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Study of 2457 MHz WIFI Network Signal Strength at Indoor and Outdoor Enviroment

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Abstract: This paper presents a study of free space path loss of WIFI network using Cell Info Lite App and WIFI analyzer tool. This paper focuses on experimental tests by using WIFI router, mobile phones to measure and analyze the loss of signal strength over distance from 0 meter to 9 meter. The result of Free Space Path Loss (FSPL) for frequency 2457 MHz shows that the longer the distance, the worse the signal get. In addition, the experiment test indoor and outdoor was done analyse. The results of the comparison conclude that the signal strength becomes weak can affect by distance and obstacles such as door, wall. Signal strength also can say from colors which is when the measurement result shows green color is strong signal while orange color is weak signal and red color is bad signal. When the signal strength become weak Wi-Fi analyzer was displayed green zone to red zone. The paper purpose showed that where the area have a stronger/weaker connection in a house environment.

Index Terms: Free Space Path Loss, Wi-Fi signal strength, Distance

1. Introduction

Nowadays, wireless communication technology becoming more and more important because its impact on almost every aspect of modern life, and has inspired useful research in almost all fields of human endeavor. In radio propagation, there are three major scales are used to calculate channels, spatial and temporal variations. Fast fading is signal variation on a small scale, shadowing is a signal variation on a small area average, and path loss in signal variation across a wide area distance [1]. The difference (in decibels) between the effective transmitted and received power is known as path loss, and it may or may not include the influence of antenna gains. There are several possible causes of path loss which are free-space loss, reflection, diffraction, refraction, and absorption (penetration) losses [2]. Rays that involve pathway may be interrupted, as well as paths that have parabolic and diffraction, scattering and propagation via doors, walls and other obstacles [3]. Mobile wireless communications have increased at a rapid speed, resulting in mobile phones being an essential feature of people's life. As a consequence, demand for mobile wireless communications services has increased [4]. WiFi is based on the IEEE 802.11x wireless technology standard that can supply up to 11 Mbps of high-bandwidth internet access (on the 802.11b standard) [5]. The 802.11 wireless local area network (WLAN), also known as Wireless Fidelity (Wi-Fi) is a widespread wireless internet access technology used in buildings. This is because, as compared to existing cable and mobile networks, it has sufficient mobility and connection speed [6]. Moreover, Wi-Fi Access Points are being installed in almost every possible site, including hotels, restaurants, train stations, coffee shops, airports, and private houses.

Several researchers in the field of path loss propagation models have been done, with promising findings. All of these studies are critical to wireless network planning. Most of the technology's equipment operates at a frequency of roughly 2457 MHz, which is an unregulated frequency [7]. Poor signal strength could be caused by the structure of the house itself. There are some research investigated path loss signal for outdoor [8] and indoor [9] environments It may be more difficult to use the wireless network in specific regions of the house if the walls are thick or include certain building materials [10]. The solution is to add WIFI extender or move the router to an area of the house where the consumer can access the internet most frequently. Studying FSPL will assist us in determining the range of a Wi-Fi signal. Wi-Fi survey software also uses it to estimate Wi-Fi signal propagation. FSPL can be utilized to every other waves that use different frequencies. The losses is proportional to two important factors: distance and frequency [11].

In this paper, the analysis of WLAN and Smartphone Mobile HotSpot (SMHS) signal strength with different distances was discussed. Received signal strength indicator (RSSI) is found to ensure that the objective for an indoor environment which may be used with any access point or wireless router. It works by determining the signal strength from the standpoint of the tag or the access point [12]. Table 1 shows reference for signal strength Wi-Fi. When the signal strength measurement become lower, the quality would be unusable. Its' mean it expect no service at all, it may due to obstacle such as multiple wall or the router is too far away.

Table 1. Reference of Wi-Fi signal strength.

Signal Strength	Quality	Description
-30 dBm	Perfect	Maximum signal strength
-50 dBm	Excellent	Excellent for all uses
-60 dBm	Very good	Good, reliable signal
-67 dBm	Good	Good for all uses except HD
-70 dBm	Ok	Light browsing and email
-80 dBm	Unreliable	Unreliable connection
-90 dBm	Unusable	Expect no service at all

In this paper, the WLAN and SMHS signal strength at indoor and outdoor environment had been measured and analyzed. A simple experimental environment setup by using WIFI router, mobile phones, or laptops to measure and analyze the loss of signal strength. The path loss between a transmitter and a receiver could be calculated using the free space path loss formula. The scope of the study is organized as follows: The formulations and equations are described in Section 2. Section 3 is an experimental arrangement. The results and discussion are given in section 4. In section 5, the conclusions are discussed. In the final section, the research references are listed.

2. Theory of FSPL

2.1. Theory of Transmission on Free Air

Maxwell's equation is the foundation of antenna concept for the propagation of electromagnetic waves. However, the Friis Transmission Equation can be simplified for propagation in free air when it is regarded as the standard formula for the power received. (Friis, 1946).

$$\text{Pr} = GrGt\ (\frac{\lambda}{4\pi d})^2\ Pt \quad (1)$$

Where,
Pr = Power received,
Pt = Power transmitted,
Gr = receive antenna gain,
Gt = transmit antenna gain,
λ = wavelength and
d = distance apart

2.2. Free space path loss calculation

The free space path loss can define in terms of either the wavelength or the frequency. Both equations are given below:

$$\text{FSPL} = \frac{Pt}{Pr} = \left(\frac{4\pi R}{\lambda}\right)^2 = \left(\frac{4\pi Rf}{c}\right)^2 \quad (2)$$

Where
FSPL = Free space path loss
R = distance from the transmitter to the receiver (meters)
λ = signal wavelength (meters)
f = signal frequency (Hz)
c = speed of light (meters per second)

2.3. Free Space Model

Free space path loss (FSPL) is defined as the loss incurred by an electromagnetic wave as it propagates with no absorption or reflection of energy from a nearby object. In Free Space L, a path loss is the amount of signal power lost during transmission from transmitter to receiver. The frequency and distance of the Free Space Model vary [13]. Equation 3 is used to calculate it.

$$L = 32.45 + 20\log(f) + 20\log(d) \quad (3)$$

Where,
f is the Frequency in (MHz)
d is the distance in (Km)

3. Experimental

To begin, an examination of accessible Wi-Fi analyzer apps on the internet was made, followed by a comparison based on features and platform availability. As shown in Fig. 1, an app download from Google playstore named Network cell info lite was used as a Wi-Fi analyzer to observe the Wi-Fi network information and signal strength. The purpose of this app is to measure signal strength of the house environment. From the app, user would know detail of the information for wireless network and displayed result in figure.

Fig.1. Wi-Fi analyzer (Network cell info lite) with the icon app in google playstore.

3.1. Distance between Mobile phone and WIFI router

The experimental test by using WIFI router, mobile phones to measure and analyze the loss of signal strength. It used measurement tape to measure the distance for 3 m, 6 m, and 9 m. Figure 2 shows the simple setup experiment. This experiment was tested in the house area, the place of the wifi router at the fixed point, and a person using a mobile phone to measure the different distances. Every result from receiver would show different measurement signal strength due to the distance is different.

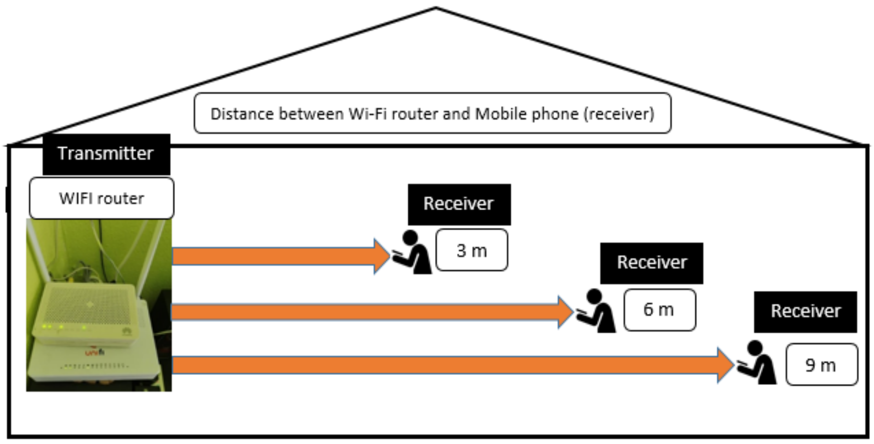

Fig.2. Setup of experiment distance between Wifi router and Mobile phone (receiver).

The mobile phones was install Network Cell Info Lite app to analyze the signal strength of different distances. Table 2 shows two methods of signal strength with different distances. First is with Wi-Fi router and secondis using SMHS as the transmitter. Table 2 illustrates that when signal strength is in the green zone, it indicates areas with strong Wi-Fi network signal strength and quality. The yellow zone, on the other hand, denotes areas where signal strength and quality are adequate. Last but not least, the red zone denotes unreachable areas that are outside of the Wi-Fi network's range.

Table 2. Signal strength with different distance for Wi-Fi and Phone data.

<table>
<tr><th>Distance</th><th>WIFI</th><th>WIFI SMHS</th></tr>
<tr><td>Beside Router</td><td>
</td><td>
</td></tr>
<tr><td>3 m</td><td>
</td><td>
</td></tr>
<tr><td>6 m</td><td>
</td><td>
</td></tr>
<tr><td>9 m</td><td>
</td><td>
</td></tr>
</table>

3.2. Obstacle

Experiment test by indoor and outdoor of the house was done analyze. Figure 3 shows the setup of the experiment of indoor and outdoor. While figure 4 shows result signal strength for indoor and outdoor. The signal becomes weak when it is outdoor (from green zone to red zone). It is because the signal can't transmit fully cause by obstacle (multiple walls). Another experiment had been try by using the same distance (3 m) but had an obstacle (door) as shown in Figure 5. While figure 6 shows result signal strength for no obstacle and obstacle. When a door as an obstacle, the signal becomes weak compare with no obstacle. This is due to the door as dielectric properties of wooden doors, which may absorb some of the WIFI signal strength. When electromagnetic wave passes through any object, it will happen three phenomena such as reflected, absorbed by the object, and transmitted through the object. Therefore, when the WIFI signal passes through the wood, the signal strength is reduced.

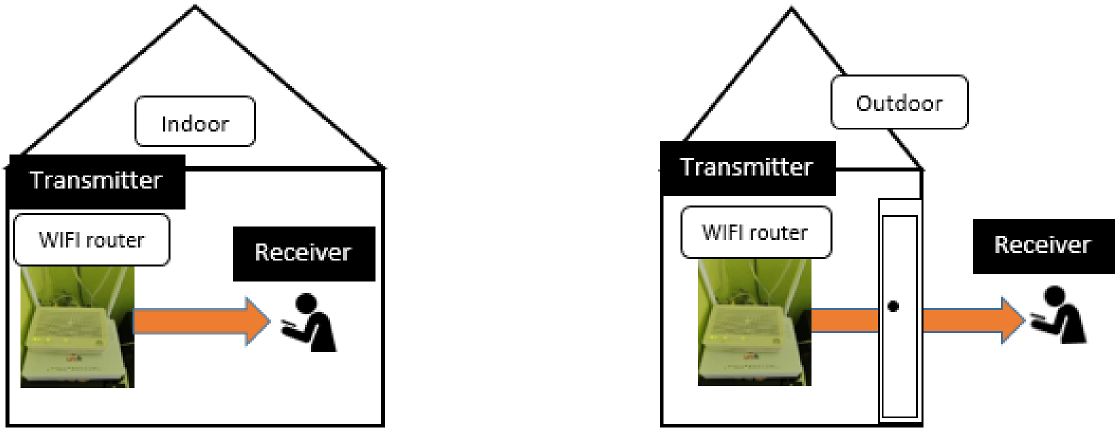

Fig.3. Setup of experiment indoor and outdoor enviroment.

Fig.4. Signal strength for indoor and outdoor.

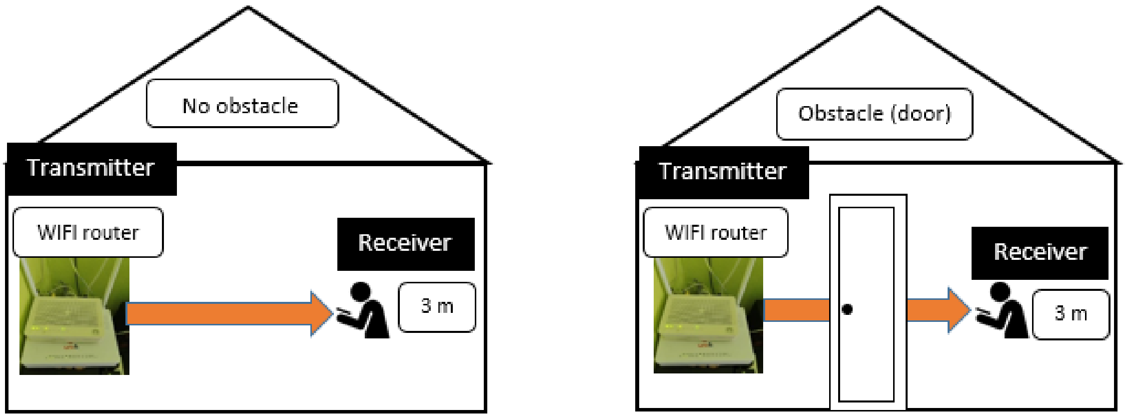

Fig.5. Setup of experiment obstacle and no obstacle (door).

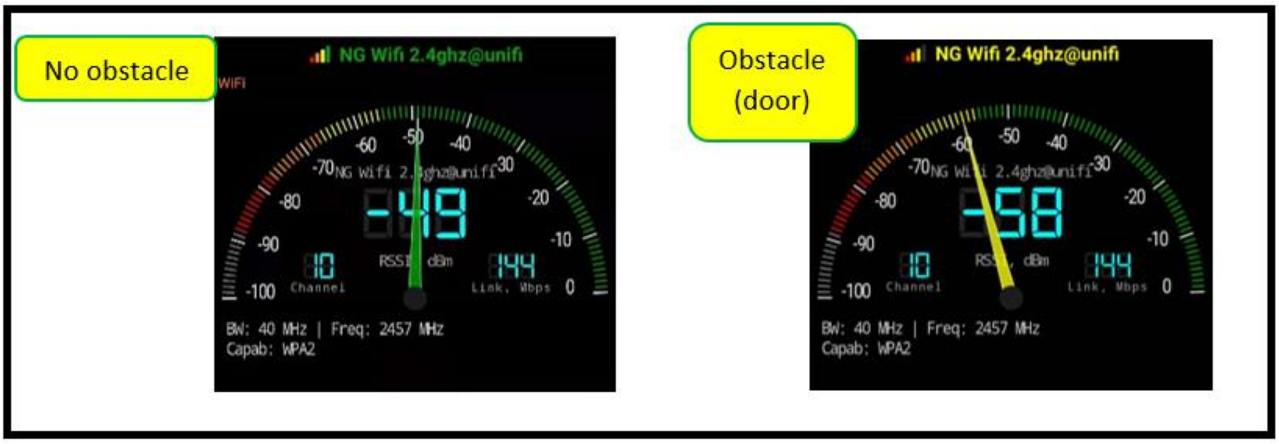

Fig.6. Signal strength for no obstacle and obstacle.

4. Result and Discussion

The measured signal strength for Wi-Fi routers and access point from SMHS 3 m, 6 m, and 9 m as shown in Table 3, when the distance increases, the lower of signal strength received. Figure 5 shows the results of the experiment in Figure 2 the graph of Power Received (dBm) vs Distance (m) for frequency 2457 MHz. As the distance between transmitter and receiver increases, the average signal level decreases.

Table 3. Power Received for Wi-Fi router and WIFI connect with SMHS 3 m, 6 m, and 9 m.

Distance (m)	Power Received for Wi-Fi (dBm)	Power Received Access Point from SMHS (dBm)
0	-24	-33
3	-49	-57
6	-60	-69
9	-66	-73

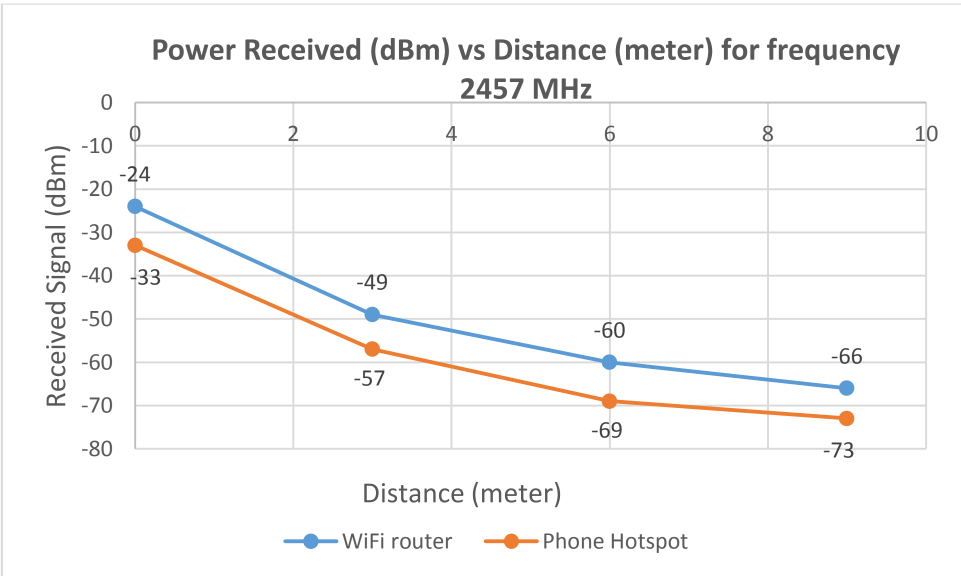

Fig.7. Results of Power Received (dBm) vs Distance (m) for frequency 2457 MHz.

Figure 7 shows the result of a WIFI router and a WIFI connection with SMHS with different distances and frequency at 2457 MHz. The initial result of power received for WIFI router was get -24 dBm while the result of 3 m is -49 dBm, 6 m is -60 dBm and 9 m is -66 dBm. Besides that, the initial result of power received access point from SMHS was get -33 dBm while the result of 3 m is -57 dBm, 6 m is-69 dBm, and 9 m is -73 dBm. From the graph, it can conclude that as the distance is longer, the power received will get lower.

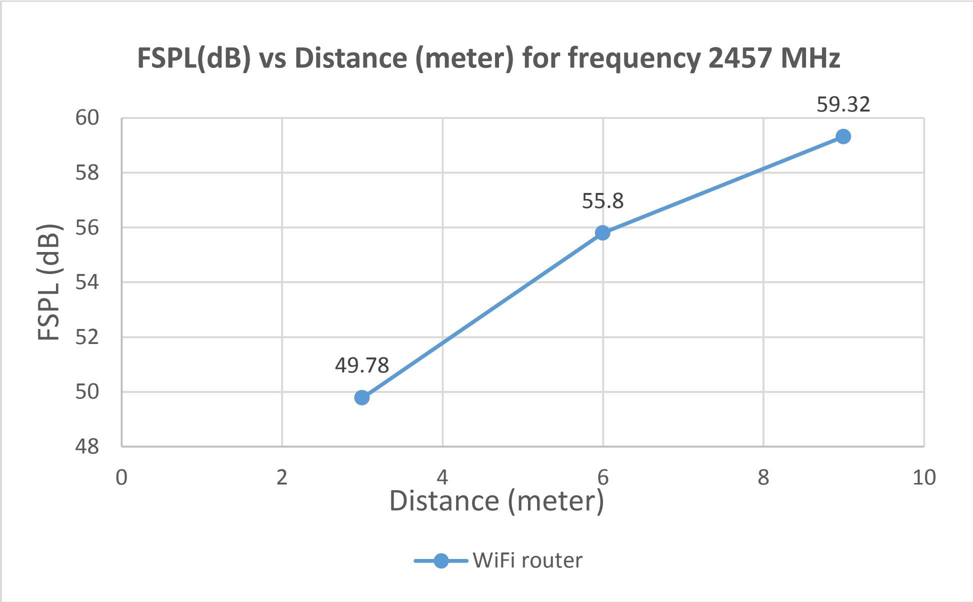

Fig.8. Result of FSPL (dB) vs Distance (m) for frequency 2457 MHz.

Figure 6 shows the result of the graph of FSPL (dB) vs Distance (m) for frequency 2457 MHz. By using Free Space Path Loss (FSPL) formula, the result of path loss of WIFI router for 3 m is49.78 dB while the result of 6 m is 55.8 dB and the result of 9 m is 59.32 dB. From the graph, it can conclude that as the distance is longer, the value of path loss increases.

As a result, the path loss depends on distance and wavelength. When the distance increase the signal strength also will increase. The propagating wavefront will break out into multiple directions if there are many objects in the signal path and the items are small relative to the signal wavelength. The resulting signal will disperse in every direction, increasing the signal's constructive and destructive interference.

According to the results of the previous investigation, there are numerous ways to enhance Wi-Fi signal strength. The first step is to select a booster kit with the highest output power. Second, look for "max gain" on the signal meter when plugging into the connector at the end of the cable run during installation. Third, install an indoor antenna in the area where mobile devices are most frequently used to remove the distance between the user and the source of the boosted signal. It can also increase the Wi-Fi router transmit power, which was set to an ideal 70mw because boosting it too much can sometimes make the signal weaker [14].

5. Conclusion

To the study of WLAN and SMHS signal strength at the indoor and outdoor environment and with obstacle condition have been investigated. At the frequency of 2457 MHz, the measured data/Wi-Fi and signal strength values are evaluated and compared. The results conclude that the strength of the Wi-Fi signal and SMHS signal decreases as the distance from the network increases. In the future, before installing a WLAN router, determine the coverage area and preliminary access locations so that it can be optimized for the majority of the workplace, house, or campus. It is important verifying access sites because it can enhance the signal strength and signal quality. The importance of high-quality and large networks, as well as precise coverage estimation, cannot be overstated. As a result, precise design scope of advanced wireless networks and signal strength test results must be considered in order to ensure an effective and stable network coverage [15]. If the router is further away and signal strength is a problem, consider Wi-Fi extender to enhance the capacity of network in home. The study also found that path loss lowers as distance increased, implying that when the receiver is close to the transmitter, it receives a stronger signal.

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