Comparative Analysis of Resource Utilization on 2.4 GHz and 5.8 GHz Wireless LAN Network Frequencies (OpenWrt Firmware Case Study)

Analisis Perbandingan Pemanfaatan *Resource* pada Frekuensi Jaringan LAN Nirkabel 2,4 GHz dan 5,8 GHz (Studi Kasus *Firmware OpenWrt*)

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Abstract

The purpose of this study is to analyze the comparison of the use of dual-band wireless router device resources on the 2.4 GHz 802.11n standard network and 5.8 GHz 802.11ac standard using a 40 MHz frequency using the Linksys EA7500 version 2 router with OpenWrt firmware case study with supporting IPerf3 and HTop applications. The research results obtained in the study compare throughput and resource usage using wireless LAN networks at frequencies of 2.4 GHz and 5.8 GHz. The use of 5.8 GHz frequency in the same frequency (40MHz) range results in higher throughput, which has practical implications for network engineers and researchers. While using CPU and RAM at a frequency of 2.4 GHz, it is concluded that every 1% utilization of the CPU can transfer data at 0.78 Mbit/sec, or 6.24 MBps, and for a frequency of 5.8 GHz, it is 1.11 Mbit/sec, or 8.88 MBps. While in the use of RAM, it is concluded that every 1% of RAM can be used to transfer data 0.32 Mbit/sec or 2.56 MBps for frequency 2.4 GHz and frequency 5.8 GHz, which is 1.32 Mbit/sec or 10.56 MBps

Keywords: HTop, IPerf3, Resource Utilization, Wireless LAN

Abstrak

Tujuan penelitian ini adalah untuk menganalisis perbandingan penggunaan *resource* perangkat *Wireless router Dual Band* Pada Jaringan 2.4 GHz Standar 802.11n dan 5.8 GHz Standar 802.11ac menggunakan frekuensi 40 MHz menggunakan Perangkat Router Linksys EA7500 Versi 2 dengan Studi Kasus *Firmware OpenWrt* dengan pendukung aplikasi Iperf3 dan Htop. Metode penelitian yang digunakan pada penelitian ini menggunakan metode studi literatur dan observasi sebagai media pengumpulan data. Manfaat penelitiannya adalah mengetahui efektifitas penggunaan teknologi Wi-Fi 2.4 GHz dan 5.8 GHz pada sebuah perangkat. Hasil penelitian yang didapatkan pada penelitian yaitu menemukan beberapa informasi terkait berapa kecepatan *rill* atau *throughput* dan penggunaan *resource* menggunakan jaringan Wireless LAN pada frekuensi 2.4 GHz dan 5.8 GHz. Dalam kasus data yang diperoleh, penggunaan frekuensi 5.8 GHz pada rentang frekuensi yang sama menghasilkan *Throughput* yang lebih tinggi dan memiliki efisiensi penggunaan *resource* untuk transfer data yang lebih baik dibandingkan dengan frekuensi 2.4 GHz sehingga perlu dipertimbangkan dalam pemilihan frekuensi dan spesifikasi perangkat yang akan digunakan. Sedangkan dalam uji dalam penggunaan RAM, untuk frekuensi 2.4 GHz dan 5.8 GHz tidak terjadi perbedaan yang terlalu jauh dalam persentase penggunaan RAM. .

Kata Kunci: HTop, IPerf3, *Resource Utilization*, LAN Nirkabel

I.   INTRODUCTION

In the context of the ongoing COVID-19 pandemic, the Director General of Public Information and Communication (*IKP*) at the Indonesian Ministry of Communication and Informatics (*Kominfo*), Prof. Widodo Muktiyo, has asserted that Wi-Fi (Wireless Fidelity) has become a basic human need [1]. In response to this need, the government is digitizing to support the community in its efforts to work and study [2]. This, of course, requires a smooth internet network in each region. With these considerations in mind, the Internet has become a mandatory communication medium for government and private agencies to communicate with each other. In addition to local area network (LAN) cable-based networks, wireless local area network (WLAN) networks are often utilized due to their convenience in facilitating communication both within the local network and beyond it. WLANs have become a necessity for individuals as users of smartphones, laptops, and other devices. Each device owned is equipped with a wireless adapter that is capable of receiving different signal frequencies to connect to wireless networks that have been provided in the workplace, public, and other locations [3].

The current range of Wi-Fi frequencies is considerable. However, the two most commonly used standards are 2.4 GHz and 5 GHz [4]. With a wireless network, computer devices can be moved from one location to another without the need for a new and troublesome network installation [5]. Indeed, the number of devices connected to wireless networks has increased to 20 billion by 2018 [3]. In terms of ease of use and support for network devices that are already available, there is a growing number of wireless router devices that were originally only single band with a frequency of 2.4 GHz, with dual bands now supporting frequencies of 2.4 GHz and 5 GHz. These devices offer significant resources to support the needs of the community, allowing users to choose the frequency to use themselves.

The background information presented above suggests that a potential issue in research may be the resource usage of dual-band 2.4 GHz and 5.8 GHz router devices when used to transfer data. To gain insight into the comparative analysis of resource usage of dual-band wireless router devices on 2.4 GHz and 5.8 GHz networks, researchers conducted a case study using the Linksys EA7500 Version 2 router device (with OpenWrt firmware). The objective was to ascertain the efficacy of utilizing 2.4 GHz and 5.8 GHz Wi-Fi technology on a device, to establish a reference for selecting the optimal frequency and device for network installation. This was achieved through the use of supporting applications, namely Iperf3 and Htop.

II.   LITERATURE REVIEW

The research, entitled "Analysis of Wireless Local Area Network Transfer Rate with IEEE 802.11a and IEEE 802.11g Standards on Line of Sight Channel," concluded that the IEEE 802.11a standard exhibited superior transfer rate capabilities in comparison to the IEEE 802.11g standard. The IEEE 802.11a standard operates at a frequency of 5 GHz, which is less susceptible to interference than the 2.4 GHz frequency used by IEEE 802.11g. These findings suggest that for applications requiring high speed and stability, IEEE 802.11a is a more suitable option [6].

Moreover, the study "Comparative Analysis of Performance and Quality of Service Between Default Firmware and Open WRT Firmware on Tp-Link MR3020 Access Points" revealed that Open WRT firmware outperforms the default firmware in terms of throughput, delay, and jitter parameters. Conversely, the default firmware demonstrated superior performance in packet loss parameters. Open WRT, as an open-source firmware, offers enhanced flexibility and optimization, which can enhance network performance in certain aspects. Nevertheless, with regard to the reliability of data packet transmission without loss, the default firmware remains the superior option [7].

The research, "Designing a Monitoring System with Video Streaming and Recording as a Classroom Monitor Using Open WRT-Based Webcam," demonstrates that using Open WRT in monitoring systems can be a cost-effective and practical alternative. With video streaming and recording capabilities, this system can provide effective room monitoring solutions. The incorporation of Open WRT allows for more flexible settings and is tailored to the specific needs of the user [8].

The study, entitled "Performance of 5 GHz WLAN Network Performance as an Alternative to 2.4 GHz WLAN in Office Areas," asserts that 5 GHz WLAN exhibits superior performance in comparison to 2.4 GHz WLAN, particularly in terms of throughput and delay. The 5 GHz frequency offers a greater number

of non-overlapping channels, which reduces interference and enhances network performance. This is particularly crucial in user-dense office environments [9].

The study, entitled "Analysis and Comparison of Wi-Fi Networks with Frequencies of 2.4 GHz and 5 GHz with the QoS Method," revealed that the 5 GHz frequency with the 802.11ac Wave 2 standards, exhibited superior data transmission speeds and signal quality compared to the 2.4 GHz frequency. The 802.11ac Wave 2 standard offers significant capacity and spectrum efficiency enhancements, which is highly advantageous for applications that necessitate high bandwidth [10].

The study "Quality of Service (QoS) Analysis of 2.4 GHz and 5 GHz Wireless Networks Indoors with Glass Barriers" examined the impact of physical barriers, such as glass, on the performance of wireless networks. The findings indicated that glass obstructions can impede the quality of service (QoS) of wireless networks, both at 2.4 GHz and 5 GHz frequencies. These physical barriers result in a decline in signal strength and an increase in latency, negatively affecting network performance [11].

The study titled "Analysis of Co-Channel Interference Impact on Wi-Fi Quality at 2.4 GHz Frequency" addresses the crucial influence of co-channel interference (CCI) on Wi-Fi network quality, focusing on throughput, delay, and packet loss parameters. Wi-Fi technology operates within the unlicensed ISM bands, particularly at 2.4 GHz and 5 GHz, enabling ubiquitous internet access. However, the unmanaged nature of ISM band usage often leads to interference issues such as CCI. The research aims to assess CCI's effects on Wi-Fi network quality by conducting experiments with four Access Points (APs), one serving users and the others acting as interfering APs. Wireshark software is employed to evaluate CCI. Results indicate a substantial 66.3% throughput decrease and a significant 187.4% delay increase due to the impact of three CCI instances. While the study assumes no traffic congestion for the 4-AP topology, leading to no recorded packet loss, it underscores the significant adverse effects of CCI on internet Quality of Service (QoS) for users, emphasizing the need for effective interference mitigation strategies in Wi-Fi networks [12].

The results of this literature review indicate that the 5 GHz frequency with the IEEE 802.11a and 802.11ac Wave 2 standards exhibits superior signal speed and quality compared to the 2.4 GHz frequency. Additionally, the Open WRT firmware demonstrates enhanced performance in certain Quality of Service (QoS) parameters when compared to the default firmware. However, it is important to note that the default firmware exhibits a slight advantage in terms of packet loss. The Open WRT implementation also provides a cost-effective and flexible solution for monitoring systems. Physical barriers such as glass affect the performance of wireless networks, emphasizing the importance of considering the physical environment in wireless network design. By synthesizing the findings from previous research, this research on the Comparative Analysis of Resource Usage on 2.4 GHz and 5.8 GHz Wireless LAN Networks with Open WRT Firmware Case Study is expected to provide a comprehensive understanding of the comparison of resource usage on wireless LAN networks with frequencies of 2.4 GHz and 5.8 GHz and demonstrate the potential and efficiency that can be achieved using Open WRT firmware.

III. RESEARCH METHOD

A. Method and Research Flow

The methodology employed in this research entails a literature review and observational data collection. The initial phase of the study entails identifying pertinent literature from previous studies that can serve as references and are relevant to the current research. This is followed by the selection of a research location that is conducive to the conduct of the study and the achievement of the desired outcomes. Subsequently, the preparation of tools and materials is of paramount importance, preceding the commencement of the research. This includes the installation of supporting applications and device configurations, such as the determination of the IP address to be utilized. After that, a connection test between devices is conducted.

The IP address configuration on the server utilizes IP address 192.168.2.3/24, which is employed when investigating wireless router devices in routing mode and for establishing connectivity between devices. Firewall security on server devices, clients, and test monitors is disabled to facilitate this process. The IP address configuration on the client in this study employs IP address 192.168.1.6/24, which will be utilized when conducting research on wireless router devices in routing mode with a wireless connection. The IP address configuration on the test monitoring laptop in this study utilizes the IP address on the LAN Ethernet port 1, specifically the IP address 192.168.1.2/24, to monitor the resource usage of wireless router devices

via the PuTTy network protocol application. The configuration of the wireless router's IP address on the WAN port employs the address 192.168.2.1/24, while the configuration on the LAN port utilizes the address 192.168.1.1/24. In the context of research, the mode utilized is routing mode. The position of the Wi-Fi interface, both at 2.4GHz and 5.8GHz, is connected to the Bridge-LAN. A server connection to the router is established via LAN cable media and is connected to the WAN port in routing mode. Additionally, the DHCP server menu in the OpenWRT application is disabled to prevent other devices from connecting to the wireless router.

B. Device Schematic

The device scheme in this study is presented in Figure 1 below. This research employed four devices: a server as a service provider, a router with routing mode as the media under test, a client used for interconnection testing, and a PC monitor for monitoring the results of testing and interconnection on router testing.
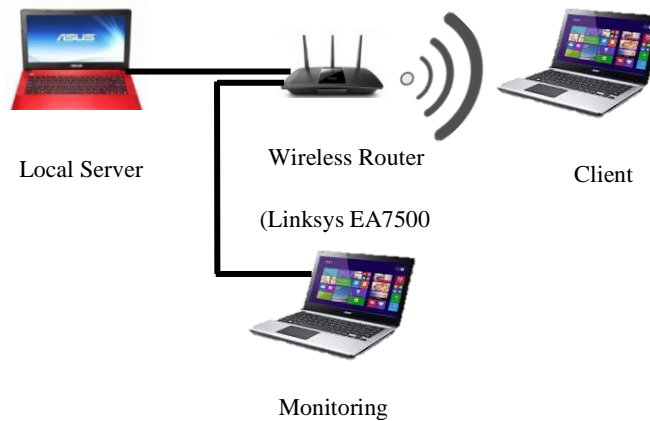

Figure 1. Device Schematic

C. Test Scenarios

The tests were conducted using several applications. First, the Channel Analyze feature in the OpenWrt firmware was used to test for network interference. Next, the IPerf3 application was employed to measure the throughput or real bandwidth received by the server and client from the wireless router. Additionally, the IPerf3, PuTTY, and HTop applications were downloaded to measure the throughput and CPU processor and RAM resource usage accessed by the tester's monitor device when the client downloaded files from the server using a wireless router as the connection medium.

Throughput and resource usage tests involved downloading the CentOS version 7 ISO file type using an Xampp-based local web server service. The client downloaded files through a wireless router set to routing mode at frequencies of 2.4 GHz and 5.8 GHz, alternating with the 40 MHz waveband, using a browser and IPerf3. Processor and RAM resource usage on the wireless router was measured using the HTop application installed on OpenWrt, accessed through the PuTTY application with the IP address hostname on port 22 and the SSH connection type on the test monitor device.

Data from throughput tests and resource usage on the wireless router were collected through screenshots and video recordings of the test process. These data were then converted into tables and graphs.

D. Interference Test Flowchart of 2.4 GHz and 5.8 GHz

The network interference test used features available on wireless routers with third-party firmware, specifically the Channel Analysis feature in OpenWrt firmware. The test continued until it achieved the least interference. If significant interference persisted, the test was paused and the channel or frequency was reset until the least or expected interference was achieved. The flowchart of Interference Test Flowchart of 2.4 GHz and 5.8 GHz Network is shown in Figure 2 below.
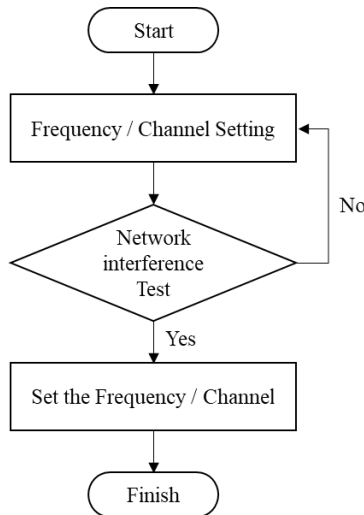
Figure 2. Interference Test Flowchart of 2.4 GHz and 5.8 GHz Network

E. Flowchart of Throughput Test of 2.4 GHz and 5.8 GHz Frequency Networks using IPerf3 Application

The flowchart of bandwidth measurement using IPerf is shown in Figure 3 below. The throughput test began by setting up the connection between two devices. Next, the connection to the Remote OpenWrt was established. Once connected to OpenWrt, IPerf3 was activated on both the PC server and the client. Subsequently, the bandwidth test was performed by the client. The test results were documented for further analysis. Bandwidth measurement was conducted on the server of the wireless router and the bandwidth received by the client from the wireless router. This measurement was performed offline. The command used for the server location was IPerf3 -s and for the client was IPerf3 -c server IP address -t 60.
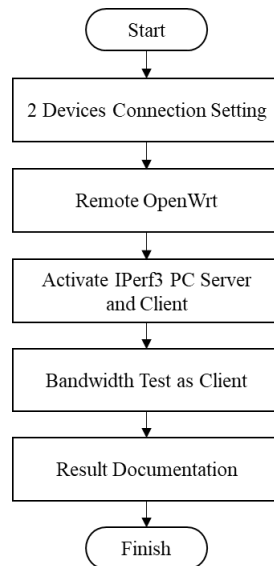

Figure 3. Flowchart of Throughput Test of 2.4 GHz and 5.8 GHz Frequency Networks using IPerf3 Application

F. Flowchart of network Throughput test Frequency 2.4 GHz standard 802.11n / 5.8 GHz when downloading files via HTTP protocol using HTop application

The procedure of 2.4 Ghz / 5.8 Ghz network throughput testing during download is shown in Figure 4 below. The throughput testing involves several critical steps to ensure accurate and reliable results. First, configure the connection settings between the two devices to establish a stable communication link. Once the devices are connected, connect to the Remote OpenWrt, the network's control center. Following this,

activate the web services on the computer server to facilitate data transmission and reception. Next, use HTop through PC monitoring to observe the system's performance and resource usage in real-time. Subsequently, perform the bandwidth test with one device as the client to measure the network's throughput. Finally, document the results meticulously to allow for thorough analysis and interpretation of the network's performance.

```
                    ┌─────────┐
                    │  Start  │
                    └─────────┘
                         │
         ┌───────────────────────────────┐
         │  2 Devices Connection Setting  │
         └───────────────────────────────┘
                         │
         ┌───────────────────────────────┐
         │        Remote OpenWrt          │
         └───────────────────────────────┘
                         │
         ┌───────────────────────────────┐
         │   Activate Web Services at     │
         │       Computer Server          │
         └───────────────────────────────┘
                         │
         ┌───────────────────────────────┐
         │     Access HTop through PC     │
         │          Monitoring            │
         └───────────────────────────────┘
                         │
         ┌───────────────────────────────┐
         │     Bandwidth Test as Client   │
         └───────────────────────────────┘
                         │
         ┌───────────────────────────────┐
         │      Result Documentation      │
         └───────────────────────────────┘
                         │
                    ┌─────────┐
                    │ Finish  │
                    └─────────┘
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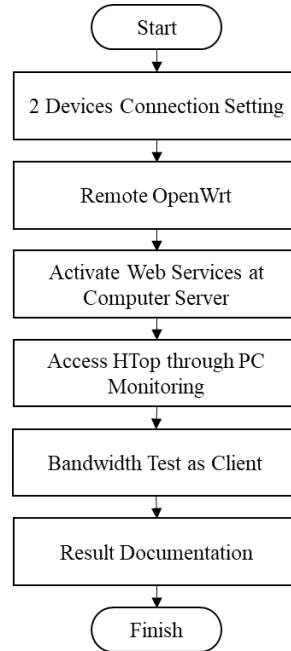
Figure 4. Flowchart of 2.4 GHz and 5.8 GHz Network Throughput Test when Downloading

Throughput and resource usage tests were conducted by downloading the CentOS version 7 ISO file using the Xampp-based local web server. The client accessed the server through a wireless router set to routing mode at frequencies of 2.4 GHz (standard 802.11n) and 5.8 GHz (standard 802.11ac), alternating with the 40 MHz wave band. The tests were performed offline using a browser and IPerf3.

Processor and RAM resource usage on the wireless router were measured while the client downloaded files from the server. This was done using the Htop application installed on OpenWrt, accessed via the PuTTY application using the router's IP address on port 22 and the SSH connection type on the test monitor device.

G. Data Analysis Formula

To get the results of the research and conclusions, there are of course calculation formulas that are used to process and complete the necessary data, including the following

1. Average Throughput

Calculation of average throughput or real bandwidth [13][14]

$$Bandwith\ Average = \frac{\Sigma\ Bandwidth\ Value}{Number\ of\ iterations} \tag{1}$$

Information:

Σ Bandwidth Value   : Number of bandwidth value

Number of Iterations   : Number of tests

Calculating the overall average CPU utilization [15]

$$CPU\ Average = \frac{\Sigma(X_1 + X_2 + X_3 + X_4)}{N} \tag{2}$$

Information:

Σ : Sum of Average per CPU

X   : Average per CPU

N   : Number of CPU

2. *Average RAM Usage*

Calculating average RAM usage [15]

$$Bandwidth\ Average = \frac{\Sigma\ RAM}{Number\ of\ iterations} \tag{3}$$

Information:

Σ RAM   : Number of value

Number of Iterations   : Number of tests

3. *Comparison of CPU Usage Between Frequencies*

The results of the calculations, expressed in equations (1) and (2), are then compared to obtain the percentage of CPU usage. The following is the calculation of the comparison of CPU usage between frequencies [10]

$$1\%\ from\ CPU = \frac{Bandwidth}{CPU\ Used} \tag{4}$$

4. *Comparison of RAM Usage Between Frequencies*

The results of the calculations, expressed in equations (3) are then compared to obtain the percentage of RAM usage. The following is the calculation of the comparison of RAM usage between frequencies [10]

$$1\%\ from\ RAM = \frac{Bandwidth}{RAM\ Used} \tag{5}$$

IV.   RESULT AND DISCUSSION

A. Network Interference Tests

The results of the 2.4 GHz Frequency Interference Test are shown in Figure 5. The presentation of these results should be straightforward. This section highlights the most important findings, including relevant statistical analyses and comparisons to other research results. Information presented in figures should not be duplicated in tables. Authors should clearly explain their discoveries in a logical sequence, ensuring clarity and coherence. This section should include appropriate references to support the findings.
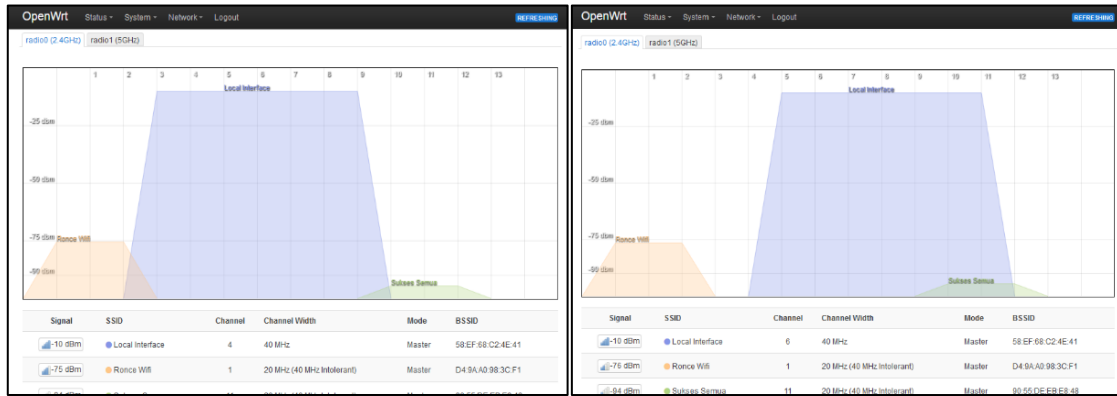
Figure 5. Frequency Interference 2.4 GHz Test

B. Throughtput or real bandwidth test

Observations of throughput data measurements at frequencies of 2.4 GHz and 5.8 GHz with the IPerf3 application with an interval of 0.00 to 60.00 iterations/test times are shown in the following Figure 6.
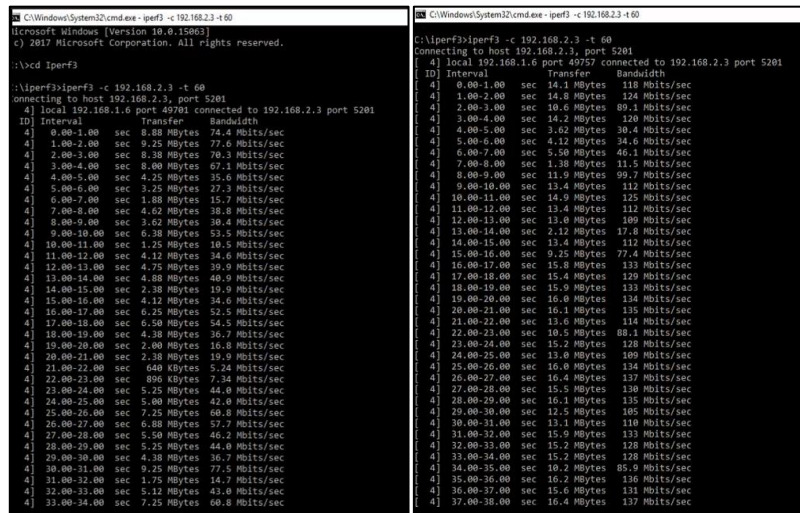

Figure 6. The 2.4 GHz and 5.8 GHz Frequency Throughput Test with IPerf3

C. Resource Usage Test of Router Devices at 2.4 GHz and 5.8 GHz Frequency

Observations of resource usage data measurements at frequencies of 2.4 GHz and 5.8 GHz with the HTop application when downloading the ISO file type with a capacity of 996,352 KB are shown in the following Figure 7.
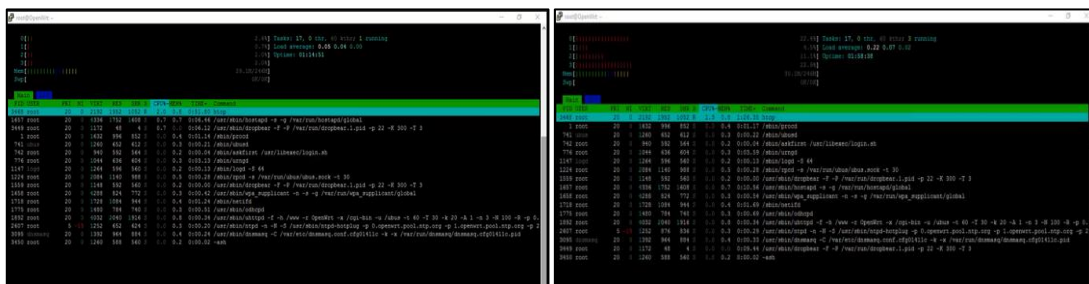
Figure 7. Resource Usage Test of Router Devices at 2.4 GHz and 5.8 GHz Frequency

D. Data Interpretation

Recap of Observation Results Measurement of throughput data at frequencies of 2.4 GHz and 5.8 GHz with the IPerf3 application with an interval of 0.00 to 60.00 iterations/test times. Based on the summary of the throughput test results in Figure 8, the throughput test at a frequency of 2.4 GHz with a transferred file of 300 Mbytes and 60-second iterations achieved an average of 42 Mbps, and at a frequency of 5.8 GHz with a file transfer of 708 Mbytes achieved an average of 98.9 Mbps. In addition, the results of the Device Resource Usage Measurement Observation when measuring throughput data at a frequency of 2.4 GHz using the HTop application with an interval of 0.00 to 60.00 iterations/test times are shown in Figure 8.
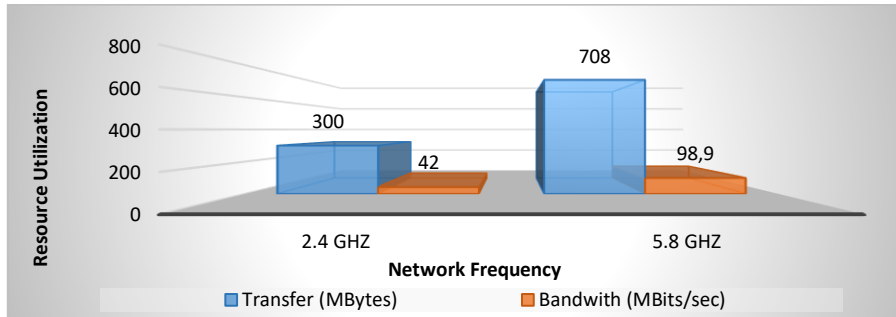
Figure 8. Throughput Testing Recap Chart using IPerf3

Then, the average resource usage of each CPU and RAM is calculated from the data in Figure 9. The average resource usage of the Figure 8 data on CPU0 is 13.54%, CPU1 is 4.26%, CPU2 is 12.35%, and CPU3 is 17.20%. The average total CPU usage (CPU0, CPU1, CPU2, and CPU3) is 11.83%. The average RAM usage from the data in Figure 8 is 12.13% of RAM with a capacity of 246MB.
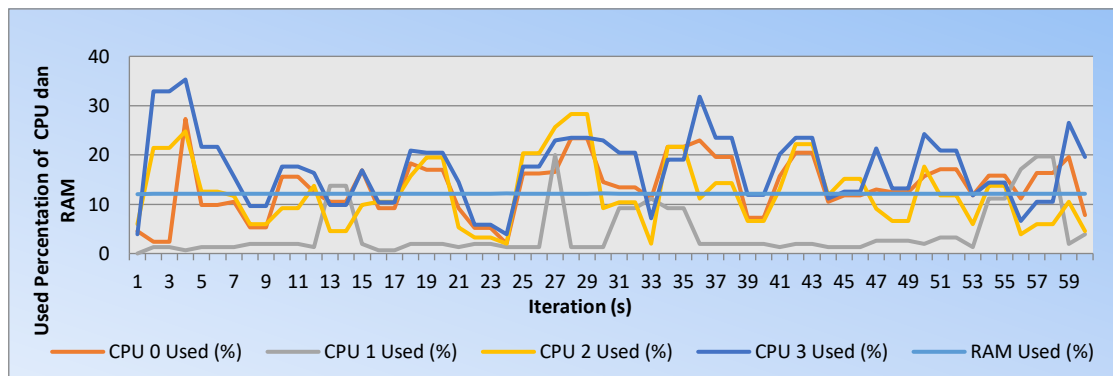

Figure 9. Throughput Testing Recap Chart using HTop

The observation results of the device resource utilization measurement when measuring throughput data at a frequency of 5.8 GHz standard 802.11ac using the HTop application with an interval of 0.00 to 60.00 iterations/test times are shown in Figure 10 below.
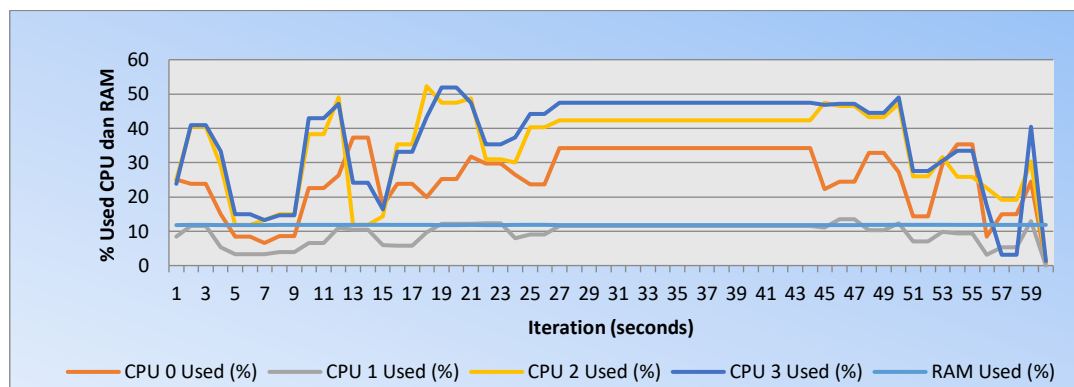

Figure 10. HTop Measurement Result of Resource Usage at 5.8 GHz Frequency during Throughput Test

In addition, the data in Figure 10 is averaged using equation (4). The average calculation result on CPU0 is 25.79%, CPU1 is 9.38%, CPU2 is 34.45%, and CPU3 is 36.94%. Thus, the average total CPU usage is 26.64% of the four processors used. Then for the average RAM usage obtained 11.81% of RAM with a capacity of 246MB.

Then observation of device resource usage measurement when downloading files at a frequency of 2.4 GHz standard 802.11n with the Htop application produces data on the percentage of CPU and RAM usage with a capacity of 996,352 KB with iterations of 260 seconds. The measurement data is shown in Figure 11 below.
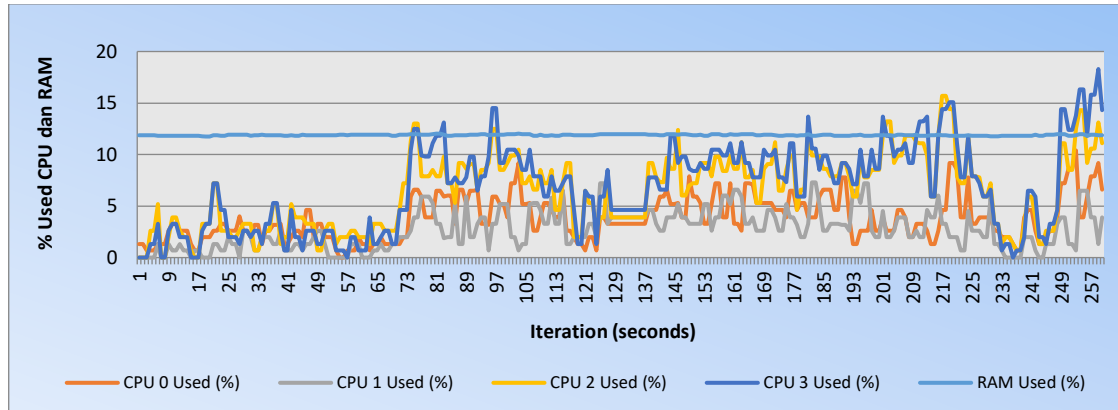

Figure 11. HTop Measurement Result of Resource Usage when Downloading at 2.4 GHz Frequency

The percentage data of CPU and RAM usage for each iteration in Figure 11 is then calculated using equation (2) for the average CPU and equation (3) for the average RAM. The average calculation result of resource usage on CPU0 is 3.81%, CPU1 is 2.69%, CPU2 is 6.42%, and CPU3 is 6.77%. Thus, the total CPU usage (CPU0, CPU1, CPU2, and CPU3) is 4.92% of the four processors used on average. The average calculation result of RAM usage is 11.88% of RAM with a capacity of 246MB.

In addition, observations of device resource utilization measurements when downloading an ISO file type with a capacity of 996,352 KB at a frequency of 5.8 GHz 802.11ac standard using the Htop application with 62-second iterations are shown in Figure 12 below.
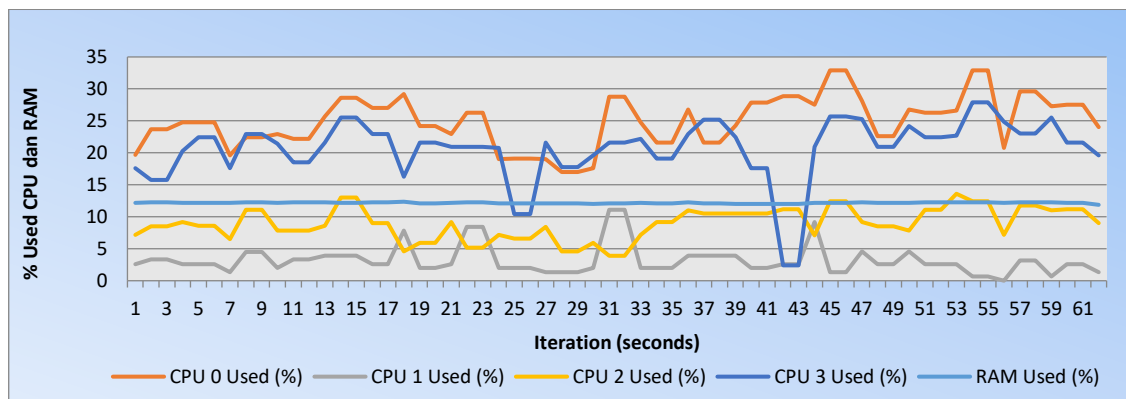

Figure 12. HTop measurement result of resource usage when downloading at 5.8 GHz frequency

The percentage data of CPU and RAM usage for each iteration in Figure 12 is then calculated using equation (2) for the average CPU and equation (3) for the average RAM. The average calculation result of resource usage on CPU0 is 24.98%, CPU1 is 3.19%, CPU2 is 8.93%, and CPU3 is 20.65%. Thus, the total CPU usage (CPU0, CPU1, CPU2, and CPU3) is 14.44% of the four processors used, when averaged. Then, for the average RAM usage, we get 12.16% of RAM with a capacity of 246MB.

Furthermore, the summary of the observations of the speed test for downloading files with a capacity of 996,352 KB at a frequency of 2.4 GHz and 5.8 GHz with HTop is presented in Figure 13 below.
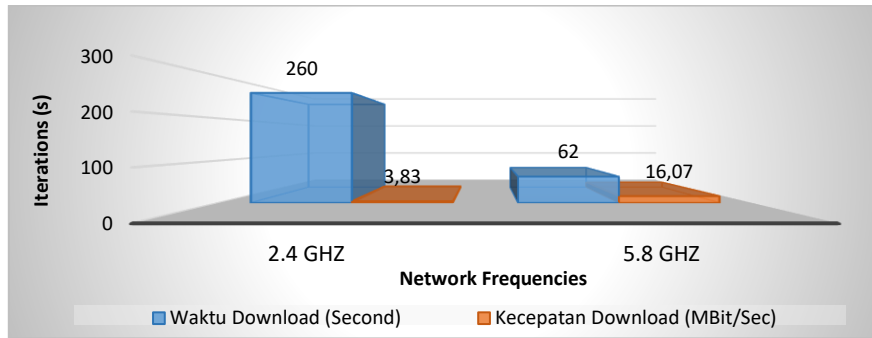
Figure 13. Graph of Download Speed Test at Frequencies of 2.4 GHz and 5.8 GHz

After testing the download speed of the ISO file type with a capacity of 996,352 KB via wireless LAN at a frequency of 2.4 GHz and 5.8 GHz, it was found that the download speed at a frequency of 2.4 GHz requires a download time of 260 seconds with a bandwidth of 3. 83 Mbits/second and at a frequency of 5.8 GHz requires a time of 62 seconds with a bandwidth of 16.07 Mbits/second, which shows that the time required by a frequency of 2.4 GHz takes more time than 5.8 GHz which is 4 times to download a file with the same extension and capacity.

E. Discussion

From the results of tests conducted, it was found that the comparison between frequencies on CPU utilization, namely in testing the use of CPU frequency 2.4 GHz 802.11n standard, it was found that the throughput obtained was 3.83 Mbit/sec and the average percentage of CPU used was 4.93% of the total CPU, then the results obtained from the division of bandwidth divided by CPU used were 0.78 Mbit/sec. This means that every 1% utilization of CPU is able to transfer 0.78 Mbps of data. While in testing the use of CPU frequency 5.8 GHz standard 802. 11ac obtained that the throughput obtained is 16.07 Mbits/sec and the average percentage of CPU used is 14.44% of the total CPU, then the results obtained from the division of Bandwidth divided by CPU used are 1.11 Mbits/sec. This means that every 1% of CPU can be used to transfer 1.11 Mbps of data. The 5.8 GHz frequency with 802.11ac standard has higher throughput and better CPU utilization efficiency than the 2.4 GHz frequency with 802.11n standard due to several key factors: newer and more advanced technology, wider channel width, better modulation technique (256-QAM), less interference, cleaner and non-overlapping channels, and the use of MU-MIMO (Multi-User Multiple Input Multiple Output) technology. All these factors allow the 5.8 GHz frequency to transmit more data with more efficient CPU utilization.

In testing the use of RAM frequency 2.4 GHz 802.11n standard, it is found that the throughput obtained is 3.83 Mbit / sec and the average percentage of RAM used is 11.88% of the total RAM, then the results obtained from the division of bandwidth divided by RAM used is 0.32 Mbit / sec. This means that every 1% of RAM can be used to transfer data at 0.32 Mbps. Meanwhile, in testing the use of RAM frequency 5.8 GHz 802.11ac standard, it is found that the throughput obtained is 3.83 Mbit / sec and the average percentage of RAM used is 12.16% of the total RAM, then the result of the division of bandwidth divided by RAM used is 1.32 Mbit / sec. This means that every 1% of the CPU can be used to transfer 1.32 Mbps of data. The 5.8 GHz frequency with the 802.11ac standard has a higher RAM usage efficiency than the 2.4 GHz frequency with the 802.11n standard due to several key factors: more advanced technology with 802.11ac, channel width up to 160 MHz, more efficient 256-QAM modulation, and the use of MU-MIMO, which allows data to be sent to multiple devices in parallel. Although the percentage of RAM usage is slightly higher, the efficiency of data processing and transmission is much better, allowing each 1% of RAM to transfer 1.32 Mbps versus 0.32 Mbps at 2.4 GHz, making it a superior choice in favorable conditions.

V.   CONCLUSION

Throughput of data transfer using frequency network 2.4 GHz standard 802.11n and 5.8 GHz standard 802.11ac, which is set with a frequency range of 40 MHz, obtained data throughput frequency 2.4 GHz of 3.83 Mbit/sec or 30.64 MBps and at a frequency of 5.8 GHz of 16.07 Mbit/sec or 128.56 MBps. The use of 5.8 GHz frequency in the same frequency range (40Mhz) results in higher throughput. While the use of CPU and RAM at a frequency of 2.4 GHz, the use of CPU concluded that every 1% utilization of the CPU

is able to transfer data 0.78 Mbit/sec or 6.24 MBps and for a frequency of 5.8 GHz is 1.11 Mbit/sec or 8.88 MBps. While in the use of RAM, it is concluded that every 1% of RAM can be used to transfer data 0.32 Mbit/sec or 2.56 MBps for frequency 2.4 GHz and frequency 5.8 GHz which is 1.32 Mbit/sec or 10.56 MBps. Based on the conclusions from the above test results, the 5.8 GHz frequency with the 802.11ac standard is significantly better than the 2.4 GHz frequency with the 802.11n standard in terms of throughput, CPU and RAM usage efficiency, and connection stability. The newer technologies in 802.11ac, including a wider channel width, more efficient modulation, and better resource management, provide a clear advantage in network performance..

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