WEB Based Monitoring System for SFP Interface Traffic, Case Study in Riyad Network Banyuwangi

Herman Yuliandoko[1], Agus Priyo Utomo[2], Ahmad Nur Maulana[3]
[1,2,3] Software Engineering Study Program,
Department of Informatics Engineering, State Polytechnic of Banyuwangi, Indonesia
[1]herman.yuliandoko@poliwangi.ac.id, [2]banksonk@poliwangi.ac.id, [3]maulanadhanang@gmail.com

Abstract— **PT Riyad Network Multi Teknologi is a company that provides internet services, commonly known as an ISP (Internet Service Provider), in Banyuwangi. This company uses MikroTIK as network management, which has an SFP interface. Through this SFP, the fiber optic network is connected to a router in their network. Therefore, traffic monitoring is needed to maintain and monitor the condition of the internet services provided. In addition, this company also does not have a notification system if there is a problem on their network. This research designs and implements a monitoring system through an SFP interface combined with a troubleshooting notification system. This monitoring requirement is very necessary for continuous maintenance or monitoring of the network, so research on the SFP Interface Monitoring System on Web-Based MikroTIK Routers at this company will be very useful. This monitoring system was created using the PHP framework codeigniter 3. The purpose of this system is to make it easier to see traffic monitor data and Rx/Tx power SFP. Moreover, the results and testing of the system-built show that the system can monitor well the problem occur in the network beside that the notification can inform to the maintenance team when problem occur.**

Keywords*— *Interface, MikroTIK, Monitoring, SFP, Traffic, Tx/Rx Power

I. INTRODUCTION

The internet has now become a necessity for society. For that we need a good support device and easy to operate. One of the devices that has this capability is MikroTIK. MikroTIK Router is one of both hardware and software vendors that provide facilities to perform bandwidth management [1]. MikroTIK uses the Linux operating system which is the basis for a network router and includes many features such as IP, network, wireless network, and hotspots. So, it can be said that MikroTIK is very helpful for users. Besides that, this device has a system specifically designed to facilitate various computer network needs. For example, designing and building a computer network system for large or small scale.

Currently the use of MikroTIK in various agencies to support their network infrastructure is very much. This is because MikroTIK has proven its reliability. MikroTIK in several tests in ip route configuration, firewall filter, NAT, Mangle for packet tagging, Queue (bandwidth management), bridge,wireless, DHCP Server and ip cloud DDNS on MikroTIK shows very good performance so many companies use it [2].

MikroTIK also supports fiber optic communication and for this application SFP is needed as a support. SFP (Small Form-Factor Pluggable) is an additional module that transmits and receives data via fiber optic media. SFP is a development of Gigabit Interface Converter (GBIC). SFPs are also known as mini-GBIC. The term GBIC means a port that is dedicated to dealing with backbone networks with large bandwidth [3].

The Network Monitoring System is a system that functions to monitor activity on network devices. The monitoring system in a network is used to monitor, supervise, and control whether or not a network device runs. The importance of monitoring is routinely monitoring problematic devices that have the potential to disrupt the internet network. Network problems that often arise are damage to network devices and unstable electricity, where errors are not detected by network monitors manually and network inspections take too long to do so.

ISP (Internet Service Provider) is a company that provides internet access to customers. Whenever we connect to the internet, our connection is routed through the ISP. Usually, ISPs are referred to as providers (providers). ISPs provide internet connections and services to individuals and organizations. Each ISP provides different services to its customers. Not only providing internet connection but also covering maintenance and installation. Currently, the growth of ISPs in Indonesia is very high along with the increasing need for internet. Likewise, in Banyuwangi, ISPs are also growing rapidly to meet the needs of the community's internet network. So that each ISP offers excellent services to its users to be able to compete with others. One of the benchmarks for the excellence of ISP services is the stability of the internet network connection to customers. Therefore, monitoring network conditions is one of the main requirements for an ISP, the better the monitoring, the faster trouble shooting can be done if a problem occurs.

PT. Riyad Network Multi Technology which is located on Jl. Jenderal Sudirman No.09, Krajan 1, Tegalsari, Banyuwangi Regency, East Java 68485, a company engaged in the field of Internet Services or commonly known as ISP (Internet Service Provider) uses MikroTIK as network management. The company monitors the main interface traffic and some monitoring including monitoring the tx/rx power interface, cpu load, interface traffic and notifications in real time on each router on the local network.

Monitoring of this system is very necessary for continuous maintenance or monitoring of the network at PT Riyad Network Multi Teknologi so that it can provide the best service

for consumers. This monitoring also needs to be complemented by the addition of a monitoring track record that is connected to the company's web service to facilitate the maintenance process in the field by a team of technicians when there is an optical infra fiber that experiences binding or broken lines.

Internet Network System

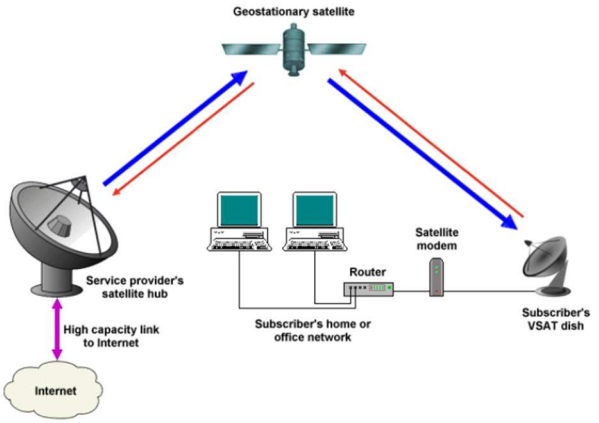


Figure 1. Internet Network System

Communication using Internet technology is almost a primary need for everyone in Indonesia. The rapid development of Information and Communication Technology (ICT) causes changes in network system patterns to become more efficient. Initially, Internet technology (interconnection-networking) was only for connecting networks between computers based on the Internet Protocol (IP) as a data packet exchange protocol (packet-switching communication protocol). In its development to serve billions of users worldwide, the largest Internet network was created, which was then called the Internet. How to connect circuits with this rule is called internetworking (between networks) [4].

Monitoring System

Network monitoring is part of network management. The basis for the concept of network management is the existence of devices that perform management and agents or devices that are managed. The method section provides details of research conducted. Network monitoring is a difficult task and a very important task for a Network Administrator. A Network Administrator always tries to maintain the smooth operation of the network. If the network experiences a decrease in quality in a short period of time, it will cause a decrease in productivity in the company. In terms of network monitoring, it is required to be proactive rather than reactive, the Network Administrator needs to monitor traffic and network performance and ensure that security breaches do not occur in the network.

The ideal network monitoring system should have the following properties [5]:

- It should be automatic and continuously monitor the network.
- It should quickly inform the administrator about the problem as soon as it arises.
- It should be intelligent enough to pinpoint the problem and its location in the network topology. It should also be able to identify the problem's effects on the rest of the network and the services that will become unavailable.
- It should keep a record of the network changes, making it easier to find the cause of the problem due to configuration changes.
- It should provide remote authentication and authorization for the administrator to access the monitoring system from everywhere.

Router System.

The working system of this tool is sending data packets through a network or the internet to the destination through a process known as routing. The routing process occurs in layer three of the open system interconnection. The router functions as a liaison between two or more networks to forward data from one network to another. A router is different from a switch [6].

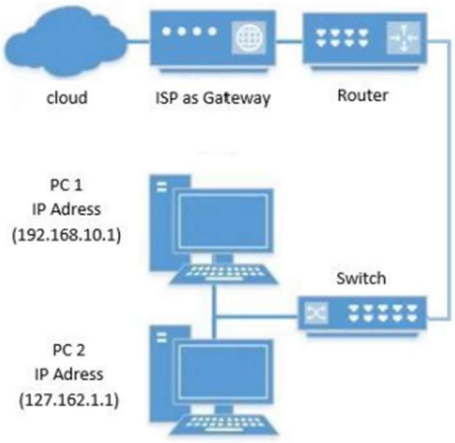


Figure 2. Router Function

The function of the router is to receive packets from the sending station to be forwarded to the destination station. For this purpose, a path in the network must be chosen so that more than one possible route will appear for sending data. The function of routing must be realized and must refer to values without errors, simple, sturdy, stable, fair and optimal in addition to remembering the calculation of efficiency factors, so to form routing, it must understand routing elements in the form of performance criteria, time decision, place decision, network information sources, routing strategy and adaptive routing updates.

Fiber Optic and Router

Optical fiber is pure optics which is very thin and can carry digital information data for long distances. This core continues in a bundle called a fiber optic cable and functions to transmit light that is successfully sent from one place to another and only experiences a very small amount of signal loss. The optical fiber forms a cable that is so fine that up to 1 mm thick for twenty-four strands of fiber optic cable. The electrical signal from the transmitter is used to modulate the laser beam which is then sent over the fiber optic cable. Fiber-optic cables

can also be used to cast shadows, by shining a light on one end of the fiber-optic cable that is facing the camera. The parts of a single fiber optic cable consist of three parts, namely (core) the core of the optical fiber, (cladding) wrapping the fiber optic cable, (coating) which protects the fiber optic cable from damage and temperature [7].

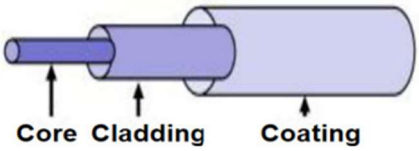


Figure 3. Schematic Diagram of Traditional Fiber Structure [8]

The fiber usually comprises three parts, as shown in Fig. 3. The outer layer to the inner layer is the core, cladding, and coating, respectively. The coating protects the optical fiber from the erosion of water vapor and, at the same time, enhances the flexibility of the optical fiber, which can protect the optical fiber to a certain extent and prolong the service life of the optical fiber. The core part of the fiber is the cladding and core, where the loss of light in the core is lower than that in the cladding, so the light wave is mainly transmitted in the core.

MikroTIK is a very popular router brand in Indonesia and is used in various industries, from small to large businesses, as well as in homes. MikroTIK routers have many ports and features that allow users to manage and monitor their network. One type of port that is often used on MikroTIK routers is the SFP port. SFP port stands for Small Form-factor Pluggable. This port is a special type of port that is used to connect the router to other devices, such as a switch or media converter. SFP ports have the ability to facilitate long distance connections using fiber optics and can be used to connect a local network with a larger network. Following are some of the functions of the SFP port on the MikroTIK router [9]:

- Connecting a router to a switch: The SFP port can be used to connect a MikroTIK router to a switch using optical fiber. This will help increase the speed and quality of the connection and reduce electromagnetic interference.
- Connecting a router with a media converter: The SFP port can also connect a router with a media converter. Media converters are used to convert signals from one type of media to another, such as converting a signal from an optical fiber to a copper signal. Using the SFP port, users can connect routers with media converters easily.
- Connecting the router to other networks: The SFP port can also connect the router to other networks using fiber optics. This will help to increase the speed and quality of the connection between different networks.

Small Form-Factor Pluggable (SFP)

Industrial growth requires good communication support, including using fiber optics. So, it also encourages the growth of transceiver technology. In this case, the transceivers are commonly connected to standardized small form-factor pluggable (SFP) modules, which come in many different form-factors; namely, SFP, SFP+, SFP28, SFP56, and QSFP. This progression of the SFP technology demonstrates how the data rates are continuously advancing [10].

Small Form-factor Pluggable (SFP) is an ODF and Switch SFP connection, one of the devices that is quite important because SFP works as a device that transmits and receives information signals with fiber-optic media. This SFP is usually installed on switch and route ports [11]. SFP optical module is small in size and can be configured with a huge number of ports on a little panel. In expansion, SFP optical module can moreover back hot plug and other capacities. In arrange to meet the developing needs of the system, optical modules are creating towards standardization, miniaturization and insights [12]. The SFP used in this study are single-mode and multi-mode SFP.

Figure 4. SFP Card

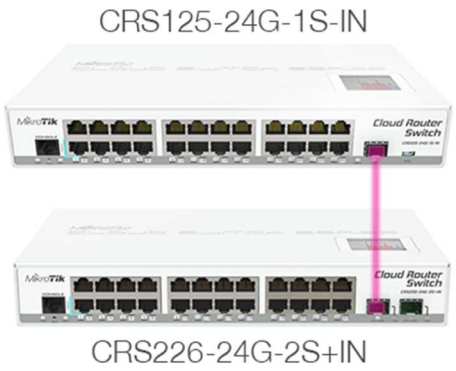


Figure 5. Connection SFP Two Router [3]

To implement SFP is actually quite easy. But before that, we must know in advance the network requirements that we will build, for example the distance of each node and the throughput that will be passed. From these needs, we can choose the type of SFP and fiber cable we need because each SFP has specifications for mode, distance, and throughput.

SFP transceiver modules come in different types based on diverse classification benchmarks. There are single-mode SFP modules and multi-mode SFP modules agreeing to the cable sort, which permits clients to choose the appropriate transceiver conquering to the desired optical extent for the organizer.

SFP module transmission rates are accessible from 100 Mbps to 4 Gbps or more. The working extent of these SFP transceiver modules is accessible from 500 meters to 100 kilometers. CWDM SFP modules and DWDM SFP modules are too accessible for WDM links. In expansion, copper SFP modules permit communication over twisted pair network cables.

TABLE I
SFP CLASSIFICATION [13]

SFP Types	Transceiver Type	Connector	Distance	Data Rate
SFP Fiber Module	SX, MX, LX, EX, ZX, EZX, BX	LC Duplex	100m-160km over MMF or SMF	100Mbps/ 1000Mbps
	CWDM/DWDM SPF	LC Duplex	10km-120km over SMF	
SFP Copper Module	1000 BASE-T	RJ45	100m over Copper Twist Pair Cable	1000Mbps
	10/100 BASE-T	RJ45	100m over Copper Twist Pair Cable	100Mbps
	10/100/1000 BASE-T	RJ45	100m over Copper Twist Pair Cable	1000Mbps

Research on the use of MikroTIK for monitoring systems is also carried out in the Application of a Network Monitoring System with the SNMP Protocol on MikroTIK Routers and the Dude Application for the Stikom CKI Case Study. In this study, the SNMP protocol is used on the MikroTIK Router and The Dude Application, to assist network administrators in monitoring networks in a university environment in real time. MikroTIK as a router that connects with various network devices such as switches, routers, and servers. The results of this study state that all devices connected to the network will be detected by The Dude application. If there is a network device that is disconnected because the device is damaged, turns off, or the cable is disconnected, information will appear on The Dude application, namely the device's color changes from green to red [14].

Furthermore, Kevin Christopher and his team conducted research on monitoring internet service systems with open-source applications. This research was conducted at PT Jaya Kartha Solusindo, Bali with approximately 80 internet subscribers. This network monitoring application uses Cacti which can view the history of customer network traffic users and the NfSen netflow application which performs initial identification of customer network anomalies. This research can facilitate the performance of network administrators in analyzing network quality and detecting customer network anomalies. Even though the number of customers served is relatively small, apart from that there is no notification in the event of damage, this research is very useful for the company [15].

MikroTIK is also used for bandwidth monitoring in "MikroTIK Bandwidth Management to Gain the Users Property Prevalent". In this research, MikroTIK manages bandwidth use can increase the functional distribution of bandwidth to the clients in order to be more equitable distribution of bandwidth. All computers can use the internet with a smooth and stability despite all computers using the internet at the same time. All the parts of the computer unit gain bandwidth according to needs that have been determined. The Administrator shall have the easier job in controlling the bandwidth of not using MikroTik [16].

II. METHOD

The research method used in research uses RAD (Rapid Application Development). RAD is a software development process model that belongs to the incremental technique. RAD emphasizes short, brief, and fast development cycles. Short time is an important limitation for this model. RAD uses an iterative (repetitive) method in developing a system where a system working model is constructed early in the development stage with the aim of establishing user requirements. The following is an explanation of the RAD stages developed in this study.

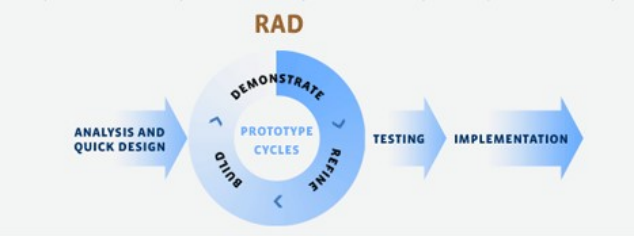


Figure 5. RAD

Stages of needs analysis is a collection of software requirements required by the user. To collect this data, the researchers immediately conducted a field survey to PT. Riyad Network Multi Technology. From the data obtained obtain data that includes needs

1. Monitoring Tx/Rx power interface SFP
2. Traffic interface SFP
3. CPU load device and
4. Notification of the status of the device interface state.

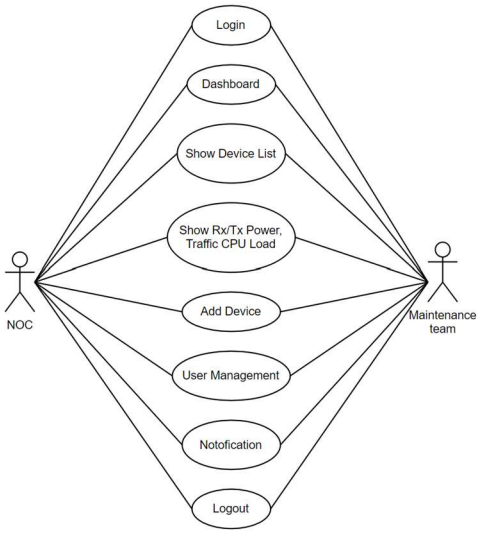


Figure 6. Use Case Diagram

The design stage is the system design stage for solutions to existing problems by using modeling such as Use Case systems, Entity Relationship Diagrams (ERD), designing application mockup displays to make it easier to build systems.

TABLE II
USE CASE LOGIN

Use Case Name	Login
Actor	NOC, Tim Maintenance
Description	The actor validates to enter the system
Normal Course	1. The system displays the login form 2. The user enters the username and password that has been registered in the database
Alternative course	Login was not successful because the user username and password have not been registered
Pre-Condition	The actor must visit the website and head to the login page
Post_Condition	The system displays the dashboard page

TABLE III
TX/RX TRAFFIC

Use Case Name	Displays Tx/Rx power and Traffic
Actor	NOC, Tim Maintenance
Description	The actor looks at the proxy router monitoring data
Normal Course	1. The actor selects a list of devices 2. The system displays the monitored MikroTIK router device data
Alternative course	The system will not display device data if the actor has not selected the proxy device list
Pre-Condition	Login as NOC and Maintenance Team
Post_Condition	The system displays Mikrotik router device data such as Tx/Rx Power, Traffic

TABLE IV
ADDING DEVICE

Use Case Name	Adding Devices
Actor	NOC
Description	NOC carries out the process of adding monitored MikroTIK router devices
Normal Course	1. The actor chooses to add a MicroTIK device on the Device list page. 2. The system displays the add form for the router MikroTIK device. 3. NOC enters device data that matches the MikroTIK to be monitored. 4. The system will save the data that has been added.
Alternative course	The system will not display data if the data entered is incomplete
Pre-Condition	Login as NOC Go to the Add Device page
Post_Condition	The system displays device data that has been added

TABLE V
USER MANAGEMENT

Use Case Name	User management
Actor	NOC
Description	NOC performs the process of changing or adding users
Normal Course	1. NOC selects edit on the user management page 2. The system displays the user form 3. NOC change or add User 4. The system stores user data that has been changed and added
Alternative course	Data will not appear if you have not done user management
Pre-Condition	Login as NOC and go to the User Management page
Post_Condition	The system displays User Data

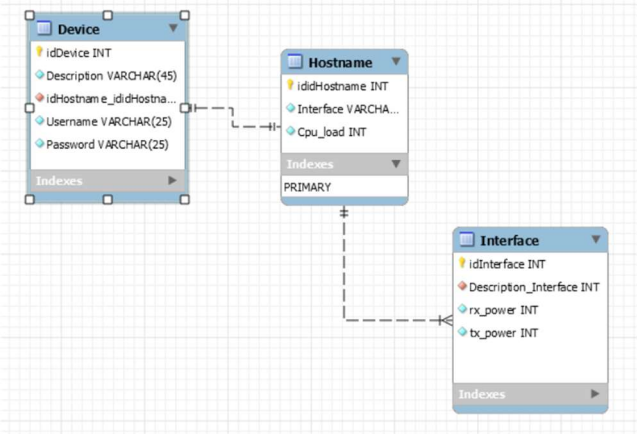


Figure 7. ERD Diagram

The SFP Interface Monitoring System on Web-based MikroTIK Routers at PT Riyad Network Multi Teknologi was built using the PHP and MYSQL programming languages which can be used to create and manage databases and their contents. This programming language has many references that can be used.

At the demonstration stage, an assessment is carried out which aims to find out the weaknesses and weaknesses of the system as an improvement to the application to make it better. At this stage the system created shows temporary results, in this process it will produce information that can be used as evaluation material for programs that are useful for developing web-based monitoring systems. The next stage is updating the system for system changes.

In the evaluation and update stage after carrying out demonstrations and studies to find deficiencies in the web-based monitoring system. By fixing the deficiencies found in the development of a web-based monitoring system, repeating repairs when there are deficiencies in the web-based monitoring system.

At the system testing stage, it is carried out to find system weaknesses, and then a review and improvement of the web-based monitoring system are done to improve it. Testing of the web-based monitoring system is carried out using the UAT method to produce a document of results used as a web-based monitoring system developed to run according to user needs.

System implementation is a process for implementing a web-based monitoring system that has been created so that it can be used and replaces the old system; at this stage, several stages are carried out, namely:

- Introducing a web-based monitoring system to PT Riyad Network Multi Teknologi, which uses the system, namely NOC, the Maintenance Team.
- Conduct training on NOC to add devices to be monitored, as well as add or change users that need to be changed.

The system that is currently running is shown in Fig. 8 above, namely when the client complains to the admin then the admin forwards the information to the NOC then checks the router which then coordinates with the Maintenance Team who

will carry out the repair process. Then the maintenance team confirmed the Tx/Rx power value after the fiber optic line repair process. The NOC (Network Operation Center) retrieves Tx/Rx power data on the proxy router and monitors traffic and CPU load to determine whether fiber optic cable maintenance is normal or is still experiencing trouble. The results obtained will then be informed to the Maintenance Team.

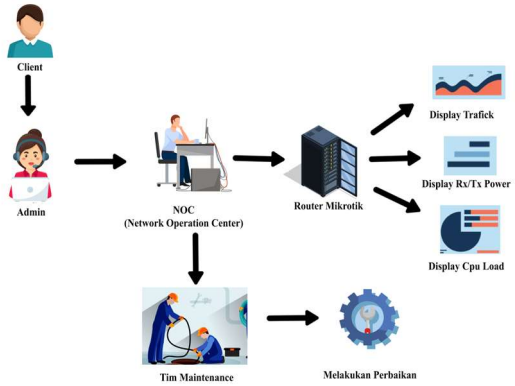


Figure 8. Overview of the Running System

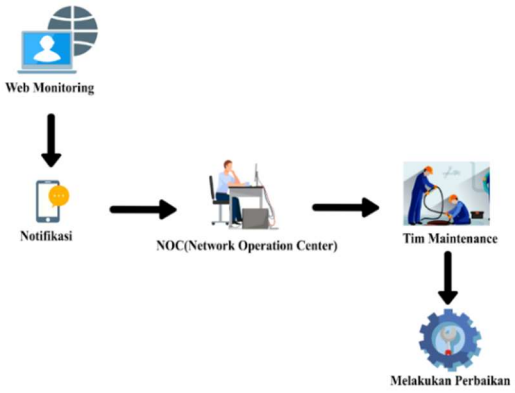


Figure 9. System Proposed

The proposed system is when there is damage to the fiber optic line (down), there is a telegram bot notification that gives notification about the damage. Then the NOC will coordinate with the maintenance team which will later carry out repairs to the damaged fiber optic lines. After completing the repair process, the maintenance team can see how much Tx/Rx power the SFP has without waiting for a response from the NOC and asking the NOC to confirm monitoring traffic, Tx/Rx power of the device.

The proposed system is very efficient and economical because web monitoring can be accessed easily by the Maintenance Team and NOC. Besides that, notifications when network damage/problems occur, will provide information to the manager more quickly so that the repair process can be carried out immediately. Therefore, this research will be very useful.

III. RESULTS AND DISCUSSION

SFP Interface Monitoring System on Web-Based MikroTIK Routers at PT Riyad Network Multi Teknologi is an application that is used to facilitate monitoring of Tx/Rx Power in the Company, this application is also designed to overcome problems that exist in companies. For example, to facilitate monitoring so as to facilitate maintenance within the company.

The system display includes every page contained in the SFP Monitoring Interface System on the Web-Based MikroTIK Router at PT Riyad Network Multi Teknologi, accompanied by an explanation.

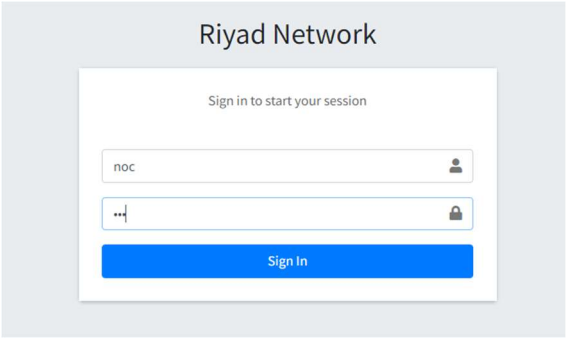


Figure 10. System Login

This main display is the first display when entering the system. Where there are two types of user logins namely login as the Maintenance Team and user login as NOC.

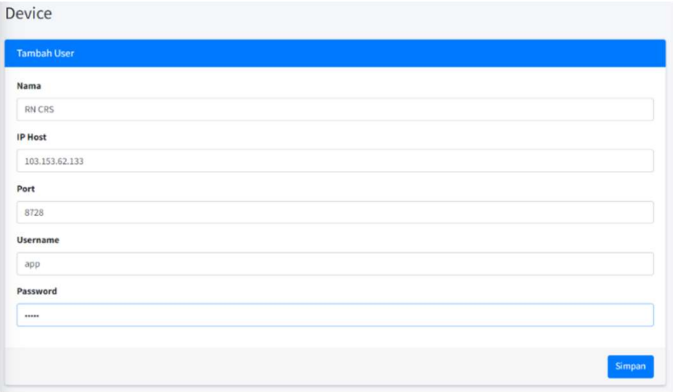


Figure 11. Device Input Form

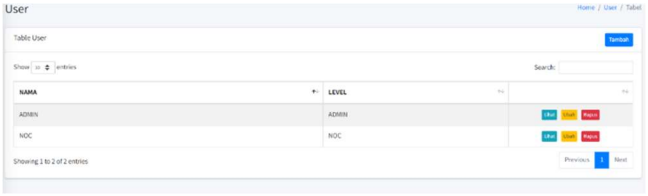
After logging in the user can add devices by pressing the add button to display the page adding device data. Then enter the device data by entering the name, ip host, port, username, password so that it is registered in the database to be able to enter the system. Then the save button to save the device data that has been entered.

```
function view($id=null)
{
  $device = $this->myModel->getOneQuery("SELECT * FROM t_device WHERE id='$id'");
  if($device==null){
    redirect('device');
  }

  $data = array(
    'view' => 'device_view',
    'data' => $device
  );
```

Figure 12. Code Program to Show Input Device

Besides that, users can also add users according to their position as the Maintenance Team or as NOC so that each member can fill in the data in the system properly.



(a)

(b)

Figure 13. (a),(b) Input User Form

From the user input from above, there is an add button to display the user addition page. Then you can enter or add user data by entering your name, username, password, and level. Then end by pressing the save button to save the user data that has been entered.

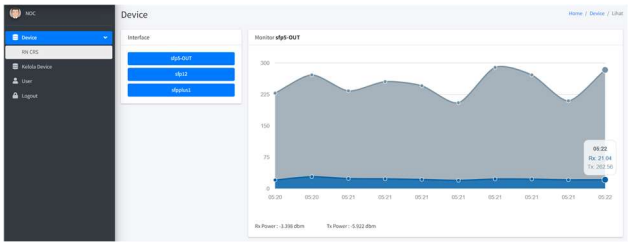


Figure 14. Interface monitoring

This feature functions to display traffic monitoring data and Tx/Rx power interface. Where the data is taken from file view => device_viface by Controller Device.php. From this view, the NOC and the Maintenance Team can check network traffic conditions.

```
function monitor()
{
  $device = $this->input->post('device');
  $iface = $this->input->post('iface');

  $rxpower = 0;
  $txpower = 0;
  $datamonitor = array();

  $monitors = $this->myModel->getAllQuery("SELECT * FROM (SELECT * FROM t_monitor WHERE device=$device AND iface='$iface' ORDER BY i
  foreach($monitors as $m){
    $dt = new stdClass();
    $dt->x = date("H:i", strtotime($m->waktu));
    $dt->y = $m->rx;
    $dt->z = $m->tx;
    $datamonitor[] = $dt;

    $rxpower = $m->rx_p;
    $txpower = $m->tx_p;
  }

  $data = array();
  $data['rxpower'] = $rxpower;
  $data['txpower'] = $txpower;
  $data['datamonitor'] = $datamonitor;

  echo json_encode($data);
}
```

Figure 15. Function Monitor

Telegram notifications are used to provide information to the NOC and the Maintenance Team when problems occur on the network. Moreover, this notification uses Telegram to send the information and get parameters from web monitoring. When the Tx/Rx power is above -25 dbm, it will automatically send notifications to Telegram.

Figure 16. Telegram Notification

The next step is to test the system that has been made. This test uses the User Acceptance Testing (UAT) method. The SFP Interface Monitoring System was tested on Web-Based MikroTIK Routers at PT Riyad Network Multi Teknologi using the Windows 10 operating system. This test was carried out directly by NOC PT Riyad Network Multi Teknologi as the user, namely:

TABLE VI
TESTING ACTOR

Name	M. Sukron Rushadi
Male/female	Male
Position	NOC PT Riyad Network Multi Teknologi
Address	Jl. Jenderal Sudirman No.09, Krajan 1, Tegalsari, Kec. Tegalsari, Kabupaten Banyuwangi, Jawa Timur 68485
Email	NOC@riyadnetwork.id

TABLE VII
TESTING RESULT

No	Scenario Testing	Test Case	Target Result	Result Testing	Status
1	Login with no username, wrong username and unregister username	Username NOC	The system will display an incorrect username or password	according to expectations	Valid
2	Login using the Username and Password that have been registered in the system	Usename NOC Password NOC	System displays menu page	according to expectation	Valid
3	Adding empty device data	Data is not filled	The system displays required data	according to expectation	Valid
4	Adding empty user data	Data is not filled	The system displays required data	according to expectation	Valid
5	Displays Interfaces	Choose Interfaces	The system displays traffic monitoring data and Tx/Rx power	according to expectations	Valid

The tests carried out above, it shows that the system built can run well. The login test with an unauthorized username shows that the system can only be entered by people who have access rights to avoid improper use.

Testing for entering appropriate and inappropriate device data shows that the system can accept input according to the data entered and cannot be entered with empty data. In addition, the Tx/Rx traffic monitoring test also shows that the system can display network traffic conditions properly so that the NOC and the Maintenance Team can monitor network conditions easily. Therefore, this test shows that the system built can be implemented according to real conditions in the field and work well.

IV. CONCLUSION

Based on the discussion previously described regarding the SFP Monitoring Interface System on Web-Based MikroTIK Routers at PT Riyad Network Multi Teknologi, it can be concluded that SFP Interface Monitoring System on Web-Based MikroTIK Routers at PT Riyad Network Multi Teknologi built with the PHP programming language. This system uses codeigniter 3 framework with MySQL database. The SFP Monitoring Interface System on Web-Based MikroTIK Routers at PT Riyad Network Multi Teknologi is used by NOC PT Riyad Network Multi Teknologi and Admin of PT Riyad Network Multi Teknologi with conditions of access rights set. NOC PT Riyad Network Multi Teknologi can add device data, view device data, add user data, view user data, and view monitoring interface results. Meanwhile, the PT Riyad Network Multi Teknologi admin can see the monitoring interface. This system also can send UP and Down orders notifications to the Telegram application.

ACKNOWLEDGEMENTS

This research was supported by the Software Engineering Study Program, State Polytechnic of Banyuwangi and the Wireless Laboratory. So that it can produce quality research. In addition, the Banyuwangi State Polytechnic is very supportive of conducting research that can support the advancement of science and is beneficial for the industrial world. Support was also provided by PT Riyad Network Multi Teknologi for this research so that it could be implemented there.

REFERENCES

[1] M. D. L. Siahaan, M. S. Panjaitan and A. P. U. Siahaan, "MikroTik Bandwidth Management to Gain the Users Prosperity Prevalent," *International Journal of Engineering Trends and Technology (IJETT),* vol. 42, no. 5, pp. 218-222, 2016.

[2] T. Rahman, Sumarna and H. Nurdin, "Performance Analysis of MikroTik RouterOS on Internet Networks," *JURNAL INOVTEK POLBENG,* vol. 5, no. 1, pp. 178-192, 2020.

[3] C. WEB, "Koneksi Port SFP antar RouterBoard Mikrotik," 13 Februari 2015. [Online]. Available: https://citraweb.com/artikel/127/. [Accessed 6 Juni 2023].

[4] A. Aptika, "Keminfo," Kominfo, 8 December 2015. [Online]. Available: https://aptika.kominfo.go.id/2015/12/sistem-jaringan-internet-di-indonesia/. [Accessed 30 Juni 2023].

[5] R. Khan, S. U. Khan, R. Zaheer and M. I. Babar, "An Efficient Network Monitoring and Management System," *International Journal of Information and Electronics Engineering,* vol. 3, no. 1, pp. 122-126, 2013.

[6] M. Mufadhol, G. Aryotejo and D. E. Kurniawan, "The Network Planning Concept for Increase Quality of Service using Packet Tracer," in *2019 2nd International Conference on Applied Engineering (ICAE)*, Batam, Indonesia, 2019.

[7] E. S. Wijaya, "COMPARISON ANALYSIS OF PERFORMANCE BETWEEN FIBER OPTIC CABLE MEDIA AND COPPER CABLE ON MIKROTIK ROUTER," *JTIULM (Jurnal Teknologi Informasi Universitas Lambung Mangkurat),* vol. 3, no. 2, pp. 77-86, 2018.

[8] B. Yuan and H. Cai, "Research on The Current Situation and Development Trend of Optical Fiber Communication technology," *Journal of Physics: Conference Series, doi:10.1088/1742-6596/1873/1/012013,* vol. 1, no. 1, 2021.

[9] Sigit, "Pemburukode," 8 5 2023. [Online]. Available: https://pemburukode.com/fungsi-port-sfp-mikrotik/. [Accessed 30 6 2023].

[10] T. Mauldin, Z. Xu and T. Wei, "Software defined optical time-domain reflectometer," in *30th Annual International Symposium on Field-Programmable Custom Computing Machines (FCCM)*, New York City, NY, USA, 2022.

[11] G. Santoso, TEKNIK TELEKOMUNIKASI., Yogyakarta: AKPRIND PRESS, Institut Sains & Teknologi AKPRIND Yogyakarta, 2018.

[12] W. Zhan, J. Yuan and H. Lv, "Research and implementation of communication system optical fiber interconnection of airborne IMA platform," in *International Conference on Electrical, Communication and Computer Engineering*, Kuala Lumpur, Malaysia, 2021.

[13] P. D. M. Persada, "Mengenal Modul SFP dan Bagaimana Cara Memilihnya," PT. Digital Mitra Persada, 4 June 2023. [Online]. Available: https://pemasangan.com/mengenal-modul-sfp-dan-bagaimana-cara-memilihnya/. [Accessed 14 8 2023].

[14] Z. MIFTAH, "Application of a Network Monitoring System with the SNMP Protocol on Mikrotik Routers

and the Dude Application for the Stikom CKI Case Study," *Faktor Exacta,* vol. 12, no. 1, pp. 58-66, 2019.

[15] K. C. Bakkaraa, I. M. A. D. Suarjaya and A. N. H. S. , "Analysis And Monitoring Of Internet Services To Customers Using Open Source-Based Applications (Case Study: Pt Jaya Kartha Solusindo)," *JITTER-Jurnal Ilmiah Teknologi dan Komputer,* vol. 3, no. 1, 2022.

[16] M. D. L. Siahaan, M. S. Panjaitan and A. P. U. Siahaan, "MikroTik Bandwidth Management to Gain the Users Prosperity Prevalent," *International Journal of Engineering Trends and Technology (IJETT),* vol. 42, no. 5, pp. 218-222, 2016.