Wifi-friendly building, enabling wifi signal indoor: an initial study

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Abstract. The 802.11 network (wireless fidelity/WiFi) is the most common wireless infrastructure applied for internet access indoor. Widespread devices and installation simplicity make it better than similar technologies such as 802.16 and other 802.xx series. The access points are the most influential devices for indoor access. However, building indoor architectures contribute to the signal quality. Since WiFi installation in buildings becomes prevalent, the architecture should consider WiFi-friendliness into consideration. The more friendly the building to WiFi signal, the more efficient the 802.11 based wireless infrastructure. This paper present preliminary study how the building, specially the obstacle material, effects the WiFi signal propagation indoor. The study was performed by using ESP8266-based WiFi signal reader, to determine the impact indoor obstacles to WiFi signal propagation. The initial study shows that simple reflecting materials increase signal level about 1.14 dBm. WiFi-friendly building can be achieved by transforming building properties into signal interconnector. A simple photo frame with aluminium sheet insertion increase signal level on the second floor up to 6.56dBm.

Keywords: WiFi, signal propagation, WiFi-friendly building, obstacle, reflector

1. Introduction

Internet has been important part on daily life. Mobile connection anytime anywhere has been enabled mainly by mobile communication system. However, high speed connections still rely on traditional networks such as local area network (LAN) and wireless (WLAN). WLAN based on 802.11 technology is preferred as the flexibility movement within the building. As mobile computer is becoming popular, users in houses and offices tend to choose WLAN when available.

Even though the demands of WLAN in both houses and offices are high, the awareness of the infrastructure integration on how building be designed to also support the wireless infrastructure is not yet emerged. On the scientific side, there is an empty gap on this matter. WLAN and building relationship generally discusses the following topics:

- How locate the optimum replacement of an access point in the building to cover as much as possible the area. This determination is mainly based on propagation analysis [1], user density traces [2], based on the overall Euclidian distance [3]or even the consideration of interferences possibilities[4].
- Other topic is location based services on how to find a terminal by analyzing the received access point signal or often referred to as indoor localization [5-8].
- Lastly, the topic relates to building and WiFi is home automation using internet connection bridged 802.11 networks [9].

2. Indoor Propagation and Reflective Materials

Indoor propagation is affected by reflection, diffraction, and scattering by the materials. Indoor propagation has been intensively studied and modeled in mathematical expression. Some deterministic models involve a free space loss model, log distance path loss model, and log normal shadowing model. Deterministic model simplify the calculation with a fixed mathematical expression.

A more sophisticated model uses a complex approach such as impulse response [10] and statistic dispersion [11]. The modeling is performed only for a specific frequency band.

Reflective materials can be conductive but mostly isolative. Conductive materials generally reflect WiFi signal, while isolative materials absorb and disperse the signal. The characteristics of those materials are approximated by using conductivity and complex permittivity parameter. The more conductive materials, the more reflective to radio signals. The more primitive a material, it is like the more absorbing to radio signals. Table 1 shows the examples of permittivity and conductivity of some materials exist on buildings [12].

| Material         | Relative Permittivity | Conductivity (S/m) | Frequency (GHz) |
|------------------|-----------------------|--------------------|-----------------|
| Concrete         | 5.31                  | 0.0326             | 1-100           |
| Brick            | 3.75                  | 0.038              | 1-10            |
| Plasterboard     | 2.94                  | 0.0116             | 1-100           |
| Wood             | 1.99                  | 0.0047             | 0.001-100       |
| Glass            | 6.27                  | 0.0043             | 0.1-100         |
| Ceiling board    | 1.50                  | 0.0005             | 1-100           |
| Metal            | 1                     | 10                 | 1-100           |

3. Research Method

Initial stud on how building friendliness to WiFi signal propagation is performed by showing how the obstacles reduce WiFi signal and how the reflective materials in some cases are helpful enlarging the access point coverage. Research method on these initial studies uses the real experiment as outline in the following sections.

3.1. Initial Study on Obstacles

An experiment as depicted in Figure 1 has been develop to show what obstacles done to WiFi signal and what the goodness of reflectors.

![Obstacle experiment](image1.jpg)  ![Reflector experiment](image2.jpg)

**Figure 1.** Obstacle and Reflector Experiments
A smart phone is turned on to broadcast WiFi signal that will be blocked by an obstacle, separated 2.5m to 15 m from a smart phone and 20 cm from the receiver. WEMOS D1 ESP8266-E12 integrated circuit as a WiFi signal receptor is employed in the experiment. Obstacles are made of concrete, wood and metal while reflector is metal.

3.2. A Building Property to Help WiFi Friendliness
In order to improve the friendliness the building to WiFi, properties within the building can be optimized as signal spreaders, rather than obstacles. This paper experiments that a photo frame mounted in the wall can be used as a good signal reflector by inserting an aluminum sheet on the back of the frame. This reflective material is employed to help WiFi access point reaches the second floor users with changing position 1, 2, and 3. The experiment is depicted in Figure 2.

![Figure 2. Reflector Behind a Photo Frame](image)

The same receiver as the first experiment is used in the second experiment. The WiFi access point uses different mobile phone.

4. Experiment results

4.1. Impact of the obstacles and a reflector
Figure 3 shows the experiment results. Signal strength decreases to distance travelled. Among the obstacle materials, concrete absorbs signal the most, followed by metal and wood. The presentation of reflector reduces signal absorption.
Reflector replacement as in Figure 1 has been successfully reduce the signal absorption and increase signal level. Signal level increases 1.14 dBm in average, with details: concrete obstacle 1.53 dBm, wood 0.73 dBm, and metal 1.16 dBm.

4.2. Impact of a Building Property asa Reflector

The concrete wall blocks the received signal on the second floor. The only way signal gets through is by reflection through the door. Without additional reflector, the average received signal on the second floor is -68.69 dBm (Figure 4).

Transforming the photo frame on the wall being a reflector causes increments of received signals. There is 4.03 dBm increments in average with details: reflector in position 1 achieves 3.39 dBm, position 2 6.56 dBm and position 3 2.14 dBm.
5. Conclusion
To conclude, materials within the building reflect and absorb WiFi signal. Without efforts on making the building becoming friendly to WiFi signal, concrete is the main material blocking the signal, followed by metal and wood. The first experiment shows that a reflector in certain position reduces the signal absorption and increase signal strength about 1.14 dBm.

By transforming decorating materials in the building, WiFi signal can be boosted in certain level. The second experiment shows that by simply adding an aluminium sheet behind the photo frame, WiFi signal on the second floor can be improve up to 6.56 dBm. Future works may explore more on building properties that may help its friendliness to WiFi signal.

Acknowledgements
This research is funded by TALENTA research schema, Universitas Sumatera Utara 2017.

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