Current Approaches for Extending Range of Wi-Fi Network

Sunil Kumar[1] R.N. Shukla[2]

[2]Associate Professor

[1,2]Electronics and Communication Engineering Department

[1,2]MMMUT Gorakhpur (U.P)

Abstract— Nowadays, Wi-Fi networks have numerous emerging applications, ranging from backbone Wi-Fi networks, last-mile wireless networks and Wi-Fi direct networks. We can categorize the application into two types: (1) indoor wireless networks and (2) outdoor wireless networks. Indoor Wi-Fi networks include wireless networks and Wi-Fi direct networks, which usually have shorter links than outdoor wireless networks. Compared with indoor wireless networks, outdoor Wi-Fi networks attend as the network backbone or the infrastructure for Internet connection and usually have a longer transmission range. Besides, a data transmission usually traverses through multiple expectancy in outdoor wireless networks while it often takes only one expect in indoor wireless network. The distance limitations and data rates with Wi-Fi networks are more arduous to calculate due to varying data rates, capacity, interference, etc. In this paper, we discuss the various methodologies for increasing range of Wi-Fi network.

Key words: Wi-Fi, WLAN, IR

I. Introduction

Wireless technology is the way of delivering data from one place to another without using wires. The technology embody the radio and infrared spectrum and is employed by both terrestrial and satellite networks. Wireless LANs predominantly use radio waves as the physical media for transferring data. IEEE 802.11 Wi-Fi technology is used for originate wireless networks with a range of about 100 meters. This apparatus can be used to make point-to-point links of hundreds of kilometers with careful designing and proper antennas.

The distance over which RF and Infrared (IR) whitecap can divulge is a function of product design (in transmitted strength and receiver design) and the propagation pathway, especially for indoor environment. Most wireless LAN systems utilize RF waves because radio whitecaps can touch most indoor walls and obstacles.

However, the current range for typical Wi-Fi systems varies from under 30 meters to more than 100meters. Wireless system gives all the functionality like wired system, without the physical connection of the wire.

A. Wireless LAN Network Elements

WLANs consist of four major network elements. They are the station, access point, wireless medium and distribution system. Stations are the devices with wireless network interfaces. An access point (AP) is a wireless router or bridge that interfaces the wireless network with the wired network. The wireless medium is the physical layer standard used to move frames from station to station and the distribution system is the logical component used to forward frames from one access point to another in a large coverage area. The distribution system is often called the backbone network.

B. RF Component

Radio communication involves two or more devices tuned to the same frequency. One device acts as the transmitter while the other the receiver. Basically, the transmitting station has a transmitter that generates the radio frequency, an antenna and a transmission line that connects the two. The receiving station at the other end has a receiver, an antenna and a transmission cable. RF communication begins with an oscillating signal of a constant frequency transmitted from the transmitter to the receiver. Both the transmitter and the receiver have to be at the same frequency for communication to take place. The antenna converts the electrical signals from the transmitter through wires to radio waves for transmission.

C. Antenna

An antenna is defined by Stallings as "an electrical conductor or system of conductors used for either radiating electromagnetic energy or for collecting it." For signal transmission, radio-frequency electrical energy from the transmitter is converted into electromagnetic energy by an antenna and radiated into the surrounding environment. The reverse happens for reception. Antennas are characterized by their radiation pattern as Omni-directional antennas and directional antennas. Omni-directional antennas attempt to propagate signals in all directions e.g. a dipole antenna. Omni-directional antennas are suitable for coverage in a broad room or a whole floor where the Access point is located in the center of the room. Directional antennas are usually used for point-to-point communication. They propagate radio frequency for a longer distance using a narrow beam e.g. a dish or parabolic reflective antenna. Often the shape of the field is plotted out showing points of equipotential versus the distance away from the antenna. Figure 1shows such plots for an omni-directional and directional antenna.

1) Types of Antenna

An antenna can be any size or shape. A list of some common types of antenna is wire, aperture, micro-strip, reflector, and arrays. An antenna gives the wireless system three fundamental properties: gain, direction and polarization. Gain is a measure of increase in the power; Gain is the amount of increase in energy that an antenna adds to a radio frequency (RF) signal. The following are the proposed grouping: wire antennas (e.g., dipole and loops), aperture antennas (e.g., pyramidal horns), reflector antennas (e.g., parabolic dish antennas), micro-strip antennas (e.g., patches), dielectric antennas (e.g., dielectric resonant antennas), and active integrated antennas, lens antennas (sphere), and antenna arrays.

a) Wire Antenna

A wire antenna is an antenna that is made of a conductive wire. Wire antennas can come in different configurations and some of these configurations are dipoles, helix, and loop. Wire antennas can be seen everywhere in daily lives.

Some examples of wire antennas are on automobiles as radio antennas, and on buildings as transmitting or receiving antennas.

b) Helix Antenna

Helix antenna requires minimal amount of material. The materials needed would consist of conductive wire and a metal plate that serves as ground plane. The supports for the helix structure could be made out of wood and could be used to support the helical structure. A helix antenna is defined as an antenna whose configuration relates to a helix. The helix antenna is relatively light weight because it is constructed using a metal conductor wire, a center support the helix structure, and is usually to a ground plane at the base. An example of a helix antenna is seen in figure.

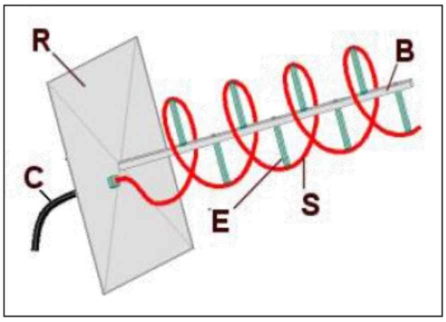


Fig.1: Basic Helix Antenna Configuration

The lossless gain of a Helix Antenna is given by

Gain (G) = (6.2 NSC^2) / (λ^3) (1)

Where:

N=Number of turns

C = Circumference of Helix

S = spacing between turns

λ = wavelength

The gain is dependent of the number of turns, the circumference of the helix, the spacing between turns, and the wavelength. We can increase the gain of the antenna by adding additional turns which will increase the length of the antenna. Another key characteristic is the input impedance of the antenna. This can be obtained using

R = 140(C/ λ) (2)

The resistance of the antenna is dependent of the circumference of the helix and the wavelength. By making the circumference smaller and closer to the wavelength, the antenna will have a smaller input resistance but a smaller achievable gain. By changing the circumference, we can match the impedance of the transmitter to the generator resistance. There are two operational modes for helix antenna: axial mode, and normal mode. In normal mode the spacing between helixes and the diameter of the helixes are small in comparison with the wavelength. The radiation pattern is along the helical direction and it is similar to that of a dipole. In axial mode, the antenna function like a directional antenna and the spacing between elements is λ/4. The antenna radiates at the top of the helix along the axis of the antenna. The radiation pattern of the operation modes can be seen in.

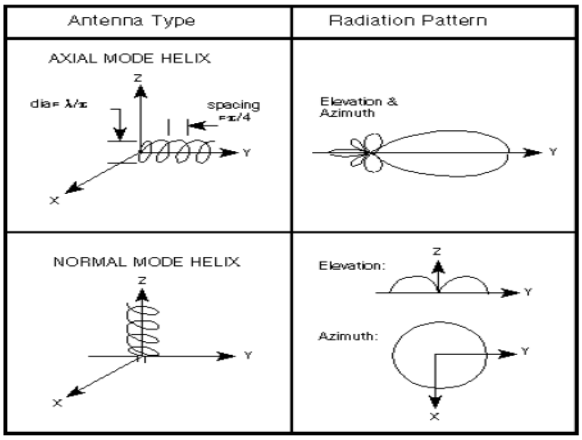


Fig. 2: Ratiation Pattern of Helix Antenna

2) Antenna Gain

Gain (also known as Amplification) is critical to improving the range of an antenna and therefore plays a critical part in determining (or extending) the range of a Wi-Fi network. Gain refers to an increase of the Amplitude or Signal Strength and comes in two forms; active and passive.

- Active Gain refers to an increase in power that is applied to the antenna
- Passive Gain is achieved by focusing the energy of the antenna in a particular direction.

Gain is usually expressed as a ratio in dB's. It is the log of the ratio of the powers. For example, a typical dipole antenna will have about 2 dBi, (i = isotropic) of Gain.

3) Transmission Power

The transmission power usually expressed in 32mW or dB that the wireless device at most Linksys, D-link and other indoor, home based access points use a 32mW transmit power. This is one of the main reasons signal strength is limited when using these devices.

4) Signal Propagation Losses

The propagation of Wi-Fi signals, as for any electromagnetic wave, is governed by the properties of materials in the propagation medium. Although the high frequency used by Wi-Fi is able to penetrate obstacles such as walls and ceilings, these obstacles affect the signal propagation. Many studies have shown that penetration loss depends on the properties of the materials in the propagation medium. For a wireless network in a home or office, obstructions such as walls, furniture, people etc. impede the propagation of signals. Losses of varying dBs are introduced depending on the material of construction for the various items in the room. In a multi-story building, losses between floors are also introduced, depending on the building materials used. A loss of approximately 6dB is usually experienced between adjacent floors.

5) Effect of Position of Wi-Fi Devices

Wi-Fi positioning plays an increasingly important role in improving performance because good positioning can improve performance in indoor environments without additional devices. Position determination using Wi-Fi technology has the advantage that it can perform indoors and outdoors, in a different way to GPS. And, although Wi-Fi was never made for positioning, it is more accurate than a GSM indoor positioning and, in some cases, it is also more accurate in regards to outdoors. Wi-Fi Positioning also allows the use of location-based services (LBS) indoors, which is interesting for the industry. Wi-Fi uses electromagnetic waves to transmit data over the airwaves. Looking at the illustration one can see that it operates in broadband, on about 2,4 GHz and 5 GHz.10 Other longer distance technologies also use frequencies in between these figures. The frequency is the number of wave occurrences per unit of time. In the best case, the radio waves spread out evenly and lose more and more of their signal strength with increasing radius. This loss of signal strength is due to the energy transformation because, in physics, energy is never lost, but instead converted. In an outdoor station the radius ratio of distance to signal strength is inversely proportional, because the decrease of the signal is log-normal. However, indoors we encounter a different problem, because the waves bump into walls, windows, doors and so on. If a wave bumps into a different material, it converts more energy than in the air. During this process, the signal strength is decreased more strongly, because the energy is transferred to the material (e.g.: in heat). More about this problem is following in the section entitled Problems and interferences.

6) Fundamentals for Wi-Fi measuring

The distance between the transmitter and the receiver has an important role in determining the position. In contrast to GPS, Wi-Fi, at a time measurement method, does not come into question, since such an exact time is difficult to achieve synchronization. Finally, the path from space to the ground is much farther than from one access point to a mobile device. The received signal strength (RSS) and the signal noise ratio (SNR) are the most suitable. These values can be calculated from the incoming signals

7) Signal Strength

The signal strength is measured in dBm (decibel in mill watt). A Wi-Fi station has a EIRP (Equivalent isotropically radiated power) of 100mW - 1000mW (20dBm - 30dBm). This is how to calculate:

$$Lp\ (dBm) = 10 * \log (P/1Mw)$$

For Example:

$$Lp(dBm) = 10 * \log(100mW/1mW) = 20dBm$$

8) 802.11 Wi-Fi

Wi-Fi is also known as wireless LAN. It operates on the 2.4GHz and 5GHz Industrial, Science and Medical frequency bands and has a distance of 100m. It is specified by the IEEE 802.11 standard and it comes in four major different variations like IEEE802.11a/b/g/n. Each generation is defined by a set of features that relate to performance, frequency and bandwidth. Although Wi-Fi was intended to be used for mobile computing devices such as laptops, it is now used for increasingly more applications including internet, gaming and basic connectivity of consumer electronics like TV and DVD players.

9) Features

- Interoperability- means any Wi-Fi product from different manufactures can work together.
- Backward compatibles- means new Wi-Fi products are able to work with older Wi-Fi products that operates in the same frequency band.
- Distance of 100m
- Choice of modes
- Ad hoc mode
- Infrastructure mode

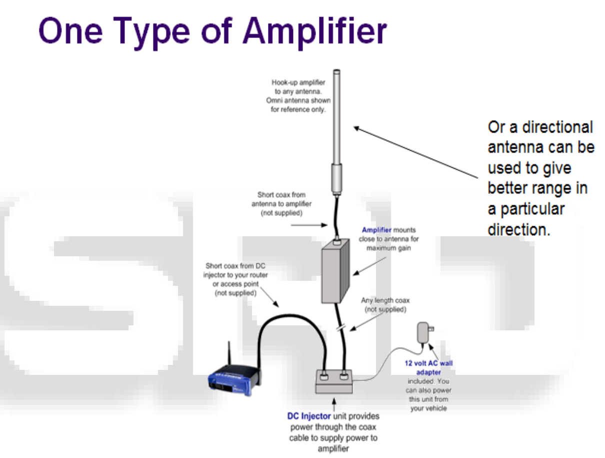
10) Wireless Range and Coverage

The range of a wireless signal can be defined as the maximum distance at which two radios can operate and maintain a connection. The range of an access point is affected by various factors such as the transmitting power of the access point, the number of antennas being used and the gain and directivity of the antennas. The coverage area is the total area at which all radios can maintain a connection to one another sometimes called a cell. Clients within a cell can associate with the AP and use the wireless LAN.

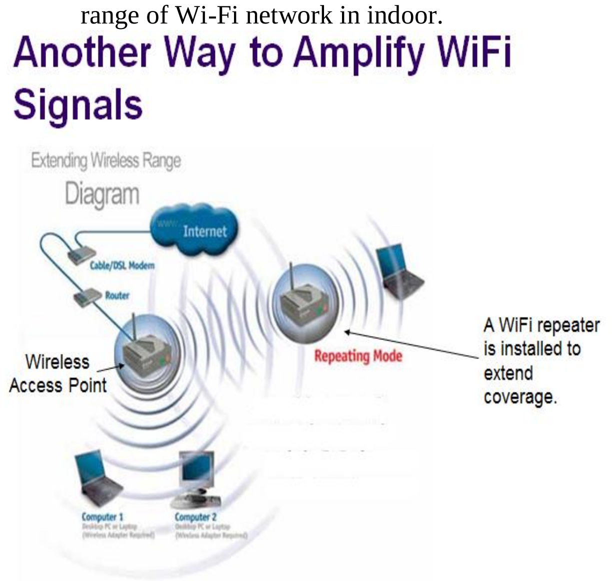
In a limited range there are limited numbers of users if more users want to utilize the Wi-Fi network but there is a problem with the range of Wi-Fi network which is not in their coverage area so that to solve this problem we should have to increase the range of Wi-Fi.

zThere are many ways to extending the range of Wi-Fi network which are given below:

- With the help of directional antenna we can extend the range of Wi-Fi network for outdoor.



- With the help of Wi-Fi repeater we can extend the range of Wi-Fi network in indoor.



D. Wireless Repeater

A repeater is an electronic device that receives a signal and retransmits it at a higher level or higher power, or onto the other side of an obstruction, so that the signal can cover longer distances. It's a device usually used to extend wireless coverage in wireless network by repeating the wireless signal generated by wireless router/access point. Some better repeaters also able to improve wireless transmission rate. This device is also referred as wireless range extender, booster or expander. Repeaters are used to increase the range of a transmitted signal by re-transmission. A wireless signal repeater that receives, amplifies and transmits a wireless signal and that includes an integrated display screen that provides concurrent indications of

- Receive signal level and
- Transmit signal level, wherein the integrated display screen concurrently displays
- A receive signal indicator reflecting receive-signal level,
- A transmit-signal indicator reflecting transmit-signal level and
- A textual indication of wireless signal quality reflecting an extent to which the wireless signal repeater is operable to repeat wireless signals.

Wireless repeater works at OSI layer 1(physical layer). Wireless repeater is used for extending wireless network which is shown as in the figure.

II. CONCLUSION

In this paper, we have highlighted several ways to improving the range or signal strength of the Wi-Fi network. Placing the Wi-Fi router in the center position will provide best signal in the coverage area in all direction. Try to change the position of the router’s antennas (horizontal, vertical, at a certain angle) to see which direction works best to intensify the signal. Go to the wireless router’s configuration page to change channels. Changing the Wi-Fi channel, much like fiddling with the dial of a radio to find the best signal, may also help in choosing a channel that is free of interference. Wireless repeaters are used to extend the range of wireless network for indoor purpose and directional antenna is used for outdoor purpose.

III. REFERENCES

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