Wajanbolic reflection antenna for 4g service in urban and sub-urban areas

Jon Endri¹, Ade Silvia Handayani¹*, Raudatul Jannah¹, and Jefri Al-Kausar¹

¹Telecommunication Engineering, Politeknik Negeri Sriwijaya, Palembang, Indonesia

*Corresponding authors: ade_silvia@polsri.ac.id

Abstract. This paper discusses the wajanbolic reflection antennas on 4G services in urban and sub-urban areas. The antenna uses a reflector from a frying pan with an iron waveguide with its driver a Mobile Wi-Fi (MiFi). Reflector from the antenna is intended to amplify and increase the range of 4G signal coverage, especially in urban areas surrounded by tall buildings and sub-urban areas that have a narrow range of 4G signals. In this research, the strengthening of 4G signal at some point is observed by using WirelessMon software. Increased signal power when using wajanbolic reflection antenna is about 14 dB gain in urban area and 13 dB gain in sub-urban area and increase signal gain within a range of a distance of 1 km. The number of access points in urban area is significant enough where there are 12 new hotspots detected, but neither in sub-urban area.

1. Introduction

The antenna is an interface in the dissemination of information [1]. Wireless communication, or better known as a wireless communication using radio waves as the transmission medium. The development of the antenna followed by the development of wireless networks [2]. Wireless communication is no longer required connecting cable news sources with news wearer so that the communication link is to be more flexible and support the mobility of users. Wireless network, or better known as Wireless Fidelity (Wi-Fi) to optimize its performance can be helped with a Wi-Fi antenna. Wi-Fi antenna serves to increase the distance range and strengthen the wireless network.

Antennas used for wireless network eg directional antennas and an omnidirectional antenna. The directional antenna has a radiation pattern that receives and transmits signals to one direction. While the omnidirectional antenna has a radiation pattern 360° which means the signal radiates in all directions [3]. Examples of directional antennas are can antennas, biquad antenna, double biquad antenna and wajanbolic antenna. Wajanbolic antenna includes the directional antenna which has signal and polarization alignment which is in line with the transmitter antenna [4].

Wajanbolic antenna is a breakthrough in the technology of RT / RW-net with a frequency of 2.4 GHz [5]. With the frequency of the antenna can be said to be legal wajanbolic accordance with the decision of the Minister of Transportation in 2005. Antennas of this type serve to reinforce and extend the signal up to 5 km.

The development of Wi-Fi networks is shown with their wireless devices with 4G services router that acts as a Wi-Fi hotspot that Mi-Fi. Mi-Fi is short for Mobile Wi-Fi [6]. Mi-Fi has the same working principle as it features Wi-Fi hotspot or tethering found on smartphones. However, Mi-Fi devices to share an Internet connection with a more optimal. Mi-Fi devices devoted to work as a Wi-Fi
tathering. Mi-Fi is portable and is supported by using the 4G network. The 4G LTE (Long Term Evolution) network has greater data capacity than previous cellular networks [7].

The coverage of 4G network services is still limited to some areas both urban and sub-urban area. Weak signal due to a communication network base stations away lies with the user's location service. This causes the range to receive the 4G signal is still narrow. To strengthen the 4G signal in the suburb is to install a signal booster antenna that has a high gain. Wajanbolic antenna is the right choice in strengthening the signal is large enough, based on the design of the antenna that has been done [5].

Therefore, the present study was taken, where design and build a reflector antenna using wajanbolic were able to strengthen and increase the distance the signal range of 4G in the urban and sub urban area. This antenna is able to amplify the signal power with up to 14 dB gain and increase signal gain within a range of a distance of 1 km.

2. Wajanbolic antenna

The main tool in transmitting and receiving waves can be referred to as an antenna. Antennas transmit and receive electromagnetic signals. Transmitting antenna will convert electrical signals into electromagnetic signals and then transmitted to the air. While the receiving antenna will change the electromagnetic field into an electrical signal. By definition these antennas, we can conclude that every wireless communication there is a component that can turn the tide of a waveguided into the free space and vice versa, this component is an antenna. The antenna consists of various types in accordance with the design, deployment and gain patterns. In wireless networks, there are several types of antennas are used, among others, omnidirectional antennas, sectoral antennas and directional antennas. Wajanbolic antenna is a directional antenna is an antenna that has a directional radiation pattern radiance [5].

Wajanbolic antenna is included in the type of directional antenna, the antenna that has a radiation beam pattern in the same direction. So, the effectiveness of radio beam in only one direction (Muslim, Much Aziz, 2008). Wajanbolic antenna is the right choice in strengthening the signal is large enough, based on the design of the antenna that has been done. Another example of the directional antenna is an antenna can biquad antenna, brick antenna, antenna biquad and the double biquad antenna.

Wajanbolic antennas are one of the parabolic antennas that have the principle of a large reflector capable of emitting more energy than a smaller reflector. Working principle This antenna is almost like a parabolic antenna that is directed at one point the signal originates. This causes the antenna to receive the signal at the focal point and then can reflect back the signal. The Mi-Fi signal obtained is then fed to laptop devices and other gadgets.

Mobile Wifi or abbreviated with Mi-Fi is a brand that is used to describe the wireless router device that acts as a WiFi hotspot. MiFi acts as a modem as well as the relatively small size and minimalist so that it can be taken anywhere.

As shown in Fig.1, how antennas work wajanbolic. The principle of a Wajanbolic antenna is like any other parabolic antennas. The Wajanbolic antenna consists of 3 main components, namely: Reflector made of wajan, it can use a grid with a minimum diameter of 40cm. The bigger the size of the pan, the better because the more radio frequencies that can be captured. Sensitive parts of the antenna are shaped Tubes containing USB WLAN, as a tube can be used Paralon Pipe and wrap, its length with Aluminum foil. Antenna is connected cable to a computer, it is using a USB cable that is usually provided in a USB WLAN package.
Figure 1. How it works wajanbolic antenna

3. Implementation of Wajanbolic Reflector Antenna

3.1 Reflection Antenna Design Model Wajanbolik

The following figure shows the design of the antenna reflection is wajanbolic which consists of two main parts. Wajanbolic as a reflector and modem drivers EV-DO be placed at the focus point of the pan.

Figure 2. Forms of reflection wajanbolic antenna design

In designing the reflection of wajanbolic antenna, there are some parameters that are needed. :

1. Air wavelength (λ)

\[ \lambda = \frac{c}{f} \]  

Where :
- c = speed of light in air (3xm / s)\(10^8\)
- f = Frequency of use (2400 MHz)
2. Focusing skillet \( f_w \)

\[
f_w = \frac{D_w^2}{16 \times d_w}
\]  

Where:
- \( D_w \) = Diameter reflector
- \( d_w \) = Depth reflector

The gain calculation is done theoretically:

\[
G = 10 \log e + 20 \log f + 20 \log D_w + 20.4
\]  

Where:
- \( e \) = Efficiency skillet (0.4)
- \( f \) = Frequency of use
- \( D_w \) = Diameter reflector

Variable values reflector of wajanbolic antenna design above can be entered into the following table 1.

| No | Variables | Input          | Result        |
|----|-----------|----------------|---------------|
| 1  | The Focus Point | Dw = 38.5 cm  | \( f_w = 9.7\) cm |
|    |            | dw = 9.5 cm   |               |
| 2  | Gain       | f = 2.4 GHz   | Gain = 14 dB  |
|    |            | D = 0.32 m    |               |

As can seen, after the variable values counted using the formula above, we can see the result from the table 1, the value of Focusing Skiller \( f_w \) = 9.7 cm and the value for the Gain = 14 dB.

4. Test method

After doing the manufacture of antennas, the next step is to test the antenna that has been made. Location tests are made on two areas, namely urban areas and suburban area. Selected urban areas are Demang Lebar Daun area (shown in Figure 3), the population density is higher than in the surrounding area. While testing in sub-urban area is in the accreditation form rather mature as in the area of Suka Mulya (Figure 4). Suka Mulya area is a mixed-use or residential area, existing either as part of a city or urban area. In both, these areas carried out two tests with some of the testing points is tested MiFi signal power without using wajanbolic reflector antenna and testing Mi-Fi signal power using the wajanbolic reflector antenna.
5. Test results and analysis

Measurements were taken in the form of power level measurements (Table 2 and Table 3), and measurement of access points (Table 4 and Table 5). Table 2 show in urban area (Demang Lebar Daun), took 3 different times and the the value of Signal Power Level (dBm) in 7 a.m to 10 a.m within distances 50-500m increase to 14 dBm, and distance 1km the signal power level increase to 24 dBm. In 12 p.m to 9 p.m within distance 1km the signal power not detected without antenna, after using the antenna, signal power level detected -87 dBm to -85 dBm.
Table 2. Power level measurement results in urban areas (Demang Lebar Daun).

| Time          | Distance | Without Antenna | Using Antenna |
|---------------|----------|-----------------|---------------|
| 7 a.m. to 10 a.m. | 50m      | -38             | -24           |
| 500m          | -73      | -59             |               |
| 1 Km          | -95      | -71             |               |
| 12 p.m. to 5 p.m. | 50m      | -43             | -29           |
| 500m          | -86      | -74             |               |
| 1 Km          | N / A    |                 | -85           |
| 6 p.m. to 9 p.m. | 50m      | -45             | -33           |
| 500m          | -87      | -74             |               |
Table 3 show in sub urban area (Suka Mulya), took 3 different times and the the value of Signal Power Level (dBm) in 7 a.m to 9 p.m within distances 50m to 1km increased 11 dBm to 14 dBm, and with the same time within distance 1.5km the signal power not detected without antenna, after using the antenna, signal power level detected -93 dBm to -89 dBm.

**Table 3.** Power level measurement results in urban sub region (Suka Mulya).

| Time       | Distance | Without Antenna | Using Antenna | Picture | Picture |
|------------|----------|-----------------|---------------|---------|---------|
| 7 a.m. to 10 a.m. | 50m      | -57             | -44           | ![Picture](image) | ![Picture](image) |
|            | 500m     | -68             | -55           | ![Picture](image) | ![Picture](image) |
|            | 1 Km     | -78             | -66           | ![Picture](image) | ![Picture](image) |
|            | 1.5 Km   | N / A           | -89           | ![Picture](image) | ![Picture](image) |
| 12 p.m. to 3 p.m. | 50m      | -59             | -47           | ![Picture](image) | ![Picture](image) |
|            | 500m     | -70             | -58           | ![Picture](image) | ![Picture](image) |
| Time            | Distance | Access Point Without Antenna | Access Point Using Antenna |
|-----------------|----------|------------------------------|----------------------------|
| 7 a.m to 10 a.m | 50 m     | 4                            | 4                          |
|                 | 500 m    | 4                            | 11                         |
|                 | 1 Km     | 6                            | 13                         |
| 12 p.m to 3 p.m | 50 m     | 4                            | 10                         |
|                 | 500 m    | 4                            | 13                         |
|                 | 1 Km     | 9                            | 13                         |
| 6 p.m to 9 p.m  | 50 m     | 5                            | 10                         |
|                 | 500 m    | 5                            | 13                         |
|                 | 1 Km     | 4                            | 16                         |

**Table 4. Number of access point urban region**
Table 4 show the amount of access points in urban area (Demang Lebar Daun), took 3 different times and the amount of access points detected in 7 a.m to 9 p.m within distances 50m to 1km only 4 to 9 number of access point without using antenna. After using the antenna the amount of access points detected 4 to 16 number of access point, and the high increasing amount of access points happen in 12 p.m to 9 p.m.

**Table 5. Number of Access Point Regional Sub-Urban**

| Time          | Distance | Access Point | Without Antenna | Using Antenna |
|---------------|----------|--------------|-----------------|---------------|
| 7 a.m to 10 a.m | 50 m     | 4            | 4               |
|               | 500 m    | 3            | 4               |
|               | 1 Km     | 3            | 4               |
|               | 1.5 Km   | 4            | 4               |
| 12 p.m to 3 p.m. | 50 m   | 3            | 4               |
|               | 500 m    | 3            | 4               |
|               | 1 Km     | 4            | 4               |
|               | 1.5 Km   | 4            | 4               |
| 6 p.m to 9 p.m. | 50 m | 3            | 4               |
|               | 500 m    | 3            | 4               |
|               | 1 Km     | 4            | 4               |
|               | 1.5 Km   | 4            | 4               |

Table 5 show the amount of access points in sub urban region (Suka Mulya), took 3 different times and the amount of access points detected in 7 a.m to 9 p.m within distances 50m to 1.5km only 3 to 4 number of access point without using antenna. After using the antenna the amount of access points detected stop at 4 access point.

5.2. *Addition calculation power (Gain)*

Added power (gain) is done by calculating the difference between the signal power to the antenna signal strength using the signal strength without antenna, where:

\[
G = P(\text{Ant}) - P(\text{Without Ant})
\]

Where :
- \( G \) = Extra power level (dB)
- \( P(\text{Ant}) \) = with antenna signal power (dBm)
- \( P(\text{Without Ant}) \) = without antenna signal power (dBm)
Table 6. Calculation of doubling the power (gain) in urban areas

| Time               | Distance | P Without Ant (DBm) | P With Ant (DBm) | G (dB) |
|--------------------|----------|---------------------|------------------|--------|
| 07 a.m. to 10 a.m. | 50m      | -38                 | -24              | 14     |
|                    | 500m     | -73                 | -59              | 14     |
|                    | 1 Km     | -95                 | -71              | 14     |
| 12 p.m. to 3 p.m.  | 50m      | -43                 | -29              | 14     |
|                    | 500m     | -86                 | -74              | 12     |
|                    | 1 Km     | N / A               | -85              | N / A  |
| 6 p.m. to 9 p.m.   | 50m      | -45                 | -33              | 12     |
|                    | 500m     | -87                 | -74              | 13     |
|                    | 1 Km     | N / A               | -87              | N / A  |
|                    | 1.5 Km   | N / A               | -93              | N / A  |

Table 6 show the calculation of Doubling The Power (Gain) in urban area (Demang Lebar Daun) in 7 a.m to 9 p.m within distances 50m to 1km are 12 dB up to 14 dB.

Table 7. Calculation of doubling the power (gain) on urban sub region

| Time               | Distance | P Without Ant (DBm) | P With Ant (DBm) | G (dB) |
|--------------------|----------|---------------------|------------------|--------|
| 07 a.m. to 10 a.m. | 50m      | -57                 | -44              | 13     |
|                    | 500m     | -68                 | -55              | 13     |
|                    | 1 Km     | -78                 | -66              | 12     |
|                    | 1.5 Km   | N / A               | -89              | N / A  |
| 12 p.m. to 3 p.m.  | 50m      | -59                 | -47              | 12     |
|                    | 500m     | -70                 | -58              | 12     |
|                    | 1 Km     | -83                 | -69              | 14     |
|                    | 1.5 Km   | N / A               | -91              | N / A  |
| 6 p.m. to 9 p.m.   | 50m      | -57                 | -45              | 12     |
|                    | 500m     | -72                 | -59              | 13     |
|                    | 1 Km     | -82                 | -68              | 16     |
|                    | 1.5 Km   | N / A               | -93              | N / A  |

In table 7 show the calculation of Doubling The Power (Gain) in sub urban area (Suka Mulya) in 7 a.m to 9 p.m within distances 50m to 1.5km are 12 dB up to 16 dB.
6. Analysis
Generates power level test data signal power (gain). The use of the Wajenbolic Reflection Antenna is quite significant which increase the average power for urban areas is 14 dB, whereas for sub-urban areas 13 dB. The resulting gain differences are not so significant. The magnitude of the measurement results in relative gain equal to the gain the design.

Power level test data also showed that decreased levels of power to increase the distance to the larger urban areas compared with urban sub-region. This means that the barriers 4G signal in urban areas is greater when compared with the sub-urban area. Barriers signal in urban areas dominated by tall buildings, while barriers signals on suburban areas more in the form of trees.

Data monitored access point shows that the increase in the number of access with the use of Wajenbolic Reflection Antenna in urban areas is quite significant when compared to the suburban area. For example, at a distance of 1 km in urban areas gain access point there were 12 hot spots, while for the same distance in the suburban area there is no gain access point. This data illustrates that the number of hot spots in the sub-urban area far more than sub-urban area.

Based on the measurement time, 07:00 to 10:00 o'clock is the time productively. This is shown by the strong signal generated power. Compared with other measurement times, a strong signal power at 7:00 to 10:00 a.m. strong signal power is greatest, good for urban areas or sub-urban area.

7. Conclusion
Based on the process, the results of research and testing, it can take several conclusions:
1. Antenna Measurement Wajenbolik Reflections on the 4G signal produces an average gain of 14 dB in urban areas and 13 dB in the sub-urban area. These measurement results relative gain equal to the gain of the design.
2. Decrease power level to increase the distance to the larger urban areas compared with urban sub region. This means that the barriers 4G signal in urban areas is greater when compared with the sub-urban area. Barriers signal in urban areas dominated by tall buildings, while barriers signals on sub-urban areas more in the form of trees.
3. Range 4G signal for sub urban region relatively farther than urban areas. Additions within range for urban areas reached 1 Km, while the sub-urban area of 1.5 Km.
4. Increasing the number of access with use of Wajenbolic Reflection Antenna in urban areas is quite significant when compared to the sub-urban area. For example at a distance of 1 km in urban areas gain access point there were 12 hot spots, while for the same distance in the sub-urban area there is no gain access point. This data illustrates that the number of hot spots in the sub-urban area far more than sub-urban area.

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