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Design and Implementation of Internet Network Infrastructure Using the Network Development Life Cycle Method at SMK Rahmatullah Al-Maarif

[1*]Hartono Wijaya, [2]M. Fawazi Hadi
[1,2]Department of Computer Science, Universitas Bumigora, Lombok, Indonesia
Email: [1]Hartonowijayax@gmail.com, [2]mfawazi252@gmail.com

Abstract: The advancement of technology in the Industrial Revolution 4.0 era requires educational institutions, especially vocational schools, to have reliable internet network infrastructure to support technology-based learning. However, prior to this community service activity, SMK Rahmatullah Al-Maarif in Lombok, West Nusa Tenggara, Indonesia experienced several network problems, including slow internet connections, limited coverage areas, and inadequate network hardware, which hindered the implementation of digital learning activities. Therefore, this activity aimed to improve the school's internet network infrastructure using the Network Development Life Cycle (NDLC) method through the stages of analysis, design, prototype simulation, implementation, monitoring, and management. Network testing was conducted using Speedtest under normal school operational conditions by measuring download speed, upload speed, and latency on wired and wireless devices. The results showed that the implemented network infrastructure achieved an average download speed of 41.55 Mbps on wired devices and 35 Mbps on wireless devices, with a latency of 34ms, indicating a stable internet connection that supports technology-based learning activities more effectively. The implementation also improved internet accessibility and network coverage across the school environment.

Keywords: Community Service; Network Development Life Cycle; Network Implementation Network Infrastructure; Vocational School

1. INTRODUCTION

Advances in information and communication technology have brought significant changes in various fields including education (Sambuari et al., 2022) . One crucial aspect of this development is the internet, which has now become a primary requirement in the learning process. With the internet, students and teachers can access various information sources, utilize e-learning platforms, and collaborate globally. In the era of the Industrial Revolution 4.0, digital literacy and technological skills are key competencies that students, especially those in Vocational High Schools (SMK), must possess. As educational institutions focused on developing student skills, SMKs play a strategic role in preparing graduates for an increasingly technology-based workforce. Therefore, internet infrastructure is a fundamental requirement in supporting the learning process (Tomi Tristono, 2022).

However, in reality, many schools still face challenges in providing adequate technological infrastructure (Susanto, 2020). Based on observations at Rahmatullah Al-Maarif Vocational School, several issues were identified that hinder the optimal use of technology. Before the implementation process, the existing network infrastructure at SMK Rahmatullah Al-Maarif had an average internet speed of below 10 Mbps, with Wi-Fi coverage limited to only 30% of the school area. Approximately 4 classrooms and 1 computer laboratory were not adequately covered by the network, while the old networking equipment consisted of basic routers and limited access points that were unable to support more than 40 connected users simultaneously.

These conditions caused unstable connections and disrupted technology-based learning activities. Consequently, technology-based learning processes such as the use of e-learning platforms and digital skills training for students cannot run optimally (Hasan & Purnama, 2024). This demonstrates the urgent need for a stable and equitable internet network across the school. As an institution that routinely uses computers for learning, SMK Rahmatullah Al-Maarif requires stable and equitable internet access to support technology-based learning and enhance students' competencies in the workplace (Afdhol. P. Y. et al., 2023).

As a solution, a computer network can connect various devices such as computers, via cables or wirelessly, enabling these devices to communicate with each other and share data to achieve common goals (Wulandari et al., 2020). One example is the use of LAN cable-based networks which are often implemented in small areas such as schools, because they offer high connection stability (Rahmanto, 2021). Furthermore, the internet, as a global communications network, enables the transfer of information in various forms, such as images, audio, text, and video, which supports educational activities. At SMK Rahmatullah Al-Maarif, computers are routinely used for learning, making reliable network infrastructure a crucial requirement to support this process (Priyandoko, 2021).

This is in line with various previous studies that have made important contributions to the development of network infrastructure. Such as research (Arafat et al., 2022) shows that designing internet and intranet network infrastructure in Pemangkat Kota Village using the Packet Tracer application and VLAN configuration successfully increased information access and supported e-learning-based learning. Meanwhile, the research (Danuasmo et al., 2023) emphasizes the importance of adding access points in areas with high

user density to improve connectivity and the use of authentication systems such as RADIUS to improve network security.

Other research by (Arther Valentino Mananggel, 2021) and (Pelealu et al., 2020) successfully demonstrated improved network quality at SMK Negeri 1 Tabukan Utara and SMK Negeri 1 Tahunan with significant reductions in delay and packet loss. On the other hand, (Dafwen Toresa, 2023) reported that basic computer network training at the Riau Innovation Oil and Gas Vocational School succeeded in motivating students in understanding network concepts, while (Dani Daryos Papaceda, Alfrina Mawengkang, 2023) emphasized the importance of network development and management to improve infrastructure performance at SMK Negeri 8 Halmahera Tengah.

In addition, research by (Regar Devitasari, 2020) shows that the use of NodeMCU microcontrollers can improve control and data processing effficiently, while (Nugraha & Harefa, 2023) proving that LTE signals can be used for internet distribution in blank spot areas. (Na'im, 2022) and (Sindy Nova, Nurul Khotimah, 2022) also found that good network design, such as the use of star topology and effective authentication systems, can improve network efficiency and accessibility in educational environments.

In response to existing problems and supporting previous research findings, strategic steps in the form of designing and implementing a stable, reliable internet network that covers the entire school area are the main solution (Abdul Haris Muhammad et al., 2023). This research aims to design and implement a reliable internet network infrastructure at SMK Rahmatullah Al-Maarif to support technology-based learning activities and improve school operational efficiency.

The specific contributions of this activity include expanding Wi-Fi coverage to classrooms and laboratory areas, improving internet connection stability and speed, configuring network management and bandwidth distribution, and providing training for school IT staff regarding network maintenance and troubleshooting. Through this implementation, students, teachers, and administrative staff are expected to gain more stable and equitable internet access, thereby supporting digital learning, online collaboration, and the development of technological competencies in the digital era. This effort is expected to prepare SMK Rahmatullah Al-Maarif

as an educational institution better prepared to face the challenges of technology-based education and the workplace.

2. METHOD

This research was conducted at SMK Rahmatullah Al-Maarif, Lombok, West Nusa Tenggara, Indonesia. The school area covered in this activity was approximately 1,500 m², including classrooms, computer laboratories, administrative offices, and teacher rooms. The method used in this research is NDLC (Network Development life cycle) which consists of the stages of analysis, design, prototype simulation, implementation, monitoring, and management which can be seen in Figure 1.

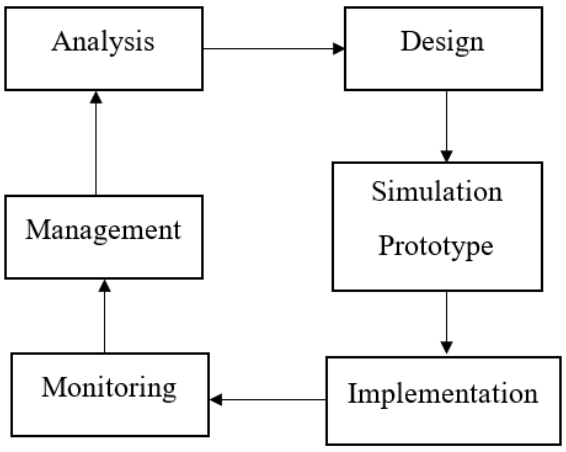

Figure 1. NDLC Method

During the analysis stage, data collection was carried out through direct observation, interviews, and network testing. Interviews involved 10 respondents consisting of the principal, teachers, administrative staff, and school IT personnel to identify internet usage needs and existing network problems. Observation activities were conducted using laptops, LAN cable testers, and Speedtest software to measure the initial internet connection quality, including download speed, upload speed, and latency (Eko Nugroho & Daniarti, 2021).

The analysis results showed that several classrooms and laboratory areas were not adequately covered by the Wi-Fi network. The existing network infrastructure only used one basic router and limited access points, causing unstable internet connections when accessed simultaneously by many users. The school network served approximately 40–60 active users per day consisting of students, teachers, and staff.

In the design stage, a star topology network was developed using one MikroTik RB750 router, one Cisco Catalyst 2960 switch, and three TP-Link access points distributed across strategic locations in the school environment. IP addressing and subnetting configurations were also designed to optimize network traffic management (Saputra et al., 2023).

The prototype simulation stage was conducted using Cisco Packet Tracer software to test routing configuration, network connectivity, and bandwidth distribution before implementation (Sumarni & Purnama, 2023). After validation, the implementation stage involved installing routers, switches, access points, and LAN cabling according to the proposed design.

The monitoring stage was carried out for two weeks using PRTG Network Monitor and Speedtest software under normal school operational conditions. Network performance evaluation included measuring download speed, upload speed, latency, connection stability, and Wi-Fi coverage (Septuvania & Purnama, 2023). Finally, at the management stage, training and technical guidance were provided to school IT staff regarding network maintenance, troubleshooting, and bandwidth management to ensure long-term network sustainability (Rahman et al., 2023).

3. RESULT AND DISCUSSION

This community service activity aims to address internet access issues at Rahmatullah Al-Maarif Vocational School through a network technology implementation program. In the initial analysis phase, An initial site visit was conducted at SMK Rahmatullah Al-Maarif to directly observe the existing network infrastructure and identify the school's internet network requirements which can be seen in Figure 2.

Figure 2. SMK Rahmatullah AL-Maarif

The observations included mapping areas requiring internet access, analyzing available hardware and software, and interviewing school officials, including principals, teachers, and IT staff. The observations revealed that most classrooms and laboratories lacked adequate internet connections, while available devices were limited to computers and routers with basic specifications that were unable to support the optimal number of users which can be seen in Figure 3.

Figure 3. Room Layout

Next, at the design stage, the network topology is designed to ensure data distribution efficiency and scalability which can be seen in Figure 4.

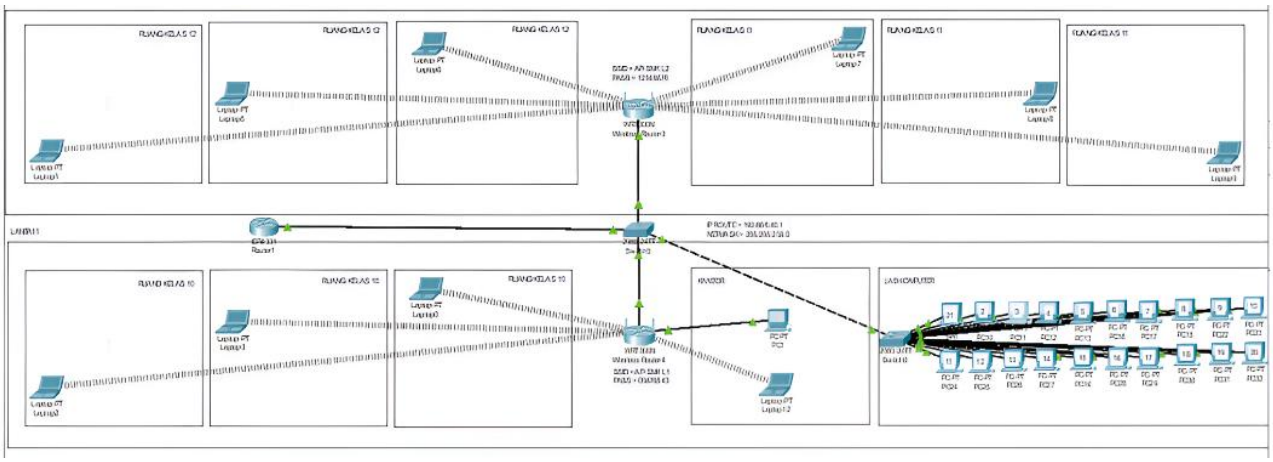

Figure 4. Topology Design

A main router was chosen to manage network traffic, with a main switch to distribute connections to computers in the labs and classrooms. Access points were installed on each floor of the building to provide wireless connectivity to specific areas such as meeting rooms and offices. The design also included static IP

addresses with separate gateways for each building, allowing each building to manage its own data traffic which can be seen in Table 1.

Table 1. IP Addressing

Device	IP Address	Netmask
Router	192.168.40.1	255.255.255.0
Lab Komputer 1-20	192.168.40.2 to 192.168.40.21	255.255.255.0
Access point 1	DHCP	255.255.255.0
Access point 2	DHCP	255.255.255.0

Next, a simulation was conducted using Cisco Packet Tracer software to validate the design. The simulation tested the connection between devices, routing settings between subnets, and connection stability under high load conditions with a large number of connected devices. The main router (ISR4331) functions as a gateway, managing data traffic and connecting the school network to the internet service provider (ISP). This router is connected to the main switch (2960-24TT), which distributes wired connections to computers in the laboratory and administration room. In addition, two access points (WRT300N) are used to provide wireless connections on the first and second floors, with different SSID and password configurations to maintain network security.

The simulation results showed that all wired and wireless devices were successfully connected and able to communicate with each other through ping testing. Network performance evaluation was also conducted by measuring connectivity quality indicators such as packet loss, delay, and response time. The testing results demonstrated stable network communication with low latency and no significant packet loss during data transmission. The detailed ping testing results are presented in Table 2. Based on the testing results, the implemented network infrastructure demonstrated stable connectivity with low delay and reliable communication performance for supporting technology-based learning activities.

Table 2. Network Connectivity Testing Results

Source Device	Destination Device	Average Ping (ms)	Packet Loss (%)	Status
Router	Computer Lab 1	2 ms	0%	Connected
Router	Computer Lab 2	3 ms	0%	Connected
Router	Access Point 1	1 ms	0%	Connected
Router	Access Point 2	2 ms	0%	Connected
Wireless Client	Internet Gateway	34 ms	0%	Stable

In the implementation stage, hardware such as routers, switches, internet servers, and access points are installed according to the design that has been made. The main router was configured to assign IP subnet addresses to connected devices, while the main switch was used to distribute connections to computers in each laboratory. Access points were installed in three strategic locations to ensure even Wi-Fi signal coverage. After installation, the network was tested live by connecting user devices such as computers, laptops, and smartphones. Testing included download speed, latency, and connection stability. After implementation is complete, two weeks monitoring phase is conducted to ensure the network is operating as expected. Monitoring is performed using software such as PRTG Network Monitor to monitor data traffic, bandwidth usage, and network stability.

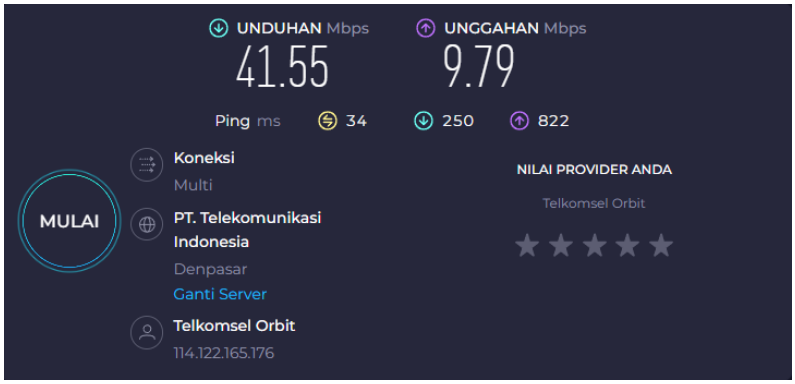

Figure 5. Speedtest

The test results in Figure 5 using the Speedtest service show the network performance evaluation was conducted through five consecutive tests at different times during school operational hours. The results showed an average download speed of 41.55 Mbps, an average upload speed of 9.79 Mbps, and an average latency of 34ms. These results provide an initial overview of the quality of the internet connection available at the school. A download speed of 41.55 Mbps is considered good for supporting the need to access digital learning resources, such as learning videos, e-learning, or downloading materials.

However, an average upload speed of 9.79 Mbps is considered sufficient for supporting moderate simultaneous activities, such as uploading assignments, accessing cloud-based learning platforms, and conducting online communication by multiple users under normal school operational conditions. To ensure network sustainability, the community service team provided training to the school's IT staff on network

management and maintenance. The training materials covered how to inspect hardware such as routers and switches, monitor bandwidth usage, and perform basic troubleshooting.

Simple technical guides were also compiled into manuals to assist staff in addressing issues such as connection loss or device reconfiguration. Furthermore, network management policies were implemented, such as restricting access for specific devices to prevent unproductive bandwidth usage. For example, access to entertainment sites and social media was restricted during school hours to ensure optimal bandwidth utilization for learning activities. The school team also established an IT working group consisting of teachers and staff to act as internal monitors, tasked with regularly monitoring the network and reporting issues to the internet service provider (ISP) if necessary.

4. CONCLUSION

This community service activity successfully improved the internet network infrastructure at SMK Rahmatullah Al-Maarif using the Network Development Life Cycle (NDLC) method through the stages of analysis, design, simulation, implementation, monitoring, and management. The implementation involved the installation of one router, one switch, and three access points distributed across strategic areas of the school to expand network coverage and improve connection stability.

Based on five network performance tests conducted under normal school operational conditions, the implemented network achieved an average download speed of 41.55 Mbps, an average upload speed of 9.79 Mbps, and an average latency of 34ms. The testing results also showed stable connectivity with minimal packet loss for both wired and wireless devices. In addition, the network infrastructure successfully expanded internet coverage to classrooms, laboratories, administrative offices, and teacher rooms that previously experienced limited or unstable internet access.

Furthermore, this activity contributed to improving the effectiveness of technology-based learning activities, online communication, and access to digital learning resources for approximately 40–60 active users consisting of students, teachers, and administrative staff. To support long-term sustainability, technical training and network maintenance guidance were also provided to the school IT staff.

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