Institut Riset dan Publikasi Indonesia (IRPI)
MALCOM: Indonesian Journal of Machine Learning and Computer Science
Journal Homepage: https://journal.irpi.or.id/index.php/malcom
Vol. 4 Iss. 3 July 2024, pp: 1130-1138
ISSN(P): 2797-2313 | ISSN(E): 2775-8575

Analysis of WiFi Reliability at 2.4 GHz and 5 GHz Frequencies in the Environment of STMIK Sinar Nusantara Surakarta

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Received May 15th 2024; Revised Jun 25th 2024; Accepted Jul 5th 2024
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Abstract

This research is expected to provide solutions to improve the performance and reliability of the WiFi network at STIMIK Sinar Nusantara, thus supporting teaching and learning activities and enhancing the quality of education. By comparing the quality of WiFi networks between 2.4 GHz and 5 GHz, it aims to shed light on the differences and advantages of each frequency band. Furthermore, the findings of this research can be beneficial for the design of future networks, helping network designers to better understand the importance of frequency management in network infrastructure planning. This research employs an experimental method by testing QoS parameters (throughput, delay, and packet loss) as well as reliability (connection and uptime) at both frequencies. The results of the research indicate that the 5 GHz frequency provides better QoS performance and reliability compared to 2.4 GHz. This research concludes that the 5 GHz frequency could be a solution to improve the WiFi network quality at STIMIK Sinar Nusantara.

Keyword: 2.4 GHz, 5 GHz, Frequencies, Wifi Reliability

1. INTRODUCTION

Wireless networks have experienced rapid development over the past two decades [1]. In an era where wireless connectivity serves as the primary foundation of communication, WiFi signal analysis plays a crucial role in ensuring network quality and efficiency [2]. The use of Wi-Fi is commonplace in this generation, where it has rapidly proliferated worldwide as a popular means for Internet access and the management of data, voice, and audio quality [3]. Many people connect to wireless networks through their devices such as mobile phones or laptops. In 2018, the number of devices connected to Wi-Fi reached 20 billion. It is also reported by the Cisco Visual Networking Index (VNI) that internet traffic generated by Wi-Fi devices was 55% in 2013 and is projected to reach 61% in future trends [4]. Nowadays, wireless networks on campuses are highly beneficial as they play a crucial role for any organization. The implementation of wireless networks on campuses allows academic users such as students, researchers, lecturers, and staff to access the Internet, and many recent studies are still being developed to provide the best quality of service (QoS) support for campus networks [5].

Data communication technology has rapidly evolved, and WiFi networks have become one of the most widely used technologies. The rapid growth of the Internet-of-Things (IoT) has led to the proliferation of low-power wireless technologies [6]. Various devices such as computers, laptops, smartphones, smart TVs, and printers rely on this network. Currently, only a 2.4 GHz WiFi network is available at STMIK Sinar Nusantara. This network often experiences interference and is challenging to use, despite the LAN internet connection reaching 1Gbps with internet speed at 300 Mbps.

Wireless networks have become a standard facility in various public places such as cafes, campuses, schools, malls, offices, and hotels. Many people connect to wireless networks through devices such as smartphones or laptops [7]. To ensure that the wireless network functions properly, monitoring is essential. Network monitoring for wireless networks can be done using tools to check network traffic, speed, and signal strength of each existing network [8].

Cable networks offer stability and high data link with minimal interference. However, cable usage has some drawbacks, such as requiring many cables and complex installations. Not all devices support cable connections, such as smartphones and tablets, and even if they do, they may require additional adapters. On the other hand, WiFi offers convenience and flexibility, allowing users to connect to the internet wirelessly. However, WiFi 2.4 GHz often encounters issues such as interference from other devices using the 2.4 GHz frequency, such as microwaves, Bluetooth, and other electronic devices, leading to signal interference and quality degradation [9].

Students at STIMIK Sinar Nusantara often use the internet for various learning purposes. Campus WiFi connections that are unreliable, intermittent, with signal losses and slow speeds, can disrupt the teaching and learning process and hinder student activities. Even the author prefers to use cellular data on campus despite the availability of campus WiFi. STIMIK Sinar Nusantara is located in a densely populated city area with many WiFi users, causing the 2.4 GHz frequency to be congested and prone to interference from other WiFi networks in the vicinity. One solution to address interference issues in the 2.4 GHz network is by using WiFi 5 GHz, which offers several advantages over WiFi 2.4 GHz, such as less interference and higher speeds.

This drives researchers to analyze and compare the Quality of Service (QoS) performance and reliability of WiFi networks at 2.4 GHz and 5 GHz frequencies. QoS is a technology that allows network administrators to handle various effects of disruptions in wireless networks [10]. QoS is a method of calculation and data analysis that tests the network's ability to provide information about good network quality by providing information on bandwidth, throughput, packet loss, delay, and jitter [11]. The research conducted by [12] evaluates the performance of Wi-Fi router placement in the Communication Technology laboratory area to address intermittent connectivity issues. Through simulations using Altair WinProp, it was found that optimal router placement can significantly increase signal strength throughout the laboratory area, reducing the number of access points, equipment costs, and electricity bills. While the simulation results of the study conducted by [13] showed that the 2.4 GHz microstrip trisula antenna had a return loss value of -18.514 dB, VSWR of 1.26 dB, and Gain of 4.71 dB. Meanwhile, the 5.8 GHz microstrip antenna had a return loss of -40.437 dB, VSWR of 1.02 dB, and Gain of 4.19 dB. The measurement results indicated that the 2.4 GHz microstrip trisula antenna had a return loss of -24.767 dB, VSWR of 1.122 dB, and Gain of 3.24 dB. On the other hand, the 5.8 GHz microstrip antenna had a return loss of -37.554 dB, VSWR of 1.027 dB, and Gain of 3.57 dB. Overall, both simulation and measurement results demonstrated that the 5.8 GHz microstrip antenna exhibited good performance for the desired parameters. Study revealed that the accuracy performance of Wi-Fi fingerprints is similar when utilizing both 2.4 GHz and 5 GHz frequencies. However, employing the 5 GHz frequency results in higher response speeds, while the use of 2.4 GHz consumes less power [14]. With the emergence of recent standards, wireless solutions are ready to be applied in building automation networks [15].

The gap in this analysis lies in the need for a deeper understanding and comparison of the performance and reliability of Wi-Fi networks at 2.4 GHz and 5 GHz frequencies, particularly in terms of QoS and power consumption. Previous research has provided insights into signal strength and antenna performance at these frequencies, but there is still a lack of analysis on QoS metrics such as bandwidth, throughput, delay, and packet loss. Additionally, there is limited information on the impact of frequency selection on response speed and power consumption. Practical studies focusing on educational institutions are also needed to optimize Wi-Fi networks in educational environments. Therefore, this research aims to address these gaps by measuring and comparing Wi-Fi performance at STIMIK Sinar Nusantara.

2. MATERIALS AND METHOD

This research employs an experimental method by testing QoS parameters (throughput, delay, and packet loss) on both frequency bands. The schedule for conducting Wireless network measurements using QoS parameters is set for Thursday, 18/04/2024, at STMIK Sinar Nusantara. The measurement will be carried out by connecting a personal router to the STMIK Sinar Nusantara campus network in building B using LAN cable. The WiFi router used is the Totolink A720R, which supports dual bands. The QoS parameters analyzed include Delay, Packet loss, Bandwidth, and Throughput. Since the internet speed at STMIK Sinar Nusantara is 300Mbps, Throughput testing is not necessary unless there are issues with the ISP. However, it should be noted that the Throughput will also not reach 300Mbps due to the limitations of the testing equipment, which only supports LAN Port 100Mbps.

Hardware used includes the Asus Vivobook A1502za Laptop, which supports up to WiFi 6ax, the Samsung A51 phone, which supports up to WiFi 5ac, and the Totolink A720R Router, which supports dual-band WiFi. Further specifications of each device are detailed in the table below:

Table 1. Hardware and Software Specifications

Device	LAN Port	WLAN Support Up to	Frequency
Totolink A720R Router	3x Fast Ethernet 100 Mbps	WiFi 5ac	2.4 GHz, 5 GHz
Asus Vivobook A1502ZA Laptop	-	WiFi 6ax	2.4 GHz, 5 GHz
Samsung Galaxy A51 Phone	-	WiFi 5ac	2.4 GHz, 5 GHz
STMIK SINUS Ethernet	Gigabit Ethernet 1 Gbps	-	-

Due to the router's limitations, regardless of how good the connection is, it will be limited by the 100 Mbps LAN Port. However, 100 Mbps is still very good. Software used includes the Edge browser, WiFiman APK, and CS File Explorer APK.

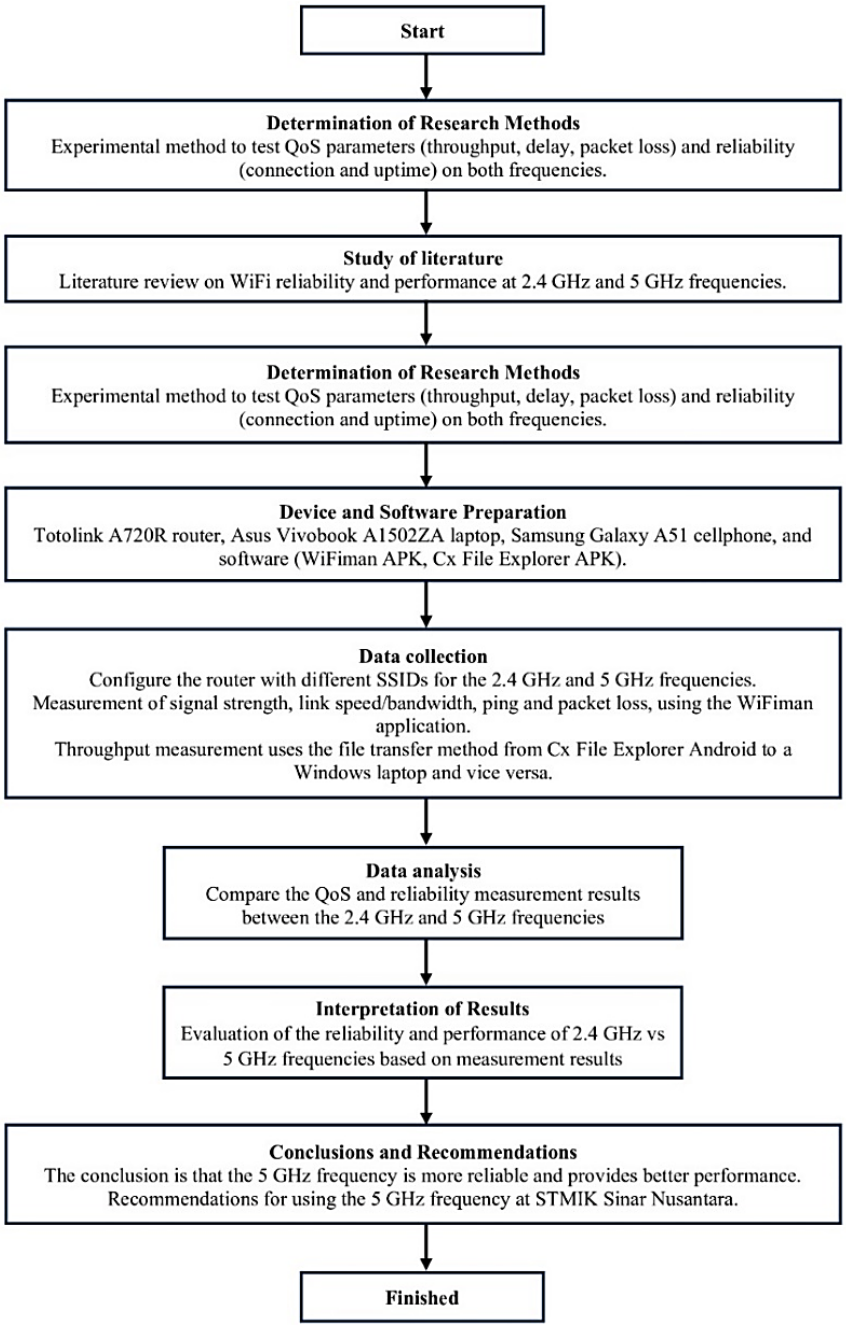

Figure 1. Flowchart in this research

3. RESULTS AND DISCUSSION

In this study, the first step examined is to the B building of STMIK SINUS because it is located in the middle of the campus. After that, I configured the basic router settings as usual until it could be used, giving different SSID names between frequencies to facilitate internet sources from the LAN of building B on campus. Once completed, for example, as figure 2. After that, prepare an Android phone and download the WIFIman and Cx File Explorer apps from the Android Play Store.

3.1 Testing WiFi Spectrum and Signal Strength

Here is the initial display of WIFIman and the scan menu. The internet speed test is available in this main menu, but for testing signal strength, bandwidth, and WiFi spectrum in both 2.4GHz and 5GHz bands, it is located in the scan menu. WiFi signal strength is usually measured in decibel milliwatts or dBm. dBm values are a way to measure wireless signal strength, with higher dBm values indicating stronger signals. In the WiFi Spectrum image, stacked images are visible, indicating interference or disturbances in the WiFi network, we show as figure 3.

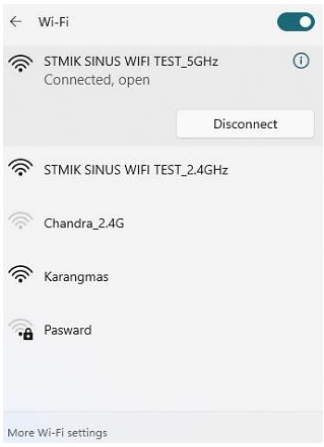

Figure 2. Example Result of Creating Different WIFI SSIDs

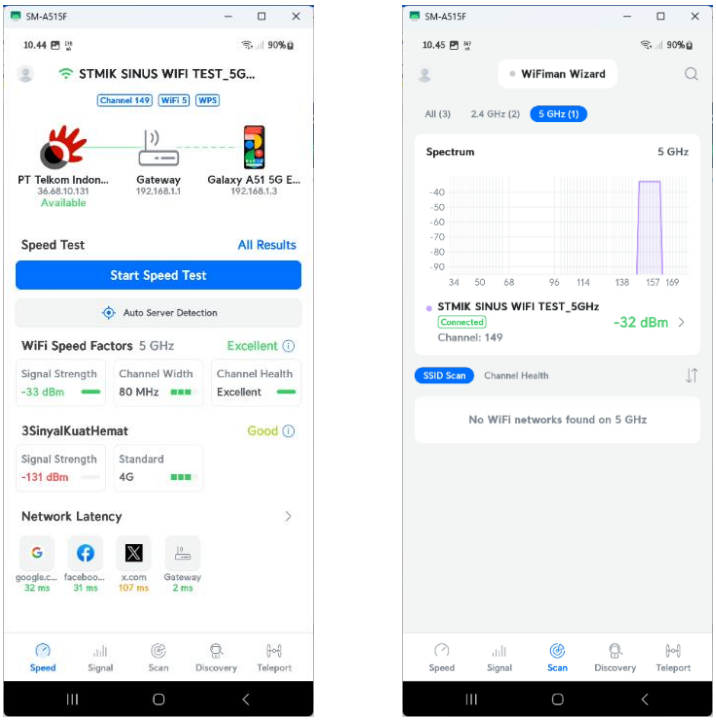

Figure 3. WIFIman Android Application Interface

3.2 Testing Link Speed/Bandwidth Speed, Ping, and Packet Loss

To test the link speed/bandwidth speed, go to the WiFi settings on your laptop. In the properties section, you will find the link speed. To test latency and packet loss to the router, open CMD and type ping (router IP address). Below is the CMD menu display, show as figure 4.

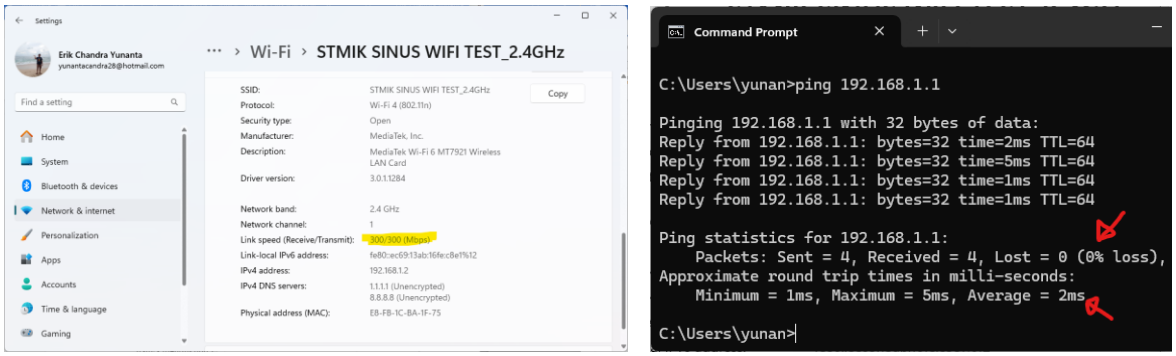

Figure 4. Example Display of Link Speed and Ping Testing

Link speed is the maximum theoretical speed of data transmission wirelessly between devices, while ping is the time it takes for data to travel between two devices or across a network. Packet loss refers to the percentage of data packets that fail to reach their destination while traversing a computer network.

3.3 Throughput Testing

Throughput is the actual speed at which data is processed and transferred from one location to another. In the context of networks, throughput refers to how much data can be transferred from a source to a destination within a certain period. Throughput measures how many packets successfully reach their destination. So, even with high internet speed, if the throughput is lower, data will only flow at the throughput speed. In short, throughput reflects the actual network conditions. For throughput testing, you can use two laptops connected via network sharing to transfer data and measure the speed. Since this testing only involves one laptop and one mobile phone, you can use the Cx File Manager application. Here are the steps, as figure 5-10.

Connect to the same network between the laptop and the mobile phone.

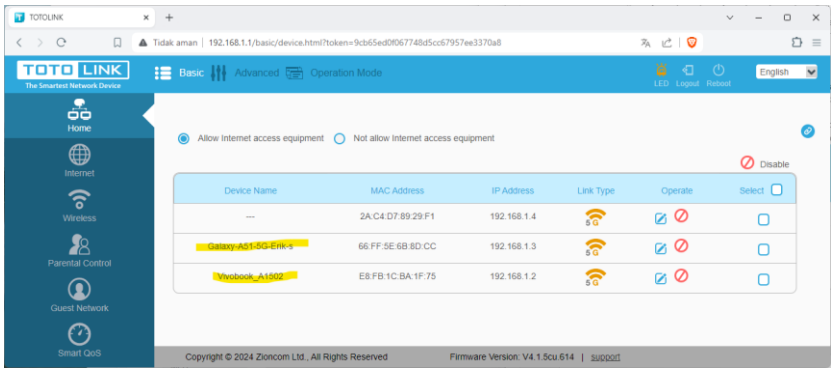

Figure 5. Display of Router Settings when Both Devices are Connected

Open the network menu and click on "Network Access," then click "Start."

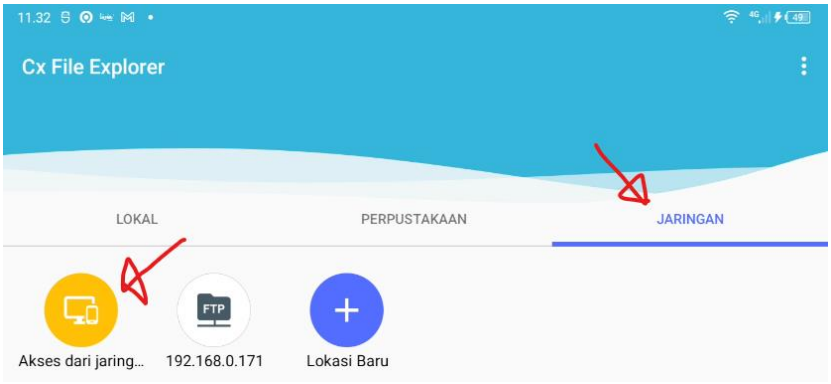

Figure 6. Display of the Cx File Explorer Application

Please type the FTP address shown on your phone into the Windows File Explorer.

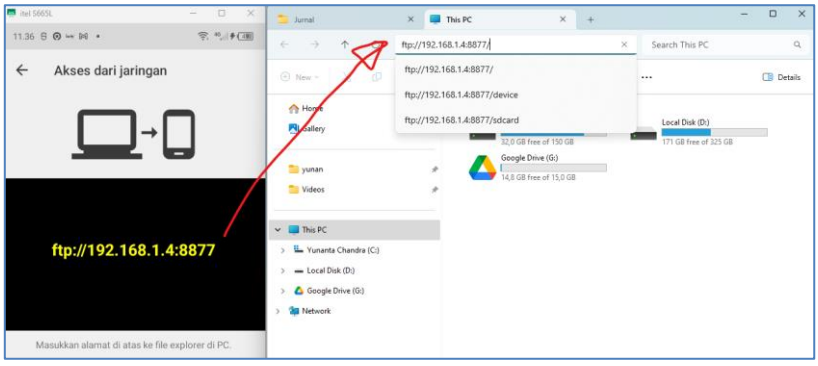

Figure 7 . How to FTP to Laptop

Once connected, it will appear like this, showing both the device (internal storage) and SD card.

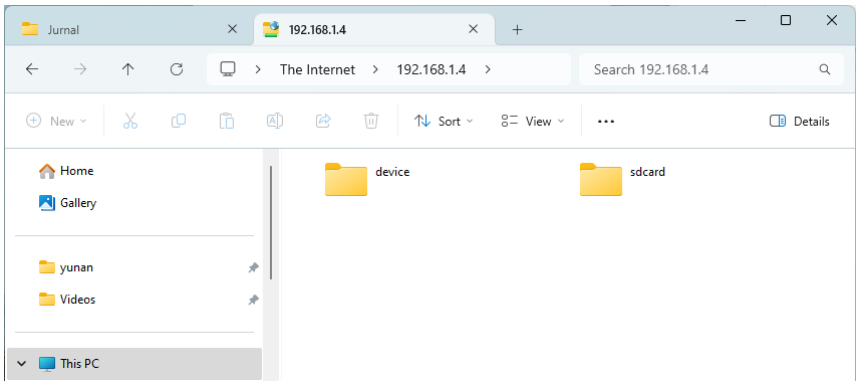

Figure 8. Display after connecting to the phone's FTP

Perform data transfer to that location by using the usual copy-paste method.

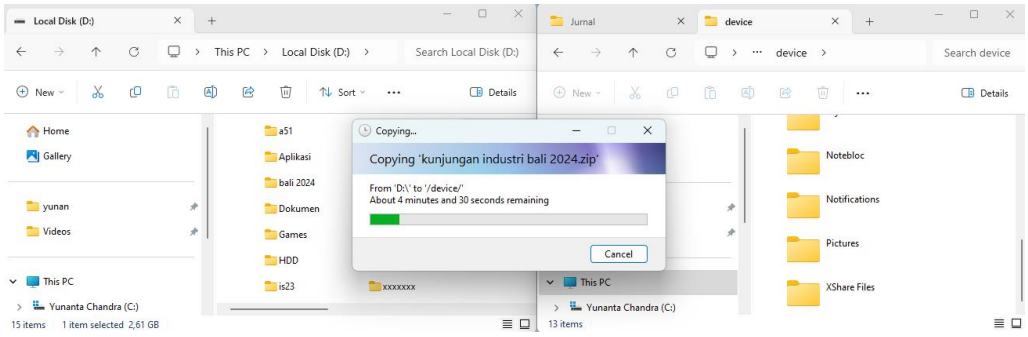

Figure 9. Data Transfer Process for Throughput Testing

Open Task Manager on the laptop, click on the Performance tab, then click on WIFI. There, you can see the Receive speed when transferring data from the phone to the laptop or the Send speed when transferring data from the laptop to the phone.

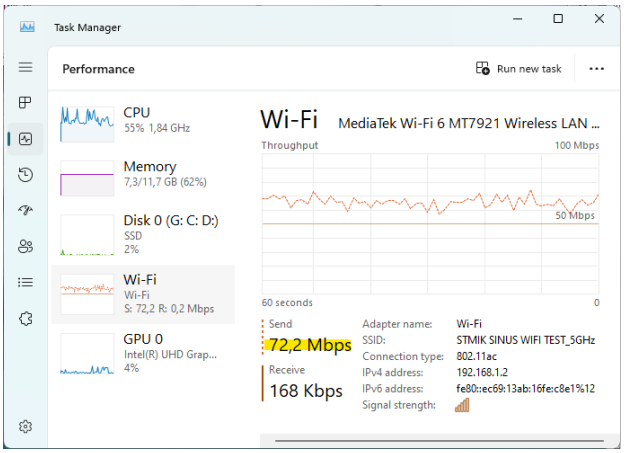

Figure 10. Display of Speed from Task Manager to View Real-Time Transfer Speed

Thus, these are the steps the researcher took to test several parameters. The researcher repeated these steps on both frequencies and repeated them again at different distances.

Ethernet Type/ Speed : Gigabit 1Gbps
Speed Test Via Ethernet Direct : 100Mbps
Through WiFi : Here is the comparison of the WiFi Spectrum between 2.4GHz and 5GHz in the environment of STMIK Sinar Nusantara.

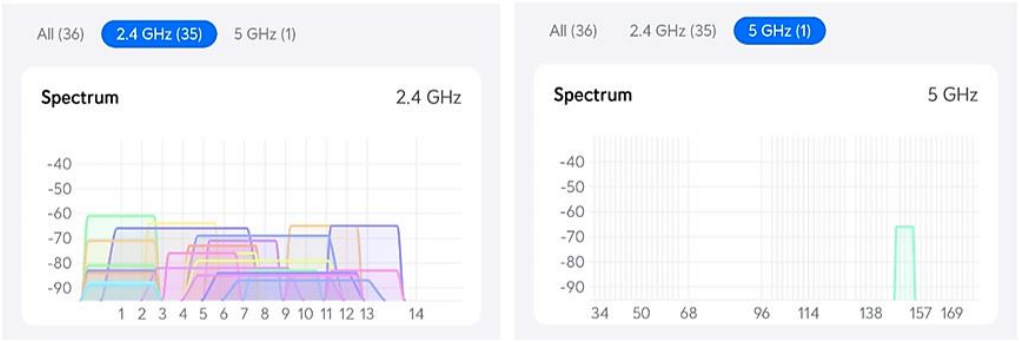

Figure 11. WiFi Spectrum of Building A at STMIK SINUS

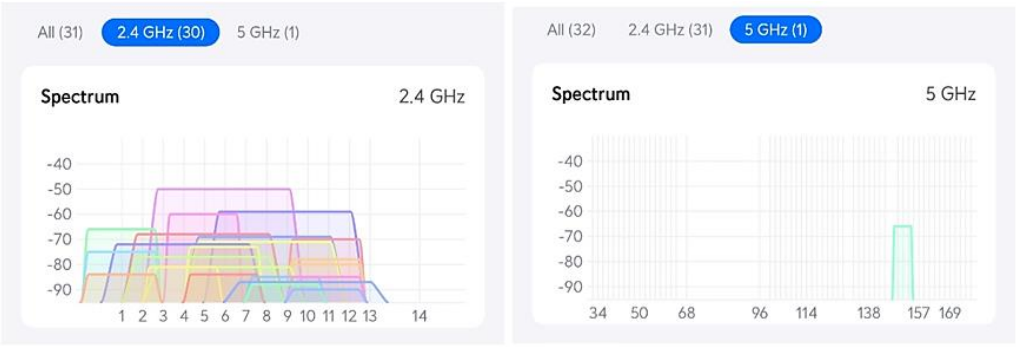

Figure 12. WiFi Spectrum of Building B at STMIK SINUS

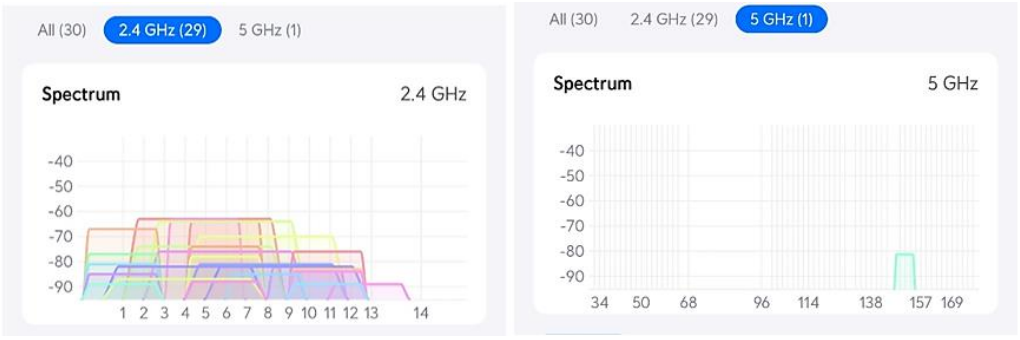

Figure 13. WiFi Spectrum of Building C at STMIK SINUS

The overlapping images indicate interference, as seen in the 5GHz spectrum where there is only one signal, originating from the researcher's device, but in the 2.4GHz frequency, there is significant overlap. From the above image, it can be concluded that STMIK SINUS does not have any 5GHz WiFi networks. The 5GHz spectrum appears narrow due to the available frequency range, which offers hundreds of channels, while the 2.4GHz spectrum has only 13 channels. Based on the comparison of the spectrums in the above image, it is already apparent that the 5GHz WiFi network will be much more reliable to use considering the congestion of the 2.4GHz WiFi frequency at STMIK Sinar Nusantara. However, let's proceed with this test, and the further testing results will be included in the table below.

Table 2. Comparison Table of QoC Using WiFi 2.4GHz and 5GHz

WiFi Freq	Distance	Signal Strength (dBm)	Delay / Ping	Bandwidth (MHz)	Bandwidth Speed	Packet Loss	Throughput
2.4GHz	2 M	-25	3ms	20MHz	300 Mbps	0%	14.4 Mbps
5GHz	2 M	-27	3ms	40MHz	400 Mbps	0%	102 Mbps
2.4GHz	15M (Gedung B-C)	-73	22ms	20MHz	72 Mbps	0%	1.6 Mbps

WiFi Freq	Distance	Signal Strength (dBm)	Delay / Ping	Bandwidth (MHz)	Bandwidth Speed	Packet Loss	Throughput
5GHz	15M (Gedung B-C)	-78	2ms	40MHz	177 Mbps	0%	61 Mbps
2.4GHz	1 Floor	-79	25ms	20MHz	11 Mbps	0%	0.85 Mbps
5GHz	1 Floor	-88	3ms	40MHz	39 Mbps	0%	32 Mbps

From the research results, it is evident that the 5GHz frequency provides better QoS performance and reliability compared to 2.4GHz.

4. CONCLUSION

Based on the test results, it is highly recommended to use the 5GHz WiFi network at STMIK Sinar Nusantara to achieve optimal performance. As seen in the table above, the difference between the two frequencies is quite contrasting. Even when the signal strength is lower in the 5GHz frequency, all other parameters excel.

REFERENCES

[1] F. Juliansyah and R. Rachmatika, "Analisis Pengaruh Interferensi Wifi Terhadap Quality Of Service (Qos) Pada Modem Wireless Huawei Eg8145v5 Dengan Metode Action Research," *OKTAL J. Ilmu Komput. Dan Sains*, vol. 2, no. 11, Art. no. 11, Nov. 2023.

[2] S. Andriyani *et al.*, "Analisis Kualitas Sinyal WiFi Fakultas Teknik UNNES dan Implementasinya dalam Kegiatan Perkuliahan Khususnya Akses Elena," *J. Angka*, vol. 1, no. 1, Art. no. 1, Feb. 2024.

[3] O. O. Khalifa, R. J. B. Roslin, and S. S. N. Bhuiyan, "Improved voice quality with the combination of transport layer & audio codec for wireless devices," *Bull. Electr. Eng. Inform.*, vol. 8, no. 2, Art. no. 2, Jun. 2019, doi: 10.11591/eei.v8i2.1490.

[4] K. Sui *et al.*, "Understanding the Impact of AP Density on WiFi Performance Through Real-World Deployment," in *2016 IEEE International Symposium on Local and Metropolitan Area Networks (LANMAN)*, Jun. 2016, pp. 1–6. doi: 10.1109/LANMAN.2016.7548845.

[5] M. Kassim, N. L. Ismail, R. Mohamad, S. I. Suliman, and M. Ismail, "Self-similarity Hurst Parameter Estimation with Rescaled Range Method on IP-based Campus Internet Traffic.," *Pertanika J. Sci. Technol.*, vol. 25, 2017, Accessed: May 12, 2024. [Online]. Available: https://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=01287680&AN=130391342&h=McTopfYCytHeyMkRUHMNmEeoS8frU9tSA1UfsAIyLbz5l99tDK1qQ%2BOyl%2FxTsbKdagGI4zXfOnLM754iibWevw%3D%3D&crl=c

[6] R. Natarajan, P. Zand, and M. Nabi, "Analysis of coexistence between IEEE 802.15.4, BLE and IEEE 802.11 in the 2.4 GHz ISM band," in *IECON 2016 - 42nd Annual Conference of the IEEE Industrial Electronics Society*, Oct. 2016, pp. 6025–6032. doi: 10.1109/IECON.2016.7793984.

[7] S. E. Prasetyo and E. Tan, "Analisis Quality of Service (QoS) Jaringan Wireless 2.4 GHz dan 5 GHz di Dalam Ruangan dengan Hambatan Kaca," *J. Ilm. Teknol. Inf. Asia*, vol. 15, no. 2, pp. 103–114, Sep. 2021, doi: 10.32815/jitika.v15i2.609.

[8] A. A. Ghafar, M. Kassim, N. Ya'acob, R. Mohamad, and R. A. Rahman, "QoS of Wi-Fi performance based on signal strength and channel for indoor campus network," *Bull. Electr. Eng. Inform.*, vol. 9, no. 5, Art. no. 5, Oct. 2020, doi: 10.11591/eei.v9i5.2251.

[9] L. T. Common, "Propagation losses through common building materials 2.4 GHz vs 5 GHz," *E10589 Magis Netw. Inc*, 2002, Accessed: Jun. 12, 2024. [Online]. Available: https://www.am1.us/wp-content/uploads/Documents/E10589_Propagation_Losses_2_and_5GHz.pdf

[10] Y. Yusantono, "Analisis dan Perbandingan Jaringan WiFi dengan frekuensi 2.4 GHz dan 5 GHz dengan Metode QoS," *J. Inf. Syst. Technol. Jt.*, vol. 1, no. 1, pp. 34–52, Oct. 2020, doi: 10.37253/joint.v1i1.1283.

[11] M. R. Kamil, F. Arzalega, R. Rosalinda, and A. Sani, "Analisis Kualitas Layanan Jaringan Internet Wifi PT.XYZ Dengan Metode QoS (Quality Of Service)," *J. Bid. Penelit. Inform.*, vol. 1, no. 1, Art. no. 1, Feb. 2023.

[12] A. S. Haron, Z. Mansor, I. Ahmad, and S. M. M. Maharum, "The Performance of 2.4GHz and 5GHz Wi-Fi Router Placement for Signal Strength Optimization Using Altair WinProp," in *2021 IEEE 7th International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA)*, Aug. 2021, pp. 25–29. doi: 10.1109/ICSIMA50015.2021.9526299.

[13] L. M. Silalahi, S. Budiyanto, F. A. Silaban, I. U. V. Simanjuntak, P. S. Hendriasari, and Heryanto, "Design of 2.4 GHz and 5.8 GHz Microstrip Antenna on Wi-Fi Network," in *2020 2nd International*

Conference on Broadband Communications, Wireless Sensors and Powering (BCWSP), Sep. 2020, pp. 6–11. doi: 10.1109/BCWSP50066.2020.9249450.

[14] D. Duong, Y. Xu, and K. David, "Comparing the Performance of Wi-Fi Fingerprinting Using the 2.4 GHz and 5 GHz Signals," in *2018 IEEE 87th Vehicular Technology Conference (VTC Spring)*, Jun. 2018, pp. 1–5. doi: 10.1109/VTCSpring.2018.8417848.

[15] W. Guo, W. M. Healy, and M. Zhou, "Impacts of 2.4-GHz ISM Band Interference on IEEE 802.15.4 Wireless Sensor Network Reliability in Buildings," *IEEE Trans. Instrum. Meas.*, vol. 61, no. 9, pp. 2533–2544, Sep. 2012, doi: 10.1109/TIM.2012.2188349.