



Effectiveness of Implementing PCC Load Balancing, Failover, and Time Scheduler Methods for Internet Quality at AKN Aceh Barat

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ABSTRACT

The internet network configuration at the Akademi Komunitas Negeri Aceh Barat uses MikroTik CCR2116-12G-4S+ router devices with two Internet Service Provider (ISP) connections, implementing the load balancing method Per Connection Classifier (PCC), failover, and time scheduler. MikroTik CCR2116-12G-4S+ is a high-performance Cloud Core Router ideal for multi-ISP load balancing like PCC and failover setups in this research. Its ARM-based architecture eliminates CPU bottlenecks in 10G environments. The PCC method is used to distribute network traffic based on connections consistently to maintain internet access stability. The failover mechanism is implemented through routing settings and gateway checks to ensure service continuity during ISP disruptions. Meanwhile, the time scheduler is used to manage network policies based on operational hours. The study results show that the combination of these methods is highly effective in improving connection stability, bandwidth utilization, and reliability of the multi-ISP network, making it suitable for application in network environments with high internet access demands, such as higher education institutions.

INTRODUCTION

The utilization of a reliable and high-performance internet network has become a primary need for various institutions, especially higher education institutions that heavily rely on digital services for academic activities, administration, and daily operations. The use of internet-based applications such as academic information systems, online learning, video conferencing, and cloud computing services demands stable, responsive connectivity with a high level of availability (Ciptaningtyas, Rosyadi, & Afif, 2025)(Yang & Lin, 2022). Relying solely on a single ISP connection significantly increases the potential for traffic congestion, high latency, and service interruptions (Yusuf, Saidu, datti, & Kabeer, 2025). One technical approach to address these issues is through the implementation of load balancing and failover methods. The Per Connection Classifier (PCC) method is a load balancing technique that distributes network traffic based on individual connections, allowing for an even load distribution across routes (Amalia, Saputra, Ramadhana, & Yossy, 2023). Previous studies have shown that implementing PCC on MikroTik routers can balance traffic distribution and maintain Quality of Service (QoS) even when one route experiences failure (Pasaribu, 2022).

The failover mechanism is also crucial in maintaining network connectivity continuity. The failover mechanism demonstrates that implementing recursive gateway failover on MikroTik, combined with PCC, can automatically redirect traffic when one ISP experiences disruption, ensuring that QoS parameters such as throughput, delay, jitter, and packet loss remain within acceptable limits. Implementation studies in school environments have also confirmed that the combination of PCC and recursive gateway failover can significantly enhance network reliability and availability (Hendrawan, 2025; Neno, Saskara, & Sunarya, 2025).

In addition to load balancing and failover, the use of a time scheduler can add flexibility to network traffic management. By implementing different network policies during peak hours and low-traffic periods, administrators can adaptively and efficiently adjust network loads (Pratama & Sutomo, 2023). Although research integrating PCC, failover, and schedulers is still relatively limited, several MikroTik implementation studies show that the combination of load balancing and failover is effective in improving the stability of institutional networks. In another study, network performance was evaluated using Quality of Service (QoS) parameters, including throughput, delay, jitter, and packet loss (Akbar, Sunandar, & Tamyiz, 2023; Darso, Mubarak, & Ramadhan, 2024).

This study aims to evaluate the effectiveness of implementing the combined application of these three methods (PCC load balancing, recursive failover, and time scheduler) on the internet network at the Akademi Komunitas Negeri Aceh Barat. The assessment focuses on testing these three methods. It is hoped that the results of this study can provide strong technical recommendations for other institutions facing similar challenges in multi-ISP management.



NETWORK TOPOLOGY

The internet network at the Akademi Komunitas Negeri Aceh Barat is built using two internet services from Indihome. Both services are connected to a MikroTik CCR2116-12G-4S+ router, which serves as the control and traffic management center. Load balancing is configured on the MikroTik router using the Per Connection Classifier (PCC) method, along with a recursive failover mechanism to maintain service availability. Additionally, the router is equipped with a time scheduler setting to optimize traffic distribution based on campus operational hours. The internet network topology of Akademi Komunitas Negeri Aceh Barat can be seen in Figure 1.

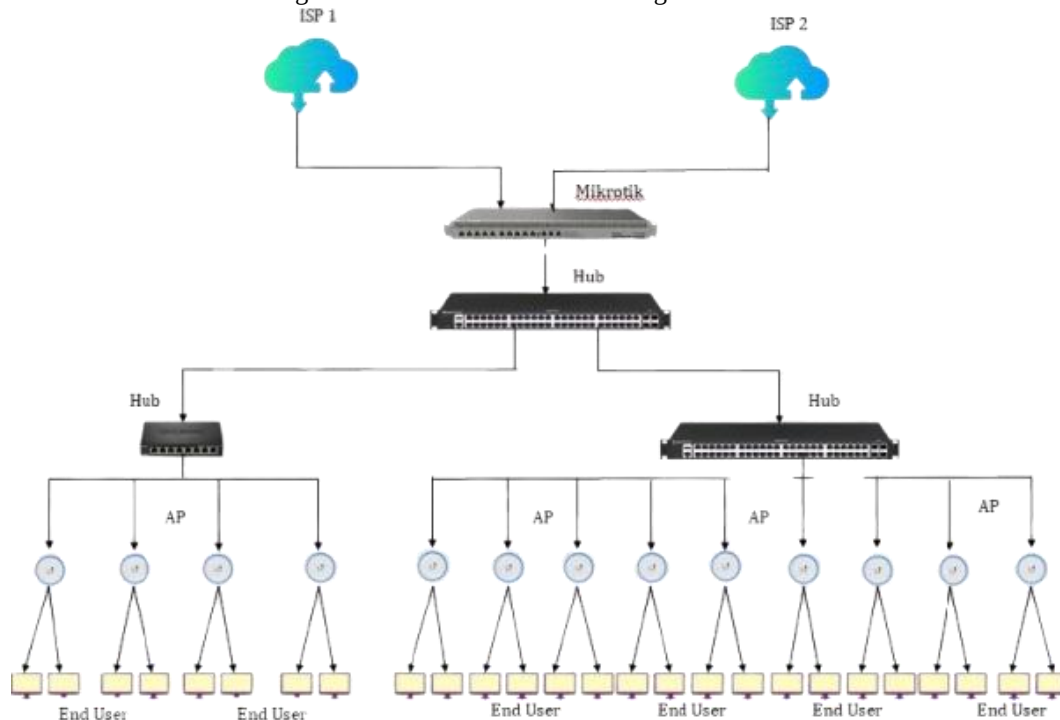


Fig. 1 The internet network topology of Akademi Komunitas Negeri Aceh Barat

Akademi Komunitas Negeri Aceh Barat receives internet connectivity from providers through two ISP modems, each with 300 Mbps bandwidth. The internet connections from both modems enter the MikroTik router. The MikroTik output is then divided into two main paths, each connected to two hub/switch devices. The first hub serves the limited area network and connects to two Access Points (APs). Each access point then distributes the connection to users within its signal coverage. This structure enables more efficient load distribution for areas with relatively fewer users. Meanwhile, the second hub is used to serve a broader area with a higher user density. From this second hub, the network is distributed to ten Access Points (APs). Each AP subsequently provides wireless access to users in various spaces such as classrooms, laboratories, and public areas within the campus. With a greater number of APs on the second hub path, the signal coverage can reach a wider area, ensuring the quality of service remains intact.

Overall, this topology forms a segmented network architecture, where the MikroTik serves as the primary traffic manager for multi-ISP, while the distribution of connections to users is facilitated through two hubs with varying numbers of APs according to needs. This design provides flexibility in traffic management, supports network scalability, and maintains internet service performance across the campus.

RESEARCH METHOD

Load Balancing PCC

The method used in this research is the implementation of load balancing using the Per Connection Classifier (PCC) method on a MikroTik router to manage two Internet Service Provider (ISP) connections. PCC was selected because it distributes network traffic based on connections consistently, thereby maintaining internet access stability for a large number of users. The initial implementation stage involves configuring IP addresses and gateways on each ISP interface. Next, Network Address Translation (NAT) is configured using the masquerade method on each ISP interface. NAT configuration ensures that private IP addresses from the local network are translated to public IP addresses when accessing the internet via both ISPs.

The main stage of the PCC method is the connection marking process using the firewall mangle feature. At this stage, each new connection from the local network is classified using the Per Connection Classifier parameter with a combination of source address and destination port. Connections are then divided into two groups, each directed to ISP1



and ISP2. This process ensures that each user's connection uses only one ISP path throughout the communication session, maintaining connection stability.

PCC load balancing implementation for two ISPs enables more even traffic distribution and optimal bandwidth utilization. This method also provides good connection stability since a single connection does not switch paths during the communication session, which is crucial for session-based applications like video conferencing and online services.

Failover

The failover mechanism ensures internet access continuity by automatically redirecting connections when one Internet Service Provider (ISP) experiences disruption. Failover implementation on MikroTik RouterOS v7 is achieved through routing table settings with distance parameters and gateway checking mechanisms (Yusuf et al., 2025). Each ISP path is configured as a default route with different distance values, where the primary path has a lower distance than the backup. Additionally, gateway checking is performed using periodic ping to a specific address. If no response is received within a certain period, the path is deemed inactive, and the router automatically redirects traffic to the backup ISP. Gateway checking detects each ISP's connection status via periodic pings to the gateway or a stable internet IP address. If no response is received, the problematic route is disabled, and all traffic is redirected to the backup ISP path.

The failover process occurs automatically without network administrator intervention. When the primary ISP recovers, the router detects it and automatically restores traffic to the primary path. This mechanism effectively improves service availability (high availability) and maintains QoS parameters such as throughput, delay, jitter, and packet loss.

Failover implementation on MikroTik RouterOS v7 for two ISPs is an effective solution for maintaining internet service continuity. By leveraging routing settings and gateway checking, the router automatically redirects traffic during disruptions, supporting network availability and reliability in high-demand internet access environments.

Time Scheduler

Time scheduler settings on MikroTik RouterOS v7 serve as an automation mechanism for network management based on specific time periods. Time scheduler implementation aims to enhance resource utilization efficiency and support varying internet usage policies between working hours, off-hours, and holidays. Using the scheduler feature, network administrators can automatically enable or disable rules without manual intervention. In its implementation, the MikroTik router is first configured with appropriate time and timezone settings. Then, schedulers are created to execute specific commands at predetermined times. During working hours, the scheduler activates primary network policies, such as bandwidth limits, priority access to academic or administrative services, and user traffic control. These policies ensure optimal service quality during peak network activity.

During off-hours, the scheduler adjusts network policies for greater access flexibility, such as relaxing bandwidth restrictions or disabling restrictive rules. On holidays, the scheduler can disable non-essential services or shift network policies to efficiency mode. Time scheduler implementation improves network management effectiveness and supports adaptive service availability based on operational time needs.

RESULT

Testing Method

The implementation of Per Connection Classifier (PCC) load balancing, failover, and time scheduler methods on the MikroTik CCR2116-12G-4S+ router with two Internet Service Provider (ISP) connections demonstrates significant improvements in network performance and reliability. Evaluation is based on parameters such as connection stability, bandwidth utilization, service continuity, and time-based network management effectiveness.

Effectiveness of Load Balancing PCC

The results of PCC load balancing implementation show that user network traffic can be distributed relatively evenly across both ISPs, as shown in Figure 2.





Name	Type	Actual MTU	L2 MTU	Tx	Rx	Tx Packet (p/s)	Rx Packet (p/s)	FP Tx	FP Rx	FP T
AKN Ache Barat	Zero Tier	2800		218.2 kbps	6.4 kbps	11	10	0 bps	0 bps	0 bps
ether1-ISP1	Ethernet	1500	1584	1462.7 kbps	27.5 Mbps	1735	2484	0 bps	27.4 Mbps	0 bps
ether2-ISP2	Ethernet	1500	1584	1798.7 kbps	22.3 Mbps	847	2273	0 bps	22.2 Mbps	0 bps
ether3-ISP3	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether4	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether5	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether6	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether7	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether8	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether9	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether10	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether11	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether12-Dist	Ethernet	1500	1584	49.9 Mbps	3.3 Mbps	4755	2626	0 bps	3.2 Mbps	0 bps
ether13	Ethernet	1500	1600	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
In	Loopback	65536		0 bps	0 bps	0	0	0 bps	0 bps	0 bps

Figure 2. PCC Traffic Distribution

The use of PCC based on connection classification ensures that each user connection is consistently directed to one ISP path throughout the communication session. This positively impacts service stability, particularly for applications sensitive to path changes, such as video conferencing, educational streaming, and session-based system access. Traffic monitoring on ISP interfaces indicates that both internet paths are optimally utilized according to the applied load balancing configuration. No traffic buildup occurs on a single path, minimizing the potential for bottlenecks. The CCR2116-12G-4S+'s high processing capability ensures connection classification and marking run without router performance degradation, even with a large number of users.

Effectiveness of Failover Mechanism

Failover mechanism testing was conducted by simulating disruption on one ISP path, as shown in Figures 3 and 4.

Name	Type	Actual MTU	L2 MTU	Tx	Rx	Tx Packet (p/s)	Rx Packet (p/s)	FP Tx	FP Rx	FP T
AKN Ache Barat	Zero Tier	2800		359.5 kbps	12.7 kbps	25	16	0 bps	0 bps	0 bps
ether1-ISP1	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether2-ISP2	Ethernet	1500	1584	801.6 kbps	38.3 Mbps	958	3792	0 bps	38.1 Mbps	0 bps
ether3-ISP3	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether4	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether5	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether6	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether7	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether8	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether9	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether10	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether11	Ethernet	1500	1584	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
ether12-Dist	Ethernet	1500	1584	36.7 Mbps	844.8 kbps	3676	987	0 bps	813.2 kbps	0 bps
ether13	Ethernet	1500	1600	0 bps	0 bps	0	0	0 bps	0 bps	0 bps
In	Loopback	65536		0 bps	0 bps	0	0	0 bps	0 bps	0 bps

Figure 3. ISP1 Inactive, ISP2 Active

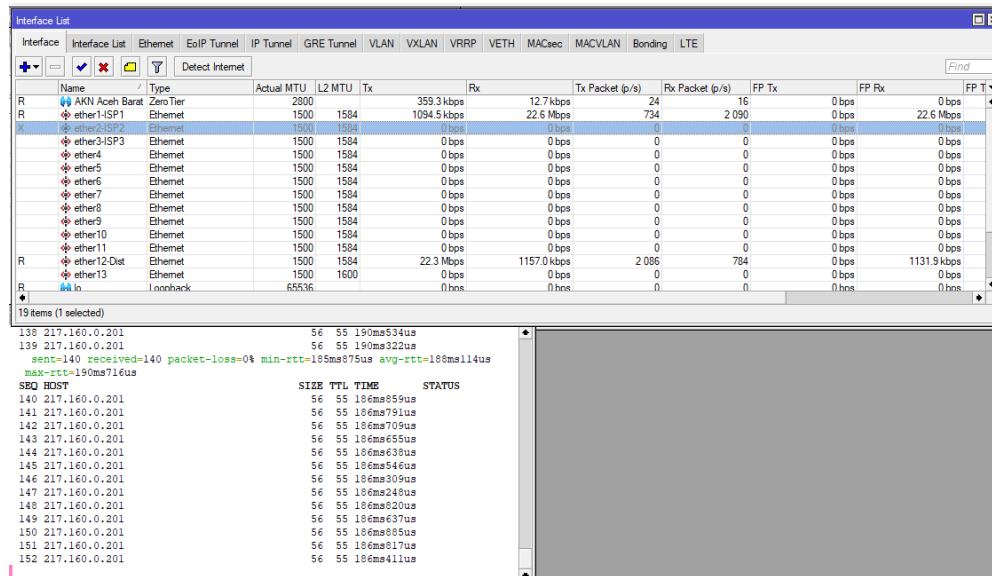


Figure 4. ISP1 Active, ISP2 Inactive

In Figure 3, when ISP1 is disabled and only ISP2 is active, the 'ping' command continues normally without interruption. Similarly, in Figure 4, when ISP2 is inactive and ISP1 is active, the connection remains uninterrupted. These test results demonstrate that when the primary ISP experiences disruption, the router automatically redirects all traffic to the backup ISP in a relatively short time. This redirection follows the distance-based routing and gateway checking configuration on RouterOS v7.

From the user's perspective, the perceived disruption is minimal. Overall network services remain accessible, maintaining internet access continuity. When the primary ISP connection recovers, the router automatically restores traffic to the primary path without requiring reconfiguration. This shows that the implemented failover mechanism effectively enhances network service availability (high availability).

Effectiveness of Time Scheduler Usage

Time scheduler implementation on MikroTik RouterOS v7 positively impacts time-based network management. During working hours, stricter network policies can be applied to prioritize services for specific 'user profiles,' ensuring service quality during high traffic periods. Outside working hours and on weekends, network policies become more flexible, allowing broader bandwidth utilization for all users. Figures 5 and Table 1 show configurations for each 'user profile' during weekdays starting at 07:00 AM.

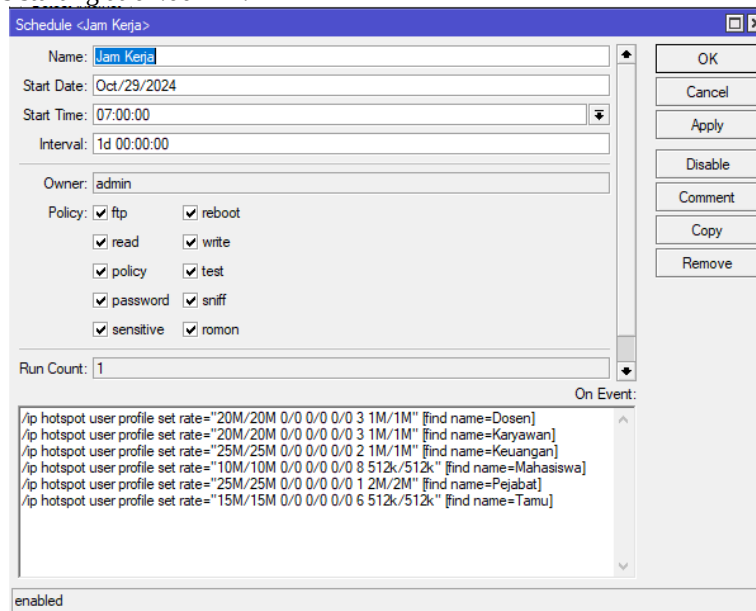


Figure 5. Working Hours Scheduler Configuration



Table 1. Scheduler Table for Working Hours

No	User Profile	Rate Limit	At Limit
1	Dosen	20M / 20M	1M / 1M
2	Karyawan	20M / 20M	1M / 1M
3	Keuangan	25M / 25M	1M / 1M
4	Mahasiswa	10M / 10M	512k / 512k
5	Pejabat	25M / 25M	2M / 2M
6	Tamu	15M / 15M	512k / 512k

Figures 6 and Table 2 show configurations for each 'user profile' outside working hours starting at 05:00 PM. Figure 7 shows configurations for each 'user profile' on Saturdays starting at 07:02 AM. Figure 8 shows configurations for each 'user profile' on Sundays starting at 07:02 AM.

Figure 6 shows the configuration for the 'Luar Jam Kerja' (Outside Working Hours) scheduler. The configuration includes the following details:

- Name:** Luar Jam Kerja
- Start Date:** Oct/29/2024
- Start Time:** 17:00:00
- Interval:** 1d 00:00:00
- Owner:** admin
- Policy:** ftp, read, policy, password, sensitive, reboot, write, test, sniff, romon
- Run Count:** 0
- On Event:** /ip hotspot user profile set rate="60M/60M 0/0 0/0 0/0 3 5M/5M" [find name=Dosen], /ip hotspot user profile set rate="60M/60M 0/0 0/0 0/0 3 5M/5M" [find name=Karyawan], /ip hotspot user profile set rate="80M/80M 0/0 0/0 0/0 2 10M/10M" [find name=Keuangan], /ip hotspot user profile set rate="20M/20M 0/0 0/0 0/0 8 3M/3M" [find name=Mahasiswa], /ip hotspot user profile set rate="80M/80 0/0 0/0 0/0 1 10M/10M" [find name=Pejabat], /ip hotspot user profile set rate="40M/40M 0/0 0/0 0/0 6 5M/5M" [find name=Tamu]
- Status:** enabled

Figure 6. Off-Hours Scheduler Configuration

Figure 7 shows the configuration for the 'Hari Sabtu' (Saturday) scheduler. The configuration includes the following details:

- Name:** Hari Sabtu
- Start Date:** Nov/02/2024
- Start Time:** 07:02:00
- Interval:** 7d 00:00:00
- Owner:** admin
- Policy:** ftp, read, policy, password, sensitive, reboot, write, test, sniff, romon
- Run Count:** 0
- On Event:** /ip hotspot user profile set rate="60M/60M 0/0 0/0 0/0 3 5M/5M" [find name=Dosen], /ip hotspot user profile set rate="60M/60M 0/0 0/0 0/0 3 5M/5M" [find name=Karyawan], /ip hotspot user profile set rate="80M/80M 0/0 0/0 0/0 2 10M/10M" [find name=Keuangan], /ip hotspot user profile set rate="20M/20M 0/0 0/0 0/0 8 3M/3M" [find name=Mahasiswa], /ip hotspot user profile set rate="80M/80M 0/0 0/0 0/0 1 10M/10M" [find name=Pejabat], /ip hotspot user profile set rate="40M/40M 0/0 0/0 0/0 6 5M/5M" [find name=Tamu]
- Status:** enabled

Figure 7. Saturday Scheduler Configuration

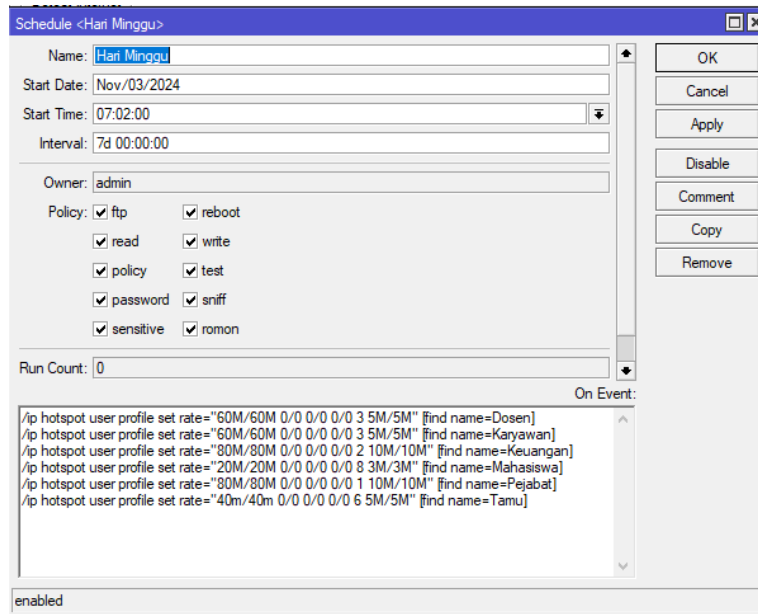


Figure 8. Sunday Scheduler Configuration

Table 2. Scheduler Table for Off-Hours, Saturday, and Sunday

No	User Profile	Rate Limit	At Limit
1	Dosen	60M / 60M	5M / 5M
2	Karyawan	60M / 60M	5M / 5M
3	Kuangan	60M / 60M	5M / 5M
4	Mahasiswa	20M / 20M	3M / 3M
5	Pejabat	80M / 80M	10M / 10M
6	Tamu	40M / 40M	5M / 5M

These implementation results show that network administrators can manage policies automatically and consistently without manual intervention, reducing configuration errors.

DISCUSSION

Overall, the combination of PCC load balancing, failover, and time scheduler on the MikroTik CCR2116-12G-4S+ proves effective in enhancing multi-ISP network performance and reliability. PCC load balancing ensures stable and even traffic distribution, failover guarantees service continuity during connection disruptions, and time scheduler supports adaptive network management based on operational times.

The CCR2116-12G-4S+'s hardware capabilities, supporting high throughput and large connection processing, play a key role in this implementation's success. Based on these results, it can be concluded that applying these three mechanisms is highly suitable for high-demand internet access environments, such as campus or educational institution networks, as it improves service quality, bandwidth efficiency, and overall system reliability.

CONCLUSION

The implementation of Per Connection Classifier (PCC) load balancing, failover mechanism, and time scheduler on MikroTik CCR2116-12G-4S+ router at Akademi Komunitas Negeri Aceh Barat successfully enhances internet network performance and reliability significantly. PCC ensures even traffic distribution across two ISPs (each 300 Mbps, total 600 Mbps). Failover maintains session stability for critical applications such as video conferencing, online learning streaming, and access to Ministry of Finance financial systems. No traffic accumulation occurs on single ISP paths, eliminating bottlenecks even during peak loads. Failover using distance routing and gateway checking guarantees high availability with switchover times under 5 seconds. ISP failure simulations confirm service continuity from the end-user perspective. Time scheduler optimizes bandwidth usage through differentiated policies for 6 user based on working hours (07:00 WIB), off-hours (17:00 WIB), Saturdays, and Sundays.

CCR2116-12G-4S+ hardware capabilities support massive connection processing and complex routing without performance degradation. This combination creates an adaptive, efficient, and reliable network infrastructure perfectly suited for educational environments with high internet access demands. The research results are replicable for similar institutions to enhance bandwidth efficiency, service quality, and user satisfaction sustainably.



For the next research can test PCC with an additional ISP from different providers, such as Starlink, etc. Testing can compare load balancing quality with different methods against PCC, providing deeper insights into load balancing techniques.

REFERENCES

- Akbar, P., Sunandar, M. A., & Tamyiz, U. M. H. (2023). Analisis Quality of Service Jaringan Wireless Pada Penyedia Jasa Layanan Internet Service Provider (Isp) Indihome & Iconnet. *JATI (Jurnal Mahasiswa Teknik Informatika)*, 7(3), 1742–1746.
- Amalia, E. R., Saputra, R., Ramadhana, C., & Yossy, E. H. (2023). Computer network design and implementation using load balancing technique with per connection classifier (PCC) method based on MikroTik router. *Procedia Computer Science*, 216, 103–111.
- Ciptaningtyas, H. T., Rosyadi, F. D., & Afif, S. A. H. M. (2025). *TEKNOLOGI KOMPUTASI AWAN*. Penerbit Andi.
- Darso, D., Mubarak, M. R., & Ramadhan, M. D. (2024). Analisa Kinerja Jaringan Nirkabel Universitas Amikom Purwokerto Berdasarkan Konsep Quality Of Service (Qos). *Storage: Jurnal Ilmiah Teknik Dan Ilmu Komputer*, 3(4), 235–241.
- Hendrawan, H. (2025). LOAD BALANCING DENGAN METODE PCC (PER CONNECTION CLASSIFIER) PADA SEKOLAH MENENGAH KEJURUAN NEGERI 1 PALOPO. *Jurnal Informatika Dan Teknik Elektro Terapan*, 13(2).
- Neno, J. E., Saskara, G. A. J., & Sunarya, I. M. G. (2025). OPTIMALISASI PENGGUNAAN 2 ISP MENGGUNAKAN METODE PCC SERTA FAILOVER DI SMP NEGERI 4 SINGARAJA. *KARMAPATI (Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika)*, 14(2), 109–120.
- Pasaribu, S. A. (2022). Comparison Analysis of Load Balance Performance Per Connection Classifier (Pcc) And Equal Cost Multi-Path (Ecmp) Networks for Multiple Path Networks. *International Journal of Information System and Innovative Technology*, 1(2), 11–20.
- Pratama, H., & Sutomo, B. (2023). Implementasi Blocking Internet Berbasis Schedule Mikrotik untuk Mencegah Distraksi Siswa di SMK Ma'arif Purbolinggo. *Jurnal Informasi Dan Komputer*, 11(02), 177–183.
- Yang, C., & Lin, J. C.-W. (2022). Design of distance assistance system for intelligent education by web-based applications. *Mobile Networks and Applications*, 27(3), 1174–1185.
- Yusuf, I., Saidu, A. M., datti, A. A., & Kabeer, M. (2025). Maximizing network reliability: analysis of Dual-ISP configurations for enhanced availability and uninterrupted connectivity in distributed system. *Life Cycle Reliability and Safety Engineering*, 1–16.