INTRODUCTION

Wireless network technology became familiar as main communication infrastructure today. Wireless Fidelity technology or better known as Wi-Fi technology, offers various forms of convenience and high flexibility in communicating (Titahningsih et al., 2018). Wi-Fi is a communication technology that uses radio waves as a transmission medium, which the most widely used is Wireless Local Area Network (WLAN). WLAN is a type of LAN network which is built as an extension of wireless communication technology that provides all the features of a wired LAN network (Meng et al., 2012).

The easiness of installation and usage of WLAN networks made these networks are often built without considering propagation aspects, such as infrastructure or building architecture (Mukti, 2019). Propagation can be defined as the process of radio waves spreading from transmitter to receiver. Predicting the propagation of radio waves has always been a difficult task, because it is influenced by many environmental factors. In addition, the signals from transmitter often reach the users' devices after going through many paths, thus increasing the complexity of propagation predictions (Zrno et al., 2004).

A study was conducted to determine the characteristics of indoor propagation using a mathematical approach and measurement data. Both approaches were used to make comparisons and obtain pathloss coefficient that applies to WLAN networks at 2.4GHz. The pathloss value prediction model is basically an empirical mathematical formulation to determine the characteristics of radio wave propagation. These model usually developed to predict the behavior of the propagated signal in various places and environments. There are three mathematical approach model has been done through this research, namely log-distance model, ITU pathloss model, and AFC model. Different propagation models are presented to predict the effects of partition walls, number of floors and building layout. This study is conducted in two separate buildings. Comparison between the measurement results and the predicted pathloss value is shown. The prediction results obtained are relatively suitable with the building structure/layout (Jadhavar & Sontakke, 2012).

Institut Asia Malang is an educational institution that deploys WLAN technology for its wireless network. With the four-story vertical building architecture, most of the wireless network devices used in this campus building are located in a closed area (indoor). Based on the results of site survey measurements that have been carried out in previous research (Mukti & Sulistyo, 2018), most of the signal strength values received by users at several measurement points were in the range of -95dBm to -76dBm, which belong to the poor signal category (percentage of signal strength of 0-39%) (Sirait, 2017). This occurs because the installation of wireless network devices, which is Access Point (AP), is carried out without considering propagation for the indoor network, resulted in uneven signal distribution.

AP placement is one of the main keys to providing even coverage in the desired area (Mukti & Junikhah, 2019; Puspitasari & Pulungan, 2015). There is different signal propagation between indoor area and outdoor area, especially in terms of distance and variability in the environment around the device. Indoor areas allow multipath

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Access Point Placement Recommendation Using Cost-231 Multiwall Propagation (Case Study: Malang Institute Of Asia)

Rekomendasi Titik Penempatan Access Point Menggunakan Propagasi Cost-231 Multiwall (Studi Kasus: Institut Asia Malang)

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Abstract

This study provides an overview of signal distribution pattern using Cost-231 Multi-Wall (MWM) propagation model. The signal distribution pattern is used as a reference in projecting indoor Access Points (AP) placement in Malang Institute of Asia. The MWM approach estimates the actual radio wave propagation value for measurements are made by considering obstacles between APs and user devices. The study recommends 10 optimal points of AP placement for the 1st, 3rd and 4th-floors, and 7 optimal points for the 2nd-floor. Determination of these placement points was based on the estimated signal strength obtained by users, at -50dBM up to - 10dBm, which is the range for good and excellent signal category.

Keywords: prediction, access point, propagation, indoor, Cost-231 Multi Wall,.

propagation due to reflection, diffraction, signal scattering, signal distortion, and even fading or signal loss (Zvanovec et al., 2003). Therefore, it is necessary to calculate propagation that takes into account the environment around the device (Mukti, 2019).

This study aims to calculate AP signal distribution using the Cost-231 Multi-Wall Model (MWM) propagation model. The calculation process will involve interference from objects around the device, such as walls, glass, tiled floors, wooden doors, and others. The results of this calculation will be used to provide recommendations in AP placement for indoor area of Institut Asia Malang.

COST-231 Multi Wall Model

This modeling provides better accuracy than the One Slope Model. The model also provides specific results because it uses a description of the surrounding environment as the input variable. The main idea of the MWM model is illustrated in Figure 1 (Zvanovec et al., 2003). The Pathloss value between TX and RX (LMW) is calculated using equation 1 (Mukti, 2019).

$$L_{MW} = L_{FSL}(d) + \sum(N, i = 1)\ k_{wi} L_{wi} + k_f L_f \qquad (1)$$

Keterangan:

L_{MW} = nilai *pathloss* yang dihasilkan MWM (dBm)

L_{FSL} = free space loss on distance d (dB)

k_{wi} = number of type i walls

L_{wi}= attenuation value of type i walls (dB)

N = number of wall types

k_f = number of floors (dB)

L_f = number of floor attenuation (dB)

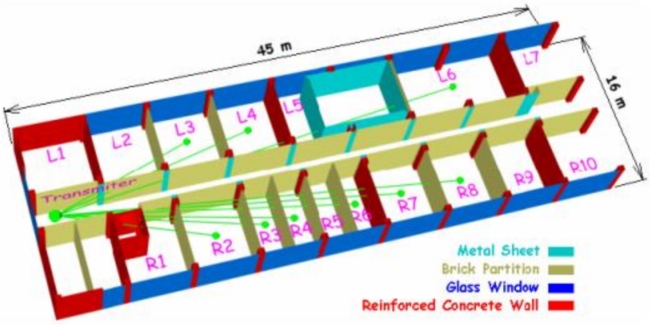


Figure 1. Multi-Wall Model Geometry
Source: (Zvanovec et al., 2003)

In order to obtain a good prediction accuracy, it is important to pay attention to the empirical parameters of the right wall attenuation factor. The attenuation factor in Equation (1) does not represent the actual physical attenuation value, but is a statistical value obtained from representative calculations in previous studies (Zvanovec et al., 2003).

In MWM modelling, two types of walls are considered: light walls (L1) - thin walls or partitions, and heavy walls (L2) - thick structured walls (Zvanovec et al., 2003). Other interior empirical parameters of this modelling are defined in Table 2 (Akin et al., 2002) and Table 3 (Mukti, 2019).

Table 1. Radio Frequency (RF) Attenuation Value for Indoor Areas

No.	Parameter	Attenuation value
1.	Foundation wall	15dB
2.	Brick, concrete, concrete block	12dB
3.	Elevator or metal particle	10dB
4.	Metal shelf	6dB
5.	Drywall or sheetrock	3dB
6.	Glass window	3dB
7.	Wooden door	3dB
8.	Cubicle wall	2dB
9.	Ceramic floor	13.2dB

Table 2. Signal Attenuation Value on 2.4GHz

No.	Parameter	Attenuation value
1.	Brick wall windows	2dB
2.	Metal glass wall frame	6dB
3.	Office walls	6dB
4.	Office wall metal doors	6dB
5.	Cinder block wall	4dB
6.	Metal door on brick wall	12.4dB
7.	Brick wall next to metal door	3dB

Free Space Loss (FSL)

Free Space Loss (FSL) is the attenuation value of the RF signal energy transmitted, along the distance traveled to the receiver antenna. The amount of FSL can be calculated using equation 2 (Amanaf et al., 2018).

$$L_{FSL}(d) = 32{,}44 + 20 \log (d) + 20 \log (f) \quad (2)$$

where:

L_{FSL} = free space loss on distance d (dB)

d = distance between TX and RX (m)

f = frequency of the antenna (MHz)

Received Signal Strength Indication (RSSI)

To predict the efficient placement of APs, it is necessary to carry out a series of calculations that aim to measure the estimated signal strength level received by users, which is called Received Signal Strength Indication (RSSI). The RSSI value is obtained from equation 3 below (Angela, 2010).

$$RSSI = EIRP - F_{SL} + G_R - L_{MW} \quad (3)$$

where:

$RSSI$ = signal strength received by users (dB)

$EIRP$ = access point power output (dBm)

L_{FSL} = free space loss on distance *d* (dB)

G_R = gain of receiver antenna (dBm)

L_{MW} = MWM pathloss value

Effective Isotropic Radiated Power (EIRP)

Effective Isotropic Radiated Power (EIRP) is the level of output power emitted by the transmitter antenna (AP). To calculate the EIRP value, the following equation 4 is used (Sirait, 2017).

$$EIRP = P_T + G_R - L_{MW} \quad (4)$$

where:

$EIRP$ = total power emitted by AP (dBm)

P_T = device transmitting power (dBm)

G_R = receiver antenna *gain* (dBm)

L_{MW} = MWM calculation pathloss value

METHODOLOGY

This study is conducted based on the results of site survey measurements that have been carried out in a previous research (Mukti & Sulistyo, 2018). The study is conducted in Institut Asia Malang, which consists of 4 floors. Figure 2 shows the distribution plan of AP placement prediction on 1st floor, along with the types of obstacles around the device. It can be seen that there are 12 measurement points of AP distribution in both outdoor and indoor areas.

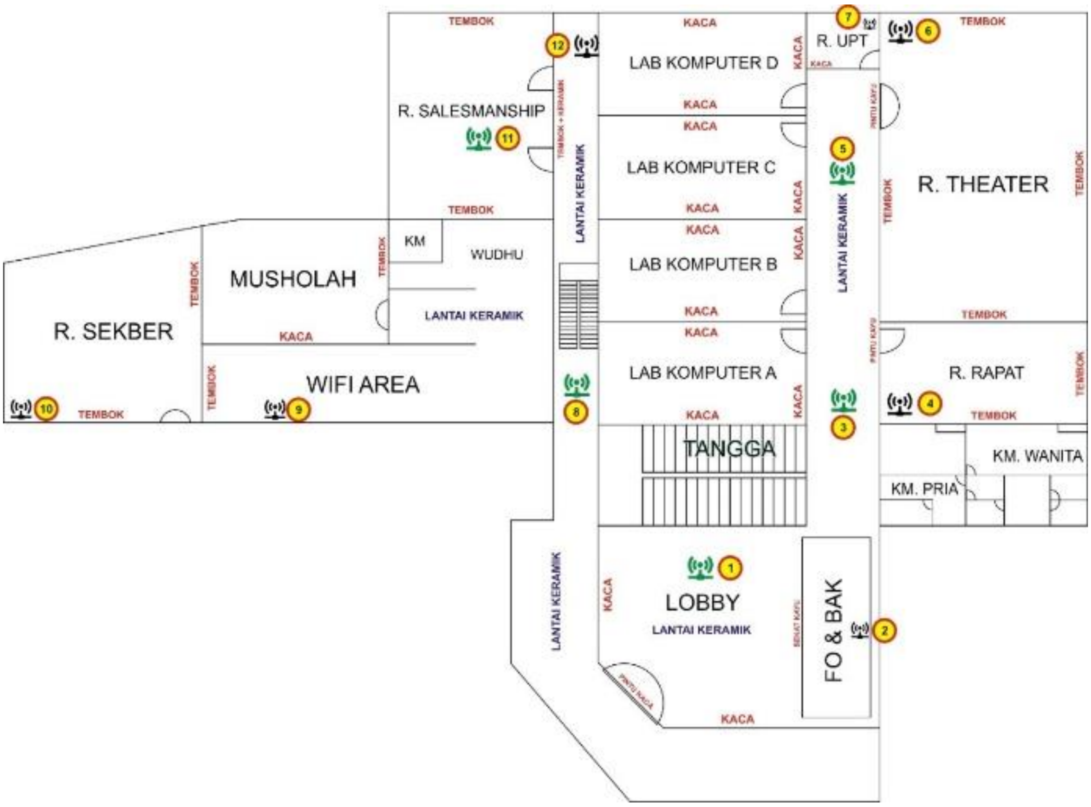


Figure 2. The 1st Floorplan with Obstacles Description
Source: (Mukti, 2019)

Site survey measurements are carried out repeatedly using the regression method (Puspitasari & Pulungan, 2015), which utilizes the the inSSIDER software to measure the signal strength obtained at each measurement point. Table 3 shows the specification of APs installed on each floor of the building, for which the propagation system will be measured in this study.

Table 3. The Access Point Specification

No.	Parameter (Unifi AP Long-Range)	Value
1.	Operating Band	2.4 GHz
2.	Gain Antenna	3 dBi
3.	Maximum TX Power	27 dBm
4.	Line loss	0,5 dB
5.	Fading margin WLAN	10 dB

Prior to the walktest, coordinates of AP and receiver positions are are determined. This determination is based on 2 types of propagation paths, namely the Line of Sight (LOS) path and the Non Line of Sight (NLOS) path (Kirana et al., 2010). From these two types of paths, 23-28 measurement points were taken on each floor, in order to gain a sample confidence level as close as possible to 90% (Angela, 2010).

Furthermore, the results of the walktest (in the form of the average signal strength value) will be evaluated using MWM propagation modeling. The calculation process from equation 1 to equation 4 uses the same empirical parameters and the same measuring points, to obtain the right measurement accuracy. Some of the parameters used for calculations in equation 1 to 4 are as follows:

a. f = *2.4 GHz*, is the frequency of the WLAN device used
b. P_T = *27dBm*, is the transmitting power measured (UniFi AP Long-Range)

c. $G_R = 0dBi$, is the gain of the antenna device used to measure (Netbook ASUS X201EP) using insider software.

Table 4. The Signal Strength Category

Category	Range	Percentage
Excellent	-57 to -10dBm	75 – 100%
Good	-75 to -58dBm	40 – 74%
Fair	-85 to -76dBm	20 – 39%
Poor	-95 to -86dBm	0 – 19%

The testing process is carried out by placing the AP points randomly and calculating the propagation by LOS and NLOS. The application of MWM propagation modeling to provide an overview of the signal distribution pattern aims to obtain a maximum prediction of the AP placement, with an estimated RSSI value of -50dBM to -10dBm, with a good—excellent signal strength category, as the standard signal category listed in Table 4 (Mukti & Sulistyo, 2018).

The research procedure is outlined through the flow chart shown in Figure 3 below.

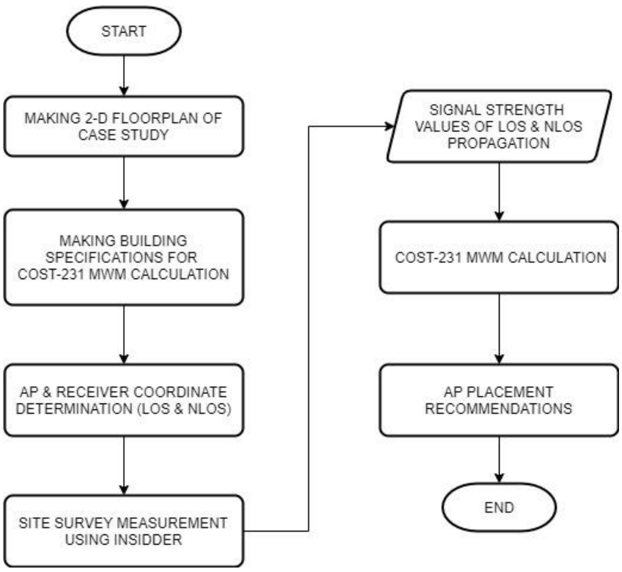


Figure 3. Research Procedure Flowchart

RESULTS AND DISCUSSION

The access point at Institut Asia Malang deploy omni-directional antenna type, which provides radiation in all directions with equal power (antenna gain of 3dBi). The analysis is carried out on each floor, with different number and distribution of access point placement, following the structure of the building. For the 1st floor, it has a building structure that leads to more free space. Meanwhile, floors 2, 3 and 4 have a more closed building interior because they are divided into classrooms and corridors.

Access Point Placement Prediction

To estimate the user's signal strength within the area around the AP placement at point 1 (lobby area), identification of obstacles around the device is made. As shown in Figure 2, it there are several obstacles in the form of glass, glass doors, wood dividers and ceramic floors. Each obstacle has a different attenuation value, as shown in Table 2 and Table 3. After identifying the types of obstacle and their attenuation value, the MWM pathloss is calculated using equation 1 and equation 2. The pathloss value is used as a parameter to calculate the EIRP value at each AP placement point.

Table 5. EIRP Calculation for First Floor

AP point	Obstacle		EIRP
	type	Attenuation	
1	ceramic floor	13.2dB	4.8dBm
	glass	3dB	
	glass doors	6dB	
	wood partition	3dB	
2	wall	6dB	12dB
	wooden cupboard	3dB	
	glass window	3dB	
3	wooden door	3dB	1.8dBm
	glass	3dB	
	ceramic floor	13.2dB	
	wooden partition	3dB	
4	wooden door	3dB	1.8dBm

AP point	*Obstacle* type	*Obstacle* Attenuation	EIRP
	wall	6dB	
	glass table	6dB	
	ceramic floor	13.2dB	
	ceramic floor	13.2dB	
	glass	3dB	
5	metal frame	6dB	-1.2dBm
	wooden door	3dB	
	wall	6dB	

We can see at Table 5 the EIRP calculation for each building structure. Based on the propagation theory for a closed room (Meng et al., 2012; Sirait, 2017; and Puspitasari & Pulungan, 2015), the best signal emission is in LOS propagation, because between there is no barrier particles between users and device. The LOS area for First Floor is located in the corridor area of the building, namely in the area around AP points 1, 3, 5, 8, 9, and 12. While other points are inside rooms, the best signal coverage is only the indoor area, so that the outdoor area is considered as the NLOS area where maximum signal cannot be captured.

Based on the results of the RSSI calculation above, the RSSI value is taken with a vulnerable value of -58dBm to -10dBm in LOS propagation. This RSSI value range is the coverage area with Excellent and Good signal standards (based on the signal performance standards in Table 5). Thus, the selected AP placement point for Floor 1 is at point 1 - point 10.

Similar process is carried out to find the best signal distribution pattern based on the AP placement points that have been assigned to the network on the 2nd, 3rd and 4th floors. With the building structure and different types of obstacles on each floor, it was found that there are 7 optimal AP placement points on the 2nd floor, 10 optimal AP placement points on the 3rd floor, and 9 optimal AP placement points on the 4th floor. The optimal AP placement points on the 2nd floor include point no.1—point no.7; and 3rd and 4th floors include point 1—point 10.

Signal Pattern Comparation

Empirical calculation using MWM to determine the RSSI is used to map the signal distribution patterns on the indoor WLAN network in Institut Asia Malang. The results of the calculation is then compared with the results in previous study (Mukti & Sulistyo, 2018) which used site survey measurement results (real values on the field) and the results of signal distribution pattern analysis using the One Slope Model propagation model.

Comparison of the results of this propagation calculation is carried out by using the same AP placement points for each floor of the building, in order to obtain the validity of the analysis. The AP placement points being compared are the AP deployment points currently used by network administrators within the campus building environment.

For the 1st floor, we used point 12 as the AP placement point (see Figure 3). The following graph shows the power level values received by user in the LOS and NLOS propagation path areas in the area around the AP point.

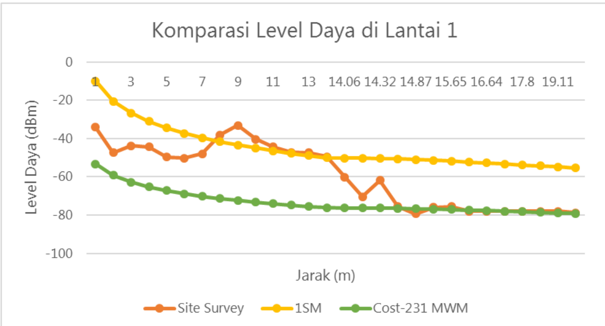


Figure 3. 1st Floor Power Level Comparation

Furthermore, for the 2nd floor, only 1 AP placement point used by the administrator. With the building structure in the form of a corridor and is more closed than the 1st floor, the comparative results of the signal distribution pattern are as shown in Figure 4 below.

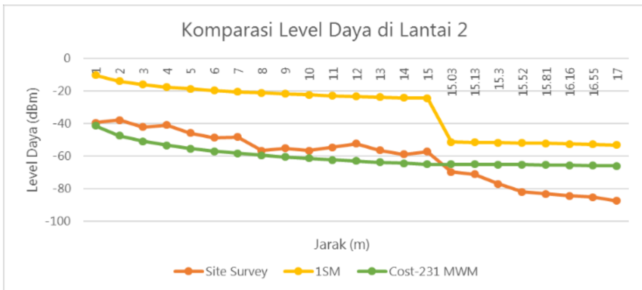


Figure 4. 2nd Floor Power Level Comparation

The 3rd floor is the most used by campus community, because almost all lectures and lecturer activities are carried out in this area. There are 2 AP placement points in this area, one in the lecturer room and another in the middle of the floor corridor. The structure of the building on the 3rd floor is similar to the structure on the 2nd floor, except that it covers a larger area. Figure 5 shows the comparative results of the signal distribution pattern on the 3rd floor, for the AP placement point at No.5.

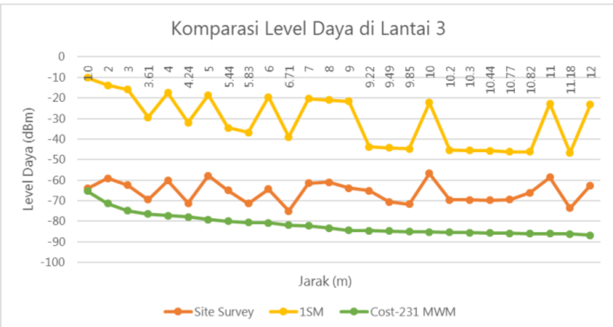
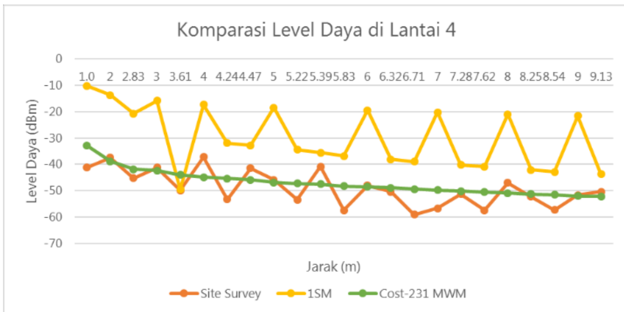


Figure 5. 3rd Floor Power Level Comparation

The same process is again carried out on the 4th floor of campus building area. AP equipment is placed in the middle of the corridor. In this area, there are 4 classes which are separated by plywood partition, which have a significant impact on the signal distribution pattern. Figure 6 shows the results of the comparison of the signal distribution pattern on the 4th floor.



Gambar 6. 4th Floor Power Level Comparation

Observing the comparison results on each level on figures 3 to 6, it is clear that the RSSI value generated through the MWM calculation is almost similar or close to the site survey measurement values. This proves that the Cost-231 Multi-Wall propagation modeling can be used as an approach in predicting signal distribution patterns for WLAN networks in closed areas. Obstacles around the device has a significant effect on the distribution of the signal, so it is very important to pay attention to the placement of the AP.

CONCLUSION

This study utilizes the empirical calculation theory Cost-231 Multi-Wall to predict the signal distribution pattern in the indoor area of the Institut Asia Malang. This signal distribution pattern is intended to determine AP devices placement points by considering the presence of obstacles between the AP and the user.

Signal strength analysis is performed on the LOS and NLOS propagation paths. The results showed that there were 10 optimal points for AP placement on 1st , 3rd and 4th floors, while for the 2nd floor there were 7 points for AP placement. That points were chosen because it have a signal strength susceptibility of -58dBm to -10dBm in LOS propagation.

The Cost-231 Multi-Wall approach provides an estimation of the true propagation value of radio waves, this is evidenced by the comparison of the signal distribution patterns in the site survey measurements. The measurement results prove that obstacles have a significant impact on the signal strength received by users.

The Cost-231 Multi-Wall propagation modeling can be used as a reference for the network administrators of the Institut Asia Malang to predict the location of the AP placement in order to obtain maximum signal coverage area. This propagation modeling can be developed in the form of a desktop or android based application program, which has the ability to measure and predict signal distribution patterns in real time.

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