you always make tradeoffs and accept compromises. However, some placement compromises are more costly to performance than others, so think carefully when deciding where to mount each AP and antenna.

Separate from the obvious mounting locations predicted by the type of AP or antenna you are using, like the ceiling, wall, corner, or pole, there are a number of other environmental conditions related to the mounting point and the type of antenna to consider. Ignoring these is the cause of many of the most common placement errors.

In the following section, the term antenna is used to refer to both external antennas and APs.

Aesthetics Over Function

There are many venues where aesthetics will prevail over function. It is important that you understand certain aesthetic choices often have trade-offs. It doesn't have to be all or nothing! If those obsessed with aesthetics had a better understanding of the real cost of matching the optimal performance of a non-aesthetic design, they may not be so adamant. Instead, they may be more willing to compromise.

DON'T give way to aesthetics without recognizing the performance trade-offs.

Typical Ceiling Mounting

In office environments, the optimum mounting height is 2-3 m (8-12 ft) off the ground. Most vendors assume that their APs will be mounted on the ceiling which is usually about 3m (10 ft) high. Some even have a slight down-tilt of the integrated antennas to radiate more energy to the target floor, rather than directly up or down. Remember line of sight is your friend! The fewer obstacles in the path, the better. Avoid mounting the antenna near thick concrete pillars, unless for intentional design purposes, as this will cast a wide weak signal shadow.

DO pick open ceiling areas, away from support pillars, or you'll cast a shadow.

Dealing with High Ceilings

Mounting omnidirectional antennas on high ceilings 4.5m (15 ft) or above has a number of problems. To begin with, most of the energy is directed sideways towards other antennas causing co-channel interference. Also, antenna gain shoots over the target area and data rates are reduced. Wi-Fi design and optimization is often counter-intuitive. Many people erroneously think they need to use high-gain omnidirectional antennas, unaware this only makes matters worse. This is due to the fact that the vertical beam width is narrower, which means clients get an even weaker signal, and adjacent antennas get even more interference. It is actually more effective to depower the Tx on standard omnidirectional antennas.

When you have high ceilings, consider wall mounted panel and sector antennas instead, and mount them at about 3m (10 ft) from the floor. If you prefer, you can mount patch or panel antennas on the ceiling.

DON'T mount omnidirectional antennas above 15 ft.

DO consider sector, patch and panel antennas on walls and high ceilings.

The fewer obstacles in the path, the better.

Above Suspended Ceiling

For purely aesthetic reasons, some customers conceal their APs or antennas above a suspended ceiling (plenum space). This is a bad idea for several reasons. First, in the ceiling space there are often a lot of metal objects, such as air ducts, which cause reflections. Second, the acoustic ceiling tiles themselves add attenuation to the signal reducing signal strength. Always try to ensure antennas are visible to users.

Another common mistake is laying the AP on top of the ceiling tile facing upward, not down. If you do this, the antenna is upside down. It is radiating more of its RF energy to the ceiling above it, not the floor below.

DON'T put antennas above suspended ceilings, as this causes unnecessary reflections and attenuation.

DO use proper mounting brackets to mount APs below suspended ceilings in the line of sight of its users.

AP among ducts and pipes

EM Interference

Electromagnetic interference is your enemy, and it comes in many forms. Large electric motors and heavy power sources are the big ones to watch out for in enterprise deployments. Keep antennas at least 4.5 m (15 ft) from large electric motors. This includes conveyor belts, escalators, and elevators. Also, avoid putting antennas near power panels, cable conduits, and cable trays.

DON'T place antennas within 15 ft of electric motors, power ducts, or cable trays.

Metal Objects

Metal objects are unavoidable in the path between the access point, and clients. However, when metal objects, such as the reflectors of light fixtures, metal air ducts, cable trays, metal shelving or metal doors are in the proximity of the antenna, they dramatically alter the near field radiation pattern from the antenna. The metal object becomes a huge RF reflector, which causes unwanted reflections and multi-path propagation. RF spreads to unwanted areas and antenna reception capability is degraded.

DON'T place antennas close to metal obstructions, light reflectors, or cable trays.

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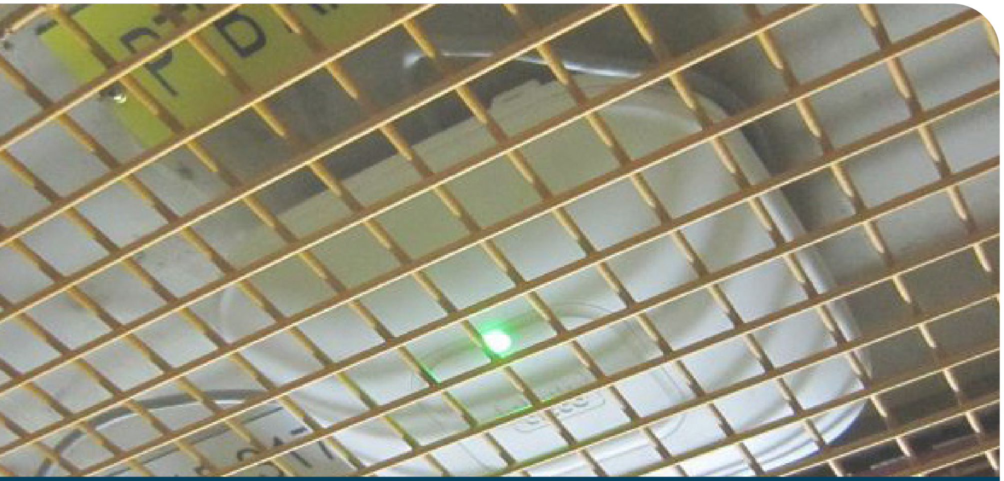


Surrounded by a metal cage!

2.4 GHz Planning

In the US and many other countries, 2.4 GHz is limited to only three non-overlapping 20 MHz channels. Because of this, the capacity of the band is extremely limited. You should only use the 2.4 GHz band for legacy and IoT devices that can't use 5 GHz, and not worry too much about maximizing performance on 2.4 GHz. You can use 5 GHz for that.

Because channel reuse is so limited in 2.4 GHz, and 2.4 GHz signals propagate farther than 5 GHz signals, in many cases it's best to selectively disable 1/3 or more of the 2.4 GHz radios in a WLAN. Those radios add no more coverage than is provided by the radios left running, but they do increase co-channel interference and beacon frame overhead significantly. Some enterprise AP's allow those radios to change modes for security monitoring or other purposes, so you can still get some value out of them.

DON'T leave all 2.4 GHz radios enabled in an enterprise WLAN.

Oversized Cells

A common misconception is that more Tx power means more performance. More often than not, the exact opposite is true. Often you will find that smaller cells are better. Increasing Tx power increases the overlap between cells resulting in co-channel interference. This is explained in more detail in the section on Coverage vs Capacity.

DON'T turn up the Tx power to increase capacity, it will increase interference and reduce capacity. It is better to reduce Tx and increase AP density.

Auto RF Tuning

Many vendors tout the ability for their APs to auto-select channels and dynamically set their own Tx power rates. While this may seem like a good idea, it is not without its risks– many of them, in fact. If you leave it on, the network can potentially thrash back and forth as a ripple of changes propagate through the network. This could be a result of possibly minor interference in one location, even something as simple as a microwave oven turning on. The denser your channel plan, the more likely this is to happen. The automation algorithms developed by Wi-Fi access point vendors have a tendency to misallocate both channels and power levels, leading to an unstable system and a variety of Wi-Fi performance issues. Sometimes, they overcompensate by leaving Tx power levels too low, which results in coverage holes.

Auto-tuning does have its place though, especially when deploying a new network in an area. This could be when you know that a neighbor, perhaps someone on a floor above or below you, has recently deployed a new network. However, it is best not to leave it unattended. Set appropriate bounds for min/max Tx power, channels to use, and time of day that automatic changes are allowed.

Bear in mind that when an AP changes channels, it drops all connections. Clients must reconnect on the new channel and that takes a moment. This is a big deal for anyone using VoIP or real-time applications! Most auto-channel algorithms are concerned only with the condition of the spectrum around them. They do not necessarily factor in some kind of weighting based on user count or applications in use.

DON'T use default (unbounded) auto RF configuration.

DON'T leave auto RF unattended after initial deployment, keep your eye on it.

2G, 3G, 4G, and 5G

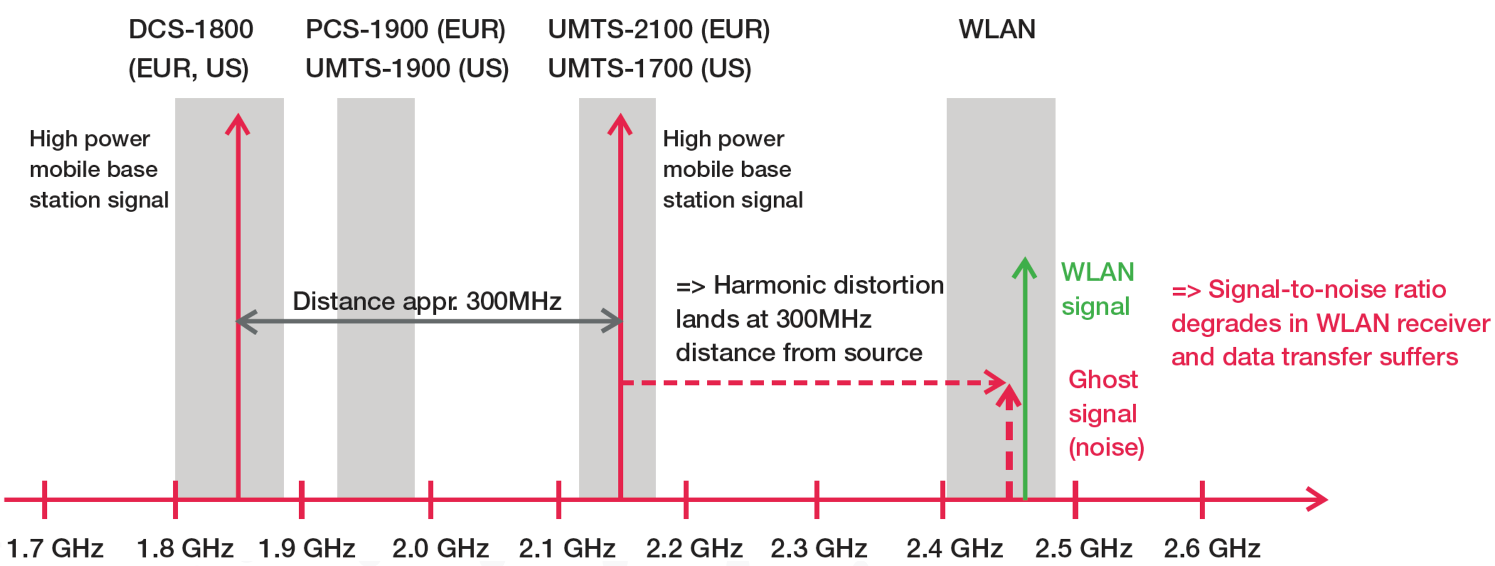
If you think Wi-Fi is immune to cellular signals because they operate in a different frequency, you'll be surprised to learn that you're only half right. Some organizations that find they have weak in-building cellular signal decide to install mini-base stations and cellular antennas. Others go in the opposite direction, deploying distributed antenna systems. To their surprise, Wi-Fi performance sometimes suffers. The reason is due to the fact that when the cellular antennas are too close to access points, they can create harmonic distortions. These distortions can fall in the 2.4 GHz spectrum, causing interference at the AP.

DON'T put cellular antennas near Wi-Fi antennas it may cause harmonic interference.

Microwave Ovens

Beware of microwave ovens. Microwaves, along with ZigBee, Bluetooth devices, and cordless phones share the same unlicensed 2.4 GHz spectrum. Whenever the microwave oven is on, you will likely see a marked degradation in performance, particularly around the center of the band, since they operate at ~2.45 GHz.

DON'T put 2.4 GHz antennas near microwaves, as this will cause intermittent interference.



*Above: Base Station transmit signals degrade 2.4 GHz WLAN signal reception

Paddle Antenna Angles

If your APs have multiple external paddle antennas, point them all in exactly the same orientation. Doing so may improve overall spatial stream performance by aligning the coverage of each antenna that transmits a unique spatial stream.

Remember, because mobile devices can be held at any angle, the antennas on mobile phones usually radiate RF uniformly in both vertical and horizontal planes and can therefore work with AP antennas in any polarity. More important than the polarity is to monitor the radiation patterns you get. You can do this with a site survey.

DO align all AP paddle antennas in the same direction.

Metallic Paint

Another innocent attempt to improve aesthetics is painting antennas. This is done so they blend in. If there is any metal in the paint, this is va big problem. It causes attenuation due to the conductive material. It's more than that, though; it invalidates your warranty!

DON'T paint antennas with metallic paint.

Polarity Mismatch

In point-to-point and point-to-multipoint links, the polarization of antennas is crucial. For outdoor links, vertical polarity is preferred as it tends to fare better over most types of terrain. Horizontal polarization is often used when there are trees or for very dense terrain.

For a strong link, the antennas at either end of the link must have the same polarization. Mismatched or “out-of-phase” polarization can reduce gain significantly, rendering the link virtually useless. It is possible to use both vertical and horizontal polarization together in matched pairs, in order to allow two RF systems using the same frequencies to use the same airspace without interfering with one another, or allow two spatial stream operations.

DON’T mix polarizations between two antennas in a point to point connection.

Outdoor APs

Most vendors have environmentally hardened versions of their access points designed for outdoor deployment, but they are expensive. An alternative approach is to put indoor APs inside an enclosure. There are special watertight enclosures designed for this purpose. NEMA enclosures of Type 3 or above are suitable for Wi-Fi applications in most outdoor conditions. When placing APs in extreme indoor conditions, such as damp, humidity, cold, or heat, it is best to apply the same precautions as you would for a similar outdoor location. These polycarbonate enclosures are also good for protecting access points in high traffic public areas indoors or outdoors. This includes railway stations or sports stadiums, where they might get vandalized or tampered with.

DON’T put indoor APs outdoors without an appropriate weatherproof enclosure.

MIMO

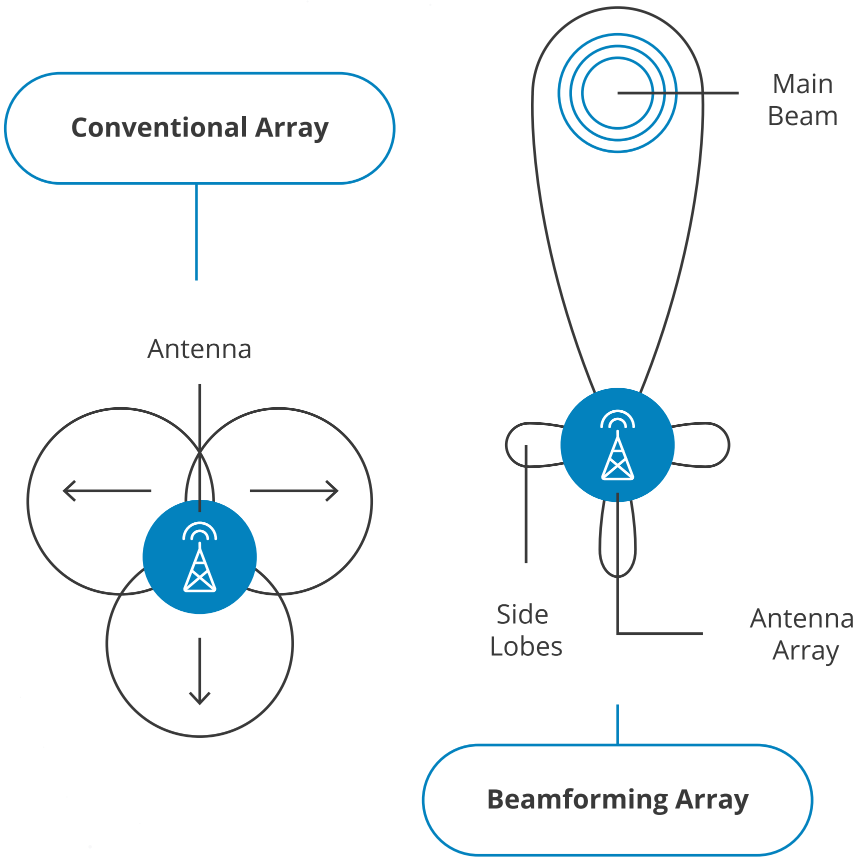
MIMO provides the best gains compared to non-MIMO setups, in environments where thesignal experiences a lot of reflections. Reflections can cause frequency selective fading, which means dips in detected power level across the transmitted spectrum. MIMO compensates for this by using several paths with dedicated antenna pairs. While one stream is suffering from fading, the other may run very well. Bits keep moving with MIMO! In contrast, non-MIMO devices experience more radical variance in performance due to these power level dips.

However, running multiple streams usually means that each stream has lower Tx power. In coverage type of deployments, lower power may cost you more than you win from the multiple streams benefit. WLAN radios can dynamically switch to single spatial stream rates or space time block coding (STBC) mode when parallel MIMO streams seem to not reach the other end.

With STBC, MIMO streams carry the same content essentially creating a parallel data stream with equivalent user data content with different pairs of antennas. The benefit of this is again the different propagation path the signal experiences when environment has reflections/multi path propagation. Combining the data from both connections at the receiving end provides protection against location specific fading. This could be caused for example by reflections from metal structures. In areas with multipath propagation, MIMO with STBC may be better than having a power level with a few dB higher.

Beamforming

Beamforming arrays are inherently different from MIMO in that the multiple columns of dipoles work together to create a single high gain signal. The basic idea is that multiple antennas are combined to radiate a high-gain beam to areas that are known to have clients in them. Both MIMO and beamforming work well, but an antenna optimized for one method does not work so well for the other. Be sure to keep that in mind!



COVERAGE VS CAPACITY

As enterprises become more and more dependent on Wi-Fi, those with high-user densities are constantly demanding more performance. Cranking up transmit power is not the answer, and neither is switching to high gain antennas.

The correct approach is to increase the AP density, as long as you simultaneously reduce cell size of each radio, to reduce co-channel interference that would otherwise arise. The generally accepted best practice for scaling capacity is to depower APs to reduce cell sizes, increase cell density, and disable lower attach rates. This is done so that clients can only attach at the higher rates. The reason for doing this is that when clients attach at the slower data rates, they consume more airtime than on faster rates.

De-powering APs may seem counter intuitive, but it is a good way to allow higher cell density without massive interference. However, with cells being closer together, the consequences of an over-powered cell is more severe. It is important that you monitor your changes closely. An over-powered access point raises the noise floor for any neighboring access points on adjacent channels, effectively reducing the potential throughput of those APs.

DON'T increase AP density without revisiting your RF plan and reducing Tx power.

DO disable lower data rates to prevent low speed clients eroding bandwidth.

SITE SURVEYS AND RF PLANNING

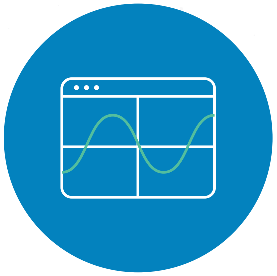
Building a wireless network without a plan is an ill-conceived strategy. What many enterprises don't seem to realize, is that over time, the network is going to change. In fact, it will change a lot! In years past, 802.11abg was replaced with the more powerful 802.11n, then 802.11ac, and now 802.11ax. AP densities have increased, radio cell sizes have shrunk.

New features and new client form factors have been introduced. You may not need to do physical site surveys in every area, but a predictive planning tool is a must. A predictive wireless planning tool gives you the means to figure out what performance levels you should expect, how many access points you'll need, and approximately where you should place them for the best results. Almost all vendors have a predictive planning tool that allows you to upload building floor plans, define the attenuation properties of building materials, and then plan your coverage and capacity around it, however many of them are unsophisticated and very inaccurate.

Planning tools are not perfect. You are always going to run into deployment obstacles in the field. They do, however, provide an approximation to the network you should deploy. What they don't do is measure the performance you are getting after the fact. For that, you need a performance management platform.

You need a performance management platform.

CONTINUOUS PERFORMANCE MONITORING



While on-the-spot site surveys using hand-held analyzers are invaluable when it comes to initial deployment verification and troubleshooting, it is naive to regard site surveys as anything more than a brief snapshot in time of the RF environment in your premises. The fact is, the RF environment inside and outside your buildings is never static. It is constantly changing. It is affected by furniture, people, machines, neighboring wireless networks, non-Wi-Fi protocols, and adjustments to your own network.

Even after carefully selecting the right locations and antennas for every AP being deployed, and closely following deployment and placement best practices described in this guide, you're not finished. In order to maintain optimum network performance, there is no substitute for continuous Wi-Fi performance monitoring.

ABOUT 7SIGNAL

You don't need to do this alone; 7SIGNAL is here to help organizations that rely on mission critical Wi-Fi to conduct business. We are a cloud-based Wireless Network Monitoring (WNM) platform that continuously tests the wireless network for performance issues– maximizing network uptime, device connectivity, and network ROI. Unlike other providers, who monitor the network from the inside-out at the infrastructure level, 7SIGNAL operates on the network's edge, monitoring the "air" and capturing the user experience on the client device. The 7SIGNAL platform is offered modularly based on the critical needs of the organization.

Modules

Sapphire Eye™ is a state-of-the-art Wi-Fi sensor developed and patented by 7SIGNAL. Sapphire Eye hardware sensors are installed onsite and are uniquely designed to measure wireless network service quality remotely by accessing cloud-based software.

Mobile Eye™ is a Software as a Service (SaaS) application developed and patented by 7SIGNAL. Mobile Eye is installed on the end user's wireless device and empowers organizations to continuously monitor the wireless network from the end user's perspective. It thereby ensures application and wireless device performance is optimized.

For additional information, reach out to our team and request a demo!

Request a Demo

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