Wireless Infrastructure Tutorial and Primer

Wireless communication involves the transport of voice, video and data using Radio Frequency (RF) or Microwaves.

Radio Frequency is defined as a rate of oscillation or frequency within a range of approximately 3kHz to 300 GHz. Typical Radio Frequency applications include AM broadcasting, navigational beacons, wireless networks, and shortwave radio.

Microwaves range from approximately between 300MHz and 300GHz and are typically used for broadcast television, FM broadcasting, aviation communications, radar and satellite links.

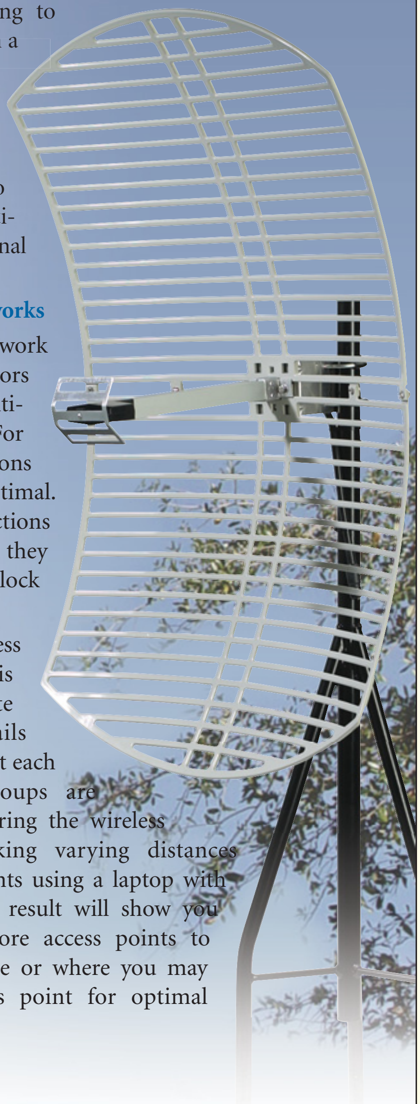
Today's business and some Government networks typically utilize the 2.4GHz-5.8GHz RF range which encompasses one or several of the IEEE 802.11a, b and g, n wireless standards. Other popular RF frequencies used today include 900MHz for ISM (Industrial, Scientific and Medical) RFID (Radio Frequency Identification) and 1.9GHz for PCS (Personal Communication Service) applications.

Indoor (in building) RF Wireless Networks

When dealing with the installation and expansion of indoor wireless networks several factors must be considered. Most manufacturers of wireless access points and routers indicate a typical range that their equipment can provide. Usually these range estimates require line of sight which means you will need a clear unobstructed view of the antenna from the remote point in the link. In most cases there will be obstacles present in an indoor installation that could affect performance. Signals generally will not penetrate metal or concrete walls. Other factors that will reduce range and affect coverage area include metal studs in walls, concrete fiberboard walls, aluminum siding, foil-backed insulation in the walls or under the siding, pipes and electrical wiring, furniture and sources of interference. Other sources include other wireless equipment, cordless phones, microwave ovens, radio transmitters and other electrical equipment. Due to the increased gain, installing range extender antennas in the presence of interference could actually yield equal or worse range.

In wireless transmissions, reflections (when wireless signals "bounce" off objects) and multi-path (when wireless signals travel in multiple paths arriving at the receiver at different times) are as important as signal strength in determining the success of an installation. A signal will also exhibit peaks and nulls in its amplitude and alteration of its polarization (vertical or horizontal) when propagating through walls, ceilings and reflecting off metallic objects.

Wireless radios have special hardware and software to deal with multi-path and signal level nulls, but if the antenna is in a poor location, the radio will not be able to communicate. When trying to get the best performance in a location with a lot of barriers or reflections, it is important to be able to move the antenna in all three axes in order to minimize the effects of multi-path and optimize the signal strength.



Outdoor RF Wireless Networks

Outdoor RF wireless network experience the same factors such as reflections and multi-path as Indoor networks. For outdoor wireless installations clear line of sight is optimal. Trees and leaves are obstructions to 802.11 frequencies so they will partially or entirely block the signal if not cleared.

Before deploying any wireless network a site survey is recommended. The site survey typically entails installing an access point at each location where user groups are located and then monitoring the wireless signal strength by walking varying distances away from the access points using a laptop with site survey software. The result will show you where out may need more access points to provide sufficient coverage or where you may need to move an access point for optimal wireless connectivity.

The proper height for an antenna depends generally on these basic factors…

- Distance between the sites: Earth Curvature, the higher the antenna needs to be.
- The Fresnel Zone: This is a electromechanical phenomenon, where light and radio signals get diffracted or bent from solid objects near their path. See Table showing the 60% of Fresnel Zone Values (Accepted clearing on path).
- Objects in the path: At a frequency of say 2.4 GHz, you need a clear line of sight (LOS). Tree tops will reflect or ground the signal. The theory is that the height of the tallest object in the path of a signal should be added to the Fresnel Zone and Earth Curvature clearance heights. In this case, one should check the height of the trees, hills or any object on the link path and add this to total Tower height.

Wireless Link Distance (Miles)	Value Fresnel Zone F (60% at 2.4 GHz.) Approx. Value	Value E (Earth Curvature) Approx. Value	Antenna Height H Antenna Height No Obstruction
1	2	3	4
3	23	4	27
5	30	5	35
8	40	8	48
10	44	13	57
15	55	28	83
20	65	50	115
25	72	78	150