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Computer Network

Implementation of Mikrotik-Ruijie Network Design Based on NDLC to Support the Learning Process at SMK LPPM RI 2 Kedungreja

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A B S T R A K

The rapid development of information technology demands educational institutions to provide reliable and efficient network infrastructure to support digital learning processes. SMK LPPM RI 2 Kedungreja, as a vocational education institution, is required to have an adequate computer network to ensure that ICT-based teaching and learning activities can run optimally. This study aims to design and implement a computer network using Mikrotik and Ruijie devices by adopting the Network Development Life Cycle (NDLC) method, which consists of six main phases: initiation, planning, analysis, design, implementation, and maintenance. The outcome of this study includes a structured network topology design, configuration of Mikrotik routers and Ruijie switches/access points, and complete network documentation that can be directly implemented in the school environment. The designed network supports user segmentation for students, teachers, and administrative staff, bandwidth management using queue and VLAN mechanisms, basic security features such as firewall filtering and access control, and centralized monitoring through Ruijie Cloud. Post-implementation testing was conducted to evaluate the effectiveness of the proposed network design. Performance measurements were carried out under normal school operational conditions. The test results show that the network achieved an average throughput of 92–95 Mbps for wired connections and 70–85 Mbps for wireless users. Average network latency was recorded at 5–8 ms for internal access and 15–25 ms for internet access, indicating responsive network performance. Packet loss remained below 1%, demonstrating stable and reliable data transmission across the network. These results indicate that the implemented network meets acceptable quality of service (QoS) standards for educational environments. By applying the NDLC method, the network design and implementation process was carried out systematically, resulting in a more structured, efficient, and easily maintainable system. The implementation of this network is expected to significantly improve internet accessibility within the school, support smooth online teaching and learning activities, and enhance SMK LPPM RI 2 Kedungreja's readiness in facing the challenges of educational digitalization.

INTRODUCTION

The rapid development of information and communication technology (ICT) has brought significant changes to the field of education. The learning process no longer relies solely on conventional methods, but increasingly integrates various digital platforms such as e-learning, computer-based exams, online classroom management, and access to internet-based learning resources. Therefore, the availability of a stable, secure, and efficient computer network infrastructure has become a fundamental requirement to support modern educational activities[1][2].

As a vocational education institution, SMK LPPM RI 2 Kedungreja is expected to adapt to these developments. However, in practice, the school still faces various challenges related to its network infrastructure. The main issues include an underdeveloped and unstructured network design, unsegmented internet access, and the absence of adequate bandwidth management and network security systems. A critical problem is the lack of network segmentation between users—

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students, teachers, and staff—which results in unequal internet distribution and potential misuse[3][4]. Moreover, poor bandwidth management allows users to access non-educational content such as video streaming or online games, which significantly degrades network performance during peak usage hours[5].

Security is also a concern, as the current network is not equipped with proper firewalls, content filtering, or user authentication systems[6][7]. This makes the network vulnerable to both internal and external threats such as malware and unauthorized access[8]. Additionally, the absence of monitoring systems and technical documentation hinders the school's ability to carry out maintenance and troubleshooting effectively[9][10].

To address these challenges, a structured, secure, and efficiently managed network design is required. One suitable method for this is the Network Development Life Cycle (NDLC), which provides a systematic framework consisting of initiation, planning, analysis, design, implementation, and maintenance phases.

In this network design, Mikrotik devices are utilized as the main router due to their strong capabilities in network management, while Ruijie devices are employed to support wireless connectivity and centralized network control through Ruijie Cloud. By combining both technologies and applying the NDLC approach, the resulting network is expected to resolve the existing problems and support the digital transformation within SMK LPPM RI 2 Kedungreja.
The combination of Mikrotik and Ruijie devices was selected to balance cost efficiency, performance, and ease of management, which are critical factors in an educational environment. Mikrotik was chosen as the core routing device due to its powerful routing capabilities, flexible bandwidth management features, and affordability compared to enterprise-grade routers. Mikrotik routers support advanced network functions such as VLAN segmentation, firewall filtering, NAT, and detailed traffic control, making them well suited for managing diverse user groups such as students, teachers, and administrative staff within a school network.

Ruijie devices were selected for the access layer, particularly switches and wireless access points, due to their reliability, strong wireless performance, and seamless integration with Ruijie Cloud management. Ruijie access points provide stable connectivity for high-density user environments such as classrooms and laboratories, where many devices are connected simultaneously.

Advantages of Ruijie Cloud Management in a School Environment
Ruijie Cloud offers significant advantages over traditional on-premise network management systems, especially for schools with limited IT personnel. Through Ruijie Cloud, network administrators can centrally monitor, configure, and manage all Ruijie devices via a web-based dashboard without the need for a local controller or complex server infrastructure. This centralized management enables real-time monitoring of access point status, user connections, bandwidth usage, and network health across the entire school campus.

Compared to traditional setups that require manual configuration on each device, Ruijie Cloud simplifies deployment and maintenance by allowing bulk configuration, remote troubleshooting, and automatic firmware updates. These features reduce operational complexity and minimize network downtime. Additionally, Ruijie Cloud provides visual analytics and alerts that help administrators quickly identify connectivity issues, making it highly suitable for a dynamic school environment where network reliability is essential to support digital learning activities.

By combining Mikrotik's robust routing and traffic control capabilities with Ruijie's cloud-based access management, the resulting network architecture achieves both technical effectiveness and operational efficiency, making it an ideal solution for educational institutions undergoing digital transformation.

LITERATURE REVIEW

The literature review on the implementation of Mikrotik-Ruijie network design based on the Network Development Life Cycle (NDLC) method to support the learning process at SMK LPPM RI 2 Kedungreja can be discussed through several relevant case studies.

1. Implementation of Mikrotik and Ruijie at SMK Ar-Rahmah
   A community service program at SMK Ar-Rahmah Yogyakarta implemented VLAN configurations using Mikrotik RB750r2 and Ruijie Switch RG-ES205GC. The aim of the training was to improve students'

understanding of network administration, addressing issues such as IP conflicts, inefficient bandwidth usage, and inadequate network segmentation.
The training provided hands-on experience for students in VLAN configuration, enhancing their practical skills in network management.

2. Server Network Design with VPN Based on Mikrotik
Research at Universitas PGRI Silampari designed and implemented a server network system with VPN based on Mikrotik using the NDLC method. The goal was to improve network security and accessibility. The results showed significant improvements in protecting the network from cyberattacks and provided more efficient and secure access for external users. This solution successfully addressed security gaps and supported digital-based academic activities.
3. IT Infrastructure Optimization at SMK Negeri 1 Kandis
At SMK Negeri 1 Kandis, IT infrastructure was optimized through the implementation of fiber optic networks and Mikrotik-based hotspot servers with Mikhom features. The school faced issues such as unstable internet connections and suboptimal network management.
NDLC was used to design and implement the network system, resulting in improved speed and connection stability, supporting digital-based learning activities.
4. Network Management Design and Implementation at SMK Negeri 1 Raman Utara
Research at SMK Negeri 1 Raman Utara involved designing and implementing internet network management using Mikrotik devices. The main challenges included limited bandwidth and network security.
NDLC was applied to design and implement the system, resulting in improved network quality and coverage, with good performance in throughput, packet loss, delay, and jitter.

The Network Development Life Cycle (NDLC) is a systematic approach used to design, implement, and maintain computer networks. In this study, NDLC is applied to ensure that the network development process is structured, measurable, and aligned with user requirements. The NDLC consists of six interconnected phases: Analysis, Design, Simulation, Implementation, Monitoring, and Management.

1. Analysis Phase
The analysis phase focuses on identifying existing network conditions and user requirements. This includes evaluating current network performance, identifying problems such as bandwidth congestion or unstable connections, and determining the needs of different user groups (students, teachers, and administrative staff). Data is collected through observation, interviews, and traffic analysis to define technical and functional requirements for the new network.
2. Design Phase
In the design phase, the network architecture is planned based on the results of the analysis phase. This includes designing the logical and physical topology, IP addressing schemes, VLAN segmentation, bandwidth allocation, and security policies. Device selection, such as Mikrotik routers and Ruijie switches/access points, is also finalized during this phase to ensure the design meets performance and scalability requirements.
3. Simulation Phase
The simulation phase is used to test the proposed network design before real implementation. Network configurations and traffic scenarios are simulated using tools such as network simulators or test environments to verify connectivity, bandwidth distribution, and routing behavior. This phase helps identify potential issues early, reducing the risk of configuration errors and minimizing implementation failures.
4. Implementation Phase
The implementation phase involves deploying the network according to the approved design. This includes physical installation of devices, configuration of Mikrotik routers and Ruijie equipment, VLAN setup, bandwidth management, and security rule implementation. The network is then activated and tested to ensure all components function as intended.
5. Monitoring Phase
In the monitoring phase, the network's performance is continuously observed to ensure stability and reliability. Key performance indicators such as throughput, latency, packet loss, and device status are monitored using tools like Mikrotik monitoring features and Ruijie Cloud dashboards. This phase enables administrators to detect performance degradation or failures in real time.
6. Management Phase
The management phase focuses on long-term network operation and maintenance. Activities include configuration updates, user management, security policy enforcement, backup and documentation, and

troubleshooting. Cloud-based management via Ruijie Cloud simplifies centralized control and reduces administrative workload, ensuring the network remains scalable and adaptable to future needs.

METHOD

The method used in this network design is the Network Development Life Cycle (NDLC)[11][12]. NDLC is a method used in the computer network development process that is systematic, structured, and incremental. This method assists in planning, analysis, design, implementation, testing, and network maintenance. NDLC consists of six stages, namely:

Figure 1. NDLC Method

1. Initiation

   The initiation phase is the initial step in the Network Development Life Cycle (NDLC) method, focusing on gathering preliminary information to understand the existing conditions and actual needs related to network infrastructure. In this phase, the identification of computer network requirements[13] at SMK LPPM RI 2 Kedungreja is conducted, serving as the foundation for technical planning in the subsequent stages. The main activities in this phase include:

   a. Observation of the existing network infrastructure, aimed at assessing the physical condition, topology, and the functionality of devices—identifying those that are still operational or require replacement. This observation also helps to recognize vulnerable points such as areas with weak signals or limited connectivity.
   b. Interviews with internal stakeholders, including the principal, ICT teachers, and IT staff, to gather information about current challenges, expectations for the new network system, and policies that need to be considered during the design process. This qualitative approach aims to understand the school's strategic needs regarding network technology usage.[14]
   c. Collection of user network requirements data, including classification of users (students, teachers, and educational staff), the number of connected devices, and frequently used services such as internet access, online learning systems, school administrative applications, and others. This data is crucial to estimate network traffic load and to allocate bandwidth proportionally.[15]

   Through this identification process, a comprehensive overview of the technical and operational requirements that must be met by the network to be designed is obtained. The information collected during the initiation phase serves as the foundation for the planning and analysis stages, ensuring that the network design aligns with real-world needs and supports the institutional objectives of the school[16].

2. Planning

   The Planning phase in the Network Development Life Cycle (NDLC) method involves the formulation of technical and managerial strategies for building the network infrastructure. In this phase, network design planning is carried out based on the user requirements identified in the previous phase. Comprehensive planning is essential to ensure that the implementation process proceeds efficiently, systematically, and aligns with the final objectives to be achieved. The main activities in this phase include:

   a. Determination of the network topology to be used. Topology refers to the logical arrangement of connections between devices within the network. The choice of topology is based on factors such as the number of users, coverage area, scalability, and ease of maintenance. Common topologies used in school environments are star topology, due to its ease of management and fault isolation, or hybrid topology, which combines several schemes to accommodate more complex requirements.
   b. Selection of network hardware to ensure the availability of equipment that meets the technical specifications and budget constraints. The devices selected in this design include Mikrotik routers as the central network controllers, Ruijie devices for switches and access points supporting centralized management, as well as

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category 6 UTP cables, patch panels, and RJ45 connectors as the primary transmission media. Hardware selection considers performance, scalability, ease of configuration, and cost efficiency.

c. Development of IP addressing schemes and Virtual LANs (VLANs), if required. IP addressing is necessary to identify devices within the network and manage communication between subnets. The use of VLANs is recommended to group users based on function (e.g., VLANs for students, teachers, and administrative staff) to enhance security and optimize data traffic efficiency.

d. Preparation of budget and implementation timeline. This planning includes estimating costs for hardware procurement, installation services (if third-party vendors are involved), and other technical needs such as cables and measuring tools. Additionally, a timeline is established covering stages from preparation, physical installation, device configuration, to network testing.

With thorough and structured planning, the subsequent implementation phase can proceed more effectively, minimize technical errors, and ensure that the designed network truly meets the operational needs of the school.

3. Analysis
   Analysis is conducted to determine the required technical specifications and evaluate potential constraints. Activities in this phase include: Bandwidth requirements analysis. Analysis of the number of users and devices. Feasibility study of the network from technical and cost perspectives.
4. Design
   In this phase, a detailed design of the network to be built is developed. The output of this phase is a network design document that includes: Network topology diagrams. Placement of network devices (Router, Switch, Access Point). Design of IP addressing, DHCP, NAT, firewall, and VLAN configurations. Configuration plans for Mikrotik and Ruijie devices.
5. Implementation
   his phase involves the realization of the network design into its physical form and configuration. Activities carried out include: Installation and cabling of network devices. Configuration of Mikrotik Router (routing, NAT, DHCP, firewall). Configuration of Ruijie devices (Access Points, Switches). Initial connection testing and basic troubleshooting.

User requirements for the proposed network design were gathered using a mixed data collection approach to ensure that both technical and operational needs were accurately identified. This approach combined teacher interviews, student surveys, and direct network traffic observation, allowing for comprehensive requirement analysis from multiple perspectives.

1. Teacher and Staff Interviews
   Semi-structured interviews were conducted with teachers and administrative staff to understand their network usage patterns and expectations. The interviews focused on identifying critical applications such as Learning Management Systems (LMS), video conferencing platforms, online assessments, and administrative systems. Teachers also provided insights into peak usage times, common connectivity issues during online classes, and the need for stable and prioritized internet access. These inputs were essential in defining bandwidth prioritization and segmentation policies for instructional and administrative users.
2. Student Surveys
   Questionnaires were distributed to students to collect information on the number of devices used, types of applications accessed, and frequency of internet usage during school hours. The survey results indicated high usage of web-based learning platforms, multimedia content, and cloud services. This data helped estimate the number of concurrent users and guided the design of wireless coverage, access point placement, and bandwidth allocation for the student network segment.
3. Direct Network Traffic Observation
   Direct traffic observation was performed by monitoring existing network activity using router and access point logs. Parameters such as peak bandwidth consumption, application types, and connection stability were analyzed. This observation provided objective data on actual network behavior, complementing the qualitative data obtained from interviews and surveys. The results were used to validate user requirements and ensure that the proposed network design could handle real-world traffic loads.

RESULTS AND DISCUSSION

Results

1. Initiation

   At this stage, the author conducted interviews by posing questions to teachers, students, and the network management staff at SMK LPPM RI 2 Kedungreja. The interview results indicate strong support for the development of the network, as a structured bandwidth management system—such as user restrictions and bandwidth limits—would improve internet access for learning activities. Furthermore, the implementation of content blocking features for non-educational sites is considered necessary to ensure more focused and productive internet usage within the educational environment. The addition of a user authentication system via a login page is also highly needed, given that the existing network previously allowed full access without user controls. This login system would provide better access control and facilitate the monitoring of user activities.

   Following the observations conducted at SMK LPPM RI 2 Kedungreja, the author received full support from the network management team. They willingly provided information and data regarding the current network system during the research process. This observation aimed to understand the existing network infrastructure condition, identify existing problems, and evaluate the need for system improvements to optimally support the learning process within the school environment.

2. Planning

   The cost analysis for the implementation of the computer network design is presented in the following table:

Table 1. Cost Requirements Analysis Table

NO	Device or Equipment	Amount	Price
1	Mikrotik RB3011UiAS-RM	1 Pcs	Rp. 2.850.000
2	Ruijie Reyee RG-RAP2200(F)	5 Pcs	Rp. 3.500.000
3	Switch TL-SG1016D	1 Pcs	Rp. 825.000
4	Socket RJ45 Giga Byte	1 Set	Rp. 114.000
5	Cable LAN UTP Cat5e	1 roll	Rp. 1.645.000
6	Installation Operational Costs	1 packet	Rp. 2.000.000
Total Cost			Rp. 10.934.000

3. Analysis

   The results of the needs analysis in the network design to be implemented include the following:

   a. Software requirements

      The software requirements analysis for designing a computer network is presented in the following table:

Table 2. Network Software Requirements Analysis Table

No	Device or Equipment	Tipe
1	*Operating System*	Windows 10
2	Winbox	Version 3.42
3	PNET Lab	Version 4.2.10
4	*Virtual Machine*	VM Ware Version 17.0
5	Router OS	v6.49.18 Lisensi level 4
6	The Dude	Version 6.49.18

   b. Hardware requirements

      The hardware requirements analysis for designing a computer network can be seen in the following table:

Table 3. Network Hardware Requirements Analysis Table

NO	Device or Equipmen	Specification
1	Laptop	HP Intel(R) Core(TM) i3-7020U CPU @ 2.30GHz

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2	Hand Phone	Oppo Reno 8T
3	Socket	RJ45 Giga Byte
4	LAN Cable	UTP Cat5e
5	Mikrotik	
6	Ruijie Reyee	
7	Switch	a. TL-SG1016D b. 16-port RJ45 Gigabit Auto-Negotiation, supports Auto MDI/MDIX c. Green Ethernet technology saves up to 40% power d. Supports MAC address self-learning and Auto MDI/MDIX e. Plug and play, no configuration required
8	Modem	Fiberhome HG6245

c. Design

The author carried out the assembly and configuration to implement a network infrastructure integrating both wired and wireless media to establish a comprehensive internet network system at SMK LPPM RI 2 Kedungreja. This implementation involved connecting all network components that were planned in the previous discussion, including the configuration of the ISP modem, MikroTik router, five Ruijie Reyee access points, and switches as the main devices for bandwidth management. The assembly process was conducted with consideration of an optimal network topology to support 485 users across various predetermined access categories.

Figure 2. Network Infrastructure

d. Implementation

The author implements the physical hotspot network using MikroTik to provide a clearer visualization. The physical implementation focuses on the placement of devices and how cables are connected to switches and access points, as well as the configuration of the hotspot on the MikroTik device

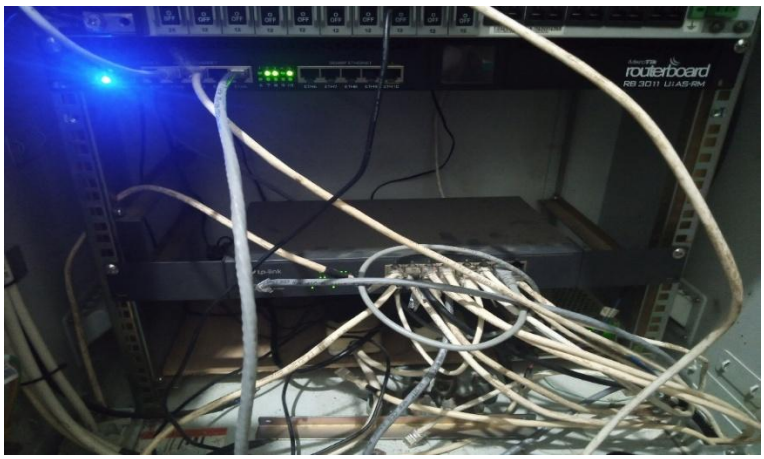

Figure 3. Server Installation

The image above illustrates a network infrastructure involving a Mikrotik routerboard as the central control unit and switches for distributing connections to various access points or users, typically in a medium-scale environment. Overall, the hotspot network connected to all devices forms an integrated ecosystem. Mikrotik functions as the central controller, managing who is allowed to access the internet, the speed of their access, and the duration of their connection. Meanwhile, the Ruijie Reyee Access Points are responsible for distributing Wi-Fi signals, enabling user devices to connect and utilize the provided internet services.

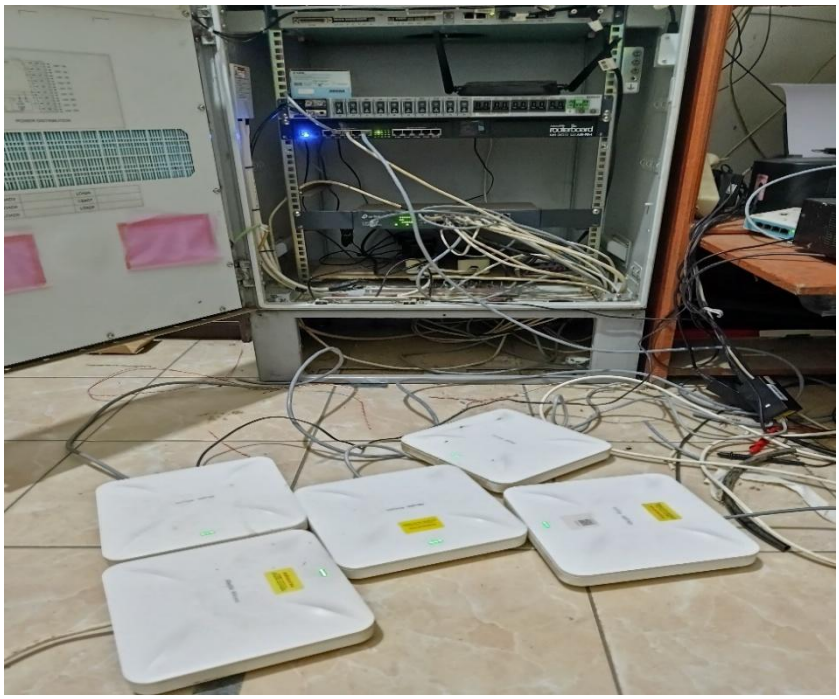

Figure 4. Installation of Ruijie Reyee Access Point

After all files are uploaded and the configurations are complete, try connecting a device (such as a smartphone or laptop) to your hotspot network. The browser should automatically redirect to your custom login page.

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Teacher Login:

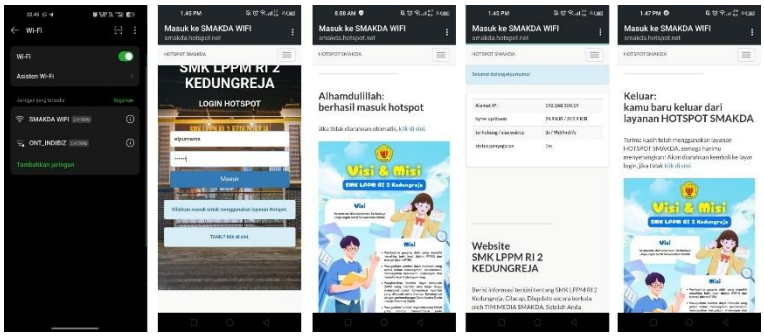

Figure 5. Teacher User Login Page

Staff User Login

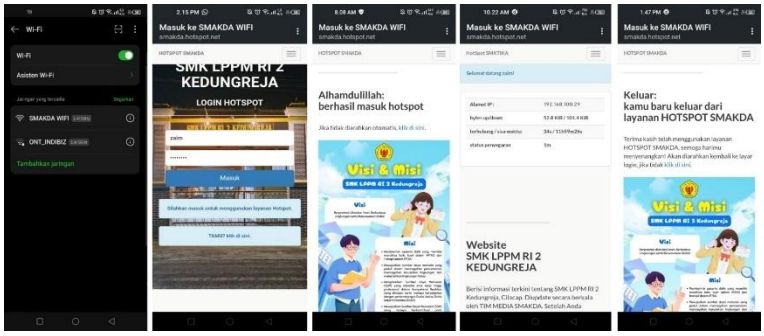

Figure 6. Staff User Login Page

Student User Login:

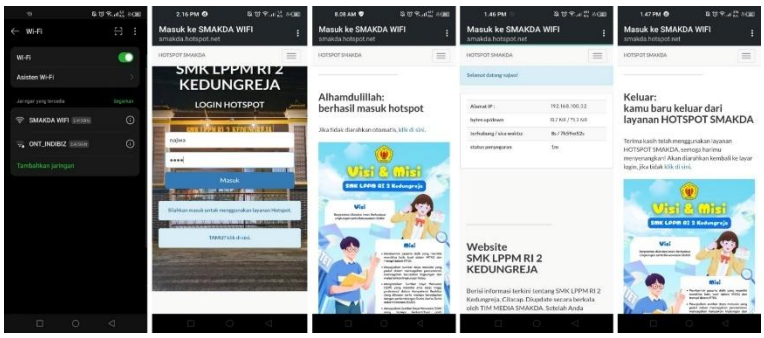

Figure 7. Student User Login Page

Guest User Login:

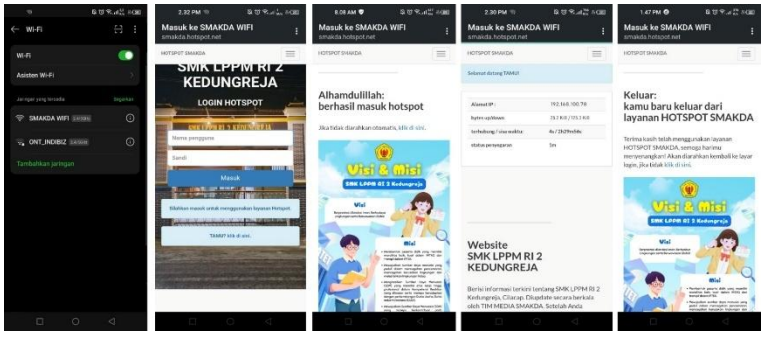

Figure 8. Guest User Login Page

Discussion

In the monitoring phase, comprehensive supervision is carried out on the performance of all integrated network components within SMK LPPM RI 2 Kedungreja. This process aims to ensure that the network system, which has been designed and implemented, functions as intended and is capable of meeting users' needs optimally. Monitoring is conducted on hardware components such as computers, routers, switches, and access points, as well as software aspects,

through internet speed testing using online tools such as Google Speed Test. These tests help evaluate bandwidth distribution quality and network stability under real-world usage conditions.

To obtain accurate and real-time data regarding the performance of the overall system, the researcher utilizes The Dude, a network monitoring application developed by MikroTik. The Dude allows centralized and visual supervision of all implemented network elements, including not only MikroTik devices but also third-party hardware such as Ruijie access points, computers, and servers. The Dude is chosen as the primary monitoring tool because it offers a wide range of features that support efficient and intuitive supervision—especially for users already familiar with the MikroTik ecosystem.

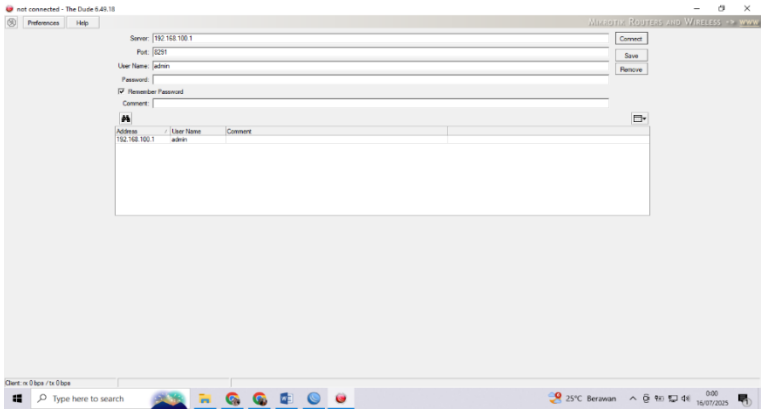

Figure 8. The Dude Login Page

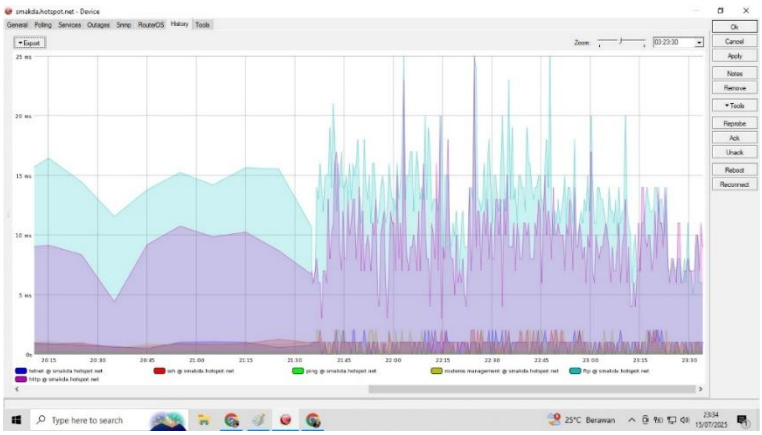

Figure 9. Hotspot Traffic for All Users

The network topology in this study is presented in a high-resolution diagram to ensure that all network components are clearly visible and easy to understand. The topology diagram was created using professional network design tools such as Microsoft Visio or Draw.io and exported in PNG or SVG format with a minimum resolution of 300 DPI. The diagram illustrates the relationship between the internet connection as the gateway, the Mikrotik router as the central network controller, Ruijie switches and access points as distribution and access devices, and segmented networks for students, teachers, and administrative staff.

Bandwidth management in the proposed network is implemented using the Simple Queue method on the Mikrotik router. This method was chosen due to its ease of configuration and effectiveness in managing bandwidth in small- to medium-scale networks such as school environments. Bandwidth allocation is based on user segmentation, where the teacher network is given higher priority and more stable bandwidth to support online learning activities such as video conferencing and access to Learning Management Systems (LMS). The administrative staff network is allocated sufficient bandwidth to support school information systems, while the student network is provided with controlled and evenly shared bandwidth to prevent network congestion during peak usage periods.

From a security perspective, the network is equipped with basic security mechanisms implemented on the Mikrotik router. These measures include the use of Firewall Filter rules to restrict access between network segments, block unauthorized traffic, and protect the network from potential misuse. In addition, user authentication is applied through the Hotspot

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feature for the student wireless network, requiring users to log in before gaining internet access. This implementation aims to enhance access control, network security, and user accountability within the school environment.

CONCLUSIONS AND SUGGESTIONS

Conclusions

Based on the results of research and network design carried out using the Network Development Life Cycle (NDLC) method at SMK LPPM RI 2 Kedungreja, the following conclusions can be drawn: The NDLC method has proven to be effective in the network design process as it provides a systematic and structured set of phases, from identifying needs to ongoing maintenance. Each phase offers a solid foundation for both technical and managerial decision-making. The network designed using Mikrotik routers and Ruijie devices successfully created a more stable, segmented, and secure local network system. Mikrotik enables efficient management of bandwidth, DHCP, firewall, and NAT, while Ruijie devices provide centralized and flexible access point management through Ruijie Cloud. Previous issues—such as the lack of user segmentation, limited bandwidth, and weak network security—were successfully addressed through this design. Network users are now segmented by function (students, teachers, and staff), bandwidth is fairly allocated, and content access can be controlled more effectively. Network testing results indicate that the connection is stable, internet access is well-distributed, and online learning activities run more smoothly compared to the previous conditions. Well-documented configuration and network design simplify the school's ability to maintain and further develop the infrastructure in the future.

Suggestions

To ensure that the designed network can be utilized optimally and sustainably, the following recommendations are proposed:

1. Maximize the use of Ruijie Cloud features for real-time monitoring and management of wireless devices. This will enable more effective oversight of network usage and performance.
2. The school is encouraged to conduct training or workshops for teachers and staff on basic network management, particularly in the use of Winbox and the Ruijie Cloud Console, to reduce dependency on external technicians.
3. It is recommended that the school perform routine maintenance on network devices, including both hardware and system configurations, to prevent potential failures and ensure consistent network performance.
4. The implementation of log monitoring systems and network activity logging is advised to enable better user activity tracking and facilitate faster resolution in the event of disruptions or misuse.
5. For future development, the school may consider adding local servers, such as e-learning or file-sharing servers, to support intranet-based teaching and learning activities more effectively.

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