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Energy Efficiency Analysis of Network Slicing Algorithm on WiFI Network

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Abstract

The 5G network generation is a modern innovation after it was first introduced by the New Generation Mobile Network (NGMN). The rapid development of mobile devices is marked by the number of companies launching mobile devices with the latest network connection technology, namely the 5G network. In addition, the rapid development of technology has led to an increase in the number of network requirements that are increasingly current. The development of network virtualization and software network functions is proposed as Network Slicing technology. Network Slicing can integrate and distribute independent network resources so that users get services with low latency and high-reliability requirements. The Network Slicing algorithm can reduce energy wastage when used and aims to divide and allocate network resources into several parts in proportion to the expected resource ratio or priority.

Keywords: WiFI Network, 5G Network, Network Slicing

Abstrak

Generasi jaringan 5G merupakan inovasi masa kini setelah diperkenalkan pertama kali oleh *New Generation Mobile Network (NGMN).* Pesatnya perkembangan perangkat seluler saat ini ditandai dengan banyaknya perusahaan perangkat seluler yang meluncurkan perangkat seluler dengan teknologi koneksi jaringan terbaru yaitu jaringan 5G. Selain itu, meningkatnya perkembangan teknologi yang begitu cepat menyebabkan terjadinya peningkatan jumlah kebutuhan jaringan yang semakin terkini. Pengembangan fungsi jaringan virtualisasi dan jaringan perangkat lunak maka diusulkanlah teknologi *Network Slicing*. *Network Slicing* dapat mengintegrasikan dan mendstribusikan sumber daya jaringan yang independent sehingga pengguna mendapatkan layanan dengan *low-latency* dan *high reliability requirements*. Algoritma *Network Slicing* dapat mengurangi pemborosan energi saat digunakan dan bertujuan untuk membagi dan mengalokasikan sumber daya jaringan menjadi beberapa bagian secara proporsional dengan rasio sumber daya atau prioritas yang diharapkan.

Kata Kunci: Jaringan WiFI, Jaringan 5G, Network Slicing

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I. Introduction

Networking is one of the things in a connection between one device and another. The network is also essential in forming packet delivery traffic from one device to another. The current phenomenon is strongly associated with 5G networks, where the Network Slicing technique is essential in the context of 5G. The 5G connection introduce by the Next Generation Mobile Network (NGMN). Network Slicing provides accommodation across a shared infrastructure allocated to different types of resources according to user needs [1].

The rapid development of mobile devices today is marked by the number of companies launching mobile devices with the latest network connection technology, namely 5G. Mobile devices are very close to life and have become an essential part of doing daily activities. The service orientation of the mobile device architecture transforms into a flexible structure and leverages technologies such as Software Define Network (SDN) and Network Function Virtualization (NFV). The framework of the 5G architecture consists of infrastructure, network functions, network service layers, and cross-sectoral service aspects of Management and Orchestration (MANO) [2].

The number of network service providers in Indonesia compares scalability, performance, and performance for the application of internet network coverage areas. In addition, the evaluation of the performance analysis of internet network service providers expects to support productivity for the community. The Network Service Provider (NSP) analyzed that the performance and scalability of the 5G Network Slicing (5GNSL) network had varied workloads. However, NSP has also adopted modeling and evaluation lines to carry out in-depth scalability and performance investigations of 5GNSL networks [3].

Mobile technology in industry 4.0 and communication networks are critical to daily activities. In addition, the increasing number of devices due to the rapid development of technology in its distribution has led to an increase in network requirements that are increasingly current and have more comprehensive coverage areas. Network Slicing technology proposes the development of network virtualization and software network functions. Thus, Network Slicing can provide a viable 5G network services solution. Network Slicing can integrate and distribute independent network resources so that users get services with low latency and high-reliability requirements [5].

The 5G network generation is one of today's innovations with relatively fast technological developments. The mobility of the 5G network is said to be very dynamic, accompanied by the faster generation of mobile devices and networks embedded with technology that can capture the 5Ghz frequency. 5G network adaptation is followed by user mobility situations, changing frequency conditions, and dynamic distribution of network traffic loads. Network architecture innovation is significant in 5G, namely Network Slicing. The advantage of Network Slicing on the 5G network is that it can allocate network resources to increase energy efficiency used on the same network device infrastructure [11]. The study uses the Network Slicing algorithm on a WiFI network because the 5G network has a reasonably large scale and can be more flexible by breaking down network resources from energy use on network devices. The research results expect to provide analysis results and recommendations for further research related to energy efficiency using the Network Slicing algorithm on WiFI networks.

II. Literature Review

This section will explain the theory and methodology used in this research. The discussion explains previous research and theoretical basis.

A. WiFI Network

WiFI network is a network technology that does not use wires or wireless. WiFI networks can share data access faster, adding network capabilities and WiFI infrastructure that can use simultaneously. Chambers [9] states that the WiFI Alliance defines a WiFI network as a wireless local area network (WLAN) product based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards.

B. 5G Network

Several contexts concerning radio access technology consider in 5G networks. In the latest technology, the 5G network provides WiFI-based RAN technology. 5G networks can be accounted for by a slicing approach that is compatible with the IEEE 802.11 standard to obtain 5G Quality of Service Identifiers (5GQIs) during slicing and in real-time for resource management [2].

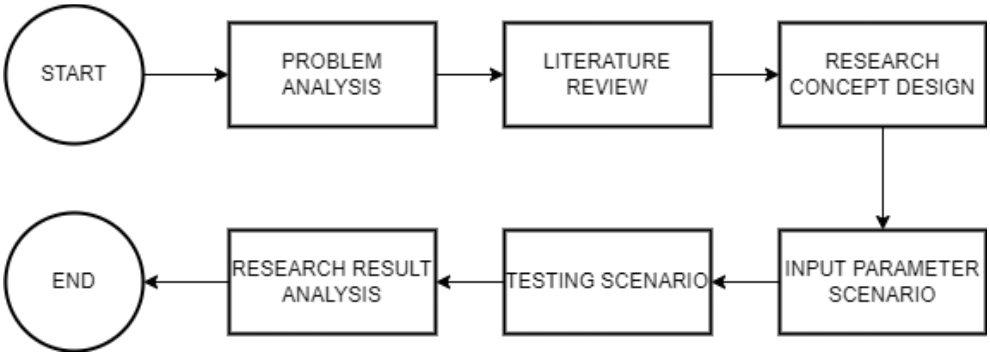
5G networks can distribute channels with a relatively large coverage area. In addition, the 5G network strengthens the network for mobile use with greater bandwidth capacity. The broad spectrum selection provides the best combination of high capacity, bandwidth, coverage area, and ultra-reliability. The main spectrum options in the early phase of 5G networks reach around 3.5 GHz and 4.5 GHz with millimeter waves at 24-28 GHz and 39 GHz with Time Division Duplex (TDD) technology [10].

C. Network Slicing

In the time domain, planning for each access point (AP) is equipped with a local scheduler that performs Network Slicing. Richart et al. [2] Stating that the presentation of a WiFI Network Slicing solution aims to allocate airtime resources to different slicing. Airtime will be allocated to the slice if sufficient resources are available, and a slice will request a percentage of the total airtime. The reason for the inefficiency of the WiFI standard is that the Medium Access Control (MAC) layer will randomly allocate all available channels to only one user as a single resource which is an entirely new access scheme for Network Slicing proposed by Makhlouf et al. Gu et al. Propose to generate a multi-tenant architecture on an AP by implementing different Service Set Identifiers (SSID) to realize separate networks that coexist and increase overall network throughput [2].

III. Research Methodology

This research method is designed in a structured manner in order to produce maximum results from the research objectives. Several steps were taken as a research method, namely by using a research flow chart so that this research could run systematically. The following is a research flowchart using a flowchart.



Fig, 1 Research Flow Chart

1. Analysis of the problem is the initial stage wherein carrying out this research; the author analyzes the 5G network, which is starting to be spread through radio network frequencies, to measure the level of energy efficiency on the WiFI network. Furthermore, the authors conducted a literature study from previous research to design a research design from the problem constraints, namely the energy efficiency of using 5G networks on WiFI.
2. Literature review is the second stage where the author identifies previous research to be used as a reference and as an evaluation for the research carried out. In addition, this stage can also use by the author as a theoretical basis that compiles systematically.
3. The design of the research concept is the third stage where the author prepares a research design of the 5G network as in the simulation scenario that will be tested especially for the analysis of the energy efficiency used.
4. Scenario parameter input is the fourth stage where the author inputs the parameters compiled from the scenario to analyze the results of 5G network energy efficiency on WiFI. This parameter is used as a benchmark to get the 5G network research results on WiFI.
5. Testing is the fifth stage, where the author runs an algorithm program compiled on a network simulator to get the 5G network energy efficiency results on WiFI. Furthermore, the test results will be processed and analyzed to obtain maximum research results.
6. Analysis of test results is the sixth or last stage, where the author analyzes the results of the tests carried out to get the purpose of the research results.

A. Simulation Scenario

Before testing, measuring the energy efficiency level on the Network Slicing algorithm requires a scenario so that when running the simulation, it runs systematically and gets the expected results. The simulation scenario adapts to a case study on the energy efficiency of the Network Slicing algorithm on a 5G network on mobile devices, as shown in figure 2. Some of the devices used for testing this research describe. Table 1 shows the network devices used to test the WiFI network on mobile devices to measure the level of energy efficiency used.

TABLE I
NETWORK DEVICE

Network Device	Information Detail
Access Point	HG6145F support 5 GHz
Transmitted Power	1.90 dBm
Received Power	-20.51 dBm
Supply Voltage	3.27 V
Power rating	1.5 – 1.7 A
Network Interface Card	IEEE 802.11 a/n/ac
Bandwith	50 Mbps
Frequency Bandwith	80 MHz
Mobile Device	Xiaomi Mi 10T Pro 5G & Xiaomi Poco F3 Pro 5G

The simulation scenario run is in a room with a width of 3 meters and a room length of 5 meters. This scenario is run by connecting two mobile devices embedded with network band technology that supports 5 GHz. After that, the mobile device starts accessing the internet from the connected WiFI network to be able to capture data usage. Furthermore, network devices that have provided WiFI network access to mobile devices will work and generate energy consumption from the deployment of WiFI network access.

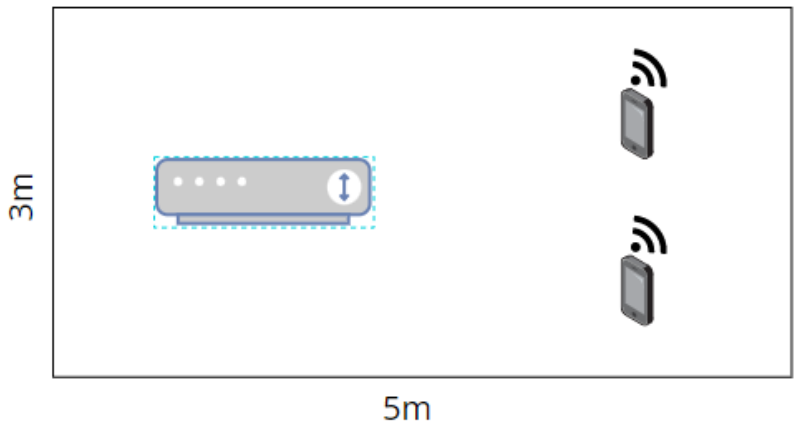


Fig. 2 Simulation Scenario

B. WiFI Network Scenario Parameters

The parameters that will carry out in this study are the benchmarks for obtaining the level of energy efficiency of the Network Slicing algorithm on a WiFI network. Furthermore, several parameters will be tested in this study as described in table 1, showing the parameters that initiate to perform the test.

TABLE II
SCENARIO PARAMETERS

Parameter	Parameter Value
Physical Model	Spectrum
Network Band	AC_5, AX_5
Simulation Time	30 seconds
Tx_Power	20 dBm
Channel_width	20 MHz

The method used in this study is to use a simulation scenario and determine the parameters that will be the benchmark for energy efficiency in the WiFI network. Simulation scenarios use to run the Network Slicing algorithm on a WiFI network to get the energy use results after using the Network Slicing algorithm on a WiFI network. This method is used for testing on physical network devices to get the results of the energy used when using the Network Slicing algorithm on a WiFI network.

IV. RESULTS AND DISCUSSION

The scenario testing results show that the network-slicing algorithm's energy efficiency on a WiFI network affects cable attenuation in different Network Bands that can capture frequencies from 2.4 GHz to 5 GHz and 6 GHz. Figure 3 showed that when the test was carried out, several network parameters were used to measure the energy efficiency level of the Network Slicing algorithm on a WiFI network. It can be seen that the network standards used for research are 802.11.AC and 802.11.AX by capturing frequencies from 2.4 GHz, 5 GHz to 6 GHz.

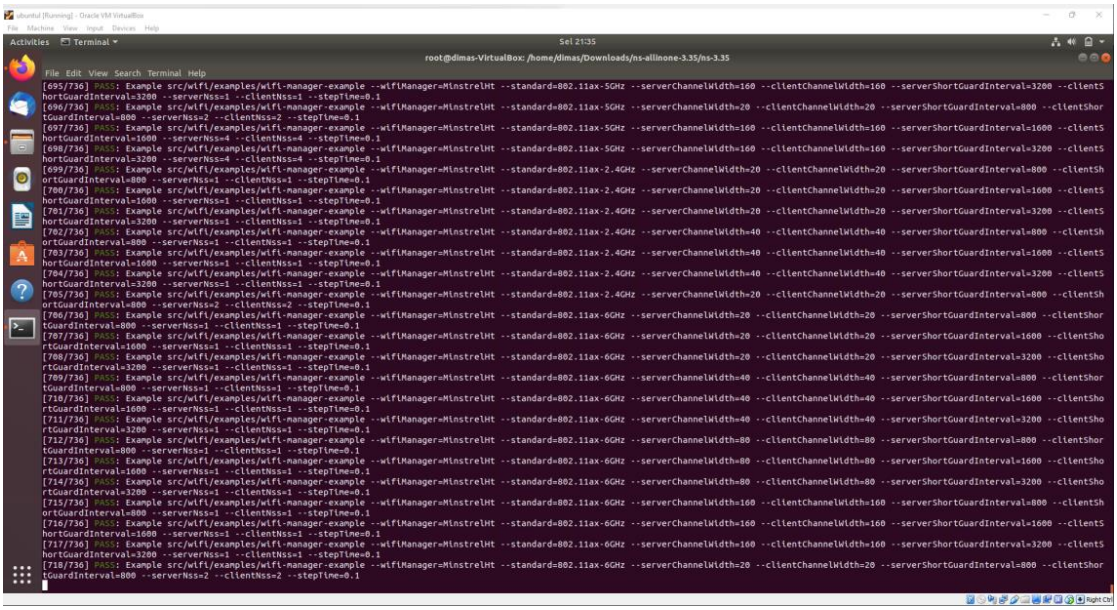


Fig. 3 Testing Process

Figure 4 shows the results of running the Network Slicing algorithm to get the test results. After running the Network Slicing algorithm, the testing process has been completed and will save in the format that initiates the Network Slicing algorithm. Some performances can also capture from the results of running the Network Slicing algorithm.

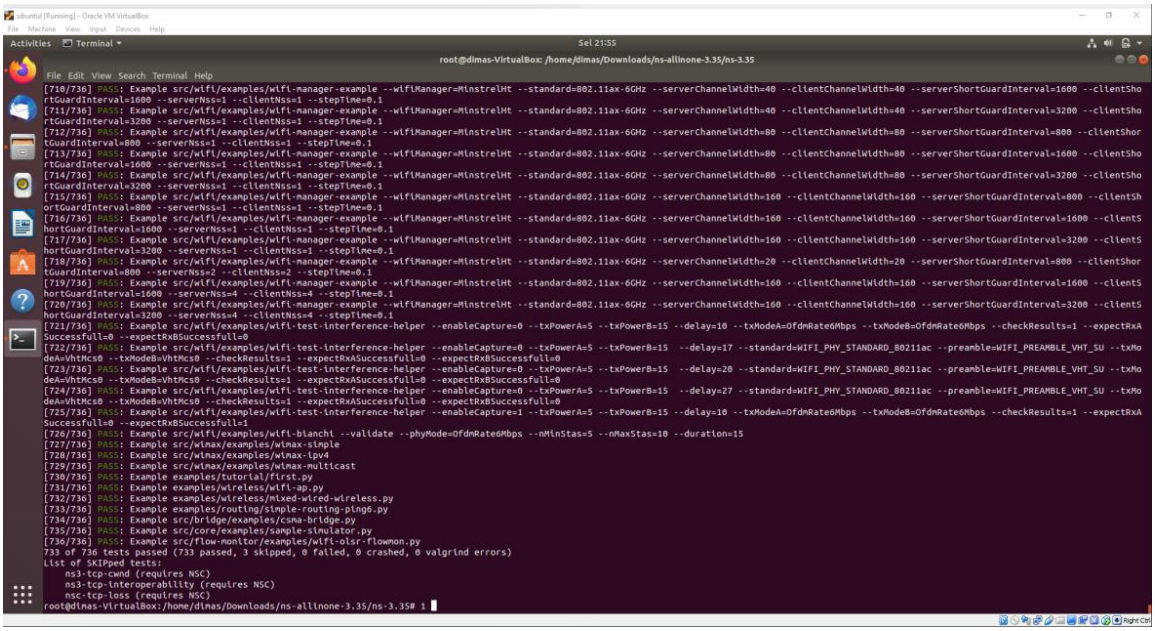


Fig. 4 Testing Results

Table III shows the algorithm's initiation and the data initiation format test formed. The initiation format in Table III intends to see the results of the data obtained after the testing process to analyze the quality of the data taken on the WiFI network.

TABLE III
TEST INITIATION FORMAT

From IdTo IdTxMeta				
channelNumber	ChannelWidth	gi	mcs	txPower
36	20	800	5	20
100	200	800	5	20
153	20	800	5	20

Figure 5 shows the data generated from running the Network Slicing algorithm on a WiFI network with a frequency of 5 GHz. In addition, for analyzing the results of the data obtained, it can be concluded from previous research that the performance quality of the access provided by network devices to mobile devices using the Network Slicing algorithm can guarantee better energy savings.

97	19.7058	6.60734	8237	1489	352.902
92	6.82402	7.20681	7812	1020	371.178
90	2.57566	4.1689	7642	930	322.949
88	1.68068	2.93441	7472	1530	451.223
87	16.708	5.11087	7387	94	19.0209
96	2.85695	9.02856	8152	155	702.801
47	8.94646	6.47048	3	3	17.4361
41	7.81375	3.29978	3	3	24.8574
38	7.19636	6.03087	3	3	21.0902
30	8.12122	4.5676	2	2	15.0304
39	7.77911	6.4921	3	3	23.7584

Fig. 5 Network Slicing algorithm data results on WiFI

The test results shown in figure 6 are the final data of the testing process from the WiFI network used by 5G mobile devices. At the end of the data testing process, the results obtained are pretty good so that the quality of the data provided for mobile devices can be stated to be better using the 5 GHz frequency and can also reduce the energy required by network devices when providing WiFI network access to mobile devices.

50	10.3783	2.95506	4	4	4.24673
48	15.3986	6.48535	4	4	13.4592
50	17.6775	4.27616	4	4	4.57348
46	4.62925	6.0432	3	3	17.8359
31	5.58221	2.43517	2	2	18.1321
40	13.6894	6.12185	3	3	21.9731
33	18.5423	7.29093	2	2	21.7448
43	17.8256	1.77806	3	3	24.5711
39	1.38654	7.48977	3311	2537	94.0485
34	14.696	8.31155	2887	2644	54.6977

Fig. 6 End of the Network Slicing algorithm data process on WiFI

From what was discussed, the research results show that when using a WiFI network that captures frequencies from 5 GHz to 6 GHz, it can cause high cable attenuation at a frequency of 6 GHz so that data quality is disrupted and causes a decrease as well as a reduction in the transmission of incoming signals. To the cable due to the higher attenuation of the cable. Meanwhile, running at a frequency of 5 GHz can reduce the energy needed so that at a frequency of 5 GHz, the energy efficiency used is better by using the Network Slicing algorithm.

Based on the results that have been analyzed against scenario testing to measure the level of energy efficiency of the Network Slicing algorithm on a WiFI network. The devices used include an Access Point (AP) with the HG6145F model supporting 5 GHz and using mobile devices, namely the Xiaomi Mi 10T Pro 5G and Xiaomi Poco F3 Pro 5G. The results obtained from the test are that the cable attenuation is relatively high because the radio frequency reaches 6 GHz. In comparison, if the AP catches the 5 GHz frequency, it can reduce the voltage and not cause cable attenuation at the 6 GHz frequency.

The increase in cable attenuation at the 6 GHz frequency, initially -20.51 dBm, increased significantly to -40.00 dBm, which caused mass disturbances to the Internet Service Provider (ISP) due to capturing radio frequencies that were too high. In addition, a frequency of 5 GHz provides energy efficiency used. The voltage used in the AP has increased significantly when capturing the 6 GHz frequency, which was initially at 3.27 V to 3.61 V.

The results obtained in testing WiFI networks with a frequency of 5 GHz are getting optical results; yes, the ISP gets a relatively constant received power of – 20.46 dBm, causing the Network Slicing algorithm to provide

a reasonable allocation of network resources. Furthermore, the results on energy efficiency can see from the supply voltage, which was initially 3.27 V to 3.00 V. These results indicate that the Network Slicing algorithm can save energy use on network devices. Figure 7 shows information regarding the optical connection to the network device.

Optical Info	
Transmitted Power	1.82 dBm
Received Power	-20.46 dBm
Operating Temperature	51.91 °C
Supply Voltage	3.00 V
Bias Current	9.59 mA

Fig. 7 Detail Optical Information

In previous studies, the results obtained from the analysis of the performance of the Network Slicing algorithm on the WiFI network have not explained the results of the energy efficiency used when running the Network Slicing algorithm to obtain efficient energy results and also get results that exceed the frequency capacity that uses as research, namely 6 GHz. At a frequency of 5 GHz, it proves that the Network Slicing algorithm can reduce network energy resources so that it can be said to be efficient to apply to WiFI networks. In addition, the difference with previous research is in the benchmark parameters that will be the study results. Previous studies have described several performance benchmarks using the Network Slicing algorithm, including throughput, latency, and packet error. In contrast, this study describes energy use by applying the Network Slicing algorithm on a WiFI network that measures energy resources, with one example being voltage.

V. Conclusion

The conclusion that can draw from the results of this study is the efficiency of energy resources used in the WiFI network using the Network Slicing algorithm with a frequency of 5 GHz to get a decrease in voltage energy on network devices using Network Slicing algorithm so that it can be said that the allocation of energy resources using the Network Slicing algorithm. A WiFI network saves energy when in use. In addition, if the more significant the frequency captured in the AP will result in an increase in cable attenuation and also the temperature on the AP, so the energy used increases significantly as well as an increase in voltage on AP, which makes cable attenuation increase at a frequency of 6 GHz.

The urgency that can use as a result of this research is that it can be a recommendation for the use of the Network Slicing algorithm on a WiFI network that can save energy and make efficient use of network resources because using the Network Slicing algorithm, the allocation of network resources can be efficient in saving energy when used. The results of this study can use as a reference for further research related to energy efficiency using the Network Slicing algorithm on WiFI networks in the future.

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References

[1] Growitsch, Christian, Tooraj Jamasb, and Michael Pollitt. "Quality of service, efficiency and scale in network industries: an analysis of European electricity distribution." *Applied Economics* 41.20 (2009): 2555-2570.
[2] M. Nerini and D. Palma, "5G Network Slicing for Wi-Fi Networks," 2021 IFIP/IEEE International Symposium on Integrated Network Management (IM), 2021, pp. 633-637.
[3] Foukas, Xenofon, et al. "Network slicing in 5G: Survey and challenges." *IEEE communications magazine* 55.5 (2017): 94-100.
[4] Arteaga, Carlos Hernan Tobar, Armando Ordoñez, and Oscar Mauricio Caicedo Rendon. "Scalability and performance analysis in 5G core network slicing." *IEEE Access* 8 (2020): 142086-142100.
[5] Hao, Yixue, et al. "Network slicing technology in a 5G wearable network." *IEEE Communications Standards Magazine* 2.1 (2018): 66-71.
[6] Richart, Matías, et al. "Slicing with guaranteed quality of service in wifi networks." *IEEE Transactions on Network and Service Management* 17.3 (2020): 1822-1837.
[7] Roberts, Lawrence G., and Barry D. Wessler. "Computer network development to achieve resource sharing." *Proceedings of the May 5-7, 1970, spring joint computer conference*. 1970.
[8] Morgan, David E., et al. "A computer network monitoring system." *IEEE Transactions on Software Engineering* 3 (1975): 299-311.
[9] Musyafa, Radhif Irzan. *Implementasi Algoritma Adaptive Wi-Fi Offloading Pada Simulasi Parameter Jaringan 5G*. Diss. Institut Teknologi Sepuluh Nopember, 2019.
[10] DESI, RIANTI. *Perancangan dan simulasi indoor 5g frekuensi 3500 mhz menggunakan radiowave propogation simulator 5.4 di pt. Sutanto arifchandra electronic*. Diss. Institut Teknologi Telkom Purwokerto, 2019.
[11] Shen, Xuemin, et al. "AI-assisted network-slicing based next-generation wireless networks." *IEEE Open Journal of Vehicular Technology* 1 (2020): 45-66.
[12] Kim, Kyu-Han, et al. "Improving energy efficiency of Wi-Fi sensing on smartphones." *2011 Proceedings IEEE INFOCOM*. IEEE, 2011.
[13] Gomez, Karina, et al. "Analysing the energy consumption behaviour of WiFi networks." *2011 IEEE Online Conference on Green Communications*. IEEE, 2011.