



Analysis and Optimization of a WiFi Network at SMP Swasta GKPS I Raya Simalungun

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ABSTRACT

The wireless network at SMP Swasta GKPS I Raya Simalungun initially depended on a single modem/router installed in the administration room. Its corner position and concrete-wall obstructions produced uneven signal distribution and blank spots in several school areas. This study analyzed the existing condition and developed an optimized network configuration using the Network Development Life Cycle (NDLC). Cisco Packet Tracer supported logical design and simulation, while TP-Link access points and a MikroTik hAP lite router were configured for addressing, wireless service, routing, firewall functions, and queue-tree bandwidth management. The implementation expanded service planning to the principal's office, administration area, library, teacher room, and computer laboratory. Configuration verification confirmed successful router access, static addressing, SSID and channel definition, LAN integration, MikroTik management, and queue-tree activation. The resulting design provides a structured basis for fairer bandwidth distribution and continuous monitoring, although future work should add quantitative measurements of coverage, throughput, delay, jitter, packet loss, and user experience.

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1. INTRODUCTION

Wireless connectivity is an essential part of contemporary school operations because teaching, administration, communication, and digital learning increasingly depend on stable network access. A school WiFi service must therefore be planned as shared infrastructure rather than as a single consumer access point [1].

The existing network at SMP Swasta GKPS I Raya Simalungun used one main modem/router located in the administration room. Because the device was positioned near a building corner and separated from other rooms by permanent concrete walls, coverage was uneven and several areas experienced weak connections or blank spots. Similar school-network studies emphasize that access-point placement and infrastructure design directly influence service availability [2].

Bandwidth contention was another concern. When multiple teachers, staff members, students, and laboratory computers accessed the same connection, unmanaged traffic could allow a small number of users or applications to dominate the available capacity. Router-based bandwidth management can organize traffic allocation and provide a more predictable service among user groups [3].

Quality of Service (QoS) provides a framework for examining throughput, delay, jitter, and packet loss, while router queues and monitoring tools translate policy into observable control [4]. However, optimization requires a development process that connects the existing condition, logical design, simulation, physical implementation, monitoring, and maintenance.

This study applies the Network Development Life Cycle (NDLC) to analyze and optimize the school WiFi network. Cisco Packet Tracer is used for topology planning and simulation, TP-Link devices provide wireless access, and MikroTik RouterOS supports routing, firewall, and queue-tree configuration [5].

The study aims to produce a structured network design, improve coverage planning, manage bandwidth more fairly, and establish a repeatable configuration and monitoring procedure. The contribution is an implementation-oriented account using original configuration screens from the thesis; the available evidence is configuration based and does not yet constitute a complete quantitative QoS benchmark.

2. RESEARCH METHOD

2.1. Research setting and data collection

The study was conducted at SMP Swasta GKPS I Raya, Simalungun. Observation focused on the existing modem/router position, rooms requiring wireless access, network devices, user groups, and the computer laboratory. Documentary study and literature review were used to define the configuration procedure and network-management concepts.

The proposed service area included the principal's office, administration area, library, teacher room, and a laboratory containing 19 computers. The analysis treated physical obstacles, device placement, IP addressing, wireless identifiers, routing, and traffic management as connected design variables.

2.2. NDLC procedure

NDLC structures network development into analysis, design, simulation prototyping, implementation, monitoring, and management. Analysis identified coverage and bandwidth problems. Design established the logical and physical topology, addressing plan, and device roles. Simulation prototyping used Cisco Packet Tracer to check connectivity before deployment [6].

Implementation configured the PC interface, TP-Link router, LAN address, MikroTik hAP lite, firewall functions, routes, and queue tree. Monitoring examined connectivity and router status. Management preserved the configuration, selected SSIDs and channels, and defined continuing maintenance. This sequence reduces the risk of applying untested settings directly to the operational network.

2.3. Requirements and implementation environment

The optimized design required wireless access, consistent addressing, routing between modem and local segments, distinguishable SSIDs, monitoring, and controlled bandwidth allocation. Table 1 summarizes the operational requirements.

Table 1. Network optimization requirements

No.	Requirement	Operational Outcome
1	Extend wireless service to priority rooms	Reduce uncovered or weak-service areas
2	Assign a consistent IP plan	Prevent conflicting or ambiguous device addresses
3	Configure SSID and channel	Identify access points and reduce interference risk
4	Integrate TP-Link and MikroTik devices	Connect wireless access to routed internet service
5	Apply queue-tree bandwidth management	Distribute available capacity among users
6	Monitor and maintain configuration	Support troubleshooting and continued operation

The software and hardware used in the thesis are reported in Tables 2 and 3. Cisco Packet Tracer supported simulation, Winbox provided MikroTik administration, and the physical devices represented the intended deployment environment.

Table 2. Software environment

No.	Software	Version or Purpose
1	Cisco Packet Tracer	Version 8.2.1; topology simulation
2	Winbox	MikroTik configuration and monitoring
3	Microsoft Windows	Windows 10 Home workstation

Table 3. Hardware environment

No.	Hardware	Specification
1	Modem	D-Link
2	MikroTik router	RB750 / hAP lite configuration
3	Wireless router	TP-Link
4	UTP cable	Category 6

No.	Hardware	Specification
5	RJ45 connector	AMP
6	Crimping tool	Multi-function modular crimper
7	Laptop	HP, 4 GB RAM, 256 GB storage

2.4. Verification approach

Verification followed the implemented configuration sequence and examined whether each management page accepted the intended values and exposed the required function. The checks covered TP-Link login, initial setup access, static WAN parameters, wireless SSID and channel, MikroTik administration, and queue-tree visibility.

Because the thesis does not report repeated numerical QoS samples, the verification is interpreted as configuration and connectivity evidence. It confirms that the optimization components were deployed but does not quantify improvements in throughput, latency, jitter, packet loss, or received signal strength.

3. RESULTS AND DISCUSSION

3.1. Implemented user interfaces

The implemented configuration screens provide direct evidence of the network setup. Each original Chapter IV screen is presented separately so its role in the optimization workflow can be explained without combining unrelated interfaces.

Figure 1 shows the TP-Link router authentication page reached through the device's default management address. Authentication restricts configuration access and establishes the starting point for changing internet, LAN, and wireless parameters.

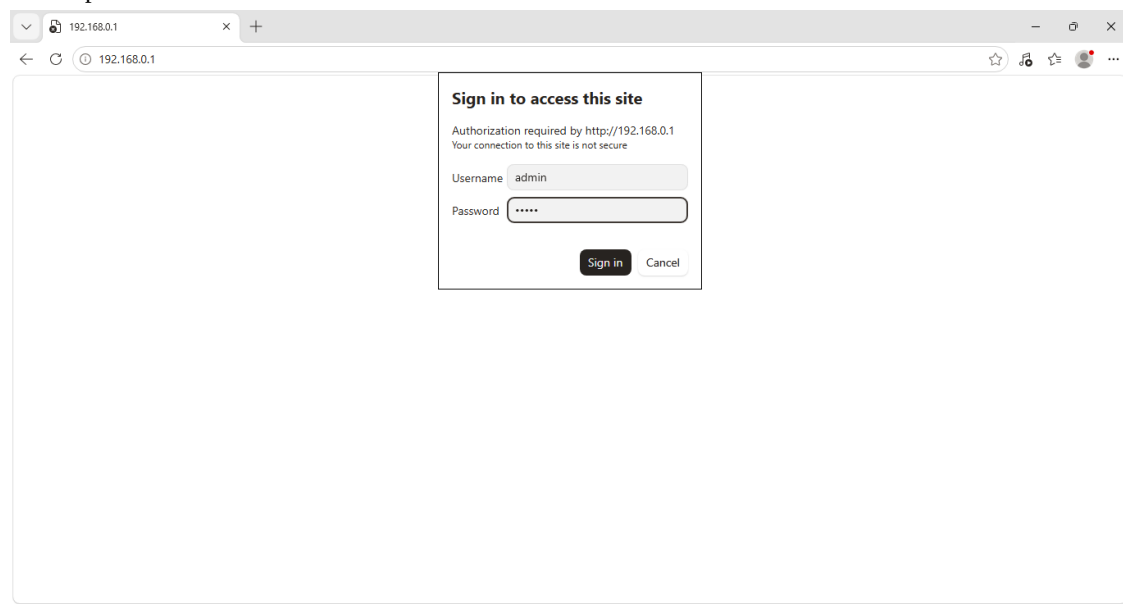


Figure 1. TP-Link router authentication page

Figure 2 presents the TP-Link main page after successful authentication. The navigation panel groups status, quick setup, network, wireless, DHCP, security, and system tools, enabling the administrator to move from basic connectivity to service management.

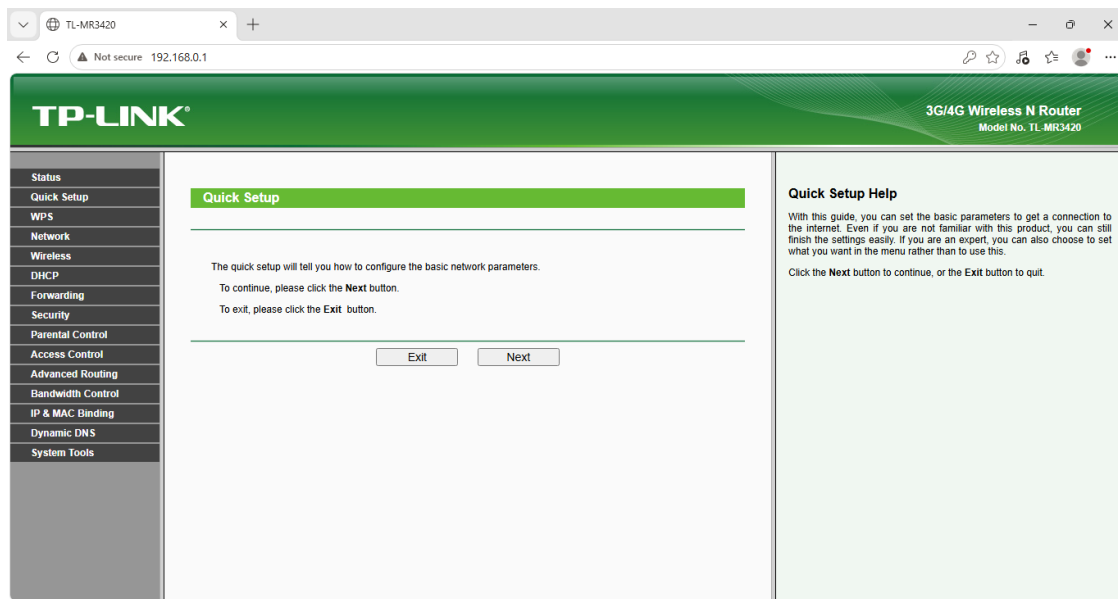


Figure 2. TP-Link router main configuration page

Figure 3 shows the static WAN configuration used to connect the wireless router to the upstream MikroTik segment. A fixed IP address, subnet mask, gateway, and DNS values provide predictable routing and make later troubleshooting easier.

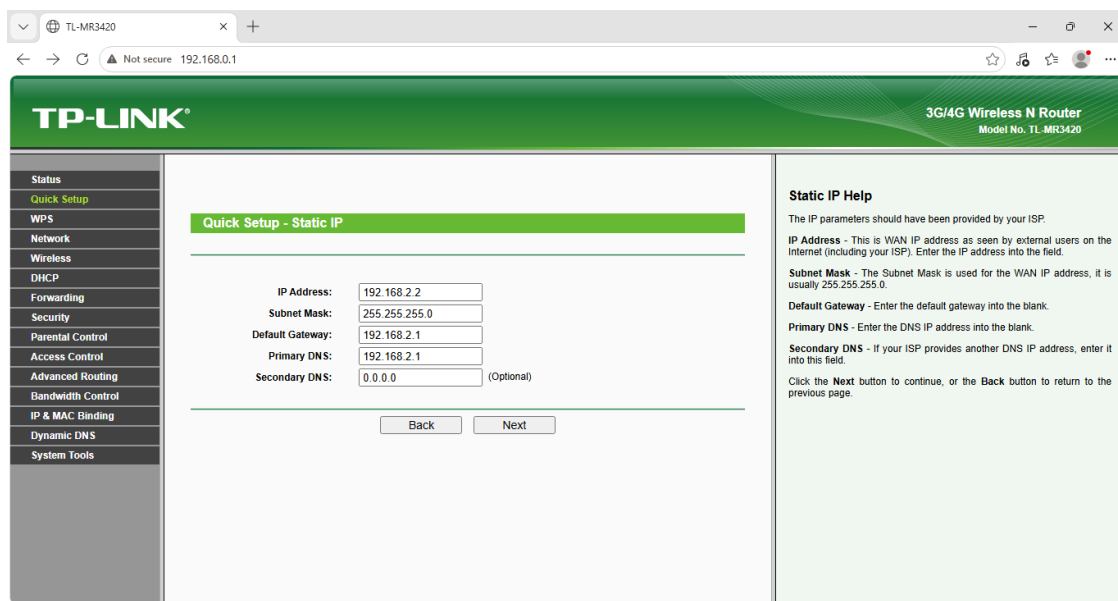


Figure 3. Static WAN IP configuration

Figure 4 shows the wireless configuration page where the SSID, region, channel, and operating mode are defined. Separate identifiers help users select the intended access point, while planned channels reduce the risk of co-channel interference between nearby devices.

The screenshot displays the 'Quick Setup - Wireless' page of a TP-Link 3G/4G Wireless N Router (Model No. TL-MR3420). The page is divided into a left sidebar with navigation links (Status, Quick Setup, WPS, Network, Wireless, DHCP, Forwarding, Security, Parental Control, Access Control, Advanced Routing, Bandwidth Control, IP & MAC Binding, Dynamic DNS, System Tools) and a main content area. The 'Wireless' section is active, showing the following configuration options:

- Wireless Radio:** Enable (dropdown)
- Wireless Network Name:** SMP-GKPS (text field, also called the SSID)
- Region:** United States (dropdown)
- Warnings:** Ensure you select a correct country to conform local law. Incorrect settings may cause interference.
- Mode:** 11bgn mixed (dropdown)
- Channel Width:** 40MHz (dropdown)
- Channel:** 4 (dropdown)
- Wireless Security:**
 - ☐ Disable Security
 - ☒ WPA-PSK/WPA2-PSK (You can enter ASCII characters between 8 and 63 or Hexadecimal characters between 8 and 64.)
 - ☐ No Change
- PSK Password:** 123456789 (text field)

At the bottom of the main content area are 'Back' and 'Next' buttons. On the right side, there is a 'Wireless Help' section with detailed instructions for each configuration option.

Figure 4. Wireless SSID and channel configuration

Figure 5 displays the MikroTik RouterOS management interface in WinBox. This environment is used to configure addresses, firewall rules, DNS, routes, traffic marking, and queues, making it the central control point for the optimized topology.

The screenshot shows the MikroTik RouterOS management interface in WinBox. The 'RouterOS Default Configuration' window is open, displaying the following information:

- RouterOS Default Configuration**
- The following default configuration has been installed on your router:
- Welcome to RouterOS!
- 1) Set a strong router password in the System > Users menu
- 2) Upgrade the software in the System > Packages menu
- 3) Enable firewall on untrusted networks
- 4) Set your country name to observe wireless regulations
- RouterMode:**
 - * WAN port is protected by firewall and enabled DHCP client
 - * Wireless and Ethernet interfaces (except WAN port/s) are part of LAN bridge
- LAN Configuration:**
 - IP address 192.168.88.1/24 is set on bridge (LAN port)
 - DHCP Server: enabled
 - DNS: enabled
- wlan1 Configuration:**
 - mode: ap-bridge
 - band: 2ghz-b/g/n
 - tx-chains: 0:1
 - rx-chains: 0:1
 - installation: indoor
 - wpd2: no
 - ht-extension: 20/40mhz-XX
- WAN (gateway) Configuration:**
 - gateway: ether1
 - ip4 firewall: enabled
 - NAT: enabled
 - DHCP Client: enabled

At the bottom of the window are buttons for 'Remove Configuration', 'Show Script...', and 'OK'.

Figure 5. MikroTik RouterOS management interface

Figure 6 presents the queue-tree configuration used for bandwidth allocation. The queue hierarchy and packet marks connect traffic classification with controlled rates, providing a mechanism for distributing capacity more fairly among network users.

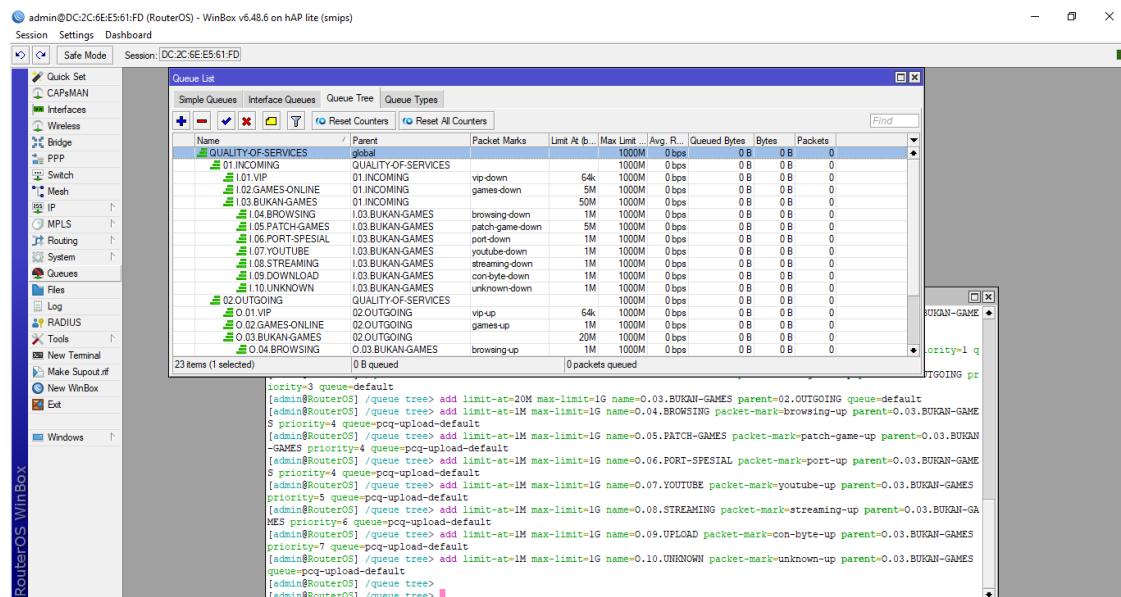


Figure 6. Queue-tree bandwidth management configuration

3.2. Functional verification results

Table 4 consolidates the configuration checks documented through the implementation screens. All six checks produced the required interface or setting, giving a 6/6 configuration pass result within the reported scope.

Table 4. Network configuration verification results

No.	Test Scenario	Expected Result	Observed Result	Status
1	Open TP-Link management address	Authentication page is displayed	Authentication page displayed	Passed
2	Authenticate and open the main page	Router configuration menus are accessible	Menus were accessible	Passed
3	Enter static WAN parameters	WAN address and gateway can be saved	Static parameters were configured	Passed
4	Define SSID and channel	Wireless identity and channel are stored	Wireless values were configured	Passed
5	Open MikroTik through Winbox	RouterOS management interface is available	Management interface opened	Passed
6	Configure queue tree	Bandwidth-control entries are visible	Queue entries were displayed	Passed

3.3. Discussion

The results demonstrate a coherent path from coverage analysis to device configuration. TP-Link access points handle wireless presentation, whereas MikroTik provides the addressing, routing, firewall, marking, and queue functions needed for centralized control. The separation of roles makes the topology easier to administer than an unmanaged single-router arrangement.

The queue-tree implementation is important because bandwidth fairness cannot be achieved through access-point placement alone. Packet marking and hierarchical queues provide a technical mechanism for allocating traffic, but the configured values should be validated under realistic simultaneous use. MikroTik documentation recommends monitoring queue behavior and interface utilization when policies are adjusted [7].

The study also shows the value of simulation before physical configuration. Packet Tracer enables addressing and connectivity checks without interrupting the production network, while the NDLC monitoring and management stages encourage continued adjustment after installation. Network lifecycle practices similarly emphasize baselining, verification, and controlled change [8].

The principal limitation is the absence of before-and-after measurements. Future evaluation should collect signal strength by room, throughput, delay, jitter, packet loss, concurrent-user load, and application response at several times of day. QoS guidelines and standardized measurement procedures can make those results comparable

[9]. Security assessment should also cover password replacement, firmware updates, protected management access, firewall review, and backup recovery [10].

Consequently, the present work should be interpreted as a successfully implemented optimization configuration, not as definitive proof of numerical performance improvement. Its practical value is the structured topology, explicit configuration sequence, and management mechanism that can support a later measurement-driven optimization cycle.

The interpretation is also supported by related work on QoS-based optimization [11]. Router-management studies similarly emphasize continuing policy adjustment [12]. Comparative routing research shows that network behavior depends on the selected topology and protocol [13]. School-network optimization studies report that infrastructure changes must be evaluated in the local environment [14]. Educational WiFi research highlights information-access benefits [15]. General information-technology studies further underline the need for maintainable operational procedures [16].

4. CONCLUSION

The school WiFi network was analyzed and restructured using NDLC, Cisco Packet Tracer, TP-Link wireless routers, and MikroTik RouterOS. The implementation established router authentication, static addressing, wireless SSID and channel settings, LAN integration, routing and firewall management, and queue-tree bandwidth control. Six documented configuration checks passed. The design provides a more structured basis for extending coverage and distributing bandwidth than the original single-router arrangement. Quantitative before-and-after measurements remain necessary to establish the magnitude of improvement and to refine capacity, coverage, and security policies.

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