Wi-Fi Access Point’s Analysis in Electrical Engineering Department, Padang State University

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Abstract. UNP has facilitated an internet wifi network to support the needs of campus citizen including the electrical engineering department which is connected through several hotspots. However, the network signal strength is unstable and uneven to serve all community members. In some places, the level signal captured by end device is very weak. This certainly affects the internet access speed used by the user. So, it’s necessary to plan the needs of the access point (AP) device both in terms of coverage and capacity. We need to estimate users & the area model. The propagation used is COST 231 multiwall which is used to describe characteristics that have many barriers. By using 2.4GHz frequency and predetermined parameters, to cover all blocks of electrical engineering, in term of coverage quite needed 1 AP but in term of the capacity, it’s needed 6 AP, with the RSL value below Receiver threshold.

1. Introduction
Today's technological developments are sure to change human lifestyles. The application of internet-based information technology is one of the keys. From the process of sending letters, exchanging information, buying and selling transactions & administrative payments, to socializing are done with utmost ease. In campus life, this changes could be seen in the learning process that no longer makes printed books the main media, learning processes and media that no longer require face-to-face but can also be internet-based.

Realizing the importance of an internet connection for the campus community, UNP has provided internet services by installing hotspots that can be accessed in all campus areas, including those in the electrical engineering department. However, unfortunately the network signal strength is deemed unstable and uneven to serve all members of the community, especially students. In fact, in some places it was found that the device was not getting a signal or better known as a blankspot. Constraints like the above are common in wireless technology, including wi-fi. The use of wireless wifi has several shortcomings, one of which is the NLOS (Non Line of Sight) condition, which is a condition where there is a barrier between the transmitter and receiver so that the level of the signal received is not the same as the signal sent [1]. These barriers can be buildings / walls, trees, doors and other objects that make attenuation and reduce signal quality. In addition, another obstacle is the position of the installation of access points that is not optimal, both in terms of number and position of installation. For that we need analysis and calculation of positioning theory before the tool is implemented in the field. The importance of planning, calculating and placing a good access point position will optimize coverage
thus saving time and costs. Regulations for access points by providing certain conditions can also be made so that signal buildup in one area and blankspot conditions in other areas can be avoided. Network installation without considering the theoretical aspects of wireless networks will cause problems that can reduce the effectiveness of a Wi-Fi network. Based on the description above, the problems that arise in this study are: How many access points are needed to cover the needs of lecturers and students of the Department of Electrical Engineering UNP, both in terms of coverage and capacity.

2. Wi-Fi
Wi-fi (wireless fidelity) is a medium for conducting data communication without cables that have a high transfer rate capability that follows the IEEE 802.11 standard. Wifi works at a frequency of 2.4GHz with a data rate of up to 100Mb / s [2]. The term Wi-fi was coined by an organization that tests and certifies WLAN devices called the Wi-Fi alliance. There are several series that refer to the 802.11 standard, which can be seen in table 1.

Today almost all communications are carried out wirelessly. Using wifi tends to be cheaper and more practical. Users only need to connect to the network without the need to use a LAN cable like wired technology so that users can move places. With its reliability in performance and security, wifi is the choice in today's networks. Currently, only the main and backhaul networks use wired. Behind all the advantages it has, Wi-Fi networks certainly still have weaknesses, including large delay, high propagation attenuation, easy interference and so on. [3]

| Specification | speed | Band    |
|---------------|-------|---------|
| 802.11b       | 11 Mbps | 2.4 GHz |
| 802.11a       | 54 Mbps | 5 GHz   |
| 802.11g       | 54 Mbps | 2.4 GHz |
| 802.11n       | 100 Mbps | 2.4 GHz |

2.1. Access Point
An Access Point or Access Point (AP) is a device in a transmission network consisting of a transceiver that functions to send and receive signals from remote clients.

2.2 Propagation
2.2.1. Line of Sight (LOS). The LOS path is a condition where the transmitter and receiver are in a straight line and there are no obstacles between them. The value of propagation loss under LOS conditions can be calculated by the following equation:

\[ FSL = -10 \log \left( \frac{\lambda}{4 \pi d} \right)^2 \]

Where:
- FSL = free space loss (dB)
- \( \lambda \) = wavelength (m)
- \( f \) = frequency (Hz)
- \( d \) = distance between transmitter and receiver (m)

2.2.2. Non Line of Sight (NLOS). The NLOS path is a track condition where there is a signal barrier (in the form of trees, walls, buildings, doors, etc.) between the transmitter and the receiver, in this case the user device which results in the signal that reaches the receiver through several multipaths. The multipath signals will experience phase shift and delay which will always change. This is why the signal power level received by the user is not the same as the power level when the signal is transmitted.
2.3 Radio Wave Propagation Mechanism

2.3.1. Reflection (Reflection). Reflection occurs when an electromagnetic wave propagates on the base of an object that has a wavelength greater than the wavelength of the signal from the transmitter.

2.3.2. Refraction (Refraction). Refraction is the process of scattering or deflecting electromagnetic waves. Refraction occurs when waves propagate from one medium to another that has a density difference.

2.3.3. Diffraction. Diffraction occurs when the path of a propagating electromagnetic wave is blocked by an irregular and sharp surface.

2.3.4. Scattering (Scattering). Scattering occurs when the path through which an electromagnetic wave passes contains objects of smaller dimensions compared to wavelengths and with a large number of obstacles per unit.

3. Methods

For system design, the daily bandwidth requirements required by the UNP electrical engineering department are calculated. For this reason, data collection on the number of people (students) in the lecture block area. In addition, it is determined the area (lecture building) which will be covered by the wifi network so that the optimum number of access points needed is obtained. At this stage the propagation attenuation that occurs is also calculated by taking into account the signal loss due to barriers in the form of walls and doors that block the transmitter and receiver.

**Figure 1.** Research’s flowchart

This research will be conducted in lecture rooms, laboratories / workshops and lecturer rooms in the
Electrical Engineering Department block, Faculty of Engineering, Padang State University.

3.1. Device parameters
Access point type : Cisco Aironet 3602I AP Access Point
Power transmit : 23dBm
Max data rate : 450 Mbps
Antenna gain : 2 dBi gain, internal omni, 360 ° horizontal beamwidth

3.2. Estimated number of users
If in a lecture session, the maximum number of students in the electrical engineering is estimated block area as follows:

| Class Name                | Capacity |
|---------------------------|----------|
| E67                       | 50       |
| E68                       | 50       |
| E69                       | 50       |
| E61                       | 20       |
| E63A (Computer Lab)       | 20       |
| E63B (Computer Lab)       | 20       |
| Library                   | 20       |
| Lecturer room             | 50       |
| Others                    | 50       |
| **Total**                 | **380 orang** |

Figure 2. Electrical Engineering Area
3.3. Link Budget
The link budget is needed to be able to design the power of a wireless system in such a way. The link budget calculation is used to get the range of a cell based on the Maximum Allowed Path Loss (MAPL) value. MAPL is the calculation of the maximum propagation value allowed from the access point to the user's device.

The signal strength received by the user is shown in dBm units, with a value range of -10 dBm to -99 dBm. The more it shows a positive number, the stronger the signal. The following table shows the signal strength ranges divided into 4 categories based on the Cisco wireless adapter standard [5].

3.4. RSSI (Received Signal Strength Indicator)
One of the values you need to know to calculate network performance is the RSSI of the device, which is the index of the signal strength received by the device interface. a. The RSSI value can increase or decrease depending on the relative distance between devices.

4. Result
4.1. Maximum Allowable Pathloss
The first step is calculate the Effective Isotropic Radiated Power (dBm) value. EIRP is the total energy emitted by the antenna and access point, after calculating the loss value due to the antenna transmission medium.

$$EIRP = T_x + G_T - L_f$$
$$= 23 + 2 - 0$$
$$= 25 \text{ dBm}$$

By the device we get that the receiver sensitivity -76dBm. So, the MAPL value would be:

$$MAPL = EIRP - \text{Margin} - S_{RX}$$
$$= 25 - 10 - (-76)$$
$$= 91 \text{ dBm}$$

4.2. The number of access points in term of coverage COST 231 propagation model

Path loss

$$P_l(d) = P_l(d_0) + 20 \log d + K_T + K_L$$

91 = 40.2 + 20 \log d + 5 + 15

Log d = 1.54

d = 34.67 m

Covered area

Area covered = building area - field area

= 4050 - 810

= 3,240 m^2

N Access point= ((Area)/(Wide Coverage))

= (3,240/3.125)

= 1 AP

From the above calculations, 1 AP in accordance with predetermined parameters is sufficient to cover electrical engineering lecture area.
4.3. The number of access points in term of capacity
The user capacity is 380 people. Potential users are considered to be 50% of the user's capacity, namely 190 people. Estimated concurrent users: 80% of potential users = 144 users.

Bandwidth per user = (Data rate/2)/(user capacity)
= (480 Mbps/2)/380
= 592,105 Kbps = 0.59 Mbps

Access point = \( \frac{BW_{user} \times N_{user} \times \%activity}{efficiency \times rate\_association} \)

Access point = \( \frac{0.59 \times 114 \times 0.37}{0.5 \times 8} \)
= 6 AP

5. Conclusion
From the theoretical calculation, 1 access point is enough to cover the lecture block majoring in electrical engineering. However, this number is not sufficient for the capacity of the existing people. To be able to meet the access needs of the entire community, electrical engineering need 6 access point.

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