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Computer Network Management and Monitoring System With SNMP and QoS Approach

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ABSTRACT

The problems network administrators often face are network performance issues, such as inefficient bandwidth usage and complex network resource monitoring. Real-time monitoring is required to keep the Internet network infrastructure stable. The objective of this research is to provide a conceptual design for a Quality of Service (QoS) system and Simple Network Management Protocol (SNMP) to manage Internet bandwidth and monitor network resources. The main focus of this research is on manageable network devices consisting of routers, servers, switches, bridges, hubs, computers, and printers. The result shows that the bandwidth utilization in the PGR agency has been exceeded, but by using the QoS system, it can recover. The monitoring system with SNMP shows that the time period in which the network administrator receives notifications is less than 5 minutes.

Keywords: QoS, SNMP, monitoring real-time, exceeded

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1. Introduction

The problems commonly faced by enterprises, educational institutions, industrial companies, and government agencies are network performance issues, such as low throughput and inefficient bandwidth utilization (Wairisal and Surantha, 2018; Syafalni et al., 2016). If the problem is not properly addressed, it will lead to wastage of cost as bandwidth is kept increasing/upgrading without considering the efficiency of usage. Therefore, an effective approach and concept is needed to improve the efficiency of usage and network performance. To solve the problem, network administrators face some difficulties in monitoring network resources in an organization. To meet the requirements of Internet bandwidth utilization management, QoS management is usually used to allocate the available Internet resources (Tung et al., 2022; Barreiros and Lundqvist, 2016).

Another problem faced by network administrators is the speed of fault detection in network devices such as routers, switches, cables, and others (Namee et al., 2020). This can affect the performance of the network as the identification of damaged/malfunctioning devices is slow. The computer network monitoring system using the SNMP approach makes it easy for network administrators to centrally manage the network (Khurniawan, Irfan, and Widiartha, 2016). Real-time monitoring of computer networks is required to ensure that a network is always secure, stable, and users on demand (Miftah, 2019).

Internet bandwidth capacity at *Diresaun Nacional Infrastrutura Comunicasaun* (DNIC) is steadily increasing. Table 1 describes the Internet bandwidth and its increase from 2002 to 2020 with the total agencies that use it (Amaral, 2020). According to this, the bandwidth distribution for download is 160 Mbps and upload is 40 Mbps. However, the problem with DNIC is that there is no system to manage Internet bandwidth for all agencies and no system to monitor network infrastructure for all devices. For example, there are four authorities using 7 Mbps, namely DNTT Balide, Metroloji Comoro, Sames Kampung Alor, and Procurador Geral.

Table 1. Internet Bandwidth

Year	Bandwidth (Kbps)	Agency
2002-2003	512	85
2003-2004	884	85
2004-2005	1256	90
2005-2006	1628	95
2006-2007	2000	100
2007-2008	2000	120
2008-2009	2000	130
2010-2011	8000	150
2012-2013	14000	150
2013-2014	20000	165
2014-2015	100000	165
2015-2016	100000	165
2016-2017	100000	180
2017-2018	133333	195
2018-2019	166666	200
2019-2020	200000	250

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All agencies complained about the unstable internet speed and another problem is the network administrator controls the entire network infrastructure manually, which means that equipment problems are slow to be detected and resolved on the spot. To solve these problems, this study proposes the concept of a Quality of Service (QoS) system and a Simple Network Management Protocol (SNMP). Both concepts are used for Internet bandwidth management and network infrastructure monitoring based on their respective agency.

The purpose of the QoS system is to manage the Internet bandwidth so that it is used to access the desired system or application according to the capacity allocated by the network administrator (Ningsih, 2004). Research on bandwidth management systems has been conducted by several researchers, such as implementation of ISP bandwidth management systems on smart homes with IoT technology (Jang and Lin, 2018), Internet bandwidth management efficiency for a cooperative network (Wairisal and Surantha, 2018), and QoS implementation to manage bandwidth resources in wireless infrastructure network (Rawat and Chaturvedi, 2018). The indicators and parameters that are the critical factors for implementing the QoS system to provide services over the network are bandwidth, jitter, delay, reliability, throughput, loss, and transmission delay (Koryachko et al., 2017; Rawat and Chaturvedi, 2018).

SNMP is a concept developed by the Internet Engineering Task Force (IETF) in 1987, which is used to monitor the integrated computer network infrastructure by the server (Miftah, 2019; Li, 2019). Its main function is to control device management. To do its job, SNMP uses a Network Management Station (NMS) or manager and an SNMP agent (Halsall and Fred, 2001; Espinel-Villalobos et al., 2022). The NMS has the function of an information-processing machine that processes data from the monitored network devices. While the function of the SNMP agent is to register devices such as routers, switches, servers, and other network instruments so that they can be easily controlled (Nugroho, Affandi, and Rahardjo, 2014; Diana, 2016).

In this study, the QoS and SNMP systems are used to manage and monitor the Internet network infrastructure for all agencies connected to the DNIC server through the Network Operation System (NOS) department. The study consists of six sections: Following this section, the second describes the theoretical concept, the third section describes the proposed topology for the computer network management and monitoring system with. Next, we use the SNMP command for monitoring and QoS for bandwidth management. The fourth section describes the experimental results. The fifth section is discussion. Finally, this research is concluded in section six.

2. Related Work

2.1. Quality of Service (QoS)

QoS is a service used to process traffic in order to reduce packet loss, latency, and jitter in the network (Ningsih, 2004). The function of QoS is to ensure maximum constraints and provide the same (balanced) Internet speed to all users connected to the same server (Wulandari, 2016). The advantages of QoS system are as follows: a) Control of network resources such as bandwidth, equipment, wide area facilities, and so on; b). Control over the efficient use of resources; c). Settings for mission-critical applications (ACAPacific, 2021).

2.2. Simple Network Management Protocol (SNMP)

SNMP is a protocol that exists in Solar winds and is used to monitor network infrastructure by servers. The SNMP command is used to communicate between the manager and the SNMP agent (Diana, 2016). SNMP consists of 3 components, namely: manager, agent and management information base (Harrington, 2002; Pradikta, 2013).

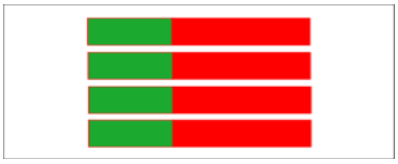

Figure 1. Indicators of SNMP

Figure 1 describes the monitoring indicators for network devices, where the red color means that the device is problematic and the green color means that all devices or equipment are working well (Diana, 2016). The requirements that organizations/institutions must meet to implement SNMP are shown in Table 2. The focus of this research is on manageable network devices, which consist of routers, servers, switches, bridges, hubs, computers, and printers.

Table 2. SNMP Management Requirements (Shaffi and Al-obaidy, 2013)

Manageable Network Devices	Routers, Servers, switches, bridges, Hubs, computer and printer
Agents	Agents are small software modules that are manages the devices
Manager	Network control center. It works on UNIX or Microsoft server

Computer network infrastructure instruments consist of routers, servers, switches, bridges, Hubs, computers, and printers. The department IT has full responsibility for maximum control over the computer network infrastructure by the network administrator using a client-server network (Shaffi and Al-obaidy, 2013). The requirements for SNMP concept have also been implemented such as monitoring system for campus network infrastructure and network devices using agent software (Espinel-Villalobos et al.,

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2022), monitoring system for network infrastructure such as booting upand shutting down systems and network devices (Safrianti et al., 2019). The SNMP concept is also used to monitor the meter reading system based on AMI (Advanced Metering Infrastructure) for around the 22 million customers. Monitoring is done by remotely sensing and controlling network devices (Kim et al., 2016).

3. Research Methodology

Bandwidth management system with QoS and monitoring system with SNMP in this study using Putty tools and Solar Winds. These two tools are used to configure QoS and SNMP connected through network administrators and routers. The QoS configuration step consists of:

a) Creating a class-map that corresponds to an access list. In this step, the system performs an inspection for all network traffic that matches the DSCP-AF21 class-map;
b) create a police-map consisting of a class-map and a packet/set of DSCP for AF2. Naming by name Outgoing-LAN-QoS, this process is used to provide device names and bandwidth to be allocated. For example, the allocated Internet bandwidth is 2 Mbps and the burst bandwidth is 384 Kbps. If the usage exceeds the specified capacity, it will be limited by the QoS system;
c) create the access list 101 that transports the allowed bandwidth speed with the traffic NCP and;
d) apply the policy-map.

The network monitoring system is performed using the SNMP protocol to access the Management Information Bases (MIB) of each host and retrieve data according to the OID (Object ID) sent through the tool Putty. The monitoring steps consist of:

a) Configure SNMP through Solar Winds based on the host name and password created on the router interface;
b) add a note to find the address of the agency configured on the router;
c) use the defined note to assign an IP address to the agency based on the community string and the read/write community string;
d) select the monitoring resource agency via Choose Resource, e.g. GigabitEthernet0/0 for LAN and GigabitEthernet0/1 for Agent.

Figure 2 describes the current network topology at DNICT. It can be seen that the Internet network infrastructure has a high level of complexity. However, no real-time monitoring system is used to detect problems with all existing devices, so the performance of the infrastructure is slow. There is no controlled management system for allocating Internet bandwidth to users, so the efficiency of usage does not match the capacity allocated by the network administrator.

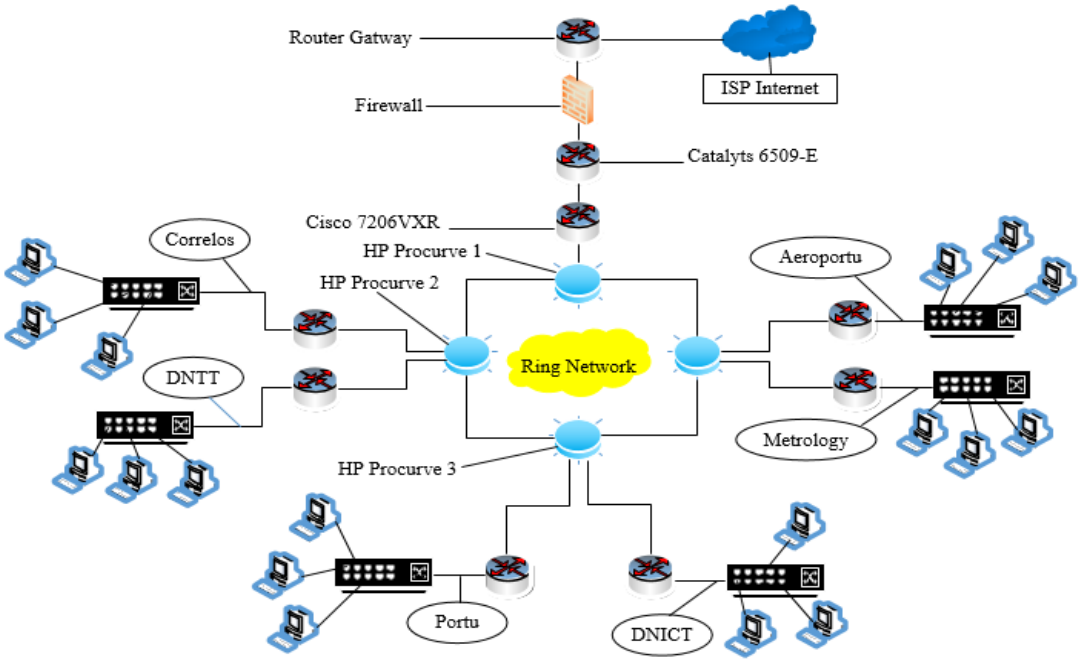

Figure 2. Current Network Topology

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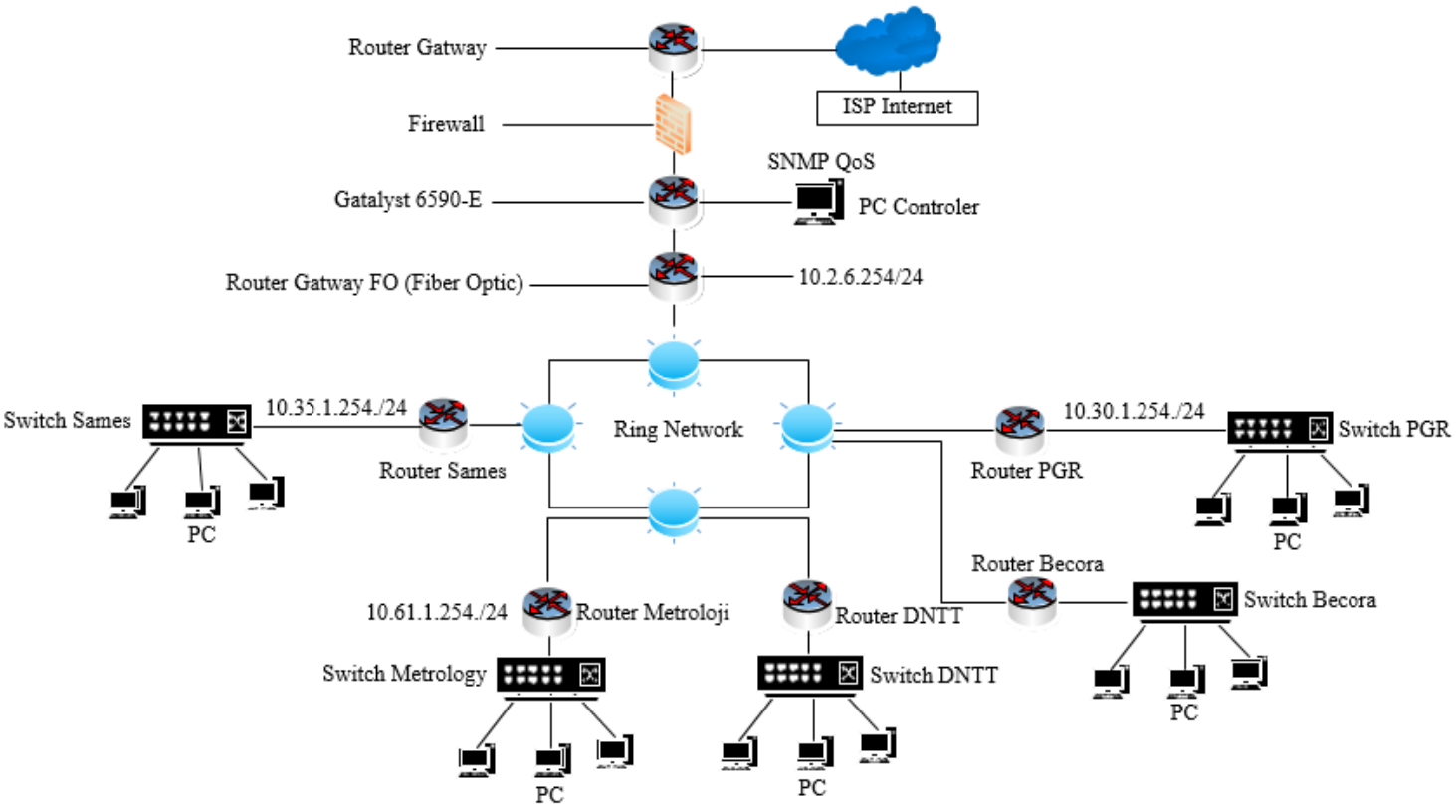

Figure 3. Proposed Network Architecture of Bandwidth Management and Network Monitoring System

Figure 3 describes the implementation of QoS and SNMP, and each QoS and SNMP is implemented on Cisco router devices. The QoS system is implemented only on the router device, while the SNMP system is implemented only on the network administrator's server through the router. The network topology in Figure 3 shows that there are 5 routers, but when implementing QoS and SNMP for bandwidth management and monitoring, there are only 2 agencies, namely PGR and Metrology. In the initial configuration phase, QoS and SNMP are configured using Putty software to connect the server to the router. Figure 3 describes the whole process, the configuration in the command uses a console cable to connect the server and the user, then login to the Putty application to determine the IP address of the PGR agency. Next, select Telnet to access the router interface to access the SNMP command on the Cisco router device to configure it.

4. Results and Analysis

Testing and implementation phase consists of 2 phases, namely QoS and SNMP testing. Configuration and implementation using any desktop and putty tools to connect PC to the router for QoS and SNMP configuration on the Cisco router. The results of the testing and implementation of QoS were determined in this study using 2 scenarios. The first scenario tested the bandwidth allocated to the agency by the network administrator, with usage exceeding the allocated bandwidth. The second scenario tested the bandwidth allocated to the agency, with usage not exceeding the total allocated bandwidth. Table 2 shows the results for the total bandwidth allocated to the Procurador Geral (PGR) agency, which is 2 Mbps. The total bandwidth is converted to the bandwidth CIR using a QoS system, which is 2048000. When the CIR is assigned by the network administrator, the QoS system displays the Burst Committed (BC) value of 384000 bytes. The total value of 2052000 bps shows that the 2049000 bps bandwidth used by the agency may increase or decrease depending on usage. The first scenario shows that the bandwidth usage in the PGR agency has been exceeded, but by using the QoS system, it can recover, namely exceed 260000 bps. The second scenario shows that the total bandwidth allocated to the Comoro Metrology Agency is 1 Mbps. The bandwidth is converted to CIR using a QoS system, which corresponds to 1024000 bps. The total number of CIR assigned by the network administrator with a Burst Committed (BC) value of 192000 bytes with a total value of Conformed 101000 bps, which means that the total value can be increased. The total number of CIR allocated by

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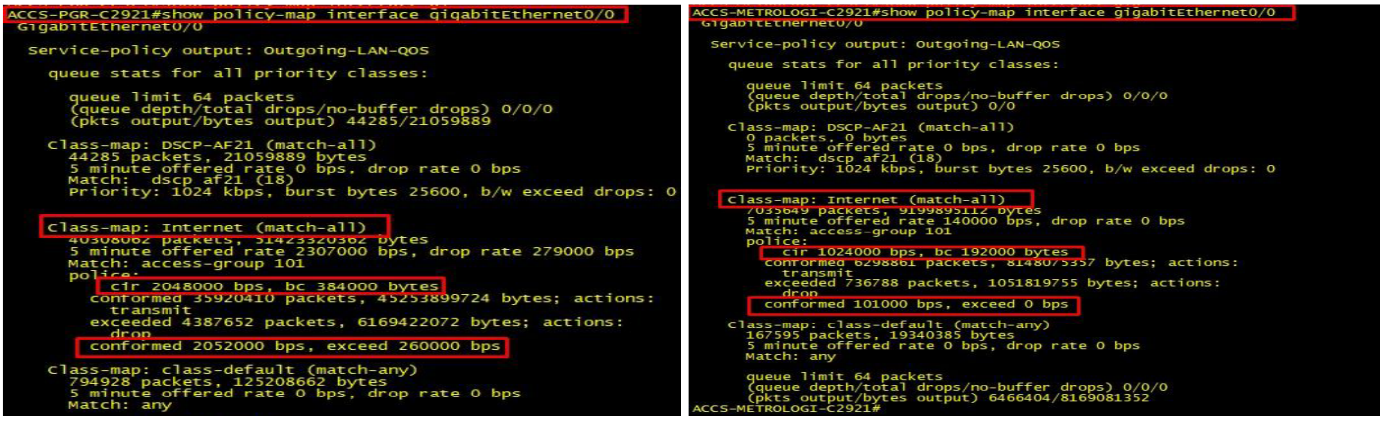
the network administrator shows a BC value of 192000 bytes when used, and the total Conformed bps value is 101000, meaning that usage can be increased or decreased. The results in the second scenario show that the bandwidth usage has not reached the target assigned by the server. When the QoS system is used, the results of Exceed bps are 0.

Figure 4 shows the bandwidth allocated by the server to the PGR agency with a capacity of 2 Mbps. The figure shows the bandwidth allocated by the server to the PGR agency with a capacity of 2 Mbps. Based on the given bandwidth capacity, it shows that the usage has been exceeded, so the QoS system can recover the bandwidth that exceeds the given capacity, such as Exceed 260000 bps.



(a) (b)

Figure 4. The Result of Allocation and Utilization Bandwidth

Table 3. The Result of Bandwidth Management with QoS

Agency	Bandwidth (Mbps)	Committed Information Rate (CIR)-bps	Burst Committed (BC) byte	Conformed bps	Exceed bps
Procurador Geral Balide	2	2048000	384000	2052000	260000
Metrology Comoro	1	1024000	192000	101000	0

Normal burst = configured rate(1 byte)/(8 bits)*1.5 seconds*
Example: bandwidth=1Mbps (1024000bps),
Normal bus= 1024000(1/8)*1.5=192000byts*

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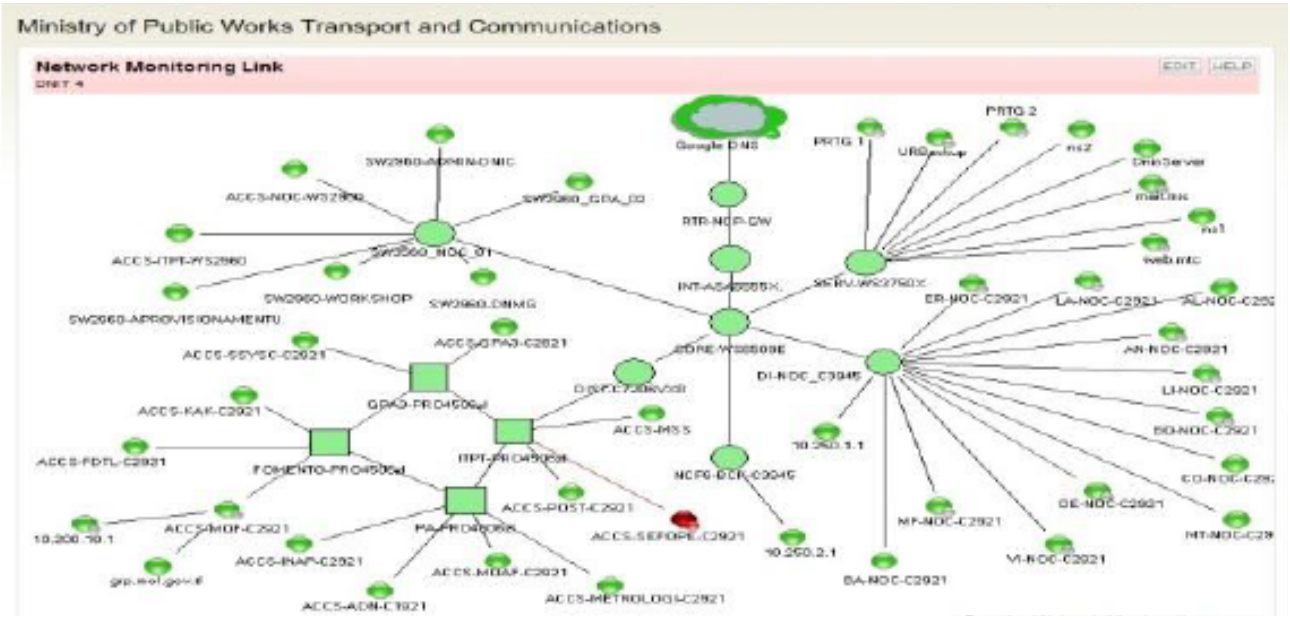

Figure 5. The Result of Network Monitoring System with SNMP

Figure 5 shows the results of the configuration and monitoring system by Solarwinds for all agencies connected to the DNIC network server. It can be seen that when there is a fault in the network, a notification (red colour) appears. To find out which device is the problem, just click on the notification (Figure 5). Then the result will be displayed as in Figure 6 (a).

Nodes with Problems

NODE	DESCRIPTION	CURRENT RESPONSE TIME	PERCENT LOSS
INT-ASA5540-2ndNode.moi.gov.tl	Node is Down One or more interfaces are in an Unknown state.	No Response	100 %
OE-NCP009-SG300	Node is Down Interface 'gigabitethernet52 - gi52' is in an Unknown state.	No Response	100 %
CORE-ITPT-C3845	Node is Down.	No Response	100 %
ACCS-CFP-C2921	Node is Down.	No Response	100 %
ACCS-EDTL-C2921	Node is Down.	No Response	100 %
BAUCAU-HOSPITAL	Node is Down.	No Response	100 %
SW-SUAI-PNTL	Node is Down.	No Response	100 %

(a)

Node Details

Management	Edit Node, List Resources, Unmanage, Pollers, Poll Now, Rediscover
Node Status	Node is Up.
IP Address	10.2.6.50
Dynamic IP	No
Machine Type	Cisco 2921K9
DNS	
System Name	ACCS-PGR-C2921.yourdomain.com
Description	Cisco IOS Software, C2900 Software (C2900-UNIVERSALK9-M), Version 15.0(1)M7, RELEASE SOFTWARE (fc2) Technical Support: http://www.cisco.com/techsupport Copyright (c) 1986-2011 by Cisco Systems, Inc. Compiled Thu 04-Aug-11 21:40 by prod_rel_team
Location	MOE Dili
Contact	dnict@moi.gov.tl
Last Boot	Wednesday, December 09, 2020 9:04 AM

(b)

Figure 6. The Notification Node with Problems

The results of the SNMP command in Figure 6 (b) show that all devices connected to the server have no problems because the node status contains a green indicator. The graph in Figure 7 (b). shows the Internet bandwidth used by users on a daily basis and the number of users using the Internet. The results in Figure 7 (d) show that the total bandwidth used by users is at most 1 Mbps/day and at least 200 Kbps of total allocated capacity.

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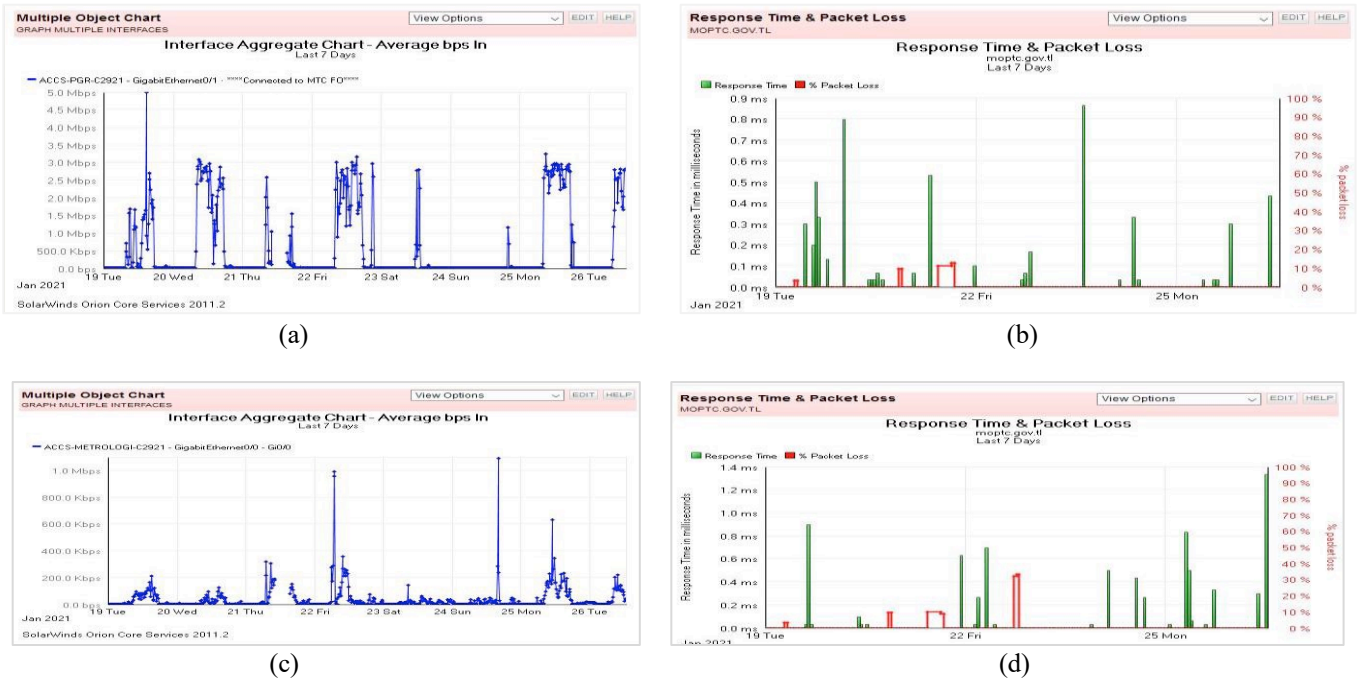

Figure 7. The Result of Bandwidth Utilization

5. Discussion

Internet management bandwidth with QoS system can be effective to manage the usage bandwidth in any agency. The testing result shows that the QoS system can recover the exceeded bandwidth. The QoS system also shows that when the bandwidth usage is excessive, the utilization far exceeds the Internet bandwidth. Then we can use the traffic shaping techniques to reduce the packet loss and get the maximum of the actual allocated bandwidth (Wairisal and Surantha, 2018). The results also show that when a QoS system is used, the total bandwidth allocated is converted to Burst Committed (BC), while the total usage by the user is converted to the Conformed parameter. The value of the Conformed parameter can be increased or decreased depending on usage. The performance of QoS-based bandwidth management must be validated by satisfying all QoS parameters (Rawat and Chaturvedi, 2018). The implementation of bandwidth management with the QoS system and its parameters can also be applied to different developed platforms such as Java (Breaban et al., 2018), and the results show that the system can perform the management automatically, followed by the authentication process of the user on an Active Directory server.

The result experiment in these studies shows that the time required to display the results of network infrastructure and registered devices according to the concept of network management station. The test results of the monitoring system using SNMP show that 1 device requires 1.3409 seconds, 2 devices 2.102 seconds, 4 devices 3.201 seconds and 5.432 seconds for 6 devices. These results show that the use of SNMP with a multi-agent approach, including the Management Information Base (MIB) value to collect information from the network equipment and network devices (Espinel-Villalobos et al., 2022). The results also show that changes in status and parameters are properly managed by SNMP by issuing notifications according to the device with problems. This shows that the monitoring system using the SNMP concept is reliable and can be applied to a complex network infrastructure (Li, 2019). The results also show that the monitoring system with SNMP concept could identify several problems with network devices such as network devices, error information, network topology, network performance, and network traffic.

6. Conclusion and Future Research

Internet Bandwidth Management and System Monitoring with QoS and SNMP Can effectively manage and control network infrastructure on a large and complex scale. In the first scenario, it shows that the bandwidth usage has been exceeded, but it can be managed and recover by using the QoS system. The monitoring system using SNMP shows that the time taken for the network administrator to receive notifications is less than 5 minutes, and technicians can easily identify devices affected by faults. It can be concluded that system monitoring services using SNMP very

effective can provide a short notification time when dealing with problems in complex networks. The system can also make it easier for network administrators to monitor all network infrastructure activities centrally.

For future research, combination and hybrid approach are needed to improve monitoring performance and bandwidth management. The use of other tools such as Packet Shaper and Nagios Core are needed to integrate with early warning system to facilitate centralized system control.

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