World Academy of Science, Engineering and Technology
International Journal of Electronics and Communication Engineering
Vol:10, No:1, 2016

Open Science Index, Electronics and Communication Engineering Vol:10, No:1, 2016 publications.waset.org/10004121.pdf

Monitoring and Prediction of Intra-Crosstalk in All-Optical Network

Ahmed Jedidi, Mesfer Mohammed Alshamrani, Alwi Mohammad A. Bamhdi

Abstract—Optical performance monitoring and optical network management are essential in building a reliable, high-capacity, and service-differentiation enabled all-optical network. One of the serious problems in this network is the fact that optical crosstalk is additive, and thus the aggregate effect of crosstalk over a whole AON may be more nefarious than a single point of crosstalk. As results, we note a huge degradation of the Quality of Service (QoS) in our network. For that, it is necessary to identify and monitor the impairments in whole network. In this way, this paper presents new system to identify and monitor crosstalk in AONs in real-time fashion. particular, it proposes a new technique to manage intra-crosstalk in objective to relax QoS of the network.

Keywords—All-optical networks, optical crosstalk, optical cross-connect, crosstalk, monitoring crosstalk.

I. INTRODUCTION

ALL-OPTICAL Networks (AONs) are nowadays achievable thanks to the development of optical switching and optical amplification. In such networks, data is transmitted from source to destination in optical form [3]. AONs provide higher capacity than existing networks and reduced costs for new applications such as the Internet, video and multimedia interaction and advanced digital services. However, AONs provide transparency[1], it renders the vulnerabilities of AON components more important for physical security than in a conventional optical network. Indeed, crosstalk is additive, and thus the aggregate effect of crosstalk over a whole AON may be more nefarious than a single point of crosstalk [2], [5]. In this way, the presence of a network management system is essential to ensure efficient, secure and continuous operation of any network. Specifically, a network management implementation should be capable of handling the configuration, fault, performance, security, accounting and safety in the network [1]. Efficient monitoring and estimation of signal quality along a lightpath[2] are of highest interest because of their importance in diagnosing and assessing the overall health of the network. AONs components are vulnerable to various forms of attacks [8]. Hence, AONs have unique features and requirements in terms of security and management that distinguish them from traditional optical networks.

In recent years, Wavelength Division Multiplexing (WDM) technology has been rapidly gaining acceptance as an important means employed for taking advantage of the enormous bandwidth in optical networks. One of the problems in this network is to established lightpaths between source and destination when to have the same wavelength in all links. The process of finding a physical route and assigning a wavelength to each of the requested lightpaths is called Routing and Wavelength Assignment (RWA). It is subject to two main constraints: the wavelength clash constraint, which prohibits assigning the same wavelength to lightpaths which share a directed physical link, and the wavelength continuity constraint, which states that each lightpath, in the absence of wavelength converters, must be assigned the same wavelength along its entire physical path. The RWA problem degrades the Quality of Service (QoS) of the WDM network [6], [7]. Performance management is still a major complication for AONs, particularly because signal quality monitoring is too difficult in AONs as the analogue nature of optical signals means that miscellaneous transmission impairments aggregate and can impact the signal quality enough to reduce the QoS without precluding all network services. This results in the continuous monitoring and identification of the impairments becoming challenging in the event of transmission failures.

Recent proposals to overcome the difficulty of monitoring the continuity and estimating the signal quality of lightpaths in AONs include error detecting codes, sampling and spectral methods. However, most of these methods are too difficult to implement in every AONs component or require access to the electrical domain [3]. Therefore, the need for expert diagnostic techniques and more sophisticated management mechanisms that assist managing and assessing the proper function of AON components is highly desirable [11], [12].

In this paper, we present a policy to monitor intra-crosstalk. Particularly, this method dived in two approaches: first detect intra-crosstalk in t instant and second estimate the intra-crosstalk at t+1. the direct benefit of this method is to help RWA sysem to choose a healthy path. The rest of this paper is organized as follow. The second chapter will briefly analyze optical intra-crosstalk that may arise in OXC nodes. Third chapter will describe the mean idea of our policy to monitor intra-crosstalk. Fourth chapter will present some results and discussion. Finally, we will present the conclusion and future work.

II. CROSSTALK IN OXCS NODES

Optical-Cross-Connects (OXCs) are essential key network elements enabling reconfigurable optical networks, where

---

A. Jedidi is with the CES laboratory, Sfax university, Tunisia and College of Engineering, Ahlia university, Bahrain(e-mail: ahmedjedidi@yahoo.fr).

M. Mohammed Alshamrani is with Technical College Dammam, Saudi Arabia.

A. Mohammad A Bamahdi is with Facility of computer Sciences and Information system, Jazan University, Saudi Arabia (e-mail: abamhdi@jazanu.edu.sa).

[1] A component is called X-transparent if it forwards incoming signals from input to output without examining the X aspect of the signal

[2] A lightpath is defined as an end-to-end optical connection between a source and a destination node.

lightpaths can be set up and taken down as needed without having to be statically provisioned. A typical structure of an OXC node is shown in Fig. 1. The OXC node consists of n wavelength demultiplexers on the input side, m optical space switches[3], and m wavelength multiplexers on the output side. On each incoming fiber, wavelength channels are separated using a demultiplexer. The outputs of the demultiplexers are directed to the optical space switches, so that the outputs having the same wavelength are directed to the same switch. Then, they are directed to multiplexers associated with output ports. Finally, the multiplexed outputs are sent to outgoing fibers. However, while cross-connecting wavelengths from input to output fibers, these AON components introduce crosstalk effects that can impact the transmission performance seriously [13], [14]. Although these components offer many advantages for communication systems, they are particularly vulnerable to various forms of crosstalk attacks. In particular, crosstalk suppression becomes particularly important in networks, where a signal propagates through many nodes and accumulates crosstalk from different element at each node such as multiplexers, demultiplexers, and switches. As the resulting degradations accumulate and grow rapidly become severe with network size, they constitute a serious issue for AONs.

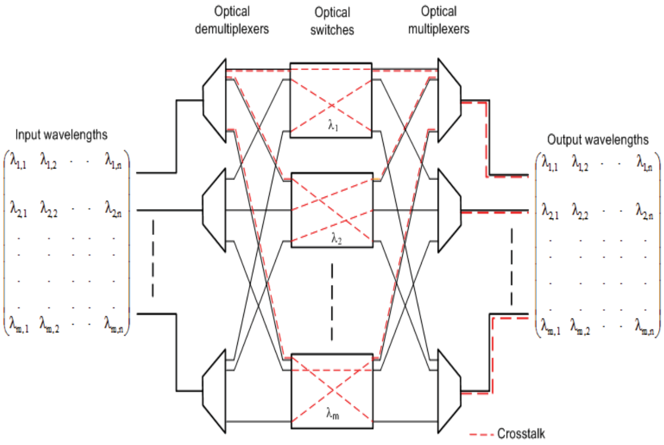

Fig. 1 A typical structure of an OXC node: The node consists of n wavelength demultiplexers, m optical switches, and n wavelength multiplexers

Optical crosstalk is present in AON components and degrades the quality of signals, increasing their BER (Bit Error Rate) performance as they travel through the network. As a matter of fact, both forms of optical crosstalk can arise in OXC nodes: inter-crosstalk and intra-crosstalk [10]. Compared to inter-crosstalk, intra-crosstalk effects are of prime importance for AONs because they can lead to severe power penalties and cannot be eliminated by filters or wavelength demultiplexers. Then, we focus only the intra-crosstalk in our work. It arises when the crosstalk signal is at the same wavelength as that of the affected signal or sufficiently close to it that the difference in wavelengths is within the receiver's electrical bandwidth. Intra-crosstalk arises in transmission links due to reflections. This is usually not a major problem in such links since these reflections can be controlled and eliminated. However, intra-crosstalk can be a major problem in AONs when it arises from other sources.

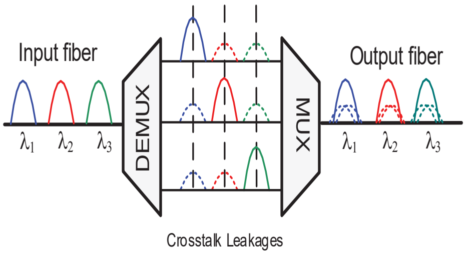

Fig. 2 Intra-crosstalk arises from cascading a wavelengths demultiplexer/multiplexer

In particular, intra-crosstalk, whose effects can be much more severe than inter-crosstalk, arises from cascaded wavelength demux/mux pairs and in optical switches. As shown in Fig. 2, the demultiplexer ideally separates the incoming wavelength channels to different output ports. It is because of the non-ideal crosstalk specification of optical filters and demultiplexers that a small portion of the signal at one wavelength, for example, λ_1 leaks into other wavelengths (λ_2, λ_3). When these wavelengths are combined again into a single outgoing fiber by the multiplexer, the small portions of λ_1 that leak into other channels will also leak back into the common outgoing fiber at the output side of the node. This causes intra-crosstalk since the signal of wavelength λ_1 and the crosstalk leakages of the same wavelength, even if they contain the same data, are not in phase with each other due to different delays encountered by them.

Another source of intra-channel crosstalk arises in an optical switch that is switching signals of the same wavelength. Fig. 3 shows schematically the traces of crosstalk components that arise by switching four channels of wavelength λ_1. The solid arrows and dashed traces indicate the affected signal and crosstalk components caused, respectively. Intra-crosstalk arises in an optical switch when a portion of a signal leaks into another signal as they pass through the same switch at the same time. This occurs due to the non-ideal isolation of one switch port from the other. As shown in Figure 3, each output port of the switch includes three additional crosstalk components. Thus, each channel that passes through an optical switch is mixed with other crosstalk leakages of the same wavelength.

III. POLICY MONITORING OF INTRA-CROSSTALK IN AONS

Fault management in AONs is a challenge to improve the QoS in such networks. Thus, there is a need for an efficient and robust management method that operates in a real-time fashion. In this section we develop a policy monitoring of intra-crosstalk in AONs (PMI). It is dived in two approaches:

- First, identify and localize crosstalk in AON.

---

[3] In this OXC node model, one switch is used for switching channels of the same wavelength.

Open Science Index, Electronics and Communication Engineering Vol:10, No:1, 2016 publications.waset.org/10004121.pdf

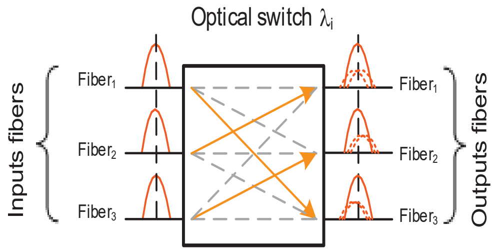

Fig. 3 Intra-crosstalk arising in an optical switch

- Second estimate the value of intra-crosstalk can be arise in new demand (sourcedestination)

In this work, we suppose that PMI use CILs devices of work [4]. To identify and localize intra-crosstalk in entire network, PMI uses different information collect from all CILs in the network. These include two types of information: The value of crosstalk and its location in the corresponding router. Then, PMI classies the various intra-crosstalks in three levels:

- Level 0: The crosstalk does not exist
- Level 1: The crosstalk is existing but its value still acceptable.
- Level 2: The crosstalk is existing and its value is unacceptable

As shown in Fig. 5, PMI proposes a novel approach to localize and identify crosstalk at any point in the network where they may occur. Then, this method guarantees an efficient localization of crosstalk in the entire network with real-times function. As a direct consequence, this method offers the benefit of relaxing the high cost and complexity of signal quality monitoring for future AON management solutions. In conclusion, the first mission of PMI is to monitor intra-crosstalk in network, exactly it is corrective mission.

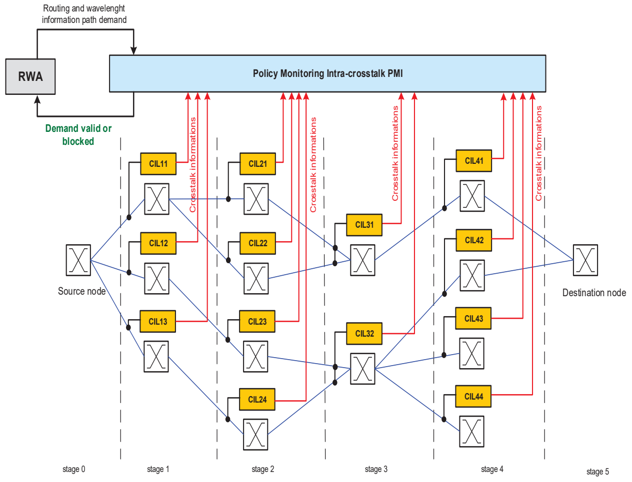

Fig. 4 Implementation of PMI in AON

The major mission of our policy is to estimate intra-crosstalk for a new demand (sourcedestination). When we have a new demand, RWA algorithm gives the information about path and wavelength corresponding. In this moment, PMI check all intra-crosstalk can be effect directly the signal passing in the select path and the associate wavelength. For that, it uses the various crosstalk information of the network and the call request i (path and wavelength). After that, we estimate the crosstalk that will be born in this call request (Fig. 6).

Let us note that X_{born} is the total crosstalks occur in the call request i (λ_k) and $X_{l,m}$ is the intra-crosstalk added at $OXC_{l,m}$ in wavelength k. Then the total crosstalk that will be born is:

$$X_{born} = \sum_{l,m} X_{l,m} \tag{1}$$

where $l \in [1, M]$, M is the max number OXC nodes by stage and $m \in [1, N]$, N is the number total of stage in our AONs. The last step is to validate the call request i. To do that, we just have to compare X_{born} at the reference value if X_{born} is less we validate the call request i, if not we block this request

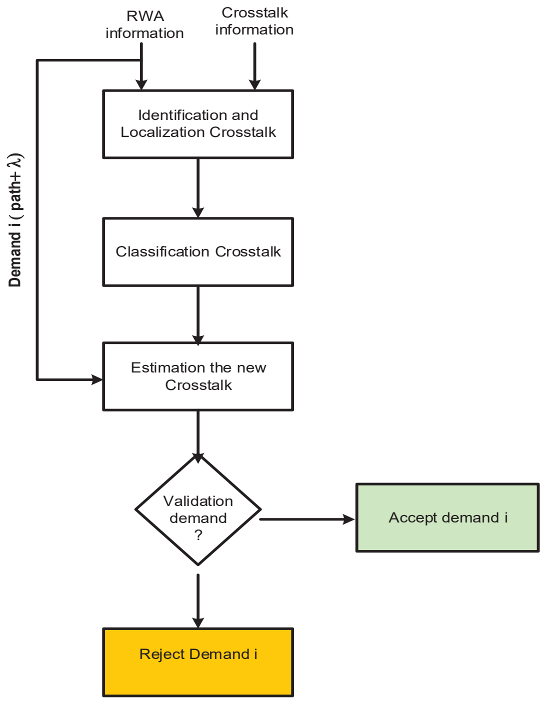

Fig. 5 PMI functional flowchart

IV. DISCUSSION AND RESULTS

One of the serious problems with crosstalk is, in fact, that is additive and this value depends on the number of stages. Therefore, the direct effect of this crosstalk is to weaken the signal power and degraded QoS. In this section we discuss the performance of PMI in two ways. First, we focus in the reliability of PMI in network. Second, we present the feasibility of PMI in the network. Especially, we discuss the

TABLE I
SIMULATION SCENARIO RESULTS AND RUN TIMES

	intra crosstalk level 0	**intra crosstalk level 1**	**intra crosstalk level 2**	**Status of demand**	**Run times**
Scenario1 S2 - D1	X			Accepted	–
Scenario2 S2 - D2			X	Blocked	21 ms
Scenario3 S1 - D2		X		Acceptted	–
Scenario4 S1 - D1		X X X		Blocked	25 ms

evaluation of PMI with the dimension of the network exactly with the number of stages and number of wavelength. To evaluate the reliability of PMI, we consider the network in Fig. 7. Then, we apply the different scenarios mentioned in Table I. Indeed, we select these scenarios to cover all possibility in our network:

- Scenario 1, there is no intra-crosstalk in path
- Scenario 2, intra-crosstalk level 2 existing in path
- Scenario 3, intra-crosstalk level 1 existing in path
- Scenario 4, three intra-crosstalk level 1 existing in path and whose the sum is major

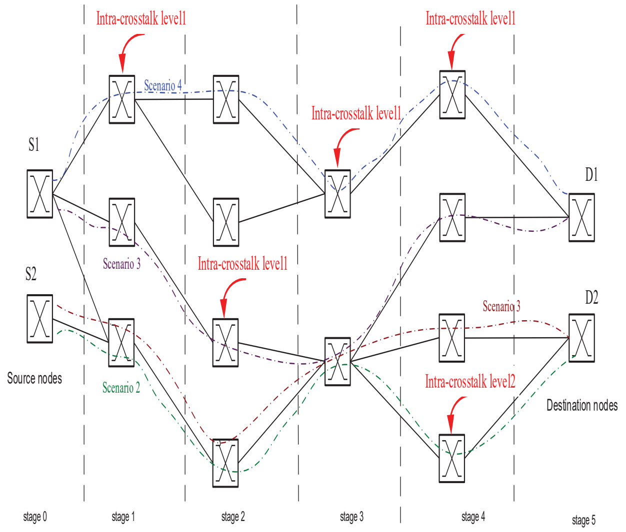

Fig. 6 The simulation network and scenarios

We implement this network with Matlab simulator then we fixed the different scenarios. We note that PMI blocked scenario 2 and 4 because the estimate values intra-crosstalk are greater than reference value of crosstalk. This result shows that PMI work correctly in different situation. In other way, we must discuss the feasibility of PMI.

The internal design is produced on RTL level in order to have an synthesisable architecture which offers a good compromise between the frequency, the area, the time execution and the flow [15]. The presented architecture has been simulated using Active VHDL. For that we made a functional simulation to validate the correct operation of this

TABLE II
SIMULATION PARAMETERS

Models	Number of wavelength	Number of demands
PMI1	1	1-20
PMI2	2	1-20
PMI3	3	1-20
PMI4	4	1-20

architecture. Then we passed to the temporal simulation which makes it possible to guarantee a success implementation of 95% on the FPGA especially the platform STRATIX-I of Altera. The simulation and implementation of this device was performed by a hardware simulation tools (Project Navigator of Xilinx and ModelSim) with a frequency of 300 MHz.

Table II summarizes the different parameters of the simulations for the four models. Indeed, we excite the input of our system of 1 to 20 different demands. For each simulation, we put in our system from 3, 5, 7 and 9 wavelength. The simulation result is show as figure 8, it describes the execution time for PMI models as a function of the number of demands for 3, 5, 7 and 9 wavelength, respectively.

The lower curves in Fig. 8 show the evolution of execution time of PMI 1 as a function of the number of demands for different wavelength. However, we note that the model PMI 1 is more efficient in terms of execution time because the number of wavelength is less.

Now we fixed the number of wavelength at 5 and evaluate the cost and complexity implementation of PMI as function the number of stages in the network. In other hand, Fig. 8 shows the cost and complexity implementation of PMI as function the size the network, particular 5, 8, 12 and 20 number of stages respectively. We evaluate these parameters with the total number of Lookup Table (LUT). Then, LUT reflects the occupation area of various PMI modules in chip. While the cost and complexity of implementation for PMI increase with the number of stages is quite important because we need N x CIL blocks for N x stage of the network.

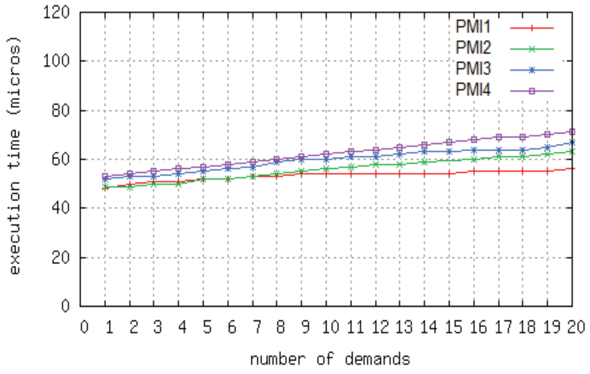

Fig. 7 Execution times and LUT vs. number of fibres

Compared with other proposed methods ([9], [10]), it is apparent that PMI is more advantageous, offering the benefit of rapid and accurate detection of performance degradation in AON components. Thus, it may ensure relaxing the high cost and complexity of signal quality monitoring in AONs. One of the main benefits of this method lies in the fact that it does not require a prior knowledge of performance-related parameters used in the network such as power levels, amplifier gain statistics, crosstalk, and amplified spontaneous emission components. Another important benefit is that this method is flexible at implementation and can be used in real-time fashion.

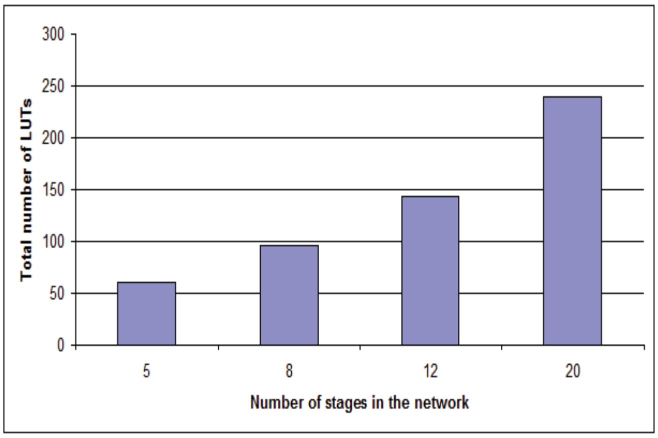

Fig. 8 Complexity implementation of PMI as a function of size network

V. CONCLUSION

As more intelligence and control mechanisms are added to optical networks, the deployment of an efficient and secure management system, using suitable controlling and monitoring methods, is highly desirable. While some of the available management mechanisms are applicable to different types of network architectures, many of these are not adequate for AONs. An important implication of using AON components in communication systems is that available methods used to manage and monitor the health of the network may no longer be appropriate. Therefore, without additional control mechanisms a break in the core of an optical network might not be detectable. In this paper, we proposed a policy monitoring intra-crosstalk in AON. PMI offers a system to detect and localize intra-crosstalk in entire network. Also, PMI predict the value of intra-crosstalk that can be occurring for a new demand. Then it judges to accept or block this demand. Consequently, PMI guarantee a nice QoS of the signal to passing this lightpath. This method can be used for supervising performance degradation in AON components offering the benefit of relaxing the high cost and complexity of signal quality monitoring for future AON management solutions.

REFERENCES

[1] R. Rejeb, M. S. Leeson and R. J. Green, Fault and Attack Management in All-Optical Networks, IEEE Communications Magazine, vol. 44, no. 11, pages 79-86, November 2006, Washington, DC, USA

[2] Ahmed. Jedidi, and Mohamed Abid, Optimal Crosstalk Detection and Localization Method for Optical Time Division Multiplexed Transmission Systems Networks, Journal of telecommunication, Volume 2 issue 1, isbn 2042-8839, April 2010,London, UK

[3] M. Medard, S. R. Chinn, and P. Saengudomlert,Node wrappers for QoS monitoring in transparent optical nodes,Journal of High Speed Networks, vol. 10, no. 4, isbn 0926-6801, pp 247-268,2001,Baltimore, USA

[4] A. Jedidi, and M. Abid,Optimal Crosstalk Monitoring and Identification Method for All-Optical Networks,The Sixth IEEE and IFIP International Conference on wireless and Optical communications Networks (WOCN2009),April 2009,Cairo, Egypt

[5] C. Larsen, and P. Andersson,Signal Quality Monitoring in Optical Networks,Optical Networks Magazine, vol. 1, no. 4, pp 17-23, 2000,New York, USA

[6] R. Bergman, M. Mdard and S. Chan,Distributed Algorithms for Attack Localization in All-Optical Networks,Proceedings of the Network and Distributed System Security Symposium,1998, San Diego

[7] L. E. Nelson and S. T. Cundiff and C. R. Giles, Optical Monitoring using Data Correlation for WDM Systems, IEEE Photonics Technology Letters, vol. 10, no. 7, pp.1030-1032,July 1998

[8] R. Gao, Z. Ghassemlooy, and P. Ball,, Crosstalk analysis for all optical routers,3rd Intern. Sympo. on Commun. Sysms., Networks and DSP, pp 173-176,July 2002, Stafford, UK

[9] A. Jedidi, R. Rejeb, B. Rejeb, M. Abid, M.S. Leeson, and R.J. Green, Hardware-based monitoring method for all-optical components, Proceedings of the IEEE International Conference on Transparent Optical Networks - 'Mediterranean Winter' (ICTON-MW07), Decembre 2007,Sousse, Tunisia

[10] T. Wu and A. K. Somani, Attack Monitoring and Localization in All-Optical Networks,OptiCom,235-248,july 2002

[11] J.Y. Yoo, and S. Banerjee, ADesign, Analysis, and Implementation of Wavelength-Routed All-Optical Networks: Routing and Wavelength Assignment Approach,IEEE Communications Surveys,1998

[12] C. Mas Machuca, I. Tomkos, and O. K. Tonguz,Optical networks security: a failure management framework,ITCom, Optical Communications & Multimedia Networks,Sep 2003,Orlando, Florida

[13] M. Mdard, D. Marquis, and S. R. Chinn,Attack Detection Methods for All-Optical Networks, Network and Distributed System Security Symposium, March 1998,San Diego, California

[14] M. Medard and S. R. Chinn, and P. Saengudomlert,Node wrappers for QoS monitoring in transparent optical nodesjournal of High Speed Networks,vol. 10, no. 4, pp. 247-268avril 2009

[15] F. Dahlgren and M. Dubois and P. Stenstrm, Sequential Hardware Prefetching in Shared-Memory Multiprocessors,IEEE Trans. Parallel and Distributed Systems,vol. 6, no. 7,733-746,July 1995