DESIGN AND IMPLEMENTATION OF A PORTABLE VPN ROUTER BASED ON OPENWRT USING RASPBERRY PI

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Abstract: Privacy is a fundamental individual right, even in the digital realm. However, awareness of the importance of online privacy is often underestimated by internet users. This research addresses this issue by implementing the Raspberry Pi 4 Model B as a portable VPN router. The research methodology involves observation and literature review. The results demonstrate that using the OpenWRT operating system, a portable VPN router based on Raspberry Pi can encrypt internet access, safeguarding privacy and providing better performance than the OpenVPN Connect application. This portable VPN router offers a practical solution to enhance user data security and network privacy in the digital world, especially when connected to public Wi-Fi networks. This research provides a better understanding of the significance of online privacy and presents an effective alternative to protect it. Using a Raspberry Pi-based portable VPN router, users can access the internet securely and maintain their privacy in the digital realm. The findings of this research contribute to the fields of information security and network technology and offer practical guidance for individuals to enhance their online privacy and security.

INTRODUCTION

The Internet has become an integral part of everyday life in the modern era of technology. It provides convenience in accessing websites (Wahyuni & Betty Yel, 2022). However, with the increasing use of the internet, privacy and data security have become increasingly important(Batubara et al., 2021) (Lubis, Hariyanto, et al., 2022). Users who connect through public networks or free Wi-Fi are vulnerable to eavesdropping and theft of their data (Lubis & Tarigan, 2017).

One way to protect user data is using a Virtual Private Network (VPN) (Milsa Pratama et al., 2023). VPN allows users to send and receive data over public networks as if their devices operate directly on a private network (Zakaria et al., 2022). VPN services have been widely used to provide secure connections and protect user data from threats on the internet. In addition to security, flexibility and mobility are also essential factors

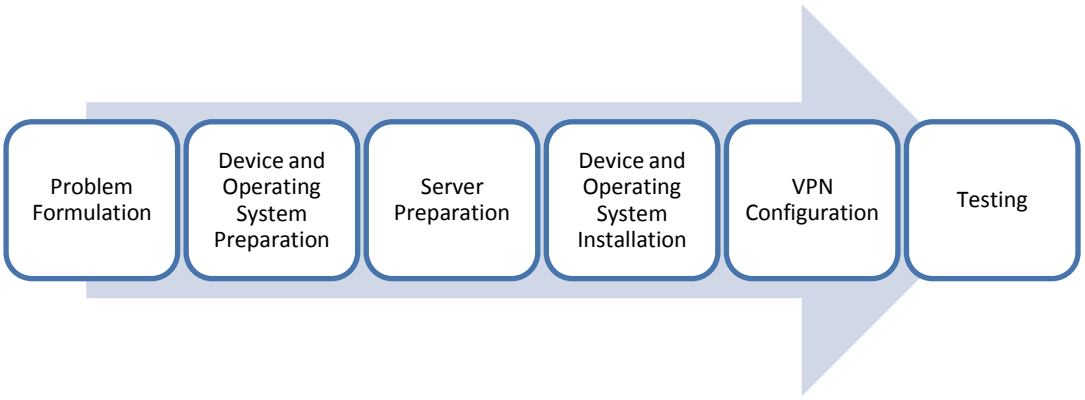
in the context of internet connectivity (Dutkowska-Zuk et al., 2022). Users want to easily access VPN networks without geographical limitations, whether at home, in the workplace, or while travelling.

OpenWRT is a Linux-based operating system specifically designed for routers and other network devices, offering high flexibility in router settings and extensive support for additional features such as VPN (Rivera-Dourado et al., 2023). Being small, flexible, and affordable, Raspberry Pi has excellent potential to address this issue. The open-source software OpenWRT is used in the router built on Raspberry Pi (Lubis, Septian, et al., 2022) . This software will enable users to quickly set up and manage their VPN connections, providing greater flexibility and control over internet access and data transmitted through the network (Osswald et al., n.d.).

Based on this background, this research aims to design and implement a portable VPN router using the OpenWRT platform on a Raspberry Pi device (Jadhav & Malode, 2019)(Gentile et al., 2022). This study configures the OpenWRT software, integrates VPN services into the router, and tests the performance and stability of the created portable VPN router.

RESEARCH METHODS

This research methodology will assist in designing, implementing, and evaluating a comprehensive OpenWRT-based portable VPN router using Raspberry Pi by the established research objectives.



Picture 1. Research Methods

Problem Formulation

Network security has become a significant issue in today's digital era. Internet users often access the internet through public or insecure networks, which can expose their data to third parties. How can we create and implement an OpenWrt-based portable VPN router using Raspberry Pi to provide internet users with a robust and affordable security solution?

Although many VPN router options are available on the market, most require permanent installation and are not easily portable. How can we design and implement a portable VPN router that uses OpenWrt technology and Raspberry Pi so that users can take it anywhere while still having a secure internet connection?

Device and Operating System Preparation

This stage encompasses the process of network requirements analysis that will be decisive in implementing Raspberry Pi 4 Model B as a portable VPN router (raspberrypi.org, 2021). The process begins with the preparation of all necessary primary and supporting devices. The primary devices used include Raspberry Pi 4 Model B, TP Link TL-WN722N Ver 1, USB Type-C cable, a 32GB MicroSD Card, and a Card Reader. Meanwhile, the supporting devices include a laptop, smartphone, and Cat 6 LAN cable.

Server Preparation

This stage involves downloading the operating system file, followed by installation. The operating system to be used in this case is OpenWRT version 21.02.2.

Device and Operating System Installation

Once the hardware and operating system have been prepared, the next step is to install the OpenWrt operating system on the Raspberry Pi and carry out initial configurations, such as local network settings. This stage encompasses preparing a VPN server, which involves building it from scratch until it can be connected and tested. This VPN server will utilise public cloud services from a DigitalOcean provider with a Public IP.

VPN Configuration

After the operating system has been successfully installed on the Raspberry Pi, the next

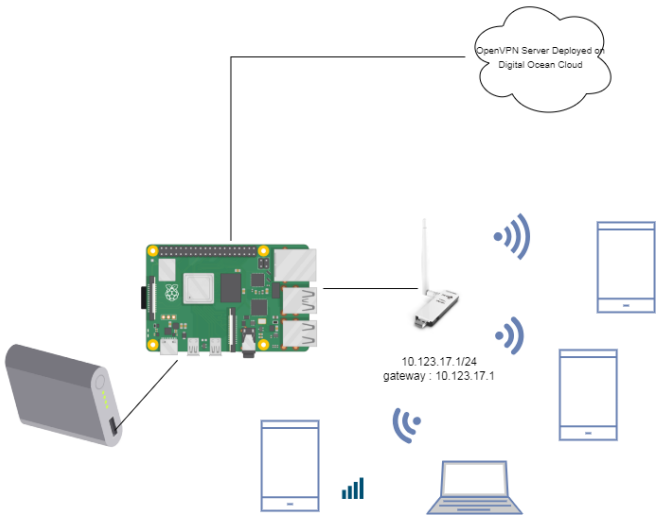
step is configuring the VPN service on the OpenWrt router using details from the previously prepared VPN server. This configuration is done using a graphical user interface (GUI). However, for initial installation and configuration, we will use a command line interface (CLI) due to its flexibility in package installation.

Testing

The final stage in this process is testing the functionality of the portable router after all components have been correctly installed and configured. The testing involves verifying functionality to ensure features are working as expected. Testing will be conducted quantitatively, aiming to measure the Quality of Service (QoS) and through real-world testing to compare the performance of the Portable VPN Router with conventional VPN authentication methods. Variables tested will include Throughput, Packet loss, and Delay.

RESULTS AND DISCUSSION

Network Topology



Picture 2. Network Topology

This research will connect all handheld devices to the same network through a Raspberry Pi. The Raspberry Pi has been installed with the OpenWRT operating system and the OpenVPN Client application, functioning as a router. When an internet connection occurs, the data sent will be encrypted using the OpenVPN encryption

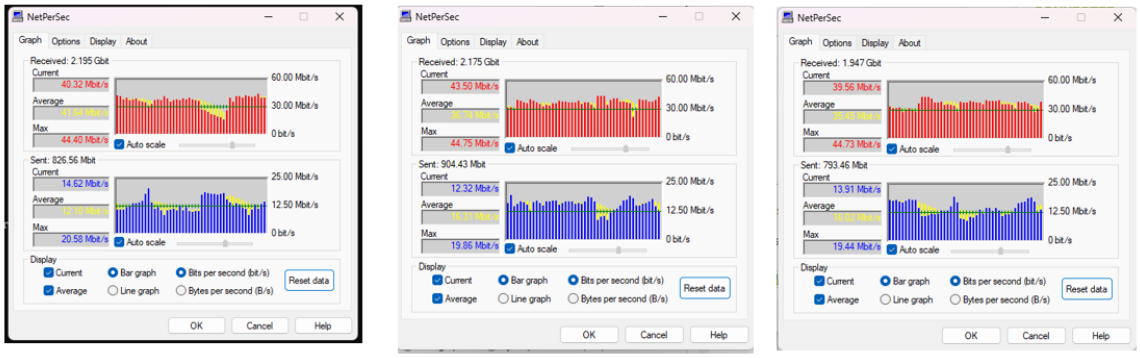
standard (Skendzic & Kovacic, 2017).

The Raspberry Pi in this study receives its power supply from a power bank. Using a power bank as a power source provides extraordinary flexibility and portability for the Raspberry Pi, allowing it to operate in locations without access to traditional power sources. This is very useful in various scenarios, such as when travelling or being in remote areas. With a power bank, the Raspberry Pi can remain active and connected, making it an ideal solution for various mobile and remote applications.

Picture 3. Connecting Raspberry Pi Devices

OpenVPN System Testing

The testing phase of this system aims to ensure that the system design that has been created is in line with the set targets. The test results show that when using a VPN and not, the packet loss rate is 0%, which means the connection is very stable and no data packets are lost during transmission. This indicates that the network can be relied upon. For latency (ping time), there is an average and maximum increase when using a VPN. This is quite normal because VPNs typically add a little latency due to data encryption, decryption processes, and additional routing through the VPN server.



Picture 4. Testing Throughput Without VPN, With a Portable VPN Router, and Using OpenVPN Connect

Testing the download speed without a VPN yielded an average speed of 41.64 Mbit/s for downloads and 12.10 Mbit/s for uploads. These values are used as a benchmark or standard of comparison for subsequent tests. During testing with the Portable VPN Router, the average download speed slightly decreased to 36.74 Mbit/s, while the upload speed increased to 16.31 Mbit/s. Then, when using the OpenVPN Connect application, the average download speed was lower than when using the Portable VPN Router, at only 35.45 Mbit/s. However, the upload speed remained relatively high at 16.02 Mbit/s.

In conducting measurements for a network's Quality of Service (QoS) analysis, the author uses four parameters based on TIPHON standards: delay, throughput, and packet loss. The following are the measurement results presented in a table.

Table .1 Delay Measurement

Condition	Average delay (m/s)	TIPHON Category	Value
Without VPN	17m/s	Very Good	4
Portable VPN Router	19m/s	Very Good	4
OpenVPN Connect	29m/s	Very Good	4

The evaluation results of the delay measurement using TIPHON standards show a "Very Good" category in all conditions, whether without VPN, when using a portable VPN router, or when using the OpenVPN Connect application.

Table 2 Measurement of Throughput

Condition	Average *throughput* (*Mbps*)	TIPHON Category	Value
Without VPN	41,64 *Mbps*	Very Good	4
Portable VPN Router	36,74 *Mbps*	Very Good	4
OpenVPN Connect	35.45 *Mbps*	Very Good	4

The evaluation results of the throughput measurement using TIPHON standards show a "Very Good" category in all conditions, whether without VPN, when using a portable VPN router, or when using the OpenVPN Connect application.

Table 3 Measurement of Packet Loss

Condition	Persentase	TIPHON Category	Value
Without VPN	0%	Very Good	4
Portable VPN Router	0%	Very Good	4
OpenVPN Connect	0%	Very Good	4

The packet loss measurement evaluation results using TIPHON standards show a "Very Good" category in all conditions, whether without VPN, when using a portable VPN router, or when using the OpenVPN Connect application.

CONCLUSION

Based on the TIPHON standard, the delay for all conditions (without VPN, with Portable VPN Router, and using the OpenVPN Connect application) falls into the "Very Good" category. This indicates that network latency is very low in all scenarios. By the TIPHON standard, throughput in all conditions also falls into the "Very Good" category. Although there is a slight decrease in throughput when using VPN services (whether portable or through an application), this decrease is minimal and does not significantly impact performance.

In all testing conditions, packet loss was 0%, which meets the "Very Good" criteria according to TIPHON standards. This shows the network is stable and reliable in transmitting data without losing packets. Packet loss was 0% under all testing conditions, indicating that the network is stable and can be relied upon to transmit data

without losing packets. This is an essential indicator of good network quality.

This research provides compelling evidence that a Portable OpenWRT Router can be an efficient solution for providing stable and fast portable internet connectivity with superior performance, whether using a VPN service or not.

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