Nusantara Journal of Artificial Intelligence and Information Systems
Vol. 1, No. 2, December 2025, pp 45-58 journal homepage: https://journal.unusia.ac.id/nuai
Research Article ISSN: 3090-8876 DOI: 10.47776/nuai.v1i2.1648

OpenWRT-Based Proxy Network with GSM Signal Integration using Network Development Life Cycle Method

Rizki Slamet Nugroho[1], Edy Yuliansyah[2*], Muhammad Rizki Maulana[3]
[1] Department of Business Information Systems, Universitas Gunadarma, Depok, Indonesia
[2,3]Department of Informatics Engineering, Universitas Nahdlatul Ulama Indonesia, Jakarta, Indonesia
[1]rizki.s.nugroho@gmail.com, [2]edyyuliansyah@unusia.ac.id, and [3]murizkimaulana@gmail.com

INFORMATION

Article history:

Received Jun 03, 2025
Revised Aug 31, 2025
Accepted Nov 16, 2025

Keywords:

OpenWRT
GSM Signal
Proxy network
NDLC
Internet

ABSTRACT

One of the most important discoveries in technological development is the internet. However, infrastructure availability and cost remain a barrier for some. For various needs, in certain circumstances, a cheap and fast connection is required. The purpose of this research is to assist PT Wisata Hutan Lestari, located in Cigobang Hamlet, Karang Tengah Village, Sentul, Bogor Regency, in improving the quality of its services by providing internet access using GSM signals and proxies. To obtain relevant data and results for this research, data collection methods such as literature review and interviews were used. Furthermore, during the implementation phase, the Network Development Life Cycle (NDLC) method was chosen to ensure the success of this month-long research. The study concluded that utilizing GSM signals with the implementation of OpenWRT demonstrated a high level of flexibility in network configuration adjustments and can be implemented in areas with minimal broadband internet access. Furthermore, the use of Trojan.go and vmess proxies on the OpenWRT network improved security and privacy when accessing the internet. Meanwhile, this study can provide several recommendations that can be implemented, such as using Mikrotik to manage bandwidth, adding router devices to expand network coverage, adding modems to increase internet speed, changing or adding to the overall network configuration.

To cite this article:

Nugroho, R. S., Yuliansyah, E., & Maulana, M. R. (2025). OpenWRT-Based Proxy Network with GSM Signal Integration Using Network Development Life Cycle Method. *Nusantara Journal of Artificial Intelligence and Information Systems*, 1(2), 45–58. https://doi.org/10.47776/nuai.v1i2.1648

Corresponding Author:

Edy Yuliansyah
Department of Informatics Engineering, Universitas Nahdlatul Ulama Indonesia
Jl. Taman Amir Hamzah No.5 Pegangsaan, Menteng, Central Jakarta, DKI Jakarta, Indonesia (10320)
Email: edyyuliansyah@unusia.ac.id

1. INTRODUCTION

Along with the development of human civilization, technology is increasingly developing and one of them is the internet. A computer network is a structure consisting of computers, software, and network devices that work together to achieve a predetermined goal [1]. While the internet is a large computer network that connects around the world. The internet can also be called an intermediary media that connects people around the world [2]. In early 2022, internet usage in Indonesia reached 204.7 million users. The data increased in 2022 or increased by 1.03% compared to the previous year. In January 2021, the number of internet users in Indonesia continued to increase in the last five years. When compared to 2018, the number of national internet users has currently jumped by 54.25% [3].

Limited internet access is a major obstacle for some people, both individuals and organizations. For example, for students, a fast and affordable internet connection is essential for accessing online learning platforms, downloading or uploading assignment files, and participating in video conferences [4]. Meanwhile, PT Wisata Hutan Lestari also needs fast and affordable internet access for the Company's operational needs. This is what underlies the great potential in implementing the OpenWRT network as a portable WiFi media. This implementation has wide development, especially in Indonesia which is known to have many areas that have not been reached by internet providers. In remote areas, the internet network from OpenWRT can be an alternative to provide WiFi internet access at a minimum cost. By modifying the default router firmware into open-source firmware, it is possible that its management authority can be optimized and OpenWRT is one of the firmware that can be used for routers [5].

PT Wisata Hutan Lestari is a tourist attraction that occupies a 26-hectare pine forest area located in Kampung Cigobang, Karang Tengah Village, Sentul, Bogor Regency. By presenting views of green rice fields and pine forests, it offers a cool and peaceful atmosphere. Various activities can be done in this forest, such as cycling, enjoying flower gardens, dishes or coffee from restaurant. However, in addition to the natural luxury offered, the internet is one of the services that must be considered, The limitations of PT Wisata Hutan Lestari are the unavailability of cable internet provider infrastructure in the area, several GSM providers do not yet have adequate signals, a condition that is quite common in remote areas, while the existence of reliable and fast internet access is needed to improve visitor comfort and the Company's needs in smoothly promoting its tourist destinations.

With regard to OpenWRT as the firmware used in this study, it should be noted that OpenWRT offers various advantages, especially in terms of resource efficiency and flexibility [6]. Previously, there were several similar studies in recent years. Aziz Abdullah conducted a study in 2020 where the OpenWRT system was used as a tool to receive commands wirelessly from SP Android and forwarded to Arduino-UNO to condition the drone according to the previously sent commands [7]. A year later, a similar study was conducted by Aminnah, where OpenWRT was used as a medium to carry out VoIP that enables the sending of voice, video, and data traffic over an IP network. The method used in this study was the Mean Opinion Score (MOS) [8]. The third study was conducted by Yogi Pratama in 2022 by implementing OpenWRT as a router. The OpenWRT router was compared in terms of performance and performance with the TP-Link Router OS, and the method used in its development was the PPDIOO Life-Cycle Approach method [9].

From the three previous studies and firmware comparisons, it can be concluded that there are differences in how OpenWRT is implemented. The first study used OpenWRT for the Internet of Things (IoT), the second study implemented it in a communication medium, and the third study implemented OpenWRT on a router and analyzed its system performance. In the firmware comparison, OpenWRT excelled in its efficient use of resources. The differences between this study and the three previous studies are the use of OpenWRT, the utilization of GSM signals in locations with limited internet coverage, and the use of NDLC as the development method.

2. METHOD

This research was conducted using several data collection methods to obtain relevant data and results, namely literature studies from several sources such as books, journals, articles, or other videos, that are related to or support the research. Then, the interview technique used is a semi-structured interview, just like a structured interview, this type of semi-structured interview does not have rigid rules but still has an outline of topics and questions prepared by the researcher [10][11].

The method used in this research is NDLC (Network Development Life Cycle) which consists of several stages. First, the process of analyzing the current conditions, including business processes, user needs, and current network conditions in the field. Second, the process of designing the topology and setting up the configuration related to the proposed network.

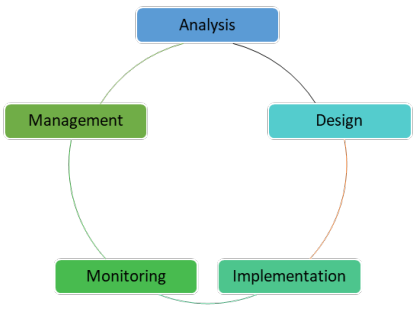


Figure 1. NDLC method

Third, implementation of the Pulpstone so that we can get full access to the STB HG680-P so that we can then install and configure the OpenWRT firmware in it, and then make configuration adjustments with the Modem that will be used later. Fourth, monitoring is carried out to ensure that the implemented network runs according to expectations by monitoring daily and monthly bandwidth which can later be used as a basis for further improvement analysis. Finally, several steps are needed to ensure the system runs securely, including implementing WPA2-PSK to log in to the network, configuring schedule tasks to clear cache and synchronizing time [12].

3. RESULTS AND DISCUSSION

In this section, it is explained the results of research and at the same time, a comprehensive discussion is given. Results can be presented in figures, graphs, tables and others that make the reader understand easily. The discussion can be made in several sub-sections according to the NDLC stages. NDLC aims to analyze, design, implement and evaluate networks based on identified needs [13].

3.1. Analysis

The internet source used by PT Wisata Hutan Lestari at this time is usually employees using local providers or SIM cards to have access to the internet, the purchased package has a quota limit at a fairly high price. In addition to the use of local providers or SIM cards by PT Wisata Hutan Lestari employees, wired internet providers such as IndiHome do not yet have access at the location. This could be caused by several factors, including infrastructure that is not yet available or the network has not been expanded to the location by the service provider.

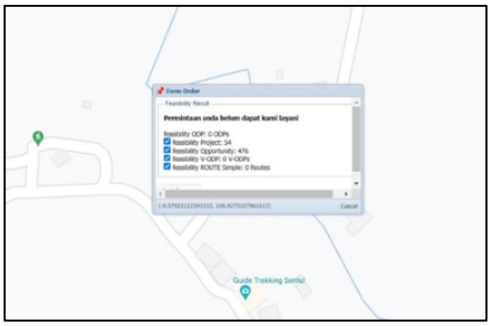


Figure 2. IndiHome network covered

Figure 3. XL axiata network covered

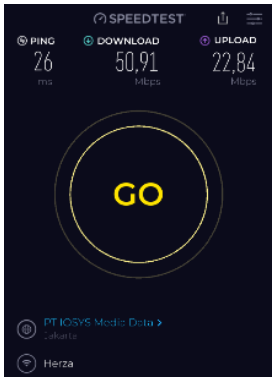


Figure 4. Internet speed test result

Although broadband connections are not currently available, we can compare the implementation budget requirements between using GSM and broadband connections to ensure this solution meets the needs of companies that want cost-efficient internet.

Table 1. Internet cost comparison

	GSM Provider		Broadband	
No	Name	Cost	Name	Cost
1	Set Top Box HG680-P	Rp. 170.000		
2	Modem MF-90	Rp. 240.000		
4	Router TP-LINK WR840N	Rp. 86.000	Internet 150Mbps +Installation Fee Max 20 Devices	Rp. 610.000
5	Internet XL Axiata 75GB	Rp. 120.000		
	Total	Rp. 616.000		

3.2. Design

The topology used is a star topology, where this topology has a hub or switch as a connection center that functions to connect one computer to each connected computer. The internet source will later come from the provider and enter the MF-90 Modem which then this modem is connected to the STB (Set-Top Box) running OpenWRT. STB (Set Top Box) is a tool containing a decoder device that is useful for managing television channels, which then produces output in the form of images, sound, and other services [3]. It can also be interpreted as a receiving device (Rx), which is placed between the receiving antenna and the AVI channel on an analog TV set [14]. OpenWRT is an open-source firmware that gives users more control over managing a router [15]. OpenWRT frees users to use router functions outside of the vendor's defaults [16]. In addition, OpenWRT also functions as a tunneling that allows encapsulation of packets from one type of protocol in a different protocol diagram [17]. While tunneling is needed for allows data in the HTTP protocol to be encapsulated (wrapped) in the SSL protocol as a payload that works at the TCP/IP model layer, namely the data on the upper layer becomes the payload and is encapsulated with the protocol on the layer below it [18].

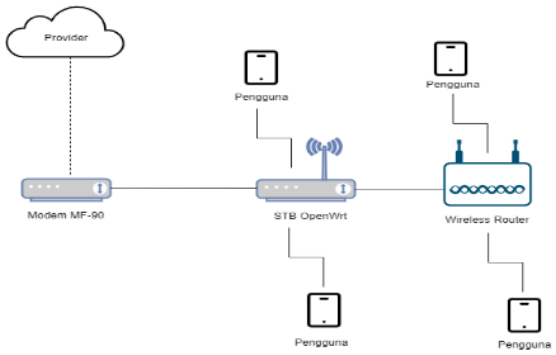


Figure 5. Topology design

From the OpenSRT STB, the connection is forwarded to the Wireless Router which provides a wireless network to the user. Users can connect to the network via two channels, either directly to the OpenWRT STB via a wireless connection, and others via the Wireless Router, either wirelessly or wired. This network allows various user devices to connect to the internet efficiently [19].

3.3. Implementation

In this section, we will discuss specifically requirement and processes carried out during implementation to achieve the expected results.

3.3.1. Specification

The following are some of the software and hardware with the specifications used during this research:

Table 2. Software and hardware specification

Hardware	Software
Notebook (i5-1135g7 16GB/1.5TB)	Microsoft Windows 11
Modem ZTE MF-90 (1,3, 8,40 Band Supported)	SpeedTest by Ookla
STB HG680-P 2GB/8GB with SoC Amlogic S905X	Minitool Wizard Partition
Router TP-Link WR840N	Balena Etcher 41
Monitor	Driver USB Amlogic
Cable (USB Micro, LAN, HDMI, USB male to male)	Tools (USB Burning, CDMA)
SIM Card	Net Monster
Flaskdisk 16GB	Firmware (Pulpstone, OpenWRT)
	OpenClash
	ZeroTier

3.3.2. Pulpstone firmware installation on STB HG680-P

The first step is to install the OpenWRT firmware. However, firmware that runs on the Android is needed to change the boot partition on the HG680-P STB, for the steps as follows:

a. Prepare USB male to male, STB HG680-P and its adapter. Open the USB Burning Tool application and import the Pulpstone 2.8 firmware into the application (Figure 6).
b. After the Pulpsone firmware file has finished importing, the next step is to start on the USB Burning Tool application (Figure 7).
c. Next, connect the USB male to male between the laptop and the STB while simultaneously pressing the on button on the STB, repeat until detected by the USB Burning Tool application. If the STB has

been detected by the application, then the flashing process is in progress and wait until the process is complete (Figure 8, Figure 9).

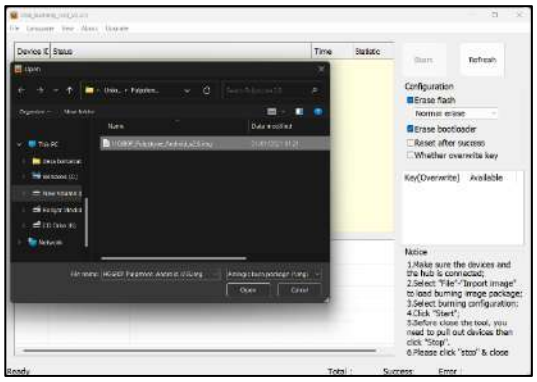


Figure 6. Import Pulpstone 2.8 on burning tool

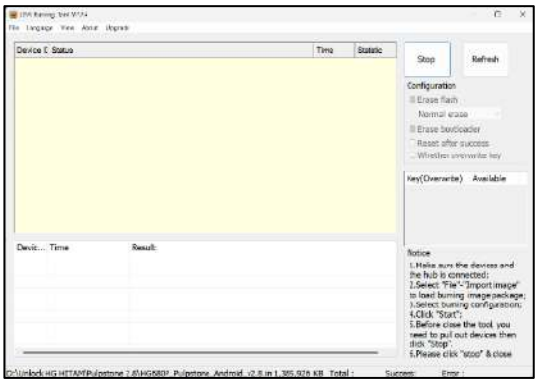


Figure 7. Start on USB burning tool application

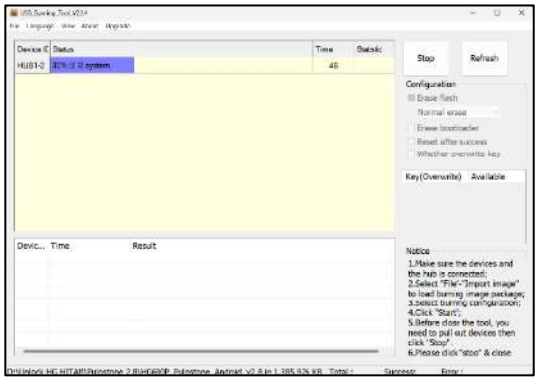


Figure 8. Flashing process is in progress

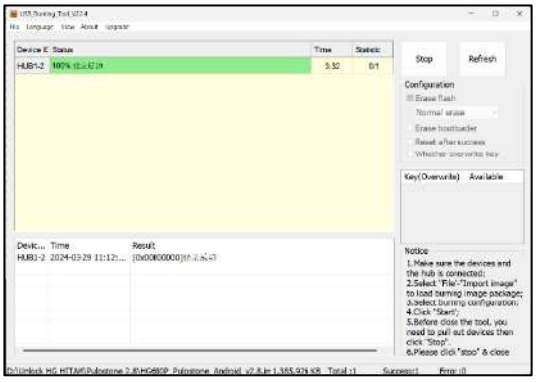


Figure 9. Flashing process is complete

3.3.3. Boot partition configuration on STB HG680-P

In this step, the boot partition is changed on the STB with the help of a monitor connected with an HDMI cable to display the output of the Pulpstone firmware. The steps are as follows:

a. Connect the HDMI cable to the monitor and STB (Figure 10).
b. After that, change the boot partition manually so that the next system defaults to using the Pulpstone firmware. The file called uboot.bin needs to be moved from the flash disk to the STB's internal storage media. Pulpstone offers several significant advantages over competitors like Aero and Reyre, transforming the HG680P STB into a reliable and feature-rich router. Its primary advantages lie in its ease of use and curated feature set (Figure 12).
c. The next step is to open the terminal emulator application on the Pulpstone firmware and type the command in the table below and ignore the text that begins with the comment mark "##" (Figure 13).

Table 3. Emulator Terminal Command

su *(enter)*
cd sdcard *(enter)*
ls *(enter)*
Check file uboot.bin##
dd if=uboot.bin of=/dev/block/bootloader *(enter)*
reboot update *(enter)*
STB will be restart##

Figure 10. Output STB on monitor

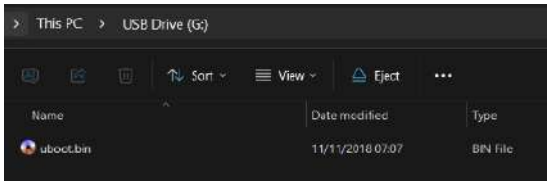


Figure 11. File uboot.bin

Figure 12. Find uboot.bin file on the flash disk

Figure 13. Execute terminal emulator commands

3.3.4. Installing OpenWRT Firmware on STB HG680-P

In this OpenWRT firmware installation step, it will be divided into three steps as follows:

a. Prepare a flash disk that will be flashed with the OpenWRT firmware. The flash disk must be formatted first to FAT32 format (Figure 14).
b. After formatting, flash the firmware on the flash disk using the Balena Etcher application. Import the OpenWRT file first for start the flashing process, attach the flash disk to the STB and then turn it on. If the output on the monitor appears different from before, it means that the process of changing the boot partition has been successful and the OpenWRT firmware is being booted (Figure 15, Figure 16, Figure 17).

Figure 14. Import OpenWRT file

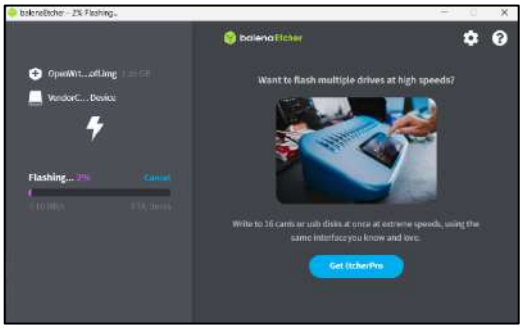


Figure 15. Flashing firmware OpenWRT

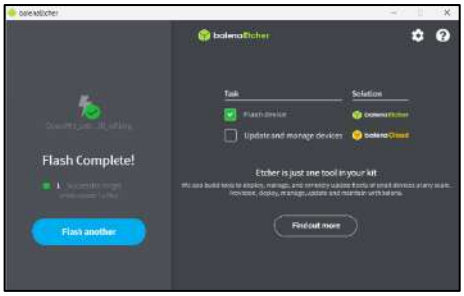


Figure 16. Firmware flashing completed

Figure 17. OpenWRT successfully booted

c. The last step, access the WiFi transmitted by the STB with the default SSID name "Reyre-STB" and the password is "indonesia" (Figure 18). After successfully connecting, access the IP address 192.168.1.1 via browser. On the login page, enter the username “root” and password "indonesia" (Figure 19). Next, go to the "System" section, select "Amlogic Service", then "Install OpenWRT",

select the "HG680-P" option for installation process (Figure 20). Wait for the installation to succeed and restart the STB.

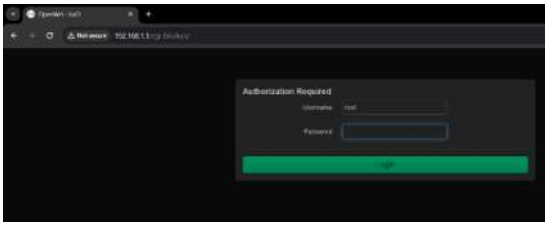


Figure 18. Login page

Figure 19. Choosing amlogic service

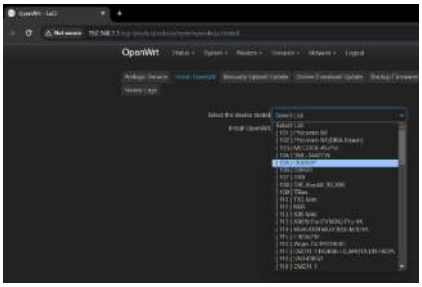


Figure 20. Selecting HG680-P in installation

3.3.5. MF-90 Modem Configuration

In this step, IP configuration and determination of the strongest band frequency are carried out on both MF-90 modems at the research location.

a. The first step is to configure the IP according to the proposed architecture.

Figure 21. Configure IP modem #1

Figure 22. Configure IP modem #2

b. Before configuring the band frequency on the modem, the modem must first enter debug mode by accessing the link on the browser.

Table 4. Link debug modem MF-90

Modem 1 http://192.168.9.1/goform/goform_process?goformId=MODE_SWITCH&switchCmd=DEBUG Modem 2 http://192.168.20.1/goform/goform_process?goformId=MODE_SWITCH&switchCmd=DEBUG

c. After that, steps will be taken to lock the strongest frequency at the research location using the CDMA Tool application.

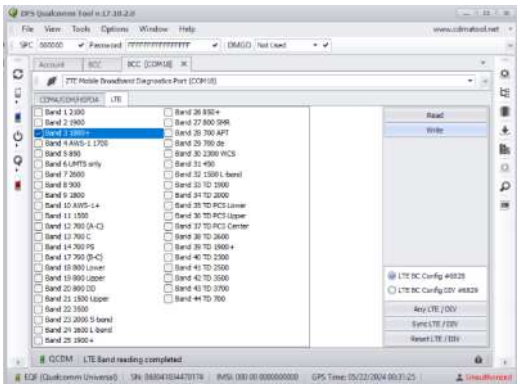


Figure 23. Lockband modem #1

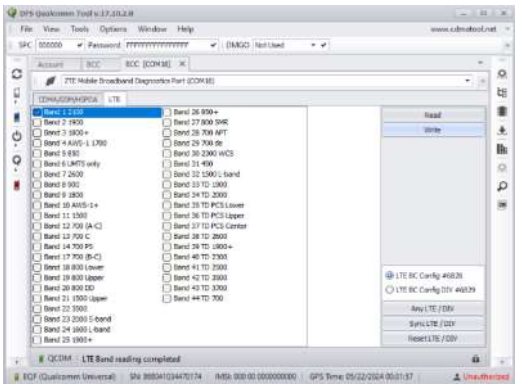


Figure 24. Lockband modem #2

d. The last step, so that the modem can run normally, the modem must first enter work mode by accessing the link on the browser.

Table 5. Link Work Modem MF-90

Modem 1 http://192.168.9.1/goform/goform_process?goformId=MODE_SWITCH&switchCmd=WORK Modem 2 http://192.168.20.1/goform/goform_process?goformId=MODE_SWITCH&switchCmd=WORK

3.3.6. Interface and SSID OpenWRT Configuration

In this step, the modem interface settings are made on the OpenWRT STB, then the OpenWRT IP is changed from 192.168.1.1/24 to 192.168.22.1/24 according to the proposed network architecture, and the internal SSID name is changed to PT Wisata Hutan Lestari.

a. Changing OpenWRT IP in Network Interface settings

Figure 25. Network inteface default

Figure 26. Network interface setup

b. Connect modem #1 and modem #2 to the OpenWRT STB using a micro USB cable. After that, go to the Network Interface settings.

Figure 27. Add network inteface modem #1

Figure 28. DNS and gateway metric modem #1

Figure 29. Firewall setup modem #1

Figure 30. Add network inteface modem #2

Figure 31. DNS and gateway metric modem #2

Figure 32. Firewall setup modem #2

c. The final step is to configure the default SSID to the desired SSID and WiFi security.

Figure 33. Changing the internal SSID of OpenWRT

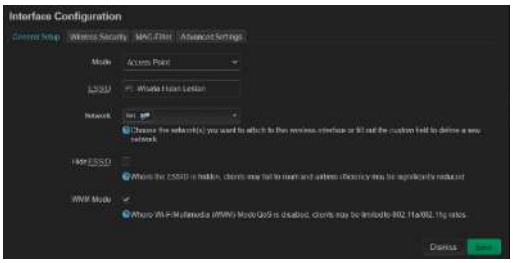


Figure 34. OpenWRT STB internal SSID security

3.3.7. Router TP-Link WR840N Configuration

In this step, the router is configured so that all DHCP can be centralized on the OpenWRT STB.

a. Access the default router IP 192.168.0.1 in the browser, and then Quick Setup and select Access Point mode, then continue by changing the SSID name and password (Figure 35).
b. The last step, change "Smart IP" to "Static IP" to be able to turn off the DHCP feature (Figure 36).

Figure 35. SSID access point setup

Figure 36. Disabled DHCP feature

3.3.8. OpenClash Proxy Configuration

The function of a proxy is to provide a service to forward user requests through another server intermediary to the internet [20] . In this step, proxy configuration is done in OpenClash to get internet access.

a. Access IP 192.168.22.1 on the browser, select “Services OpenClash”, enter “config manager”. Find the “proxy_provider” folder and create files “modem1.yaml, modem2.yaml for Load Balancing or Failover setup. Create files game1.yaml, game2.yaml for contain a list of proxies (servers) that have been specifically selected for their low latency (ping) and stability. Lastly, create file zerotier1.yaml, zerotier2.yaml also for configured to route traffic through ZeroTier nodes from a specific location.

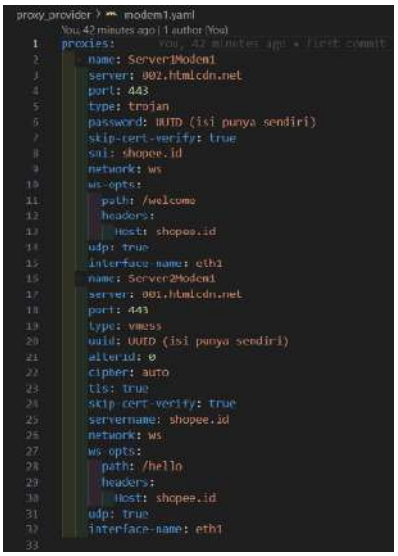


Figure 37. Create modem1.yaml

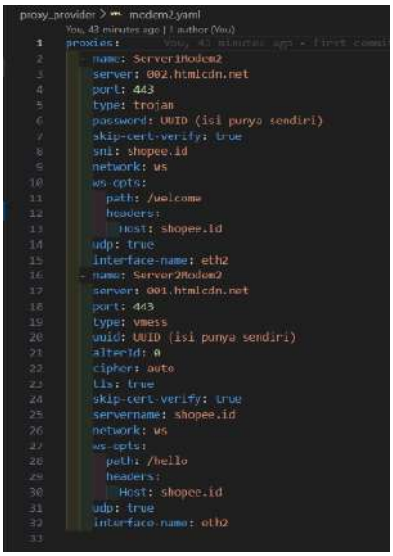


Figure 38. Create modem2.yaml

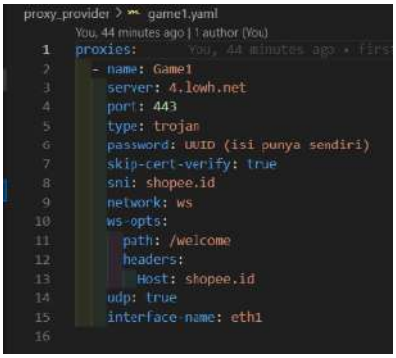


Figure 39. Create game1.yaml

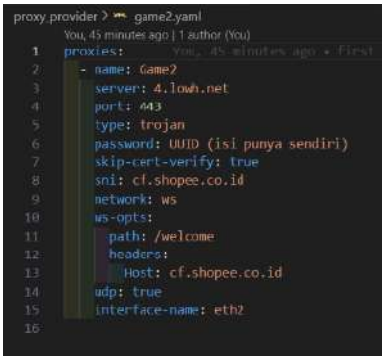


Figure 40. Create game2.yaml

Figure 41. Create remote1.yaml

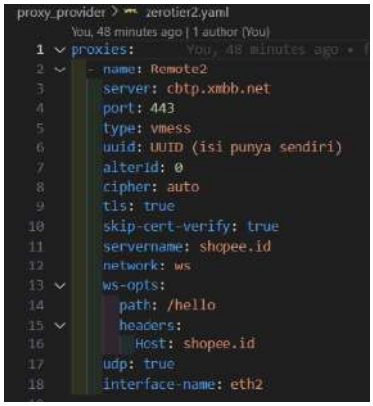


Figure 42. Create remote2.yaml

b. Go back to the main directory and find the “rule_provider” folder and create the files “umum.yaml, port-game.yaml, gaming.yaml, zerotier.yaml”. For the “rule_provider” script.
c. After that, find the “config” folder and create a “config.yaml” file. In this configuration, we will create some “rules”. For traffic distribution, modem 1 and modem 2 are configured using “Load Balance Round Robin”. Modem 1 and modem 2 also use two servers with the “url-test” method, meaning the server used is the one with the lowest latency. The “config.yaml”.

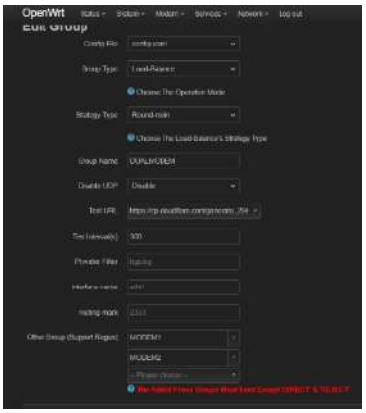


Figure 43. Load balance round robin

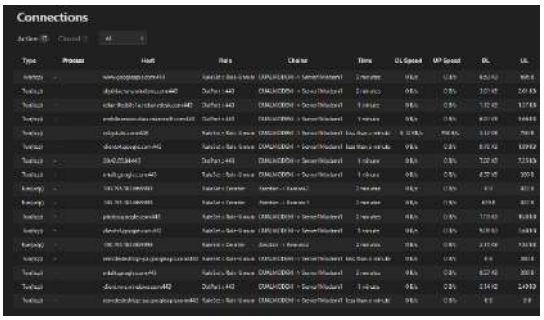


Figure 44. Internet ready to use

3.3.9. ZeroTier Configuration

In this step, ZeroTier configuration is done to make it easier for the author to access OpenWRT outside the local network. ZeroTier is a networking solution that allows users to connect devices in different locations as if they were on the same local network [21]. The steps are as follows:

a. Login to Zerotier, create a Zerotier network ID that will later be applied to OpenWRT (Figure 45).
b. Configure the remote IP. In this study, the selected remote IP is 172.30.0.0/16 (Figure 46).
c. The next step, copy the ZeroTier network ID and paste it into the OpenWRT configuration. After the settings are applied to OpenWRT, give "auth" to the remote access on the ZeroTier website and apply the remote IP (Figure 47, Figure 48).
d. After being given "auth" and the remote IP remains, OpenWRT can be remoted. However, to access the terminal, it is necessary to configure the terminal on OpenWRT. For this configuration, open the "Services" menu, then select "Terminal". Select Interface on Add Interface menu and select the “Ethernet Adapter ZeroTier” option (Figure 49, Figure 50).

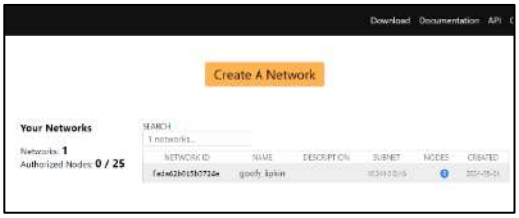


Figure 45. Create A network ZeroTier

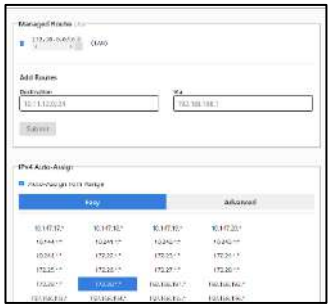


Figure 46. Remote IP configuration

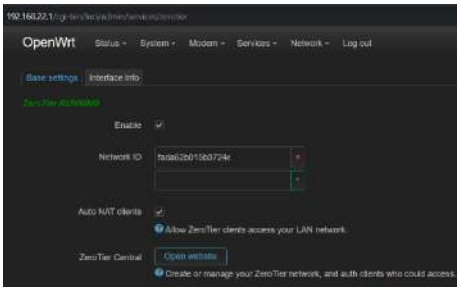


Figure 47. ZeroTier configuration on OpenWRT

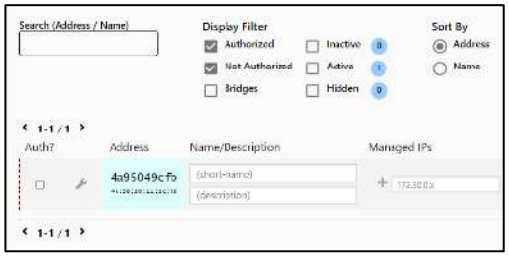


Figure 48. Auth OpenWRT on ZeroTier

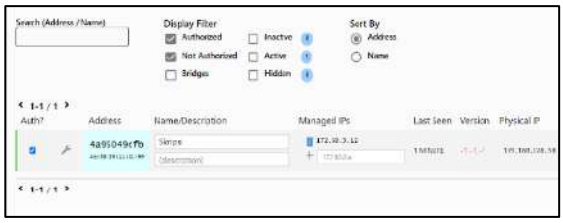


Figure 49. IP remote OpenWRT

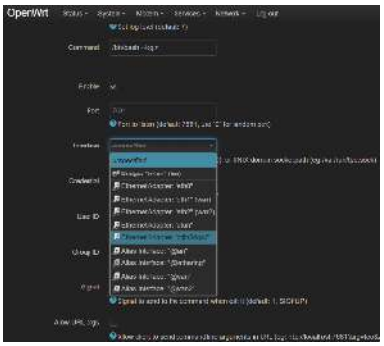
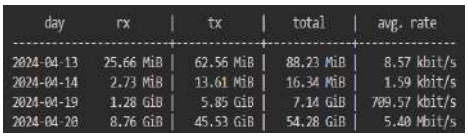


Figure 50. ZeroTier terminal configuration

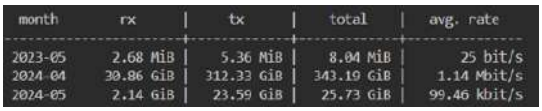
3.4. Monitoring

To ensure optimal system performance, continuous bandwidth monitoring is required to analyze bandwidth usage using OpenWRT terminal commands. OpenWRT's built-in network monitoring features are limited, more advanced features require third-party applications. For example, to check daily bandwidth usage (Figure 51) using the command “Vnstat -d br-lan”, or we can do a monthly summary to recap usage reports using the command “Vnstat -m br-lan” in the OpenWRT terminal (Figure 52).



day	rx	tx	total	avg. rate
2024-04-13	25.66 MiB	62.56 MiB	88.23 MiB	8.57 kbit/s
2024-04-14	2.73 MiB	13.61 MiB	16.34 MiB	1.59 kbit/s
2024-04-19	1.28 GiB	5.85 GiB	7.14 GiB	709.57 kbit/s
2024-04-20	8.76 GiB	45.53 GiB	54.28 GiB	5.40 Mbit/s

Figure 51. Daily bandwidth usage check



month	rx	tx	total	avg. rate
2023-05	2.68 MiB	5.36 MiB	8.04 MiB	25 bit/s
2024-04	30.86 GiB	312.33 GiB	343.19 GiB	1.14 Mbit/s
2024-05	2.14 GiB	23.59 GiB	25.73 GiB	99.46 kbit/s

Figure 52. Monthly bandwidth usage check

3.4. Management

Network management is the activity or procedure for monitoring, controlling, and maintaining a computer network [22].

a. WPA2-PSK Authentication
   The implemented WiFi network has WPA2-PSK security, meaning that users are required to enter a password as authentication before connecting to the network.
b. Scheduled Task
   This configuration refers to the process of clearing the cache, running vnstat so that it is real-time and restarting the device running the OpenWRT operating system according to the set time (Figure 53).
c. Time Configuration
   Time configuration on OpenWRT STB is important to ensure that the time on the STB is synchronized with the correct time (Figure 54).

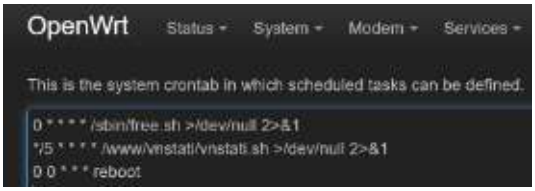


Figure 53. Scheduled task configuration

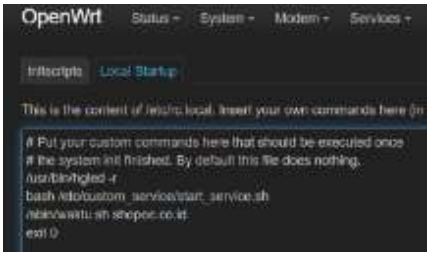


Figure 54. Time sync configuration

4. CONCLUSION

Despite several major limitations faced by PT Wisata Hutan Lestari, namely the lack of broadband coverage and limited GSM network coverage at the business location, the implementation of OpenWRT successfully addressed the company's needs for a stable Wi-Fi network, cost efficiency, flexible management, and the use of Trojan-Go Proxy and VMess to enhance user security and privacy when accessing the internet. However, it should be noted that building this network requires an initial hardware investment, and the sustainability of the OpenWRT network is highly dependent on the availability of a computer functioning as a server running the system.

For further research to achieve a broader, more stable, and more secure network, additional access points and the implementation of bandwidth management and network rules are needed. This OpenWRT concept can also be implemented in environments with similar limitations to PT Wisata Hutan Lestari's and can be used as an alternative solution for internet access in emergencies, such as nature expeditions or disaster evacuations.

ACKNOWLEDGEMENTS

The author would like to express his gratitude to the UNUSIA Institute for Research and Community Service (LPPM) for providing internal funding to support this research.

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BIOGRAPHIES OF AUTHORS

Rizki Slamet Nugroho is a graduate student in the Business Information Systems program at the University of Gunadarma, Jakarta, Indonesia. He brings over 13 years of professional experience in the Information Technology sector, with a strong background spanning IT support, systems engineering, infrastructure planning, and implementation. His multidisciplinary expertise enables him to bridge the gap between business needs and technological solutions effectively. Throughout his career, Rizki has demonstrated a consistent ability to manage complex IT projects, optimize system performance, and contribute to strategic digital transformation initiatives. He can be reached via email at: rizki.s.nugroho@gmail.com.

Edy Yuliansyah is a Magister degree in Computer Science Engineering from Bina Nusantara University, Jakarta, in 2020. He is currently a lecturer at the Faculty of Engineering and Computer Science, Nahdlatul Ulama University of Indonesia, since 2022. In addition, he is also a professional IT practitioner with 15 years of experience in the field of IT Infrastructure. His research interests are related to the IT enterprise architecture, server and network areas. He can be contacted at email: edyyuliansyah@unusia.ac.id.

Muhamad Rizki Maulana holds a Bachelor's degree in Computer Science. His research interests include network technologies, particularly proxy systems and secure internet access. His recent work focuses on configuring Trojan-Go with WebSocket TLS and SNI spoofing techniques. He is currently unaffiliated with any institution and serves as the Secretary of the Merah Putih Cooperative in Bantarjati Village. He can be contacted via email at murizkimaulana@gmail.com.