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Node Attenuation Analysis on Ring Protection Scheme in Optical Cross Add and Drop Multiplexer (OXADM) Network – With Loss Compensation Proposal

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ABSTRACT

This paper highlighted the study to examine the relationship between the attenuation/loss at optical node on output power and the BER performance of the ring protection mechanism is activated. This simulation study also seeks to obtain the magnitude of the attenuation is allowed during the operation of this ring of protection (if attenuation increases due to inclusion of other optical devices and connectors). Rate of decreasing of output power due to attenuation increased will also be studied and based on the value of the internal amplifier gain can be determined relatively. Finally, the proposed value of the internal amplifier which is suitable for miniaturization compensate signal to a directional orientation to the West and East to have the same attenuation as a ring of protection is turned on.

Key words:

Introduction

After technology SONET/SDH optical technology has been replaced by totally involving the replacement of major components of ADM to the OCS. OXC devices based OCS was used as the first device functions to integrate B-DCS, W-DCS and ADM on a device (Palais 2005) (Keiser 2000). However, the early use of OCS device is not equipped with several new features and unique addition to the basic functions of the three devices mentioned above. However, with increasing demands on data transmission rates are too high and the types of operational data causing the need for some new features like monitoring, safety and multiplex should be integrated with this device. This has led to the emergence of new devices that meet the needs of both current optical networks such as TRN and OXN.

TRN device was developed on the basis of OADM elements. TRN was introduced by Louay Eldada and Joris van Nunen from Telephotonic Inc. in 2000 (Eldada & Nunen 2000). With the addition of this device with the features of the route the direction of making operational signals are able to be directed to any output path. TRN is developed by a combination of two or more devices in parallel with the number of OADM input ports equal the number of output terminals. TRN also allow data transmission in both directions and use both the data transmission path as a path. TRN is equipped with several functions such as (Eldada & Nunen 2000):

1. Add and Drop
2. Path Routing
3. Linear Protection for Dedicated Protection Scheme (OCh-DPRing)
4. Ring Protection for Shared Protection (OMS-SPRing)

OXN devices were developed based on OXC architecture which consists of cross-connecting elements (crosslinking). To ensure stability and precision of the operational wavelength adjustment, variable Bragg grating device is used to select the wavelength of the input into the database either for cossoening to other bases or to be dropped. OXN was introduced by Edward Helsinki Mutafungwa from the University of Technology in 2001 (Mutafungwa 2001). OXN is developed for all topology of point-to-point (P2P), ring and mesh. So this OXN said to be more flexible and suitable for use in migration such s ring topology of the mesh, especially where it is equipped with security scheme for both these topologies (Ab-Rahman et al. 2006). OXN

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can be used in a bidirectional data transmission using both the data transmission path as a path. OXN is equipped with several functions such as (Mutafungwa 2001):

1. Path Routing
2. Drop and Add
3. Multiplexing for mesh and ring topology.

The 'signal collection on a path' which is in contrast to the OXC device has making OXN the next generation device. This feature is for survivability scheme for mesh and ring network topology. In a ring topology, the feature is used as a protection scheme for bidirectional path switched ring network (BPSR). In the event of failure of two lines or even damage to the optical nodes near the network ring causes the data cannot be delivered directly. The necessary protection features is for a ring protection schemes used in OMS-spring. This ring protection involving signals at the first input terminal is turned on 'U' and exit at the second input terminal allows the segmentation of failure area (Ab-Rahman & Shaari 2006). Unfortunately, this feature is not provided in the survivability architecture of OXC.

In a ring network architecture using optical OXC node, in the event of failure cases involving two or all of the line or even damage to the nodes, the nodes are near the damage will be used as a termination node and signals be dropped or navigate to a new path which would involve large areas segmentation in which it will also involve good nodes. As a result, defects occurs in the optical communication system which is previously known as self-resistant and able to recover against any possible damage. Figure 1 shows the process of segmentation or quarantine the damage in the ring network using OXC node.

Requirement Features of Tunable Multiplexing and 'U' Turn:

In the optical network using mesh topology, several types of optical devices have been identified can be used as optical nodes between OXC, OXN and OCCS which is used in current optical networks. All three devices have similar functions of the wavelength management and survivability of data transmissions. However, a feature that is quite important in optical networks that can not be done by optical devices, especially OXC and OCCS is the accumulation of signal on a line. This feature is similar to the multiplexing function, but it is applied at node optical data communications network. Here all the data from the input terminal and the terminal will be added and integrated into a signal line and is issued as multiplexed signal (Ab-Rahman *et al.* 2006). With these functions in an optical node it increases the effectiveness and efficiency in wavelength management and data transmission via multiplex protection mechanism. In addition to the features U turn also need to route to the device working in a ring topology. If the damage involves both lines cut segmentation allows certain areas through the creation of a new ring. Thus the path characteristic U-turn is also important. As well as offering flexible functionality, devices performance characteristic such as loss, crosstalk is also a prime target for researchers in developing a switching-based devices (Kirihara *et al.* 1993).
OXADM as the Compliment:

OXADM device was developed by studying the weaknesses and deficiencies in existing devices and meet the requirements are not provided by previous devices. The term of optical cross add drop multiplexing (OXADM) refers to a combination of two main devices OXC and OADM (Tzanakaki et al. 2003) (Ab-Rahman & Shaari 2004). It said the third stage of the device which was developed after the TRN and the respective OXN developed to improve the weaknesses in the original device of OADM and OXC. OXADM brought together all the features available in TRN and OXN device to incorporate a number of interesting features and update the existing functions and operational. This has complemented and improved reliability of optical communication networks today among others.

1. OXADM is the first device that integrates the three protection mechanisms of linear protection, ring and multiplex in a single architecture.
2. OXADM is the first to introduce the device in the device switching characteristics of optical multiplexer
3. OXADM is the first device which is characterized by a wavelength path revolvers without using external switching circuit and operates in full optical domain.

With these characteristics are said to be complementary to the claims OXADM world of optical communications is the
1. Value added of current optical device technology.
2. To update and improve the reliability of a ring network security system available.
3. Improve safety in FTTH networks, especially in the fallout.

Effect of Attenuation on OXADM Network Performance:

Further studies will reveal the issues of optical attenuation in node OXADM the overall performance of a ring network. Ring network with five nodes are used as test sites for this study. This study is important for the initial assessment of the effects of changes in OXADM device dissipation caused by the addition of new components in its architecture. To enhance the functions and features OXADM continuous improvement needs to be done and this study will be dismantling the impact given by OXADM the metropolitan ring network performance due to the increase in the value of dissipation/attenuation device of this OXADM.

Towards East:

Based on observations in Figure 2 is an increase the device loss decrease the value of output power with magnitude of the slope of 1 dB, indicating a linear relationship between attenuation and output power. The theoretical value of the minimum attenuation for the operation of a ring of protection orientation to the east is 12.4 dB which ensures that all signals received at each node based on the photodetector sensitivity set.

Figure 3 shows the effect of attenuation on BER performance in a ring of protection aktifan node orientation to the east. BER values give a satisfactory reading of the attenuation of 4.12 dB (1510 nm) showed this OXADM able to conduct operations to the east orientation, ring of protection without the need for an amplifier device, but if the rise exceeds the value of 13 dB, the optical amplifier architecture must be added in OXADM as a compensator of the dissipation that occurs. Because the value of relationships and power dissipation of the output is a linear with a slope of 1 dB graph, then any additional dissipative n dB loss require the n dB occurs optical amplifier is needed.

Towards West:

Since the attenuation of the difference between orientation to the east and west orientation which is 5 dB, then the internal amplifier gain is also recommended by 5 dB for compensating loss occurring during orientation to the west is activated. This is based on the rate of increase in output power of the active node attenuation is 1 dB protection ring (Figure 2 and Figure 4).

Based on observations in Figure 4 is found to increase in device attenuation decrease the value of output power with the magnitude of the slope of 1 dB shows a linear relationship between the attenuation and output power. Therefore, the maximum loss for operation of a ring of protection orientation to the west is 15.2 dB which ensures that all signals received at each node based on the photodetector sensitivity. Figure 5 shows the effect of attenuation on the BER performance in the ring cover operational orientation to the west. In the event of an increase in attenuation in power output after the signal is reflected back, it can be compensated by increasing the value of internal multiples with the same magnitude of increase in value just dissipative. It can be summarized as follows:
Internal Gain (dB) = Total loss – 15.2 dB (with internal gain of 5 dB)  \hspace{1cm} (1)

**Fig. 2:** Attenuation effect on output power measured at every node in ring optical network during ring protection activation – East orientation (at 2.5 Gbps).

**Fig. 3:** Attenuation effect on BER performance measured at every node in ring optical network during ring protection activation – East orientation (at 2.5 Gbps).

*Loss Compensation with Internal Amplifier:*

The purpose of this simulation study was carried out to obtain the optimum value for the internal amplifier gain power for the operation of a ring of protection to the western orientation, different transmission rates. Simulation was conducted on three different data transmission rates of 1.25 Gbps, 2.5 Gbps and 5 Gbps. Internal gain of the ideal value for each data transmission rate will be determined. Sensitivity of the photo-sensitive set at -25 dBm (1530 nm) at data transmission rates of 2.5 Gbps (noise terms = \(3.1347 \times 10^{-23} \text{ W/Hz}\)). Gain value for the internal amplifier for the operation of a ring of protection to the west orientation is 2.5 Gbps at 5 dB to provide the same level of magnitude of the direct path signal operations (power output = -22.98 dB). This is based on the intersection of these two graphs as shown in Figure 6. The effect of internal amplifier gain at 2.5 Gbps BER performance is shown in Figure 7 above. In the internal gain of 5.5 dB gives a BER measurement same value and satisfaction for both the operational (BER <1x10^{-19}). Despite an increase in the value of the data transmission rate to depreciate the measured BER performance, but based on the observation of Figure 7 shows the point of intersection of two main operational OXADM occurred at 5.5 dB (BER <1x10^{-2}). However,
if the BER performance is to increase the sensitivity of the value pekaftoto should be reduced or increase the
gain of the amplifier is used (Saleh & Teich 1991) (Ab-Rahman, 2011b). From observations based on Figure 6
and Figure 7 it can be concluded that the appropriate value of the internal amplifier is at 5.5 dB for a BER of
uniform value of the direct path signal operations and other operations for all data transmission rates. However,
the optimum value that can be used is 5 dB (Ab-Rahman, 2011a). The results also allow equation (1) that have
been expressed.

Fig. 4: Attenuation effect on output power measured at every node in ring optical network during ring
protection activation – West orientation (with 5 dB gain and at 2.5 Gbps).

Fig. 5: Attenuation effect on BER performance measured at every node in ring optical network during ring
protection activation – West orientation (with 5 dB gain and at 2.5 Gbps).
Fig. 6: Internal Gain determination by studying the effect on internal gain to output power for ring protection west orientation activation at 2.5 Gbps. The overlapping between pass through and new injection power will determine the internal gain value.

Fig. 7: Effect on internal gain to BER performance for ring protection west orientation activation at 2.5 Gbps.

Conclusion:

Simulation study in this paper is to examine the relationship between the attenuation /loss at activate node ring protection on output power and the BER performance of the ring protection mechanism is activated. This study is important for the initial assessment of the effects of changes in OXADM device loss caused by the addition of new components in its architecture. To enhance the functions and features OXADM continuous improvement needs to be done and this study will be dismantling the impact given by OXADM the metropolitan ring network performance due to the increase in the value of dissipation/attenuation device of this OXADM. The results show the output power at each node does not exceed -30 dBm and a shift when there is an increase of 3 dB attenuation. To ensure that the attenuation of the line to the west and east routes have the same value the entry of the internal amplifier is 5 dB is recommended. As conclusion, this study resulting shifts the attenuation at OXADM be allowed more than 3 dB, but it should be compensated by the internal amplifier (for the stability of the device) and an external amplifier (for the stability of the network).
References


