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Optical Cable Backbone Network Design in West Kalimantan Province Using OTN DWDM Technology

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ABSTRACT

In designing the backbone network for the province of West Kalimantan using Dense Wavelength Division Multiplexing (DWDM) and Optical Transport Network (OTN) devices which cover 14 districts and cities consisting of 30 segments, of which 30 segments consist of 14 DWDM OTN sites and 8 Optical Land Amplifier sites (OLA). From the results of the design and simulation of the backbone network, it was found that the value of the Optical Link Power Budget (OLPB) < 50 dBm where this value is the ideal value in deploying a DWDM OTN backbone network, and the range of the Optical Signal Noise Ratio (OSNR) is between 20 dBm < OSNR < 40 dBm, which is the ideal value for OSNR, and has an Optical Rise Time Budget (ORTB) < 60 ps, and also has a segment margin system of > 7 dB.

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1. INTRODUCTION

The Palapa Ring itself is one of the government's main priority programs to build an optical cable backbone network system that has large capacity and high speed by integrating the existing network with the network to be created. The Palapa Ring itself is divided into 3 main segments, namely, West Palapa Ring (PRB), Middle Palapa Ring (PRT), and East Palapa Ring (PTT). The Palapa Ring project has started to be implemented with the aim of connecting the islands in Indonesia, both by land and sea routes.

The Palapa Ring project has already built several large rings in Indonesia, but the 11 rings connecting Sulawesi and NTT are still unfinished. Related to this problem, the optical backbone network from Makassar – Maumere as part of the 11 The ring section is designed using Dense Wavelength Division Multiplexing (DWDM) device technology. [1]. The development of the optical cable backbone network is also planned in several areas such as the design of the Long Term Evolution (LTE) 4G backbone network in the Sleman district in the province of Yogyakarta [2]. In addition, the design of the backbone network for the North Sumatra region itself is also being planned [3].

In writing this scientific journal, the selected area is the province of West Kalimantan, where the province of West Kalimantan in the future will be projected to experience rapid progress and development. So to be able to anticipate this, it is necessary to immediately create and deploy a backbone network of land optical cables and marine optical cables that can connect all districts and cities in the province of Kalimantan. West with a total of 12 Regency Cities and 2 Madya Cities. Figure 1 below shows the Palapa Ring project.

Figure 1. Palapa Ring Project

In general, the marine optical cable communication system consists of two main parts, namely the land part (Dry Part) and the sea part (Wet Part). On the land side (Dry Part) consists of the main Site Shelter which functions as a place for the establishment of terminal equipment that connects the Site Shelters (stations) between regencies and cities located in the island provinces. While the marine section (Wet Part) consists of marine optical cables along with supporting elements which include Optical Repeater (RPT), Cable Jointing (CJ) devices, and Cable Branching Units (BU) which function to connect stations (shelters) between island.

Overall device terminal the shelter consists of Cable Terminal Box (CTB), Power Feeding Equipment (PFE), Submarine Line Monitoring (SLM), Submarine Line Terminal Equipment (SLTE), Network Monitoring System (NMS), and Network Protection Equipment (NPE), while the equipment outside the shelter consists of Ocean Ground Bed (OGB) and Beach Manhole (BMH). The device components inside the shelter function as the terminal point of the physical optical cable while those outside the shelter such as BMH and OGB serve as a landing station (LS) for the marine optical cable before going to the equipment inside the site (shelter). For devices outside the shelter, it consists of Ocean Ground Bed (OGB) and Beach manhole (BMH). Meanwhile, the equipment in the shelter includes Cable Terminal Box (CTB), Power Feeding Equipment (PFE), Submarine Line Monitoring (SLM), Submarine Line Terminal Equipment (SLTE), Network Monitoring System (NMS), and Network Protection Equipment (NPE). . Figure 2 below shows a diagram of the optical cable communication system sea.

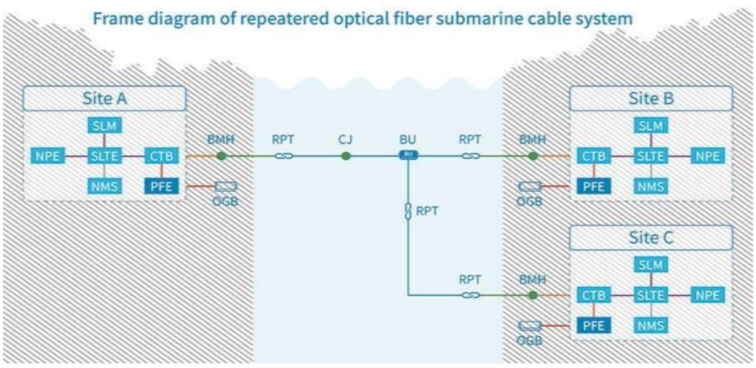

Figure 2. Diagram of Marine Optical Cable Communication System

From Figure 2 above, it can be seen that the first part includes the Ocean Ground Bed (OGB) where the function of the OGB is a device located outside the shelter that serves to provide a connection from the PFE towards sea level which is normally located near the Cable Landing Station (Landing Point), so that it gets a very light and small grounding against the earth's surface. OGB itself functions as a grounding device that connects PFE devices with marine optical cables and can be planted on the seashore or near the shelter so that it has a safe position. Figure 3 below shows the OGB

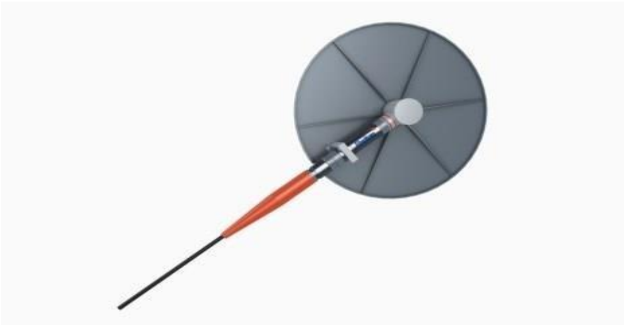

Figure 3. Ocean Ground Bed (OGB)

The second part is the Beach Manhole (BMH) where BMH is a supporting installation of a marine optical cable network installed below ground level which aims to control connections between marine optical cables and between marine optical cables and land optical cables, to then be connected to existing devices . in shelters. OGB and BMH are two types of equipment and items located outside the shelter. The following will discuss the devices contained in the shelter . The equipment contained in the shelter consists of Cable Terminal Box (CTB), Power Feeding Equipment (PFE), Submarine Line Monitoring (SLM), Submarine Line Terminal Equipment (SLTE), Network Monitoring System (NMS), and Network Protection Equipment (NPE). . Figure 4 below shows Beach manhole (BMH).

Figure 4. Beach Manhole (BMH)

The third part is the Cable Terminal Box (CTB) where the function of the CTB is to separate the optical cable and the power source (Power Supply) into two parts. When the marine optical cable reaches the terminal box at the landing station, it is divided into two parts, namely the optical cable itself and the power supply cable . Inside the CTB the power supply cable will be connected to the cable high voltage output through the PFE device in the shelter , while the optical cable will be connected to the optical cable terminal device in the shelter . The CTB itself consists of a marine optical cable terminal unit, a special lighting processing unit, Mic roswitches , Light Emitting Diodes (LEDs), and Resistors.

The fourth part is the Power Feeding Equipment (PFE) where the function of the PFE is to provide a power source to the components in the shelter and also to the repeater devices in the cable path between shelters . In addition, PFE also performs the function of repeater power and converts electric current from AC to DC and vice versa. PFE can also function when there is a disturbance in the submarine cable by switching the high voltage polarity according to need and can also sending low- frequency electrical signals to submarine cables to make it easier to determine the location of damaged cables when repairing marine optical cables. PFE generally consists of Regulator Bay, Power Monitor Bay, Test Load Bay, Switch Bay , and CTB. Figure 5 below shows the device PFE

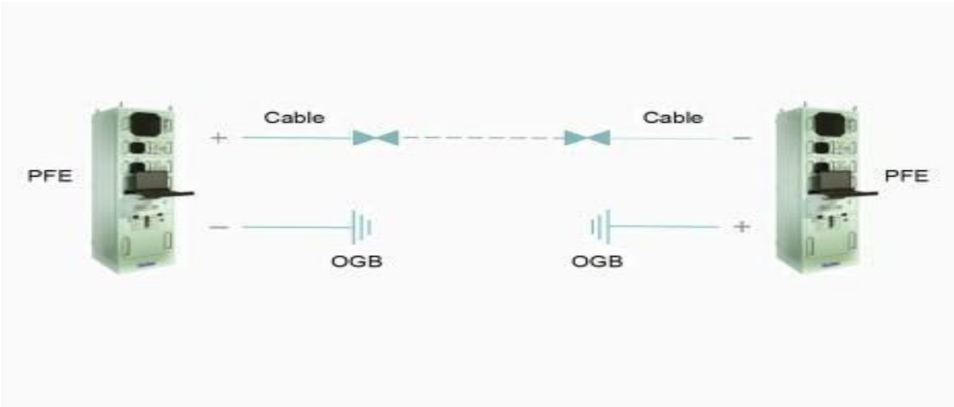

Figure 5. Power Feeding Equipment (PFE)

Figure 6. Submarine Line Monitoring (SLM)

Figure 7. The working principle of SLM

The sixth part is Submarine Line Terminal Equipment (SLTE) where the SLTE functions as a termination point for optical signals transmitted from equipment on land or at sea. The SLTE itself consists of three parts, namely the Line Terminal Unit (LTU) which functions to transmit trans-oceanic signals to devices on the land side. The LTU receives optical signals according to the SDH STM-64 and STM-16 standards with a minimum capacity of 2.5 Gb to more than 100Gb and then converts the optical signal into optical grating required by DWDM devices after adding the Forward Error Correction (FEC) code value.

Optical Grating itself is used for trans oceanic communication after passing through DWDM devices .

Inside DWDM device internals itself there are components of Optical Terminal Multiplexer (OMA), Optical Add-Drop Multiplexer (OADM), and Optical Line Amplifier (OA). The function of OTM is to unify and split multiple wavelength signals (Multiplexer/De-Multiplexer) as well as an Optical Transform Unit (OTA), Optical Power Amplifier (OA), Optical Pre-Amplifier (PA), and as an Optical Supervisory Channel (OSC).

The last part of the SLTE device is the Dispersion Compensation Module (DCM) which functions to affect the system bandwidth , transmission segment length and other characteristics of the transmission signal. To achieve the best performance of optical transmission, DCM is used as a tool to compensate for the increased dispersion of the optical transmission system. Where DCM mainly uses dispersion compensation from cable technology to replace the dispersion of each signal channel in the marine optical cable system and the value of the chromatic dispersion is negative. Figure 8 below shows high school

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2. RESEARCH METHOD

Research methodology used in writing this journal is to collect initial data on the geographical map of West Kalimantan Province. This is important in determining the next stage. To collect geographic information data and the characteristics of the province of West Kalimantan , especially the number of cities and districts in the province, the author uses *Google Map Software* and data assistance from *Google Wikipedia* .

After the initial data collection stage related to the province of West Kalimantan, the next stage is to divide the segment between districts and cities in the province of West Kalimantan to find out whether the district or city is included in the land optical cable segment or marine optical cable segment. This can also be obtained with the help of software *Google Map* and *Google Earth* . After the segment identification stage is carried out, the next step is to divide all district cities in the province of West Kalimantan into two segments, namely the land segment (*Inland*) and the marine segment (*Submarine*).

If the stage of identification and

The division of segments in all districts and cities in West Kalimantan province has been completed, then the next step is to measure the distance between cities and districts as a basis in determining the value of the optical cable length that will be held in all urban districts in West Kalimantan province. For measuring districts and cities that are included in the land segment (*Inland*) *Google Map Software is used* , while to take measurements of district cities that are included in the submarine cable segment (*Submarine*) , the *Google Earth Pro software is used* .

For the next stage, after getting the data from the measurement of the length of the cable that passes through all districts and municipalities in West Kalimantan province using Google *Map* and *Google Earth software* , *a* design drawing of the *backbone* topology network in each province is made using map the province to make it easier to make drawing designs while at the same time identifying and ensuring that each district and city in the topological drawing can be connected to each other. To design this backbone network topology image, you can use *Microsoft Word software* .

After the stage of making the topology design drawing of the *backbone network* in the province of West Kalimantan has been completed, the next step is to make tabulations of technical data from all segments of city districts, both those that are passed by land optical cable lines and marine optical cable lines in the form of an *Excel Spreadsheet table* . This needs to be done in order to facilitate the transfer of data from *Microsoft Excel* to *Microsoft Word* . In addition, the purpose of tabulating data in the form of an *Excel Spreadsheet* is to make it easier to calculate the value of *Optical Link Power Budget* (OSNR), *Optical Signal Noise Ratio* (OSNR) and *Optical Rise Time Budget* . (ORTB).

After the tabulation stage data in the form of *Microsoft Excel is* complete . So the next step is to design the backbone infrastructure of the province of West Kalimantan into the *OTN Planner Software* . *OTN Planner* itself is *software* issued by the *Fiberhome* optical cable device *vendor company* . Where this *software* is specifically designed to design infrastructure projects for optical cable *backbone network devices* using DWDM and DWDM devices as a basis OTN. Optical backbone network infrastructure for the province of West Kalimantan has been completed using the *OTN Planner Software* , the next step is to calculate the value of the *Optical Link Power Budget* (OLPB), *Optical Signal Noise Ratio* (OSNR) and *Optical Rise Time Budget* (ORTB). The calculation of OLPB and ORTB itself can be done manually using *Microsoft Excel* , while the calculation of OSNR must be done using the *OTN Planner software because the* OSNR calculation method is quite complicated and can only be generated. With a simulation of the *backbone network topology* that has been designed in the *OTN Planner Software.*

3. RESULTS AND DISCUSSIONS

In the province of West Kalimantan, the most dominant segment is the land optical cable segment through which all regency and municipal cities in the province of West Kalimantan are traversed by land optical cables, while in the province of West Kalimantan do not use marine optical cables. Figure 9 below shows the *backbone network topology of the* province of West Kalimantan.

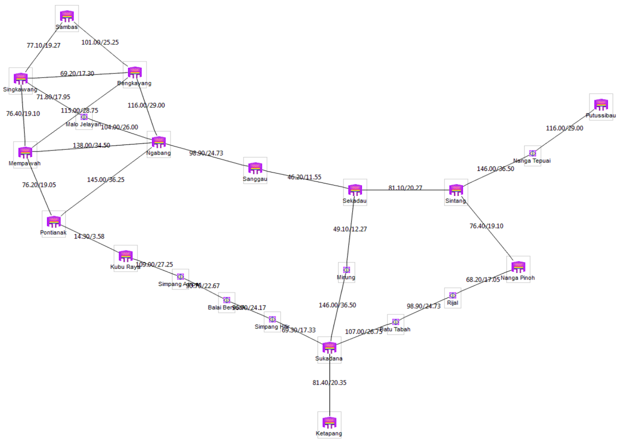

Figure 9 below shows the *backbone network topology of the* province of West Kalimantan.

What's interesting about the topology of the West Kalimantan *backbone network* is that the number of OLA sites is 8 less than the number of DWDM OTN sites which are only 14 sites. This is because the expanse of territory and the distance between districts and cities in the province of West Kalimantan are not too far apart so it does not require more OLA sites compared to other provinces on the island of Kalimantan itself. The number of OLA sites in the West Kalimantan *backbone network itself is* 8 OLA sites, fewer than the 14 OTN DWDM sites.

OLA site on the West Kalimantan *backbone network* is located in a sub-district that is interconnected and borders the district through which the cable segment passes. For the Sambas – Putussibau segment, it consists of 7 OTN DWDM sites, namely the site (Sambas Bengka yang – Ngabang – Sanggau-Sekadau – Sintang – Putussibau) and 1 OLA site, namely the Nanga Tepuai site. For OA modules and PA modules installed in this segment, there are 28 modules installed on the Tx and Rx sides, where there are 12 OA modules and 16 PA modules.

For the province of West Kalimantan, it can be seen below the value of the OLPB itself still included in the ideal category < 50 dBm this occurs due to the additional OLA site in the Singkawang - Ngabang segment, Kubu Raya - Sanggau segment, Kubu Raya - Sukdana segment, Sukadana - Nanga Pinoh segment, and the Sintang - Putussibau segment which serves to share the load *link power* from the segment into the OLA where the function of the OLA is only a DWDM device without OTN which functions as a traffic drop, in other words the function of OLA is as a *site amplifier* that functions to amplify the signal from the reduced Tx segment for As for the ORTB value itself West Kalimantan province is at the ideal value where the ORTB value range itself is in the range of 52 ps, which is still below < 60 ps. This is ideal because DWDM OTN devices that have an ORTB value of < 60 ps have a very good operational response time and are able to generate optical transmission signals very quickly so that the process of sending traffic bandwidth from Tx to Rx can take place in a short time.

4. CONCLUSION

From the results of the DWDM OTN optical cable backbone infrastructure network design in West Kalimantan province, conclusions and suggestions can be drawn as follows : following:

1. From the simulation results of *Optical Link Power Budget* (OLBP) and *Optical Signal Noise Ratio* (OSNR) show that the calculation results are still within the ideal limits for the implementation of DWDM OTN infrastructure where the limit value of OLPB < 50 dBm while the ideal range of OSNR itself ranges from 15 dBm <OSNR< 40 dBm. While the limit of the average value of OSNR is around 27 dBm < OSNR < 40 dBm.
2. From the example of the comparison between manual OSNR calculations using the OTN *Planner software* , *it* is found that the difference in value is very small, namely 0.15 dBm for *Forward OSNR* and 0.01 dBm for *Backward* OSNR or an average of < 1 dBm. This can be caused by other factors such as the *Bit Error Rate* (BER) and *Forward Error Correction* (FEC) which have a direct relationship with determining the quality of the output signal of the transmission system from the OA and PA *modules* . From the results of both manual calculations and the *OTN Planner Software , it can* be concluded that manual and manual calculations software have almost the same level of accuracy and precision.
3. When carrying out the *engineering design process* for DWDM OTN devices, it is better to avoid installing amplifier modules (OA and PA) in series (*Cascade*) because it will make the OSNR value on the Receiver side lower , which means the quality of the signal sent from the *Transmitter* Tx side to the receiver side. *Receiver* Rx side is reduced. Instead, it is recommended to place 1 OA module on the *Transmitter* Tx side and 1 PA module on the *Receiver* Rx side with compensation for adding the value of *Gain* and *Output Power* from the *amplifier* module.
4. On the site segment that have Optical cable length is quite far > 157 Km, it is better to add an *Optical Land Amplifier* (OLA) site between these segments so that the value of the OLPB remains < 50 dBm.
5. In the design of the DWDM OTN network topology in the province of Central Kalimantan, the author deliberately designed the network conditions in ideal conditions, but in its implementation the opposite could happen where the attenuation measurement results show a fairly high increase in loss , but this can be anticipated by adding a *margin loss* Becomes 7 dB for segment land and dB for the sea segment to anticipate this. In the process of designing and making the DWDM OTN infrastructure design, it is better when installing the OA and PA modules when simulating the value of of *Gain* and *Output Power* always greater than the attenuation loss and cable distance. This is very necessary in order to get a good Margin System .
6. From the results of the simulation and analysis as well as the calculation of the OLPB and OSNR values, it shows that the DWDM OTN infrastructure development project is province

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REFERENCES

Fitri Ayu Nurdiana, Sugito, Sofia Naning, “Design and Analysis of Makassar – Maumere Fiber Optic Communication System Using *DWDM* ,” JNTETI, Vol 4, No 33, 2015.
Rifa Atul Izza, Firdaus, Eka Indarto, Ida Nurcahyani, *"Design of a 4G LTE Backbone Network and Distribution in Sleman Based on Fiber Optic Networks"* , Proceedings of the 4th SNATIF 2017.
Yudiansyah, Arie Pangesti AJi, Prita Dewi Mariyam, Novietasari Chrisnariandini, *“Design of Land Optical Fiber Backbone Communication Network in North Sumatra”* , Conference Paper 2018, International Conference on Information and Communication Technology ICOIACT
The Indonesian capital is planned to be moved to the province of East Kalimantan by the government https://www.cnnindonesia.com/nasional/20190826115726-32 424625/ jokowi-i bu-kota-baru-in-kalimantan-eastaccessed 26 August 2019 .
www.opticalpatchcable.com , FOCC “Overview of DWDM Technology and DWDM System Components”, June 5, 2019
[www.packetlightnetwork.com ROADM “The Core of Agile Optical Networks”, accessed on May, 28, 2015
Ciena Corporation, “ *Optical Transport Network (OTN)* ” New Edition Expanded for Utilities. Issued by Ciena Corp @2015.
The FOA Org. Tech/Lossbudg.htm, “ *Optical Link Power Budget Formula* ”, Reference Guide.
https://www.thefoa.org/tech/lossbudg.ht m 2018, Fiber Optic Association, Inc.
www.Optcore.net, “How to Calculate Link Power Budget?”, Reference Guide. “ https: //www.optcor e.net/how-to-calculate-the-fiber-link-budget/ .
Accessed on September 17, 2020
www.mapyourtech.com , “ *OSNR: What Does This Mean, Why We Need and How to take careofit?* ”, https://mapyourtech.com/entries/genera l/osnr-what-does-this-mean-why-do- we-need-and-how-to-take-care-of-it- issued at July 2019.
https://www.ques10.com/p/29974/what-is-rise-time-budget-analysis-derive-an- expr-1/ ? Retrieved 17 September 2020
Cisco System, Inc. “ *Introduction to DWDM Technology* ” PDF Paper, issued by Cisco Headquarters, 2018 accessed on December 20, 2019 from source.
https://www.submarinenetworks.com/e n/insights/next-generation-submarine- network-i innovative-repeater-technology
https://www.thefoa.org/tech/con nID.ht m https://www.thefoa.org/conn/index.ht ml , type of fiber optic cable connector, accessed on 19 November 2021
https://www.thefoa.org/tech/ref/termina tion/fusion.html , accessed on November 19, 2020
https://www.techtarget.com/searchnetw orking/definition/dense-wavelength- division-multiplexing-DWDM , accessed on 22 October 2020
https://www.packetlight.com/technolog y/roadm , accessed on 17 October 2019
https://www.ciena.com/insights/what- is/what-Is-roadm.html , accessed on October 17th 2019
http://id.opticalpatchcable.com/info/oad m-vs-roadm-what-s-the-difference- 35921245.html , accessed on September 15 2019
https://en.wikipedia.org/wiki/Google_Maps accessed on September 15 2019