OPTIMIZATION OF WIRELESS PATHLOSS MODEL JTC FOR ACCESS POINT PLACEMENT IN WIRELESS LOCAL AREA NETWORK

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ABSTRACT

Determining the optimal placement of access points (APs) and assigning of channels to them are two of the major challenges faced by WLAN designers. WLAN services in the outdoor as well as indoor environments should be designed order in to achieve the maximum coverage and throughput. To provide the maximum coverage for WLAN service areas, APs should be installed such that the sum of signal measured at each traffic demand point is maximized. Also it is very important to know the optimum numbers of access points (APs) in order to provide an optimized design. This work provides a fundamental of understanding of the issues related to positioning indoor wireless access points while improving indoor coverage. The different path loss propagation models were compared with measured field data. For comparative analysis the log distance path loss model and JTC model were used along with the field measured data since they are suitable for indoor environment. Data was analyzed in MATLAB simulation environment. Modified JTC path loss model was proposed according to the experimental data. Using the modified path loss model the WLAN design can be optimized for any given condition easily.

***Key words*:** Access points, WLAN, optimized design, propagation path loss models, JTC model

1. INTRODUCTION

Wireless communication systems become more and more popular in recent days since it has a higher scalability, mobility and it eliminates the wiring configurations. Wireless networks promote the spirit of sharing bandwidth. In the developing world where bandwidth is mostly expensive, wireless networking makes it easy for groups to buy bandwidth and share in one wireless network. Wireless Local Area Networks (WLAN) are typically used in offices, campus environments, shopping malls. Wireless performance and reliability can vary hugely depending on particular environment, and can change constantly. Hence planning of WLAN infrastructures that covers large buildings or areas requires consideration of many aspects such as coverage, different traffic densities, interference, and cost minimization. Wireless networks often fail to meet users' expectations, exhibiting unsatisfactory performance, either because they are not set up correctly or not optimized for maximum throughput.

The objective of this work is to perform a detailed study of the wireless network on selected area and predict the path loss using the suitable path loss model. The selected area had been selected by considering the customer requirements, while reducing the number of access points.

The rest of this paper is organized as follows. Section 2 provides a brief summary about existing path loss models and model selection for selected area. Section 3 analyses about the measured data and Section 4 discusses about the proposed model with the justification.

2. PATH LOSS MODELS

Path loss models (Propagation models) are used extensively in network planning, particularly for conducting feasibility studies and during initial deployment. They are also very useful for performing interference studies as the deployment proceeds. Some existing path loss models are Free space propagation model, Log distance path loss mode, Stanford university interim (SUI) model, Okumura's model, Hata model, and Cost 231-Hata model [1-2].

Although several path loss models have been introduced by different people, most of them are only applicable for outdoor propagation. Since our experimental area is an indoor environment, we have to use path loss models which are suitable for an indoor environment. The indoor propagation depends heavily on factors which include building structure, layout of rooms, and the type of construction materials used [3].

To achieve more accurate result and to represent more realistic indoor propagation model, the surrounding environment has to be considered. Walls, floors, partitions are made up of materials that reflect the electromagnetic signal. As a result, the measured signal strength will be less than that predicted by the log-distance path loss model. There are three factors affecting the propagation, which play much more serious role in deciding indoor coverage footprint than in an outdoor environment. These are shadowing, wall attenuation factor and floor attenuation. Another most important thing is the frequency band employed. The model must be compatible with the frequency band used. When considering all these constraints, JTC (Joint technical committee) indoor model is the suitable path loss model for our lab environment. Therefore we used JTC indoor model as the basic path loss model for our testing.

2.1. JTC Indoor Path Loss Model

The JTC (Joint Technical Committee) Indoor Path Loss model is the official path loss model for office environments presented by the International Organization for Standardization (ISO). This model has traits from the Okumura-Hata model and the Log-distance Path Loss model [1]. The JTC Indoor Path Loss model can be represented as in eq.(01).

$$L_{Total} = A + B\log_{10}(d) + L_f(n) + X_\sigma \qquad (01)$$

Where A is the environment dependent fixed loss factor in dB, B is the distance dependent loss coefficient, d is the distance between the transmitter and receiver in m, Lf(n) is a floor/wall penetration loss factor in dB, n is the number of floors/walls between the transmitter and receiver, and Xσ is a normal (Gaussian) random variable in dB that has zero mean and standard deviation of σ dB (log normal shadowing). Table 1 contains the corresponding variables dependent on the type of environment [1].

Table 1: Variation of parameters according to the environment

Environment	Residential	Office	Commercial
A (dB)	38	38	38
B	28	30	22
L(f) (dB)	4n	15+4 (n-1)	6+3(n-1)
Log Normal Shadowing Std.Dev.(dB)	8	10	10

3. DATA COLLECTION

Optimization of wireless access point placement was conducted in the Department of Electrical and Electronic Engineering, Faculty of Engineering, University of Peradeniya. The Department of Electrical and Electronic Engineering (DEEE) has two buildings. Figure 1 shows the experiment conducted area and the location of WLAN APs. Two access points are located in 1st floor and 2nd floor of the new building.

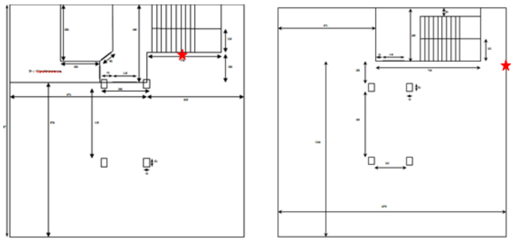

Figure 1: Location of DEEE AP in old building and WLAN APs EDISIL and ELECTRONICS LAB in new building

The APs were identified with the names of ELECTRONICS_LAB and EDISIL. The routers of two APs are same model. An open source or freely available software **Metageek InSSIDer [5]** was used to test the functionality of the WLAN APs and analyze the coverage in the area of interest. This Wi-Fi scanning software uses the native Wi-Fi API and the current Wireless network card, while it sorts the results by MAC Address, SSID, Channel, RSS and "Time Last Seen" [1], [4], [5].

3.1 Measurement Results

For each receiver located in 3rd, 2nd and 1st floors, the Transmitter-Receiver (T-R) separation and average signal strength were measured.

Figure 2 shows the path loss variation in new building of DEEE according to the measured values for Electonics_Lab AP which is located in second floor.

In Figure 2 red graph shows the measured data and blue graph shows the JTC model data

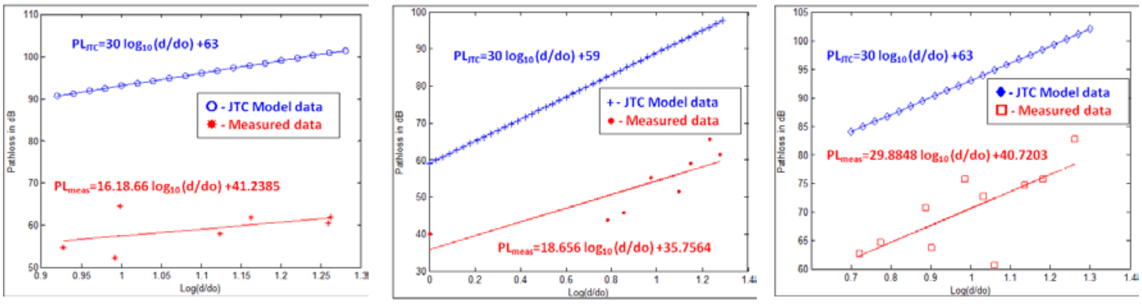

Figure 2: Pathloss variation according to the measured and JTC data for 3rd, 2nd and 1st floors

4. MODIFIED PATH LOSS MODEL

4.1. Modification of JTC Model

The JTC model provides a better approximation, of the measured data, compared to any other indoor model. The JTC model can be mathematically represented as shown in eq (02). For the selected environment the parameters of the equation should be tuned. The proposed equation is given as eq (03),

$$L_{total} = A + B * \log_{10}\left(\frac{d}{d_0}\right) + Lf(n) + B * \log_{10}(d_0) \quad (02)$$

$$L_{total} = \alpha A + \beta B * \log_{10}\left(\frac{d}{d_0}\right) + Lf(n) + \beta B * \log_{10}(d_0) \quad (03)$$

From Table 1, A=38 & B=30 were selected for the initial calculation, which is plotted in color blue in Fig 2. Then by analyzing the offset between the calculated values and the measured values (marked in blue) in Fig 2, the offset of parameters A and B of eq (02) is eliminated. These eliminated offset is indicated in eq (03) as **α** and **β**. Calculated data of Electronics_Lab AP for each case are shown in Table 2 and 3,

Table 2: Values of parameter in existing JTC model

Location	A	B	n	Lf(n)	B*lg(d/do)
1st Floor	38	30	1	15	0
2nd Floor	38	30	0	11	0
3rd Floor	38	30	1	15	0

Table 3: Values of parameter in modified JTC model

Location	α	A'	β	B'	B*lg(d/do)
1st Floor	0.415	15.72	0.996	29.88	0
2nd Floor	0.388	14.76	0.622	18.66	0
3rd Floor	0.427	16.24	0.539	16.19	0

Here $A' = \alpha * A$ & $B' = \beta * B$

Then by considering each floor average values of **α** and **β** calculated for each access points. New corrected values of Electronics_lab AP is shown in Table 4,

Table 4: Average corrected values of parameters of modified JTC Model for our the selected environment

α	β	A'	B'	Lf(n)
0.41	0.719	15.57	21.58	13.67

The fine tuned path loss model equation of Electronics_Lab access points is Department of Electrical and Electronics Engineering is given in eq (04),

$$L_{total} = 0.41*A + 0.719*B*\log_{10}(d/do) + Lf(n) + X_\sigma + 0.719*B*\log_{10}(d/do) \quad (04)$$

5. Verification of the parameters α and β

The calculated average parameter values were applied to the EDISIL access point and verified the behavior in the environment (1st floor) where the router is located. Figure 3 shows the comparison between measured and modified data for EDISIL AP.

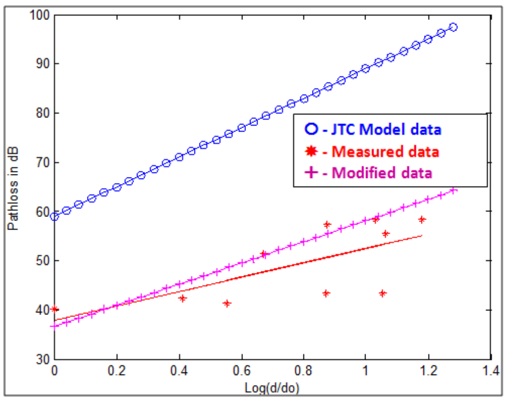

Figure 3: Comparison of measured and modified data of EDISIL access point

According to the Figure 3, it can be concluded that the new fine tuned JTC model predicts the propagation loss of EDISIL router more accurately than original JTC model.

6. CONCLUSION

In this paper we discussed about the different path loss models and the model which is suitable to the selected environment for optimizing the placement of Access points. Using the simulation results we modified the existing path loss model of JTC according to the area and APs. The derived new model is tested with new data set and it has provided accurate modeling of the path loss. Hence, it was concluded that for effective planning of WLAN network, it is advisable to use fine tuned path loss propagation models rather than the original model itself.

7. REFERENCES

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