Analysis of The Effectiveness of Online Electronic Learning System Using Data Traffic Network Performance Management to Succeed Merdeka Learning – Merdeka Campus During the Covid-19 Pandemic

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Abstract—**The problems in the Covid-19 pandemic have a major influence on the field of education with the use of technology to support the teaching and learning process to facilitate students who do home learning activities. The proposed concept of freedom of learning is a more comprehensive concept such as portfolio and assignments such as group assignments, writings, and so on that are done in full online by adding additional features such as Teaching and Learning Activities and Assessment through information technology media. (E-Learning / Learning Management System). The method proposed in this research is the Peer Connection Queue (PCQ) method on mikrotik operating systems. PCQ method is a program to manage network traffic in Quality of Services (QoS). Bandwidth management methods. The hypothesis formulated is to create bandwidth management with PCQ so that bandwidth sharing is automatically and evenly distributed to multi clients. Therefore, in this research finally formulated into the goal of E-Learning effectiveness analysis using bandwidth management analysis method, which will be measured and analyzed in this research is throughput, delay, jitter, and packet loss. So that the final result of this research obtained the feasibility of the teaching and learning process that is carried out effectively.**

Keywords—**Delay, Troughput, Packet Loss, Education**

I. INTRODUCTION

THE The Covid-19 pandemic, which hit the world in early 2020, has forced many organizations to undergo significant transformations to rapidly change the order of people's lives, including Indonesia. The world of education has been forced to replace face-to-face learning with online learning (Giatman et al, 2020). This study offers collective insight into many of the key issues and fundamental complexities affecting organizations and communities from COVID-19, through information systems and technological perspectives. Expert perspectives offer timely insights into a variety of topics, identifying key issues and recommendations for theory and practice (Dwivedi et al, 2020). The advantages of School From Home (SFH) activities include flexibility in completing work, not following working hours, no need to spend money to pay transportation costs or gasoline costs, can minimize the level of stress experienced in addition to traffic jams from home to school, have more free time. The disadvantage of School From Home (SFH) is that it can lose learning motivation, bear the cost of electricity and internet, can cause data security problems (Purwanto et al, 2020). Description of the appropriate learning process to be applied during the Covid-19 pandemic and the learning outcomes in the form of effective learning media, practical, easy to obtain, economical and easy to understand by students in receiving materials. This research design uses 3 cycles, with each cycle going through the plan-action-observation-reflection stage. Data collection techniques using observations related to designing skills and developing E-Learning learning applications. Analysis of research data is based on: (1) initial capability analysis; (2) reflections related to the online learning process (3) learning outcomes. The conclusions of this study are: (1) distance learning during a pandemic by implementing E-Learning applications built by Mikrotik, and using clear tutorials; (2) Learning outcomes in the form of learning media with E-Learning application (Wiratmo et al, 2020). Based on a paper (Kapasia et al, 2020) To assess the impact of covid-19 lockdown on undergraduate and postgraduate students from various colleges and universities in West Bengal, India. An online survey was conducted from May 1 to May 8, 2020 to gather information. During the lockdown period, about 70% of students are involved in e-learning. Most students use android phones to attend elearning. Students face a variety of problems related to depression anxiety, poor internet connectivity, and an unsupportive learning environment at home. Students from remote areas and marginalized parts especially face huge challenges to learn during this pandemic. The study suggests targeted interventions to create a positive

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space for learning among students from vulnerable parts of society. Strategies are urgently needed to build a robust education system in the state that will ensure the development of skills to be employed and the productivity of young minds. A case study in Malaysia (Sundarasen et al, 2020) concerning the Covid-19 pandemic crisis and lock-downs that have impacted students in Malaysia has affected their anxiety (Students in Malaysia), the main causes of stress are financial constraints, distance online learning, and uncertainties associated with their academic performance, and future career prospects.

From this background, in Indonesia is currently implementing the curriculum Merdeka Belajar - Kampus Merdeka quoted in the official website news KEMENDIKBUD. The form of learning activities in accordance with Permendikbud No. 3 of 2020 Article 15 paragraph 1 can be done in the Study Program and outside the Study Program including student exchange, internship / work practice, teaching assistance in the education unit, research / research, humanitarian projects, entrepreneurial activities, etc. (kampusmerdeka.kemdikbud.go.id).

The obstacles or challenges that will be faced for the implementation of the Merdeka Belajar – Kampus Merdeka (MBKM) curriculum is the Covid-19 pandemic which until now has not shown significant changes, which occurs every school / campus implements online learning. A big influence on the field of education is the use of technology to support the teaching and learning process so as to facilitate students who do home learning activities. Based on the direction of the Minister of Education and Culture, Mr. Nadiem Makariem that the Ministry of Education will implement the Minimum Competency Policy and Character Survey (Merdeka Belajar) starting in 2021 on its official website (kemdikbud.go.id). The concept of freedom of learning based on SE No.1 Year 2020, SE No.2 Year 2020, SE No.3 Year 2020, SE No.4 Year 2020 is a more comprehensive assessment concept such as portfolio and assignments such as group tasks, papers, and so on conducted in full online by adding additional features such as Teaching and Learning Activities and Assessment through information technology media (Minister of Education , 2020).

So that in this study finally formulated into a goal that is the analysis of the effectiveness of E-Learning electronic learning system online using data traffic network performance management to succeed Merdeka Belajar - Kampus Merdeka, which will be measured and analyzed in this study is throughput, delay, jitter, and packet loss. So that the final result of this research obtained the feasibility of the teaching and learning process that is carried out effectively. (Mochammad.et al, 2017; Finale, 2016; Triyono et al, 2017)

In general, this study will be divided into 2 (two) scenarios. The first scenario is to build, design and optimize internet bandwidth on mikrotik using PCQ (Peer Connection Queue) method, while the second scenario contains test results based on service quality parameters (QoS) before and after the implementation of PCQ (Peer Connection Queue) method. Both scenarios are very suitable to be conducted in the Research of Domestic Cooperation in a period of 1 (one) semester, so as to produce superior basic research at the higher education level. Therefore, this research is proposed with the Domestic Cooperation Research Scheme.

II. RESEARCH METHOD

A. Literature Review

The novelty of the research is obtained from carrying out a review of the previous research reference set. The method used to obtain research novelty is to identify problems, hypotheses, method formulation, data collection and analysis to draw conclusions. In this subsection it has been summarized that the PCQ (Peer Connection Queue) method is used as a method for analysis of service quality such as throughput delay, packet loss, etc. Implementation of this system with Mikrotik base and E-Learning interface still has development in testing the value of network quality parameters. This makes a research to have an idea in innovating by connecting the science of information and communication technology with the science of digital technology today.

In a study conducted by Liantoni, et al (2017). Researchers use queue implementation method as bandwidth sharing technique to manage and allocate bandwidth flexibly. The result of this application obtained a user satisfaction rate of 59.2%.

In the research conducted by Ramadhan. et al (2016), Researchers do bandwidth settings, in the form of Simple Queue and Per Connection Queue on mikrotik because it has similarities. However, they also have configuration differences and results in the effectiveness of the network systems studied.

In a study conducted by Zimmermann (2006), Researchers propose the development of a new streaming media service consisting of a streaming media service model, an XML-based service specification language, and several integrated implementation and configuration management tools of streaming-based e-learning services. The result of this study is to provide an interface to search for, and request streaming services

In a study conducted by Ananatharman (2012), Researchers propose management and inventory and pass on that information to users in need. Use a system that can understand student needs, and create and deliver personalized learning plans. Track instructions and know which users need instructions so that the system can be proactive rather than reactive. By providing a library of information that can be used to train employees and, students will reduce the costs incurred because learning objects can be used in different formats, for different purposes. With distributed technology, learning can be done anytime and anywhere. The end result is a knowledge management structure that includes an inventory of knowledge objects and systems that can be shared.

In a study conducted by Thomas Favale, et al (2020), Researchers analyzed the impact of the lockdown on the Politecnico campus network in Turin. PoliTO implements its own internal solutions for virtual teaching. Since then, the university provides about 600 virtual classes daily, serving more than 16000 students per day. first focus on using remote collaboration and work platforms. To provide polyto online teaching solutions organized internally, in this study traced traffic, which characterizes the audience and network footprint. Overall, the study presents footage of sudden changes seen in campus traffic due to COVID-19.

In a study conducted by Iswadi, et al (2019), Researchers conducted bandwidth management to measure and control communication (traffic, and packets) on network links, to avoid overcharging links to capacity or filling links, which would result in network congestion and poor network performance. On RouterOS, it has Bandwidth Management Per Connection Queue (PCQ) and Hierarchical Token Bucket (HTB) algorithms. PCQ is setup as a non-priority class, as opposed to HTB. This research focuses on pcq adaptive switching

algorithm - HTB bandwidth management on RouterOS. The weaknesses and advantages of these two algorithms were analyzed to propose adaptive switching mechanisms to regulate bandwidth usage. The results show that this adaptive redirection method can provide sufficient access for clients with the highest priority without causing them to aggressively dominate bandwidth or block bandwidth access to the lowest priority clients. Thus, the proposed algorithm can be an appropriate alternative bandwidth management within a typical network to meet client priority classes while allowing non-priority clients to access adequate networks.

B. Research Method

In this research, researchers used network development life cycle system development method. NDLC is a model that defines the process cycle of design or development of a computer network system, NDLC has elements that define specific phases or stages and steps or mechanisms of processes. The application of each stage of the NDLC will be illustrated in Figure 1.
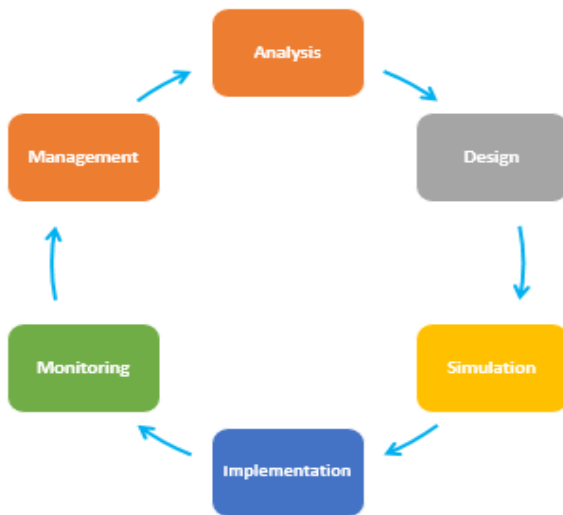

Fig. 1. Development of NDLC system

To build this system, physical devices and software are required to be built into a system based on topology that has been designed based on the proposed diagram block contained in figure 2.
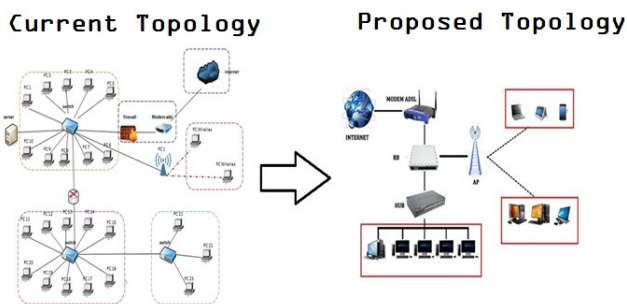

Fig. 2. Diagram block

III. RESULT AND DISCUSSION

There are network service providers that have 2 customers, namely SJ customers and ga customers who have the same center in the city of Jakarta and have branches on different islands, namely in the cities of Palembang, Balikpapan, and Manado. In addition, SJ and GA customers are also the same using IP Private Loopback Router which for palembang city uses IP 1.1.1.1 and IP 2.2.2.2, for balikpapan city using IP 5.5.5.5 and for manado city using IP 3.3.3.3 and 4.4.4.4 then besides Customer SJ and GA same use ip private for End Point (PC), for Palembang using IP 13.13.13.2 , for Balikpapan using IP 14.14.14.2 , and for Manado IP 14.14.14.2

The purpose of these 2 customers is simple, they want a connection between the center and their branch without overlaps on their respective ip address. Network service providers (ISPs) must create a network solution that is best and in accordance with customer demand.

A. System Testing

This test proves the system works by using the traceroute command. Later in this traceroute command will be seen ip interface anywhere involved in the exchange of data between the sender and the recipient in addition in this traceroute command will be seen data labels that have been created. This test will be conducted between CE-SJ-Palembang router with PC-SJ-BPP and CE-GA-Palembang router with PC-GA-MDO.

Fig. 3. Traceroute CE-SJ-Palembang results to PC-SJ-BPP

Based on the results of Figure 3 there are labels 16 and 21 that play a role in the process of sending data from the router CE-SJ-Palembang to PC-SJ-BPP, where at the time of data entry into the ip interface 192.168.100.100 there is a pcq label exchange from 16 to 21 and in ip interface 12.12.12.2 label 19 in the remove.

When SJ Companies in Palembang try traceroute IP 5.5.5.5 then we can see the data will successfully enter the network 172.18.50.1 where the network belongs to CE-SJ-BPP SJ company in Balikpapan. So that the process of exchanging data on PE-Palembang routers can distinguish SJ companies and GA companies located in Balikpapan while CE-SJ-Balikpapan and CE-GA-Balikpapan both use the same ip without any errors caused by overlaps ip address due to VRF made in both PE routers, VRF is the solution to avoid overlaps in ip address. With VRF, PE routers can distinguish which data is for Customer SJ and which data is for Customer GA.

Fig. 4. Traceroute CE-GA-Palembang results to PC-GA-MDO

The exchange occurred in Label 18 and label 23 precisely in ip interface 12.12.12.2 namely in Core and data transmission

from CE-GA- Palembang to PC-GA-MDO then using VRF, data sent via ip interface 192.168.100.100 into router PE- GA-Manado with ip interface 172.18.10.100 with label 23 then released and forwarded to network CE-GA-Manado with IP Interface 172.18.10.10 and up to network 3.3.3.3. With the process of labeling, label exchange and removal of PCQ labels and the work of VRF, PCQ VPN is fully running as shown in Figure 4.

B. OSPF Testing

PE-Palembang router, PE-Balikpapan router, and PE-Manado atapun Core Network use OSPF Protocol that uses MPLS method. Where the protocol is configured in the Interface in the PE-Palembang Router on IP Loopback 10.10.10.1 and IP 12.12.12.0, PE-Balikpapan IP Loopback Router 20.20.20.2 and IP 23.23.23.0, and PE-Manado Router on Loopback IP 30.30.30.3 and IP 34.34.34.0 and for its Core Network at LOOPBACK IP 100.100.100.1. Researchers tested by pinging data transmission from PE-Palembang Router to PE-Balikpapan, PE-Palembang Router to PE-Manado, PE-Balikpapan Router to PE-Manado and vice versa and onfiguration on this OSPF Protocol was successful.

Routing table in PE-Palembang Router and pe-palembang router and PE-Balikpapan router that has been successfully active using OSPF routing protocol. Figure 5 explains that the O in the Routing Table indicates that ospf routing configuration has been successful and can be seen ip and path passed for data transmission through this OSPF Routing Protocol.


```
PE-Palembang#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/32 is subnetted, 1 subnets
C        10.10.10.1 is directly connected, Loopback0
      12.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        12.12.12.0/30 is directly connected, FastEthernet0/0
L        12.12.12.1/32 is directly connected, FastEthernet0/0
      20.0.0.0/32 is subnetted, 1 subnets
O        20.20.20.2 [110/3] via 12.12.12.2, 00:08:48, FastEthernet0/0
      23.0.0.0/30 is subnetted, 1 subnets
O        23.23.23.0 [110/2] via 12.12.12.2, 00:08:58, FastEthernet0/0
      30.0.0.0/32 is subnetted, 1 subnets
O        30.30.30.3 [110/3] via 12.12.12.2, 00:08:38, FastEthernet0/0
      34.0.0.0/30 is subnetted, 1 subnets
O        34.34.34.0 [110/2] via 12.12.12.2, 00:08:58, FastEthernet0/0
      100.0.0.0/32 is subnetted, 1 subnets
O        100.100.100.1 [110/2] via 12.12.12.2, 00:08:58, FastEthernet0/0
```

Fig. 5. OSPF protocol test results are active

C. VRF Testing

VRF is a VPN needed for a PE Router to distinguish between which data is for Customer SJ and which data is for Customer GA as shown in Figure 6. VRF is also a technology used in a router that allows multiple instant routing tables to be configured simultaneously on the same router and at the same time. Example of the same IP Interface in both customers in the city of Palembang, namely in CE-GA-Palembang and CE-SJ-Palembang by using IP Interface 192.168.100.1. With this VRF

33solution to avoid overlaps in the destination IP Address and avoid incorrect addresses to each customer.


```
no aaa new-model
no ip icmp rate-limit unreachable
ip cef

ip vrf CE-GA
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf CE-SJ
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
```

Fig. 6. VRF configuration is on

After the VRF configuration has been active it is only then that the author configures static routing in CE for Redistribution and Connected between CE and BGP or VRF and Static Route in order to communicate with each other as well as vice versa shown in Figure 7.


```
address-family ipv4 vrf CE-GA
 redistribute connected
 redistribute static
exit-address-family
!
address-family ipv4 vrf CE-SJ
 redistribute connected
 redistribute static
exit-address-family
!
```

Fig. 7. Redistribution and Connected between CE and BGP

D. Quality of Service Parameter

QoS measurements include Delay, Throughput, and Packet Loss. QoS testing using wireshark was conducted Capture End Point Device in the form of between SJ-Palembang to PC-SJ-Balikpapan.

QoS parameter measurement steps using Wireshark:
1. Run the installed Wireshark software
2. Shows the view of the capture data being processed.
3. Shows the results of the data has been successfully achieved.

E. Analysis Data

1. Delay

Capture one of the Capture data on Wireshark, then click frame 133 and then look at the explanation column of the frame below, then click the arrow to the right on the first option and look for "time since reference or first frame" where it is the time the package received can be seen in Figure 8.

Click frame 134 and then look at the explanation column of the frame below, then click the arrow to the right on the first option and look for "time since reference or first frame" where it is the time the package sent can be seen in Figure 9.


```
Epoch Time: 1534088641.863879000 seconds
[Time delta from previous captured frame: 0.071762000 seconds]
[Time delta from previous displayed frame: 0.071762000 seconds]
[Time since reference or first frame: 46.290916000 seconds]
```
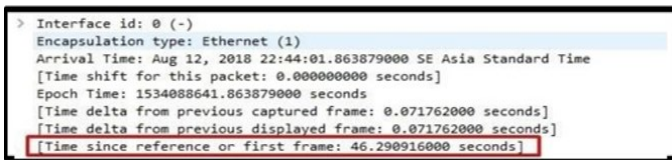
Fig. 8. Packet received

```
>  Interface id: 0 (-)
   Encapsulation type: Ethernet (1)
   Arrival Time: Aug 12, 2018 22:44:01.863879000 SE Asia Standard Time
   [Time shift for this packet: 0.000000000 seconds]
   Epoch Time: 1534088641.863879000 seconds
   [Time delta from previous captured frame: 0.071762000 seconds]
   [Time delta from previous displayed frame: 0.071762000 seconds]
   [Time since reference or first frame: 46.290916000 seconds]
```

Fig. 9. Packet transmit

Delay formula :

$$delay = Received\ packet\ time - packet\ sent$$
$$= 46,290916000 - 46,2191540$$
$$= 0,071762000\ s\ /\ 71\ ms \qquad (1)$$

In addition, from the above delay testing obtained also the average delay seen from the 10 tests captured shown in Table I.

TABLE I
DELAY TEST

TESTING	VALUE (MS)
1	63
2	82
3	68
4	86
5	76
6	62
7	99
8	90
9	96

With an average delay result of 79 ms, it can be ensured that the End Device network works well, because according to ITU-T standard, the excellent delay category is the delay value < 150 ms. Referring to the standardization of delay from ITU-T H.323 it can be said that the delay in this study is included in the very satisfactory category shown in Table II.

TABLE II
DELAY STANDARD ITU-T H.323

CATEGORY	VALUE (MS)
VERY SATISFYING	< 150 MS
SATISFYING	150 S/D 300 MS
UN-SATISFYING	300 S/D 450 MS
NO-SATISFYING	> 450 MS

2. Troughput

The data retrieval for Troughput on Wireshark can be seen in Figure 10. On the Menu Bar select Statistics and select Capture File Properties.
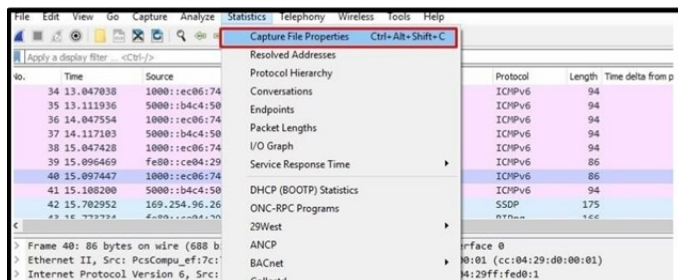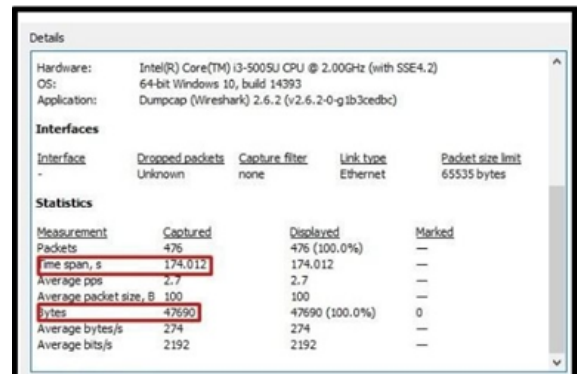

Fig. 10. Throughput display

Fig. 11. Measurement data in the Statistics column

Then a new dialog box will pop up shown in Figure 11, scroll down to the statistics options, see Bytes which is the number of data sending data.

Troughput formula :

$$Troughput = \frac{Number\ of\ Data\ Sent}{Data\ Delivery\ Time} = \frac{47,690}{174,012}$$
$$= 27,40\ bytes/s \qquad (2)$$

From the above results obtained data delivery time 174,012 s and the amount of data sent 47,690 bytes then the result troughput is 27.40 bytes / s. With a throughput result of 27.40 bytes / s, it can be said that the network works well, because according to the medium throughput value that is between 25-50 Bytes / s by looking at the reference of TIPHON standardization in Table III.

TABLE III
STANDARDIZATION OF THROUGHPUT ACCORDING TO TIPHON

CATEGORY	THORUGHPUT
VERY SATISFYING	75 S/D 100
SATISFYING	50 S/D 75
UN-SATISFYING	25 S/D 50
NO-SATISFYING	< 25

3. Packet Loss

Data retrieval for Packet Loss on Wireshark. On the Menu Bar select Statistics and select Capture File Properties. Then a new dialog box will pop up, scroll down to the statistics options, see Packets Captured which is the amount of received data shown in Figure 12.
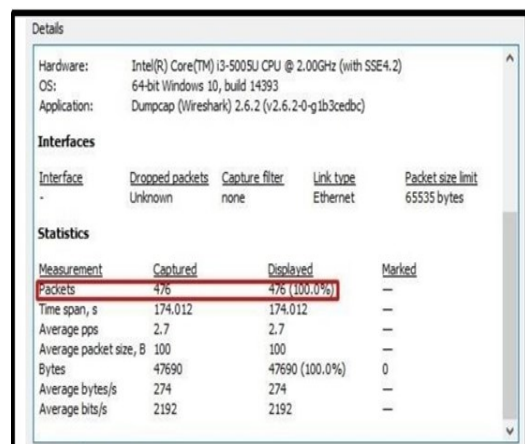

Fig. 12. Loss packet measurement data in statistics column

Packet loss formula :

$$Packet\ Loss$$
$$= \frac{Sent\ Data\ Package - Received\ Data\ Package}{Sent\ Data\ Package} \times 100\%$$
$$= \frac{476-476}{476} \times 100\% = 0\% \qquad (3)$$

From the above results obtained data packages sent as much as 476 data and data packages received also amounted to 476 data. With the result of packet loss calculation sought is 0%. Therefore, referring to itu-T standardization H.323 which can be seen in Table IV, it can be said that the network works very well because none of the packages are lost when sending data.

TABLE IV
STANDARDIZATION OF PACKET LOSS ACCORDING TO ITU-T H.323

CATEGORY	PACKET LOSS
VERY SATISFYING	0%
SATISFYING	3%
UN-SATISFYING	15%
NO-SATISFYING	25%

CONCLUSION

Based on observations when conducting simulations and tests, so that in this research get results that can be analyzed and drawn conclusions as follows:

1. Configure the network with PCQ method that uses OSPF routing protocol, with VRF network has been successfully built. This can be proven from ping/data transmission testing and Command Tracert on End Device.
2. QoS network performance testing using Wireshark measures 3 parameters, namely delay, throughput, and packet loss.
3. In the test obtained the average value of delay 79ms that is the value of the category of excellent delay (excellent) based on source: ITU-T H.323 delay value < 150 ms.
4. In the test obtained throughput value obtained is 27.40 bytes / s then it can be said that the network works well, because according to TIPHON standards, the category of good throughput of medium quality is the value of throughput that is between 25-50 Bytes / s.
5. In the test obtained packet loss value of 0%. Data packets sent amounted to 476 data and data packets received also amounted to 476 data. With the result of packet loss calculation sought is 0%. Then it can be said that the network works very well because none of the packages are lost during data transmission.

Suggestions for further research development:

1. Enable PC auto idle on each router when enabling the router on GNS3, for RAM power savings and to maximize the performance of GNS3 applications.
2. Make sure Anti-Virus and Firewall are off when opening GNS3 applications.
3. In running GNS3 applications it is recommended to have a minimum i3 Processor with 4 GB RAM for optimal.
4. Every configuration on the router get used to save configuration with write command.
5. It is recommended to use a Virtual PC (which is already available on GNS3) and use Virtual Box to get real results.

REFERENCES

[1] M. Giatman, S. Siswati, I.Y. Basri, "Online Learning Quality Control in the Pandemic Covid-19 Era in Indonesia," *Journal of Nonformal Education*, 6(2), 2020, 168-175.
[2] A. Purwanto, M. Asbari, M. Fahlevi, A. Mufid, E. Agistiawati, Y. Cahyono, P. Suryani, "Impact of Work From Home (WFH) on Indonesian Teachers Performance During the Covid-19 Pandemic: An Exploratory Study," *International Journal of Advanced Science and Technology*, 2020, 29(05), 6235-6244.
[3] Y. Wiratomo, F. Mulyatna, "Use of learning management systems in learning efforts during a pandemic," *Journal of Mathematical Pedagogy (JoMP)*, 2020, 1(2).
[4] Y. K. Dwivedi, D. L. Hughes, C. Coombs, I. Constantiou, Y. Duan, J. S. Edwards, R. Raman, "Impact of COVID-19 pandemic on information management research and practice: Transforming education, work and life," *International Journal of Information Management*, 2020, 55, 102211.
[5] N. Kapasia, P. Paul, A. Roy, J. Saha, A. Zaveri, R. Mallick, P. Chouhan, "Impact of lockdown on learning status of undergraduate and postgraduate students during COVID-19 pandemic in West Bengal, India," *Children and Youth Services Review*, 2020. 116, 105194.
[6] S. Sundarasen, K. Chinna, K. Kamaludin, M. Nurunnabi, G.M. Baloch, H.B. Khoshaim, A. Sukayt, "Psychological impact of COVID-19 and lockdown among university students in Malaysia: implications and policy recommendations," *International journal of environmental research and public health*, 2020, 17(17), 6206.
[7] https://kampusmerdeka.kemdikbud.go.id/news/kampus-merdeka-ala-mas-menteri-nadiem-makarim-seperti-apa-konsepnya
[8] https://www.kemdikbud.go.id/main/blog/2020/10/ditjen-dikti-luncurkan-buku-panduan-kurikulum-dikti-dan-aplikasi-merdeka-belajarkampus-merdeka
[9] Menteri Pendidikan, Surat Edaran Nomor 1 Tahun 2020 Tentang Kebijakan Merdeka Belajar dalam Penentuan Kelulusan Peserta Didik, dan Pelaksanaan Penerimaan Peserta Didik Baru Tahun Ajaran 2020/2021, Surat Edaran MENDIKBUD RI, 2020.
[10] Menteri Pendidikan, Surat Edaran Nomor 2 Tahun 2020 Tentang Pencegahan Dan Penanganan Corona Virus Disease (COVID-19) di Kementerian Pendidikan Dan Kebudayaan. Surat Edaran MENDIKBUD RI, 2020.
[11] Menteri Pendidikan, Surat Edaran Nomor 3 Tahun 2020 Tentang Pencegahan COVID-19 pada Satuan Pendidikan. Surat Edaran MENDIKBUD RI, 2020.
[12] Menteri Pendidikan, Surat Edaran Nomor 4 Tahun 2020 Tentang Pelaksanaan Kebijakan Pendidikan dalam Masa Darurat Penyebaran Covid-19. Surat Edaran MENDIKBUD RI, 2020.
[13] A.D. Alharthi, M. Spichkova, M. Hamilton, "Sustainability requirements for eLearning systems: a systematic literature review and analysis," *Requirements Engineering*, 2019, 24(4), 523-543.
[14] F.J. García-Peñalvo, (2021), "Avoiding the dark side of digital transformation in teaching. An institutional reference framework for eLearning in higher education", *Sustainability*, 13(4), 2023.
[15] Al Fadjri, M. K. N., Ritzkal, R., & Hendrawan, A. H., "Computer Network Analysis Using The Queue System In Mikrotik: Computer Network Analysis Using The Queue System," In Mikrotik, *Jurnal Mantik*, 2020, 4(1), 483-488.
[16] Ramady, G. D., Hidayat, R., Mahardika, A. G., & Hidayat, W., December) "Optimizing Wireless Distribution System Network Infrastructure in Hybrid Topology using PCQ Method," In *Journal of Physics: Conference Series,* 2019, Vol. 1424, No. 1, p. 012026. IOP Publishing.

[17] Pratama, Y., Ependi, U., & Suroyo, H., ("Optimization of Wireless Network Performance Using the Hierarchical Token Bucket (Case Study: Muhammadiyah University of Palembang)," *Journal of Information Systems and Informatics*, 2019, *1*(1), 49-59.

[18] Hafiz, A., Afriansyah, D., Ikhsan, F. K., Suprapto, B., & Pratama, I. W., (2019) "Measuring quality of wireless local area network using quality of service framework," *IJISCS (International Journal of Information System and Computer Science)*, *3*(3), 90-97.

[19] Sutanto, I., Wahjuni, S., Prianggono, J., & Guritman, S., (2019) "Optimization Distance Learning Computer of Network," *Computer Engineering and Applications Journal*, *8*(1), 65-76.

[20] F. Liantoni, R.I. Perwira, "Queue Tree Implementation for Bandwidth Management in Modern Campus Network Architecture," *Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control*, 2017, 3(1), 17-26.

[21] A. L. I. A. A.Ramadhan, R. E. Indrajit, N. Rokhman, E.W. Subanar, P.S. Kumar, B.T. Rao, M. Ola, "Analysis of effectiveness of using simple queue with per connection queue (PCQ) in the bandwidth management (A case study at the academy of information management and computer mataram (AMIKOM) mataram)," *Journal of Theoretical and Applied Information Technology*, 2016, 83(3).

[22] M. Zimmermann, "Towards tailormade eLearning streaming services: A framework for specification, implementation and management," in *Advanced Int'l Conference on Telecommunications and Int'l Conference on Internet and Web Applications and Services (AICT-ICIW'06)*, IEEE, 2006, February, pp. 67-67.

[23] L. Ananatharman, "Knowledge management and learning: ELearning and knowledge management system," in *2012 15th International Conference on Interactive Collaborative Learning (ICL)*, 2012, September, pp. 1-6, IEEE.

[24] T. Favale, F. Soro, M. Trevisan, I. Drago, M. Mellia, "Campus traffic and e-Learning during COVID-19 pandemic," *Computer Networks*, 2020,107290.

[25] D. Iswadi, R. Adriman, R. Munadi, "Adaptive Switching PCQ-HTB Algorithms for Bandwidth Management in RouterOS," in *2019 IEEE International Conference on Cybernetics and Computational Intelligence (CyberneticsCom)*, IEEE, 2019, August, pp. 61-65.

[26] Budiyanto, S., & Pratama, I., "Classification of Network Status in Academic Information Systems using Naive Bayes Algorithm Method," In *2020 2nd International Conference on Broadband Communications, Wireless Sensors and Powering (BCWSP)*, IEEE, 2020, September , pp. 107-112.

[27] Praptodiyono, S., Firmansyah, T., Murugesan, R. K., Alaydrus, M., Aprilia, R., & Leau, Y. B.," Improving the security of mobile IPV6 signalling using KECCAK/SHA-3," *Journal of Engineering Science and Technology*, 2021, *16*(3), 2312-2325.

[28] Ramadhan, E., Firdausi, A., & Budiyanto, S., "Design and analysis QoS VoIP using routing Border Gateway Protocol (BGP)," In *2017 International Conference on Broadband Communication, Wireless Sensors and Powering (BCWSP)*, IEEE, 2017, November, (pp. 1-4).