Potential Use of Antennas In Rural Areas To Improve Internet Connectivity

Rusfa Rusfa[1], Muhamad Mujahidin[2], Sapta Nugraha[3]

{rusfa@umrah.ac.id[1], mujahidin@umrah.ac.id[2], saptanugraha@umrah.ac.id[3]}

Universitas Maritim Raja Ali Haji, Riau Archipelago, Indonesia[123]

Abstract. This research was motivated by the conditions when the Covid-19 pandemic occurred, at that time there was a very striking change in the social conditions of the community both in terms of economy, and communication, to problems with the quality of education. Long-distance education has been implemented to reduce the viruses spreading, and education which usually took place in the classroom; then shifted to virtual classes. Another challenge that occurs is the low reception quality of the 4G signal, which certainly impacted learning quality. Although today we are about to start the lecture again in the classroom, the problem of signal reception quality is still the biggest obstacle in communicating over long distances. In this study, the author tries to explore how much potential use of an antenna to improve signal reception quality problems and the economic ability of people in rural areas to assemble them.

Keywords: 4G Signal, Rural Area, Antenna Design and Manufacturing.

1 Introduction

Riau Archipelago Province is an archipelago-based region. The condition of this area, especially on the island of Bintan, is rural. Generally, rural conditions are still far from infrastructure development, including the development of information technology infrastructure. This has an impact on the condition of people who are left behind economically and technologically [1]. As a result of the spread of Covid-19, most activities are carried out online, including the learning process at school, education which usually took place in the classroom, shifted to virtual classes. Educators and students are faced with the condition of the weak reception quality of the 4G signal, this certainly has an impact on the quality of learning. Although today we are about to start the lecture again in the classroom, the problem of signal reception quality is still the biggest obstacle in communicating over long distances.

The limited number of Base Transceiver Stations (BTS) on Bintan Island has an impact on the low quality of signal reception and internet Quality of Service (QoS). The local government is trying to add BTS infrastructure, but massive BTS construction is certainly not possible in the short term, so people must find practical solutions that can be used immediately [2, 3].

To overcome this problem, several practical solutions related to extending the signal range can be done, such as the use of wifi networks, either managed individually or by utilizing the services of an Internet Service Provider (ISP). Personal wifi network management without

MaCiFIC 2022, September 28-October 01, Tanjungpinang, Indonesia

DOI 10.4108/eai.28-9-2022.2328381

involving the ISP requires personnel who are experts in the field, and at least he understands the scope that can be reached by the wifi networks, the estimated bandwidth capacity needed, the number of users, bandwidth settings, and some technical matters relating to wifi network management, both for intranet and internet access. In addition, building a personal wifi network also costs a lot of money, because it might require several access points as signal extenders or a kind of repeater, users are also still charged for a data connection on wifi using a SIM card. Another solution by using the ISP services, it is a common thing that it does business calculations at the beginning, the ISP will detail whether the location is quite potential (business profitable) in terms of the number of internet subscribers. Several reviews can be used as a reference when opening communication lines in rural areas, first is the small population, which will affect the low number of customers. Second is the distance between people's houses is distant, one of the obstacles to the wireless network is distance, the farther the distance coupled with the condition of the presence of obstacles in the form of trees, buildings, and other natural phenomena also seriously affects the instability of the wifi (wireless) network. Third, the low economic situation of the community has an impact on weak economic activities, they have a low need for internet subscriptions (increasing expenses). [4, 5, 6, 7]

Based on those studies, other practical solutions are needed to overcome the problem of internet signal quality in rural areas.

2 Additional Antenna to Improve Internet Signal Quality

Several studies related to the arrangement and use of external antennas have been carried out, both by setting the antenna on the communication tower, namely by tilting the antenna to overcome the problem of poor signal quality, after the antenna is tilted, the Rx level quality increases. The design of additional antennas also has a good impact on the amplification of the received signal [8, 9, 10].

In this study we will design a Yagi antenna that will be used at a frequency of 1800 MHz, the reason for choosing this antenna is because the design and manufacture process is simple, so it is easy to assemble by people in rural areas, besides the cost of equipment and components needed are cheap and easy to obtain.

As is generally known, the yagi antenna has a fairly high gain, consisting of a reflector, driven, and several elements that function to focus the direction of sending or receiving signals. Several related studies have proven that the distance between elements, the length of the elements, and the diameter of each element affect the gain value and front-to-back ratio. Therefore, optimization is needed in this regard when designing a yagi antenna to obtain the best results [11, 12, 13, 14]. These antennas have been used for many wireless communication models, both for the VHF and UHF frequency ranges. Several studies have been conducted relating to the use of Yagi antennas for LoRa communication, television broadcast receivers, CDMA communication, GSM to satellite, and others [15, 16, 17, 18, 19].

In this paper, we will report the results of the 15-element antenna design used to improve 4G signal reception in rural areas that lack telecommunication tower infrastructure.

3 Materials And Design Method

This antenna is designed using MMANA-GAL software. In designing the antenna, the first thing to do is to determine at what frequency this antenna will work, then based on the frequency value, the wavelength value is sought. In this study, an antenna that works at a frequency of 1800 MHz will be made. The wavelength value is obtained by this formula :

$$\lambda = c / f \quad (1)$$

Yagi antenna is known as a multielement directive array that consists of a Reflector, Driven, and some directors. The "element" in a multielement directive array is usually a half-wave dipole. The length is not always an exact electrical half wavelength, because in some types of arrays it is desirable that the element show either inductive or capacitive reactance. However, the departure in lenght from a true half-wave is ordinarily small (not more than 5%, in the usual case), and so has no appreciable effect on the radiating properties of the element. [20]

Several independet investigations of the properties of multielement Yagi antennas have shown that ini general way the gain of the antenna expressed as a power ratio is proportional to the length of the array, provided the number, lengths, and spacings of the elements are properly chosen. The results of one such study (by Carl Greenblum) are shown in terms of the number of elements in the antenna in Figure 1, In the every case the antenna consists of a driven element, one reflector, and a series of directors properly spaced and tuned.

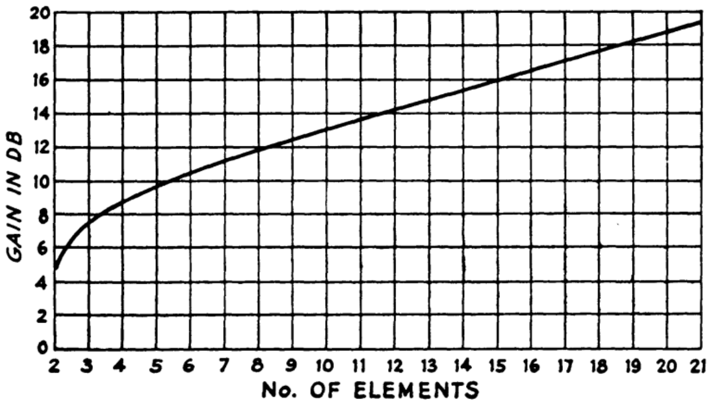

Fig. 1. Gain in dB over a half-wave dipole vs. The number of elements of the Yagi array, assuming the array length is as given in Fig. 2

Thus if the antena is to have a gain of 12 dB, Fig. 1 shows that 8 elements - driven, reflector, and sisx director - will be required, and Fig.2 shows that for such an 8-element antenna the array length required is 1.75 wavelength. [20] [21]

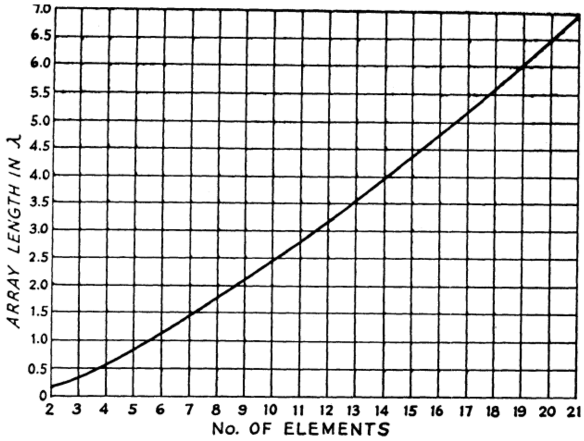

Fig. 2. Optimum length of Yagi antenna as afunction of number of elements.

Table 1 shows the optimum element spacings determined from the Greenblum investigations. There is a fair amount of latitude in the placement of the elements along the length of the array, although the optimum tuning of the element will vary somewhat with the exact spacing chosen. Within the spacing ranges down, the gain will not vary more than 1 dB provided the director lengths are suitably adjusted. [21]

Table 1. Optimum Elemenet Spacings for Multielement Yagi Arrays.

No. Elements	R – DE (λ)	DE – D_1 (λ)	D_1 – D_2 (λ)	D_2 – D_3 (λ)	D_3 – D_4 (λ)	D_4 – D_5 (λ)	D_5 – D_6 (λ)
2	0.15 – 0.2						
2		0.07 – 0.11					
3	0.16 – 0.23	0.16 – 0.19					
4	0.18 – 0.22	0.13 – 0.17	0.14 – 0.18				
5	0.18 – 0.22	0.14 – 0.17	0.15 – 0.20	0.17 – 0.23			
6	0.16 – 0.20	0.14 – 0.17	0.16 – 0.25	0.22 – 0.30	0.25 – 0.32		
8	0.16 – 0.20	0.14 – 0.16	0.18 – 0.25	0.25 – 0.35	0.27 – 0.32	0.27 – 0.33	0.30 – 0.40
8 to N	0.16 – 0.20	0.14 – 0.16	0.18 – 0.25	0.25 – 0.35	0.27 – 0.32	0.27– 0.33	0.35 – 0.42

DE – Driven Element; R – Reflector; D – Director; N – Any Number; director spacings beyond D_6 should be 0.35 – 0.42 λ

In this study, the length and spacings of each element is optimized using the MMANA-GAL to get the optimum parameter, so that the length and spacing values between elements are obtained as shown in the following table:

Table 2. Length And Spacing Between Elements

Element	Element Spacing (cm)	Length (cm)
Reflector	4,3	8,4
Feeder	-	7,1
Director 1	4,8	6,4
Director 2	5,7	6,4
Director 3	6,6	6,1
Director 4	6,9	6,5
Director 5	5,1	6,8
Director 6	4,8	6,9
Director 7	4,2	7
Director 8	4,2	7
Director 9	4,3	6,8
Director 10	5,6	6,6
Director 11	5,3	6,5
Director 12	6,1	6,4
Director 13	6,1	5,8

Based on the simulation results, the gain value is quite large, which is 19.26 dBi, and the SWR value is 1.31.

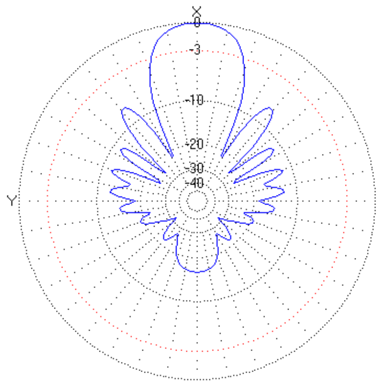

Fig. 3. Radiation Pattern diagram

Fig. 3 is a diagram of the radiation pattern from the simulation results. The radiation pattern diagram appears to focus in one particular direction and radiates a small amount at the back lobe, as well as at the side lobe. This shows that the yagi antenna that has been designed is directional as intended for yagi antennas in general.

4 Measurement

The parameters that are measured as the performance of the antenna that has been made is the RSSP value, the antenna performance test is carried out using cellular communication. The author conducts data collection with an indoor scenario, the antenna is placed inside the house which is blocked by a wall, directed to the nearest BTS. There is a change in the quality of signal reception between before and after using the antenna. Before using the antenna, the RSRP value ranges from -100 dBm to -112 dBm (Fig. 4).

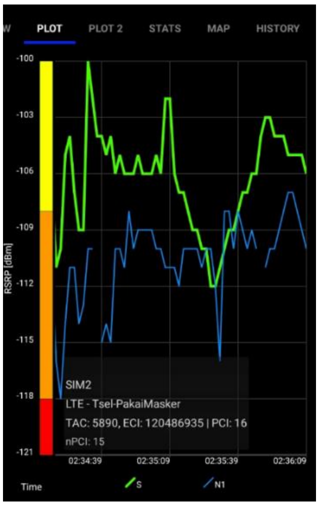

Fig. 4. RSRP value before using the antenna (Green line)

After using a yagi antenna, the signal quality improves in the value range of -99 dBm to -96 dBm (Fig. 5).

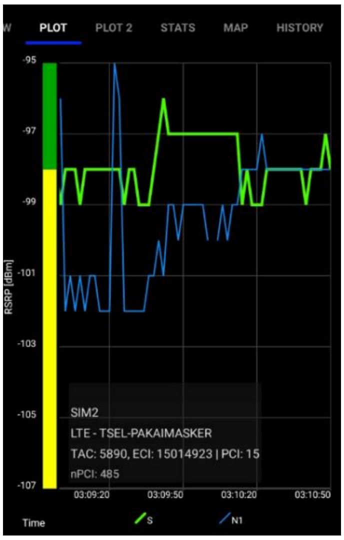

Fig. 5. RSRP value after using the antenna (Green line)

RSRP is the amount of signal power received by the EU (dBm). The farther the distance between the site and the EU, the RSRP value received by the EU will be smaller and vice versa. If the user is on the edge area, the RSRP received will be very weak, then the user will need a handover process. The RSRP value standards set by the Key Performance Indicator (KPI) standards are as follows:

Table 3 RSRP value standards based on (KPI)

Range (dBm)	Category
-80 s.d -44	Excellent
-90 s.d. -80	Good
-100 s.d. -90	Fair
-110 s.d. -100	Poor
-140 s.d. -110	Very poor

Based on the KPI standard, based on the measurement data obtained, the antenna has succeeded in improving the signal reception quality from category poor to even very poorly (-112 dBm), to category fair (-100 dBm to -90 dBm).

Table 4 Speedtest Measurement

Speedtest Measurement	Without Antenna	With Antenna
Ping	51 ms	49 ms
Jitter	10 ms	7 ms
Download	15.6 Mbps	18 Mbps
Upload	5.3 Mbps	22.2 Mbps

Based on the data in Table 4, we see that there is an improvement in the condition of the ping test, after using the antenna the ping time decreases. The jitter value also decreases after using the antenna, as well as the upload and download values have improved, so the data transfer speed after using the antenna is better than before using the antenna. This indicates that the use of antennas has a good impact on the quality of signal reception and improves data transfer rates.

4 Conclusion

In this studi, we design and implement an additional antenna to improve signal quality in rural areas. The use of an additional antenna in the form of a Yagi antenna on a 4G LTE 1800 MHz signal can improve the RSRP value of 16 dB, which is better than the condition before using the antenna. In addition, the use of this antenna also affects the better value of the data transfer rate.

References

[1] Ginting, A. (2013, Mei). Kendala Pembangunan Provinsi Daerah Kepulauan:Studi Kasus Provinsi Kepulauan Riau. Politica, 4, 49-75.

[2] Hasura. (2022, February 3). Diskominfo Bintan dan Kepri kerjasama PT Telkom Perluas Akses Sinyal 4G di Lintas Barat. Retrieved from Presmedia: https://presmedia.id

[3] Ogen. (2022, June 15). Diskominfo Kepri Temui Staf Khusus Menkominfo RI Gesa Pembangunan BTS. Retrieved from https://kepri.antaranews.com: https://kepri.antaranews.com/berita/120605/diskominfo-kepri-temui-staf-khusus-menkominfo-ri-gesa-pembangunan-bts

[4] Raman, B., & Chebrolu, K. (2007). Experiences in Using WiFi for Rural Internet in India. IEEE Communications Magazine, 104-110.

[5] Bhuiyan, M. (2020). Solutions for wireless internet connectivity in remote and rural areas. The University of Oulu, Faculty of Information Technology and Electrical Engineering, Master's Thesis, 54.

[6] Hadiyat, Y. D. (2014). Kesenjangan Digital di Indonesia (Studi Kasus di Kabupaten Wakatobi). *Jurnal Pekommas, 17(2), 81-90*.

[7] Abdelrahman, R. B. M., Mustafa, A. B. A., & Osman, A. A. (2015). A Comparison between IEEE 802.11 a, b, g, n and ac Standards. *IOSR Journal of Computer Engineering (IOSR-JEC), 17*(5), 26-29.

[8] Andre, H., Ghozal, M., & Fernandez, R. (2021). Optimization signal quality on cellular network based on Tilting-Antenna. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1041, No. 1, p. 012010). IOP Publishing.

[9] Nixon, B., & Purnomo, R. W. (2019, January). Rancang bangun antena octaquad sebagai pemancar repeater untuk aplikasi penguat sinyal 4G pada frekuensi 1800 MHz. In Seminar Nasional Teknik Elektro (Vol. 4, No. 1, pp. 31-36).

[10] Broto, S. (2020) Rancang Bangun Antena Yagi 5 Elemen Sebagai Penguat Sinyal 4G Pada Frekuensi 1800 MHz. In Seminar Maestro (Vol. 3 No. 1 pp. 116-125).

[11] Chen, C. A., & Cheng, D. K. (1975). Optimum element lengths for Yagi-Uda arrays. *IEEE Trans. Antennas Propag.*, 8–15.

[12] Cheng, D. K., & Chen, C. A. (1973). Optimum element spacings for Yagi-Uda arrays. *IEEE Trans. Antennas Propag.*, 615–623.

[13] I, O., & I.C, O. (2011). Design and Implementation of a High-Gain Compound Yagi Antenna. *Pelagia Research Library*, 41 - 50.

[14] Pramono, S., & et.al. (2019). Optimization of 4G LTE (Long Term Evolution) Network Coverage Area in Sub Urban. *The 5th International Conference on Industrial, Mechanical, Electrical, and Chemical Engineering 2019*, 030193-1 - 030193-9.

[15] Sharma, G., & et.al. (2012). Yagi-Uda Antenna For L-Band Frequency Range. *International Journal of Engineering and Technology*, 315 - 320.

[16] Subba, B., & et.al. (2019). Tuning of Yagi Uda Antenna with Gain Enhancement at 300 Mhz and 2.4 GHz Bands For Wi-Fi Application. *International Journal of Innovative Technology and Exploring Engineering*, 2355 - 2361.

[17] Van Torre, P. e. (2018). Measurement and characterization of dual-band LoRa communication in the Antarctic. *12th European Conference on Antennas and Propagation (EuCAP 2018). IET*, 110-5.

[18] Andika, A. P. (2020). Design of Yagi-Uda Antenna for CDMA Modems at 800 MHz. Journal of Physics: Conference Series, 032102.

[19] Densmore, A., & Huang, J. (1991). Microstrip Yagi antenna for mobile satellite service. *Antennas and Propagation Society Symposium 1991 Digest. IEEE*, 616-619.

[20] The ARRL Antenna Book. 1974. The American Radio Relay League, Inc. Newington, Connecticut.

[21] Greenblum, "Notes on the Development of Yagi Arrays," QST, Part I, August, 1956; Part II, September, 1956