Integrating Ethernet Over PDH Based Microwave Radio Links Using ECMP Load Balancing Method for the Rural Internet Access

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ABSTRACT
Internet is a necessity for most Indonesian people. People who live in rural areas often face problems or difficulties accessing information via the Internet. Their problems are commonly poor connectivity from Internet Service Providers (ISP), such as network breaks and slowdowns. To solve the problems, it is suggested to build a reliable and fast network. This research discusses the integration of two different ISPs Ethernet Over PDH Based Microwave Radio Links using load balancing technique. The technique is to distribute the load to the network in balance and protect the network from failover. There are several methods to do balancing and failover. In this research, the ECMP (Equal Cost Multiple Path) was used. The test results show that the load balancing router with the ECMP method can combine throughput from two radio link microwaves. The summing throughput of the two links is distributed to the load. The result shows that the total throughput measure at the output load balancing router is 6.8Mbps, which is the summing result of 1.3Mbps and 5.2 Mbps.

Keywords: *ISP, load balancing, ECMP, failover, PDH.*

1. INTRODUCTION

Currently, there are still many remote and rural areas in Indonesia that have not been penetrated by ICT infrastructure, so it will be difficult to get information in various fields such as economy, education, health, social, and culture. For this reason, a breakthrough is needed so that people living in rural areas can easily have access to ICT [1].

The Internet has become a necessity for everyone to take benefit of it because it has a function that is like the books as a window of information. In addition, the audio-visual content which is the power of the Internet has a bigger and stronger impact on the development of public knowledge in general [2]. In Indonesia, various obstacles that cause the rate of Internet penetration are still very low due to the inadequate support of telecommunication infrastructure, especially in eastern Indonesia, which is very different from the conditions in Java Island.

Nowadays the rapid spread of Covid-19 pandemic has become a big issue, especially in Indonesia. It has caused disruption to the Indonesian education sector and forced the government to lock down schools and encouraging students to make distance learning from home. The rapid spread of Covid-19 pandemic has disrupted the Indonesian education sector. The widespread of Covid-19 has forced the government to close schools and encourage distance learning at home [3]. One of Indonesia's largest telecommunications service providers saw broadband flows increase by 16% during Covid19 crisis due to the sharp increase in the use of distance learning platforms. [4].

From this statement, it can be formulated that the first need is to link ISPs and ICT infrastructure in rural areas. This can be carried out with PDH based microwave radio link. Second, it is a necessity to build the ICT infrastructure for people to access the Internet. The accessible technology proposed to answer the above issues is the standard 802.11 MWLAN which is backhauled by the microwave radio links. The purpose of this research is to develop a Mesh WLAN network that is integrated with microwave radio links to meet the needs of rural communities by using the ECMP load balancing technique.

2. METHODOLOGY

The design of radio PDH based microwave radio links using ECMP load Balancing method consists of:

1. The first is to build two PDH based microwave radio links connected to ISP 1 and ISP 2 to deliver the internet signal to Pagerwangi. The location of ISP 1 is at Polban and ISP 2 is at Tulip Office Building.
2. Second, both two radio links are then integrated into the load balancing router using the ECMP method which function is to distribute the load to all users and failover as shown in Figure 1.
3. Third, people in the rural area as the end-user will access the internet via WLAN as an application of load balancing.

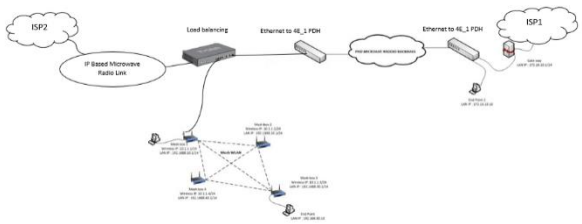

Figure 1 Mesh WLAN connected to two ISP using load balancing ECMP method

In designing a radio link microwave, the LOS condition must be achieved and the LOS condition requirements are shown in Table 1.

Table 1. Requirement of LOS conditions

Requirement	Value
LOS	At least 60%
Fade Margin	>40dB
RSL	-44dBm up to -54dBm
Link Quality	Bit Error Rate < 10^{-9}
Minimum availability	99.995%

In this research, Radio Mobile is used to simulate the radio link that has been designed. The purpose of this simulation is to know whether the radio path parameters meet the link design requirements.

2.1. Topographic data of link Polban Pagerwangi

The data at Polban site are as follows:

- Coordinate and Elevation

  a. Latitude : 6° 52’ 11.3” S
  b. Longitude : 107° 34’ 22.0’’ E
  c. Elevation : 835.5 meter

The data at Pagerwangi site are as follows:

- Coordinate and Elevation

  a. Latitude : 6° 49’ 48.6” S
  b. Longitude : 107° 37’ 50.5’’ E
  c. Elevation : 1268.8 m

Figure 2 shows the simulation result of radio link design between Polban and Pagerwangi as follows; Fade Margin is obtained more than 40dB and Received Signal Level is -46,2dBm as required in Table 1.

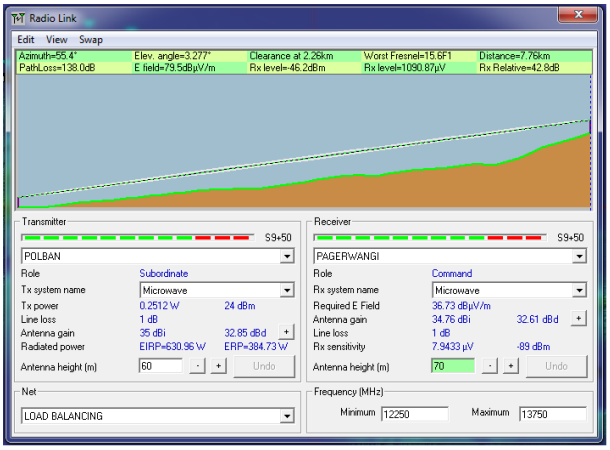

Figure 2 Radio Link Microwave Polban-Pagerwangi

2.2. Topographic data of link Tulip-Pagerwangi

The following is the site data for Tulip Office Building:

- Coordinate and Elevation

  a. Latitude : 06º 53’ 52.5”
  b. Longitude : 107º 32’ 48.1”
  c. Elevation : 1065.8 m

Figure 3 showed the simulation result of the radio link between the Tulip Office Building and Pagerwangi, as follows; Fade Margin is obtained close to 40dB and Received Signal Level is -49,6dBm as required in Table 1.

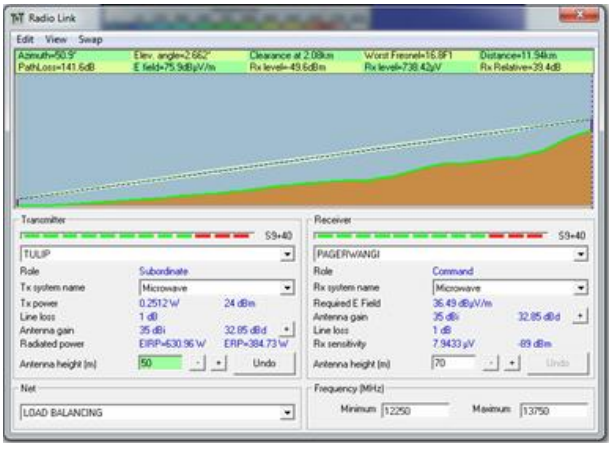

Figure 3 Radio Link Microwave Tulip-Pagerwangi

2.3. Integration of the two ISP's radio links with load balancing router

Load balancing using the ECMP method is applied to integrate two link hops which purpose is to load the distribution via the best path and failover.

2.3.1 ECMP load balancing

The hardware required to implement the network is a wireless router with the IEEE 802.11 g standard. The firmware chosen is Freifunk version 1.7.4 with the embedded Optimized Link State Routing (OLSR) protocol. This routing protocol belongs to the class of proactive routing protocols; hence the route is always available immediately when needed [5]. Implementation of Mesh WLAN used load balancing with ECMP method is shown in Figure 4.

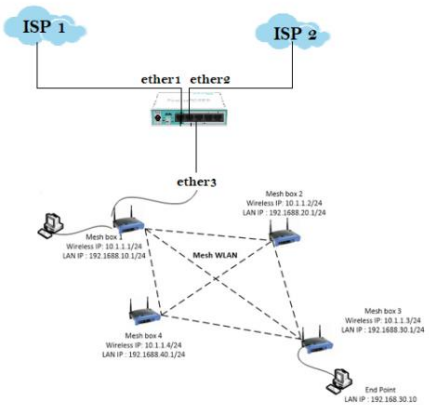

Figure 4 Topology of Load Balancing witch ECMP Method

2.4. PDH-based radio link measurement Polban-Pagerwangi

Measurement of microwave radio link based on PDH technology involves testing and measuring each 2 Mbps tributary signal where the parameters measured are Bit Error Rate (BER) and error performance G.821 measurement. Figure 3.6 below is a microwave radio link measurement setup diagram.

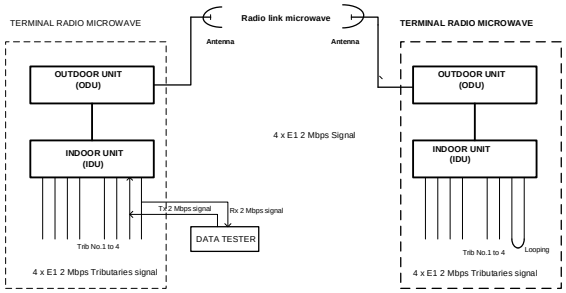

Figure 5 Set up microwave radio link measurement

The procedure of BER and error performance measurement consist of:

1) The signal to be measured and tested for BER and its performance error is a 2Mbps tributary signal with signal specifications shown in table 3-1.
2) Measurement of BER parameters and Error performance of 2Mbps tributary signal using Data Tester, which is a special measuring tool for measuring digital signal standard G.703. It is where one of the 4 attributes of the local radio IDU device is connected to the data tester while the tributary with the same tributary number from the IDU remote in the loop as shown in Figure 3.6. and Data Tester must be set according to the specification of the tributary signal to be measured.
3) After finishing measuring one of the attributes, then it moves on to measure another attribute.

Table 2. Mbps signal tributary specification

Description	Severe Error Seconds
Mode	Tx - Rx
Interface	ITU G.703
Line Coding	HDB3
Framing	PCM30
Data rate	2048 kbps
Clock	Internal
Impedance	120 Ohm balance

2.5. Load balancing router configuration

Distributing the traffic load on two or more ISPs connections in a balanced way is called a load balancing method. It is a method which the traffic can run optimally, the throughput is maximized, the response time is minimized and backup the traffic if one ISP path is down. The equal distribution of traffic will make the connection balanced thereby reducing network flow work. General load balancing can be defined as a technique used to separate between two or many paths [6].

There are many load balance methods that we can use for these needs. Sometimes, we are confused about which method to use. The ECMP (Equal Cost Multiple Paths) method can be a solution because this method since its configuration is very simple and easy, so it is very interesting to be applied. The principle of ECMP consists of the selection of alternative exit routes in the gateway. ECMP works when there are two gateways: it goes through the two gateways with the same load and is then referred to as the same cost [7]. The ECMP principle distributes the traffic according to the random principle, which means that the traffic is transmitted randomly via the gateway router of each ISP since the distance is the same as the ECMP method.

Failover is an alternative when you have more than one Internet connection and you maintain an Internet connection [8]. This failover method can work automatically on Internet links that are disconnected. It is a technique that uses multiple routes to reach a destination network. But under normal circumstances, only one link is used. The other links serve as a backup and are only used if the main link is broken. This application is known as failover [9].

The initial settings are the same as our router settings so that routers and clients under the router can connect to the internet. Since there are two internet connections, there will be 2 NAT masquerade rules.

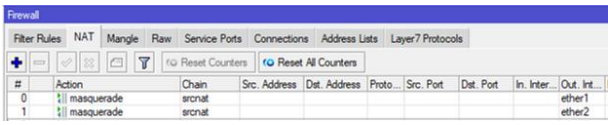

Figure 6 Set-up Firewall

After the standard configuration of the connection to the internet is completed, then we can start setting the ECMP Load balance. The method is quite easy by just adding a default gateway rule.

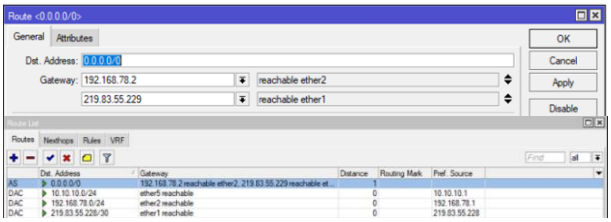

Figure 7 Set-up gateway in Route menu

ECMP stands for "persistent per-connection load balancing". Once one of the gateways is unreachable or disconnected, the check-gateway will disable the gateway and use the gateway that is still active, so that we can get a failover effect.

If we have an internet connection with different bandwidth speeds, we can make a comparison to divide the load. Suppose we have a bandwidth of 6 Mbps and 2 Mbps. For failover function indicated by two gateways as shown Fig 7. If one of the ISP traffic is down, it will be handled by traffic one automatically. This is also useful for the protection system.

3. RESULT

The telecommunications network infrastructure consisting of a digital microwave radio link backhaul network based on Ethernet over PDH technology and a Mesh WLAN with load balancing network that has been implemented is then tested and measured to determine its performance. There are three kinds of tests and measurements carried out as follows:

1. Testing and measuring Bit Error Rate (BER) backhaul digital microwave radio link refers to Rec ITU-T G.821

2. Testing and measuring Endpoint to Endpoint performance Ethernet over PDH on the backhaul side of the microwave radio link

3. Testing and measuring End to Endpoint performance on Mesh WLAN access network using Load Balancing.

3.1. BER Test and Measurement Error Performance Rec G.821

This test measures bit errors of every 2 Mbps tributaries offline rate of 2048 kbps. This digital microwave radio link uses QPSK modulation. In this measurement, only 4 of the 8 tributaries are measured. The test setup is shown in Figure 8.

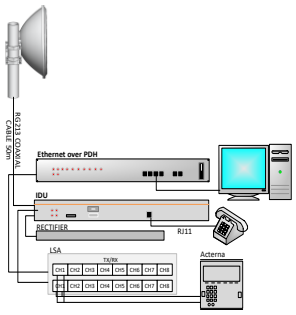

Figure 8 Setup BER measurement and error performance Rec ITU G.821 End to Endpoint performance

The results of the Error Performance measurement are shown in Table 3.

Table 3. Measurement of Error Performance G.821 Tributary 2 Mbps

Number of Tributary	Errored Free Seconds		Error Seconds		Severely Error Seconds
1	597	99.5%	PASS	0.5%	PASS
2	599	99.833%	PASS	0.167%	PASS
3	600	100 %	PASS	0%	PASS
4	600	100 %	PASS	0%	PASS

The BER measurement results show that there is no error for each measured attribute. From the results of testing and measuring, the error performance is G.826 2 Mbit/s Tributary. From Table 3, it shows good results where the measurement of all parameters such as Error Free Second (EFS), Error Second (ES), and Severe Error Second (SES) shows a satisfying results referring to ITU-T Recommendation G.821 and revised by ITU-T Study Group 13 (2001-2004).

3.2. End to End performance ethernet over PDH

The results of end-to-end measurements of Ethernet microwave link over PDH based is shown in Figures 9 where the measured throughput is less than 8 Mbps tributary signal since some bytes in tributary signal is used for framing.

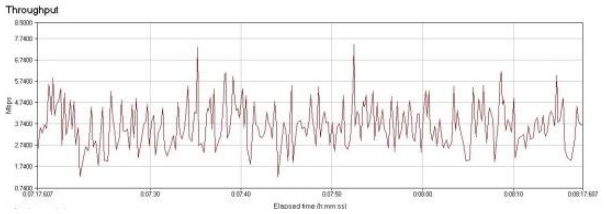

Figure 9 Result of the throughput measured of PDH Based Microwave Radio Link

The results of end-to-end measurements of Ethernet over IP-based microwave link shown in Figure 10 have 75% of the overall transmission capacity of the terminal radio itself.

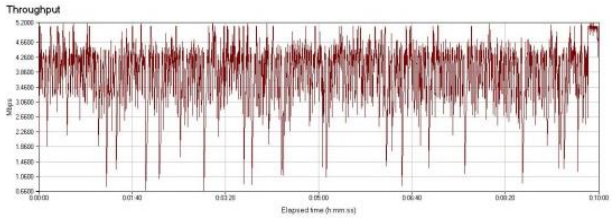

Figure 10 Result of the throughput measured of IP Based Microwave Radio Link

3.3. End to End performance using Load Balancing

The results of end-to-end measurements of microwave link Ethernet over PDH based is shown in Figure 9 where the measured throughput is less than 8 Mbps tributary signal since some bytes in the tributary signal are used for framing.

Figure 11 Result of the throughput measured at load balancing output Eth1 of PDH Based Microwave Radio Link

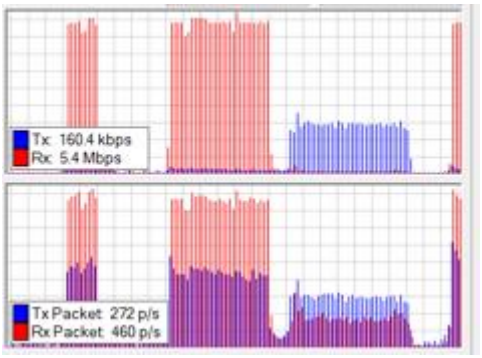

Figure 12 Result of the throughput measured at load balancing output Eth2 of IP Based Microwave Radio Link

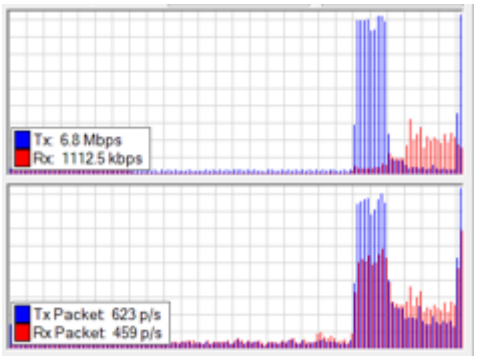

Figure 13 Result of the throughput measured at load balancing output Eth3

Based on radio Link wise measurements as shown in Figure 11 and Figure 12, both links are then combined through a load balancing router resulting in the submission of the throughput from the two-radio link. The total throughput is equal to 6.8 Mbps.

4. CONCLUSION

Telecommunication infrastructure using four backhaul radio links with ethernet over PDH based technology has already been successfully designed and implemented and satisfied BER and error performance objectives. The throughput of the Ethernet signal is less than the bit rate of the PDH tributary signal. The test results show that the load balancing router with the ECMP method can combine throughput from two radio link microwaves. The summing throughput of the two links is distributed to the load. The result shows that the total throughput measure at the output load balancing router is 6.8Mbps, which is the summing result of 1.3Mbps and 5.2 Mbps.

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