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Experimental Study of a Wireless Local Area Network

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Abstract

In this paper, we report on the field measurements of the signal strength received at the user end from an access point in a given wireless local area network. The network established for Internet access in indoor environment is based on IEEE802.11g standard operating at 2.4 GHz license-exempt band. Signal strength measurements were recorded at two slightly different positions of the user equipment. This gives two different orientations of the antenna fitted in the user equipment with respect to the access point. Two sets of measurements were recorded over observation intervals of 60 seconds and 240 seconds. Analysis of the results show that there are significant fluctuations in the received signal strength at a given position from the access point in time domain. An examination of the results reveals that large fluctuations cause frequent link drops and therefore heavy packet loss. These wide variations cause degraded performance in terms of the overall throughput available to the end user. An estimated map of the signal strength prior to fixing of the access point may be an appropriate option for obtaining good performance of an access network.

Keywords: Wireless local area networks, signal strength measurements, temporal analysis.

1. Introduction

During the last decade, we have witnessed dramatic proliferation of mobile wireless devices and extensive development and deployment of wireless networks around the world. It has become a challenge to keep up with the increasing demand for capacity. The Wi-Fi has become a ubiquitous feature on high end mobile wireless devices with

97.5% smartphone currently supporting Wi-Fi access. Wireless Local Area Networks (WLANs) based on IEEE 802.11b/g/n standards have been extensively deployed for last mile access in homes, offices, hotels, and airports. As WLANs offer flexible connectivity and economical network access, these are also being deployed in institutions, university campuses and research and development organizations for access to computing resources and information networks.

WLANs are generally deployed in indoor environment. Therefore, structures including walls, roofs, and other household goods act as reflectors and scatterers. This ultimately results in multipath dispersion and attenuate the signal strength received at the user equipment to large extent. The cause and effects of multipath dispersion have been discussed in Theodore S. Rappaport (2002) and Kaveh Pahlavan (2003). Multipath dispersion happens because signal from transmitter reaches the receiver via different paths. Traversal of the signal through different path lengths lead to constructive or destructive interference at the receiver. When the signal components meet in same phase, received signal strength is enhanced. But when, different signal components are not in same phase, destructive interference occurs and signal strength received at the end user equipment is attenuated causing fading of the signal.

There are large variations in the received signal strength at the user end, which causes poor performance of the network. This makes the design and implementation of WLAN in indoor environment a challenging issue as discussed at length in Keenan et.al (1990), Jaime Lloret (2004), Davies et al.(2008).

Several studies have been conducted and reported in literature about the signal strength measurement and radio propagation in indoor environment in regard to WLANs. Sandra et.al (2010) have compared the different variants of IEEE 802.11 for their performance through signal strength measurements in indoor environment. Their study is useful for choosing the right technology for given deployment scenario. Ogueijiofor O.S. et.al. (2012) have carried out experimental study for received signal strength measurements and have proposed mathematical prediction model for the signal strength in indoor environment.

Wireless channels are highly dynamic and hence it is always a challenge to assess the consistent performance for ensuring the desirable quality of service. In Chong Tang et.al (2012), frame delivery rate, loss rate, and signal to noise ratio have been studied for their variation in time and space.

In a wireless transmission medium, the signal strength received at the terminal is influenced by small scale and large scale fading. For large scale path loss, received signal strength in dBm at the receiving terminal 'd' distance away from the access point is given below by Tariq Ali and Mohammad Saquib (2011)

$$P_r(d) = P_t - L - 10\eta \, log \frac{d}{d_o} + \chi(\mu, \sigma) \qquad (1)$$

where $P_r(d)$ is the local mean of shadow faded received signal strength, P_t: transmitted power, L: constant path loss at a distance d_o meter away from the access point. $\chi(\mu, \sigma)$ is a Gaussian random variable. This term in Eqn.(1) reflects the fading

component in the received signal strength. Depending upon the severity of the fading, signal strength fluctuate about the mean value of the signal strength.

In this paper, we report on the signal strength measurement in a WLAN based on IEEE 802.11g standard in indoor environment. Analysis of the measurement is also carried out to assess the link quality performance of the network. The rest of the paper is organized as follows: Section 2 describes the measurement campaign used for recording the readings. Results are discussed and analyzed in section 3. Finally conclusions are drawn in section 4.

2. Measurement Campaign

In this work, we investigate the performance of WLAN for its link quality in temporal domain. Our approach is based on the measurement of received signal strength at user equipment. Signal strength measurements are conducted on a laptop which acts as mobile host. The laptop is equipped with Athreos AR9285 wireless network adapter utilizing inSSIDer software tool. Measurements are recorded in an indoor environment placing the mobile host at a fixed location about five meters away from the access point. The access point under consideration is fitted in the running corridor of the first floor houses in a large residential area.

3. Results and Analysis

Utilizing the experimental setup mentioned in section 3, we have recorded the signal strength measurements in time domain. Fig. 1 shows the scatter plot of received signal strength over an interval of 60 seconds recording 31 readings. As shown in Fig. 2, fluctuations upto -11 dBm in the received signal strength varying between -60 dBm to -71 dBm are observed. Assuming -70 dBm as the threshold for desirable quality of service, it is seen that 0.03% of the time, link goes into deep fade causing heavy packet loss. Fig.3 depicts the scatter plot of measured received signal strength over an interval of 240 seconds. These readings were recorded at a slightly different position of the user equipment. This changes the orientation of the antenna at the end user equipment with respect to the transmitting access point. Surprisingly, the received signal strength degrades significantly. As shown in Fig. 4, signal strength varies from -69 dBm to -82 dBm. It is observed that measurement set approaches an average value of -75.25 dBm over the given interval in later set of measurement. In general, indoor environment is characterized by various salient features. These include radiation fields generated by different electronic devices in the indoor environment. Movement of the human being may also cause fluctuations in the received signal strength at the user end. Metallic objects inside the buildings are also a cause of signal reflection and scattering. Interestingly, transmitter and receiver in indoor environment utilizing WLANS are relatively closer to each other. This causes significant delay spread. The fluctuations observed in our experimental results may be attributed to the varying orientation of the

obstructions in the path between transmitter and receiver in general and obstacles near the antenna in particular.

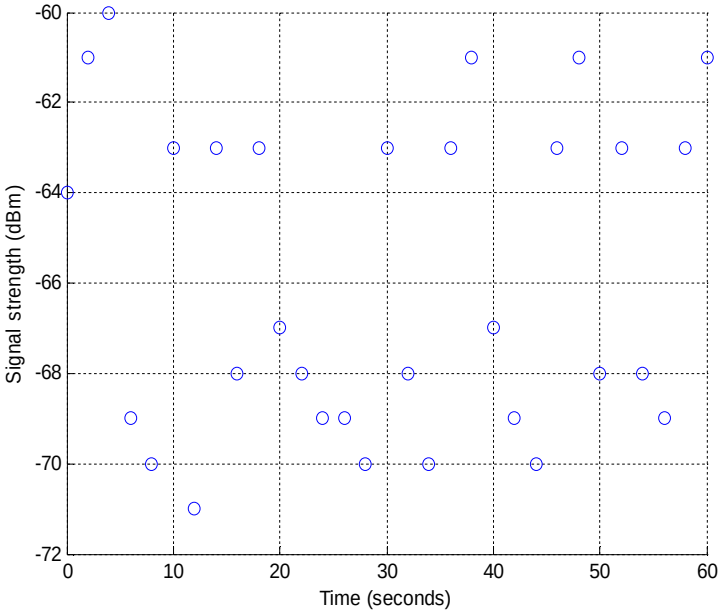

Fig. 1: Scatter plot of signal strength over 60 seconds.

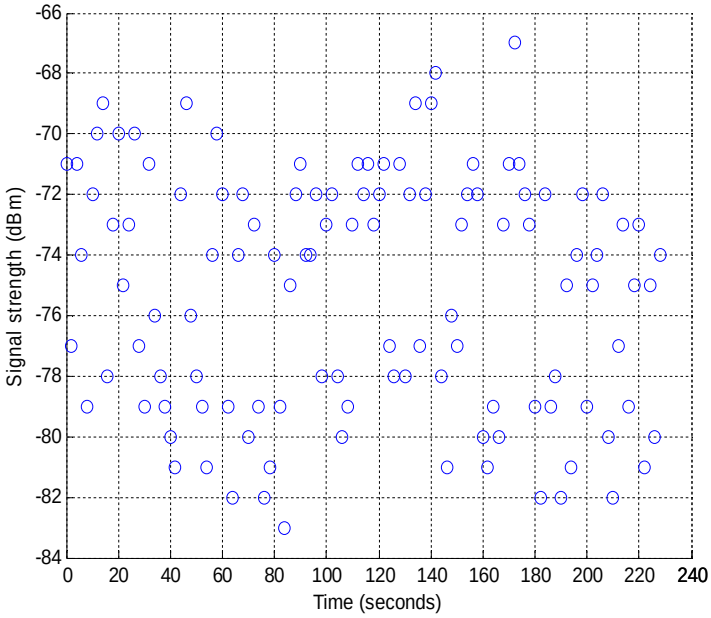

Fig. 3: Scatter plot of signal strength over 240 seconds.

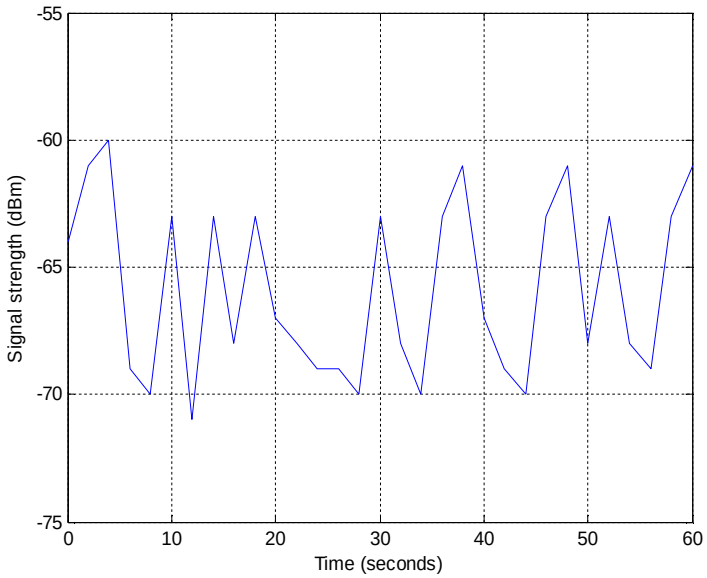

Fig. 2: Temporal variation over 60 seconds.

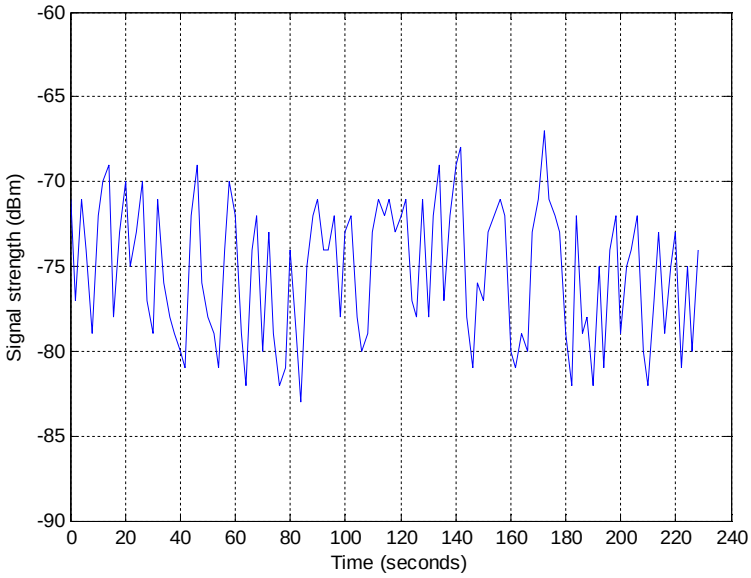

Fig. 4: Temporal variation over 240 seconds.

4. Conclusion

We have presented results on the received signal strength measured at the user end for a given access point in wireless local area network. Results were measured and analyzed in time domain. It is shown that for an interval of 30 seconds, variation is on the order of 3.5 dBm in terms of standard deviation. Temporal variation is increased to

4.0 dBm for 240 seconds observation interval. Measurement results and their analysis show that there are significant variation of received signal strength in time domain and hence it is difficult to achieve the network access performance consistently with acceptable quality. It is further observed that hardware obstructions including concrete walls and wooden doors cause significant drop in the received signal strength and hence resultant throughput at the host site may not be satisfactory. The analysis indicates that in order to get reasonable data transfer speed in the given representative environment, access point with increased transmitter power may be deployed. It is worth to mention here that using higher transmission power may cause more interference for other channels and networks. Adaptive transmission power control may optimize the performance. In order to make real life assessment of the WLAN performance, such experimental study plays an important role for planning, designing and implementing an access network.

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