Fiber Material Dependent QoS Analysis and OVPN Connection Setup Over WDM/DWDM Network

Santos Kumar Das
Dept of Electronics & Comm Engg,
National Institute of Technology,
Rourkela, India
e-mail:dassk@nitrkl.ac.in

Suraj Kumar Naik
Dept of Electronics & Comm Engg,
National Institute of Technology,
Rourkela, India
e-mail:209ec1112@nitrkl.ac.in

Sarat Kumar Patra
Dept of Electronics & Comm Engg,
National Institute of Technology,
Rourkela, India
e-mail:skpatra@nitrkl.ac.in

***Abstract*—In this paper, we suggest a QoS based OVPN framework depending on delay. Now-a-days QoS assurances by the service provider network for Optical Virtual Network (OVPN) over GMPLS/DWDM network are a demanding factor for telecommunication clients. The proposed framework computes wavelength dependent delay for all possible OVPN connections for a source and destination pair of a client and finally setup a qualitatively best OVPN connection and provides a guaranteed quality of service (QoS). This framework also computes the QoS for different fiber materials in order to choose the right material, which can help to improve the QoS for an OVPN connection.**

Keywords- delay; general purpose router; traffic control manager; optical virtual private network; quality of service; fit parameters; OVPN connection.

I. INTRODUCTION

An anycast service in a QoS- based network requires to setup paths with minimum delay guarantees and to select a route to provide secure service. As the best effort resource scheduling of traditional IP cannot supply sufficient quality of service (QoS), optical circuit-switched (OCS) networking technologies are considered better suited to support wide ranges of QoS computation in advanced scientific applications [1]. The recent hot topic is optimal co-scheduling of computing resources and network resources [2, 3, 4] for light-path establishment over optical network. Most of the proposed works are based on static scheduling strategies. In this paper, we employ Optical Virtual Private Network (OVPN). This is also known as layer one VPN (L1VPN) [5] Optical Virtual Private Network (OVPN) provides service to the customer in the form of optical connection, which also expected to be one of the major applications in future optical networks. OVPN can be a favorable approach for realizing the next generation virtual private network (VPN) services [6, 7] by providing a guaranteed QoS [8]. In this paper, the QoS requirements of the client for an OVPN light-path have been considered in terms of delay. The network will be specified based on all the QoS parameters by estimating end-to-end delay bound [9, 10] for a source-destination pair. The main objectives of this paper is to when and how to select an OVPN connection for the client based on QoS requirement such as delay at the access router. The problem can be solved by formulating a mathematical TCM model based on the idea of differentiated services [11], which maintains the QoS for all the clients. In this research work we will consider a GMPLS [12] capable hybrid network with general purpose routers (GPR), which is the combination of IP and WDM network. The GPRs supports QoS guarantees and may be used as access or gateway routers for optical switching equipment leading to the core transport network.

Similar works has been reported in [13, 11, 14, 15]. The paper [13] suggest a multicast optical level switched path (OLSP) establishment mechanism for supporting high bandwidth multicast services in OVPN and also suggest an entire OVPN control mechanism to adapt the operation of the routing and signaling protocols of GMPLS. The differentiated services architecture [11] works with aggregated flows based upon the notion of per hop behaviors. It takes static decision for the re-routing of specific flows. RSVP [14] defines a purely flow based protocol to ensure about the individual flow requirements. Another issues reported in [16], which says how Bandwidth broker works centrally and provides QoS to the clients. The paper [16] says particularly on QoS based VPN on optical WDM network. It says about traffic based guaranteed QoS which is fully wavelength and number of applicant dependent. In all the above reported works the implication of end-to-end QoS support based on quality parameter such as delay and bandwidth in IP-WDM domain are not been considered.

Following this introduction in the next section, the network design and problem formulation is explained. TCM algorithm for light-path provisioning methods is presented in section III. The simulation results are described in section VII. Finally in Section VIII concludes the simulation works.

II. SYSTEM MODEL

The model shown in Fig. 1 shows the physical topology of the network, consisting of three layers, the Service provider layer shown as the outermost layer, the Optical core layer which is the innermost Optical network layer [17], and the Electronic intermediate layer or also known as IP layer.

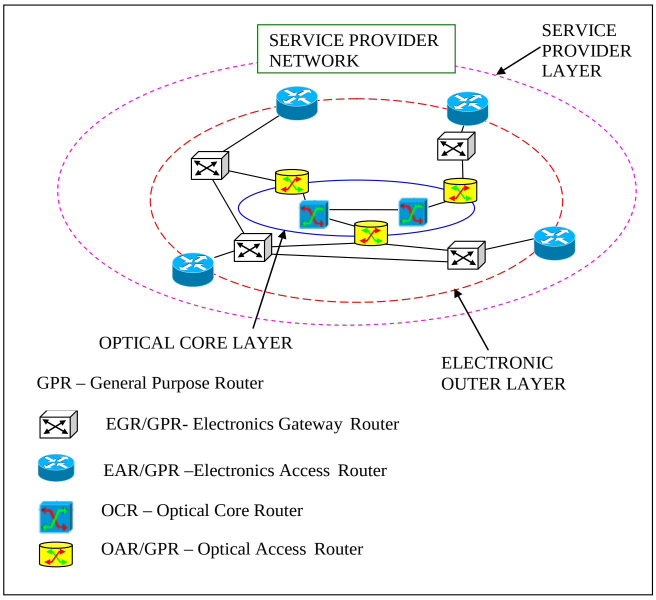


Figure 1. Physical Topology

This is an abstraction of the combined electro-optical network which allows us to focus on that portion of the network where our innovation applies, i.e. the combined electro-optical network. The optical layer provides point-to-point connectivity between routers in the form of fixed bandwidth circuits, which is termed as lightpaths. The collection of lightpaths therefore defines the topology of the virtual network interconnecting electronics/IP Routers. In IP layer the IP routers are responsible for all the non-local management functions such as management of optical resources, configuration and capacity management, addressing, routing, topology discovery, traffic engineering, and restoration etc. The IP router communicates with the TCM (Traffic Control Manager) of service provider network and provides the information about the status of the optical layer.

The service provider layer controls all the traffic corresponding to both IP and optical layers. All the routers shown in the figure are controlled by the service provider (SP). The SP maintains a traffic matrix in a Traffic Control Manager (TCM) for all the connected general purpose routers, i.e. all the Electronic Gateway Routers (EGR), Electronic Access Routers (EAR) and Optical Access Routers (OAR) within its domain of control.

The Traffic Control Manager (TCM) maintains the computation matrices such as such as delay and fiber material constraints for all the GPRs in the network, belonging to all the layers. In the following sections we outline our algorithms that carry out the computations necessary for the decisions that lead to provisioning/de-provisioning of OVPN connection.

III. PROBLEM FORMULATION

We consider a virtual topology model shown in Fig. 2. In this model, a number of flows for different applications are multiplexed at the source GPR *i* to destination GPR *j*, for a data-path. This formulation is for the provisioning and de-provisioning of data-path based on the client requirements and existing traffic. The problem formulations are based on QoS parameters such as Delay bound which is explained in following sections.

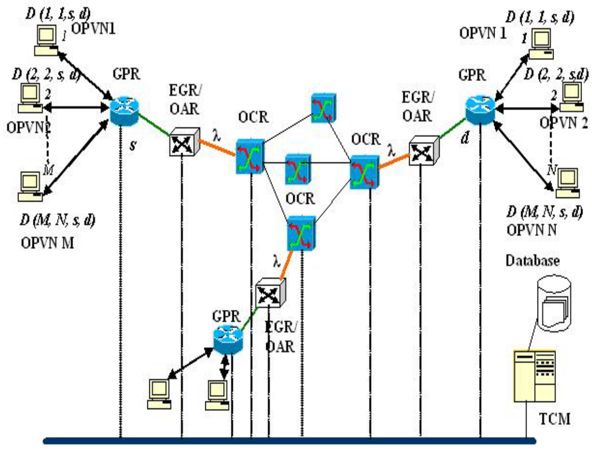


Figure 2. System Topology Graph

A. *Delay Model*

We estimating the delay requirement for the clients that support guaranteed service in terms of end-to-end delay bound. In Fig. 1, suppose the delay requirement of flow for *(m, n)* OVPN client pair from source node (SN) *s* and destination node (DN) *d* is $D(m, n, s, d)$. The maximum acceptable delay between *s* and *d* is as follows:

$$D_{\max}^{accept}(m,n,s,d) = Min\{D(m,n,s,d)\}, \forall (m,n) \tag{1}$$

Where, $m = 1, 2\ldots M$ and $n = 1, 2\ldots N$ and M and N are the total number OVPN clients attached to source *s* and *d* respectively.

As per the network condition if $D(i, j)$ is the link pair delay, then the end-to-end delay is the sum of link delays suffered by a connection at all routers along with the light-path $p(s, d)$ and computed as follows,

$$D_{\max}^{bound}(m,n,s,d) = \sum_{(i,j)\in p(s,d)} D(i,j) \tag{2}$$

Where, according to [18],

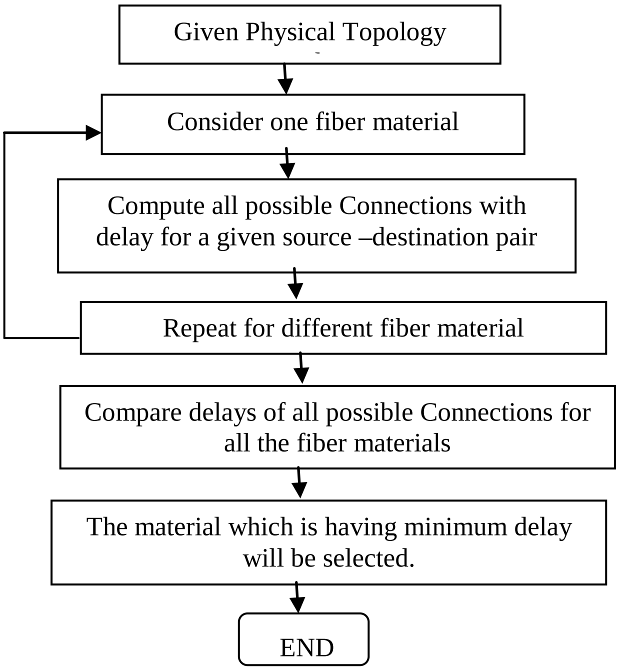
$$D(i,j) = a + b\lambda_{i,k}^{2} + c\lambda_{i,k}^{-2} \tag{3}$$

Where *a*, *b* and *c* are fiber material dependant constants also known as fit parameter, $\lambda_{i,k}$ is the wavelength at i_{th} node and its k_{th} light-path.

IV. TCM Algorithm For Fiber material selection and OVPN Provisioning

A. Fiber material selection mechanism

The fiber material which provides minimum delay during route computation that will be considered to be used in fiber network back bone. The following is the flow chart for the above mechanism.



B. OVPN provisioning Mechanism

The TCM algorithm for the provisioning of new OVPN based on the equations 1 to 3. The edge GPR aggregates the acceptable delay of the flows as mentioned in equation 1. This acceptable delay will be compared with the estimated delay bound mentioned in (2) in order to find a best suitable OVPN. The comparison takes decision, whether to provision an OVPN for the requested services as per the following conditions.

$$D_{\max}^{accept}(m,n,s,d) \geq D_{\max}^{bound}(m,n,s,d) \qquad (4)$$

V. Simulation Result and Discussion

In our simulation, we consider the parameter mention in Table I we have obtain the best suitable OVPN connection by considering Delay as the only quality requirement. In this work we have taken three fiber materials such as silica, Aluminium Oxide and Beta Barium Borate. We also considered the fit parameters (*a*, *b*, and *c)* mentioned in table 3 based Sellmeier coefficient table for simulation work.

TABLE I. Parameters for Simulation

Parameters	Value
Wavelength (λ) in nm	1280, 1300, 1330
Fit parameter (Aluminium oxide)	*a*=1.5586, *b*=1.52365, *c*=0.010997
Fit parameter (silicon oxide)	*a*=1.30907, *b*=1.04683, *c*=0.01025
Fit parameter (Beta Barium Borate)	*a*=146357, *b*=1.26172, *c*=0.01628

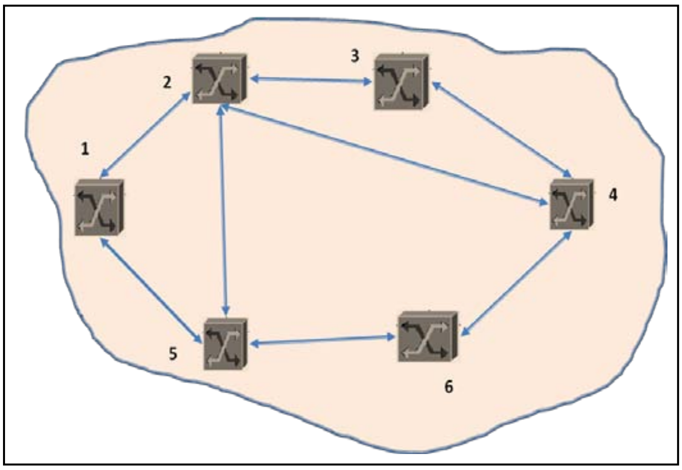


Figure 3. Physical topology used for simulation

The Fig. 3 shows the basic network topology with 6 nodes. Here we computed delays and all possible connections for three pair of source and destination nodes (1, 4), (5, 3), and (1, 6) in-order to choose the best connection based on client QoS requirement by applying the OVPN connection setup mechanism.

Fig. (4 to 9) shows the plot to compute all possible OVPN connections by taking the different fiber materials and wavelength for a given source-destination pairs. The delay for a path is computed by taking different wavelength values.
Here the plot shows the best fiber material, which is having minimal delay. This fiber material can be used for the optical domain for the reduction of delay occurs during the connection setup.

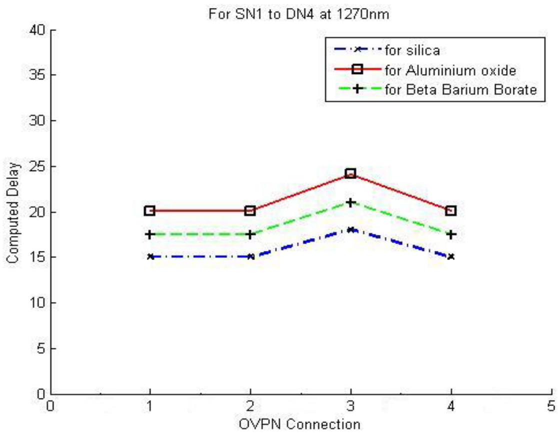


Figure 4.   . Delay variation with OVPN paths for SN1 to DN4 at 1270 nm for different fiber material

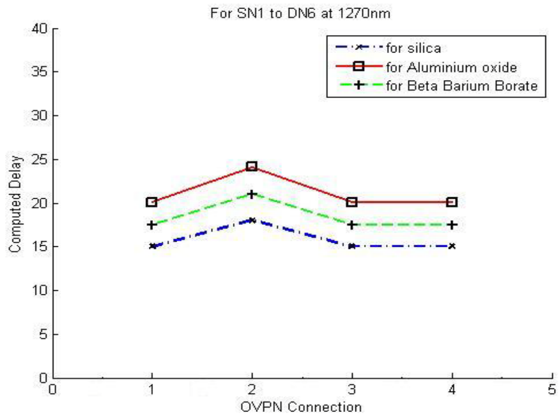


Figure 7.   Delay variation with OVPN paths for SN1 to DN6 at 1270nm for different fiber material

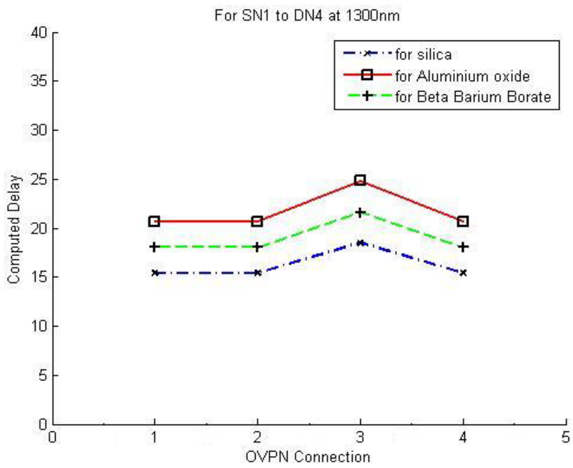


Figure 5.   Delay variation with OVPN paths for SN1 to DN4 at 1300nm for different fiber material

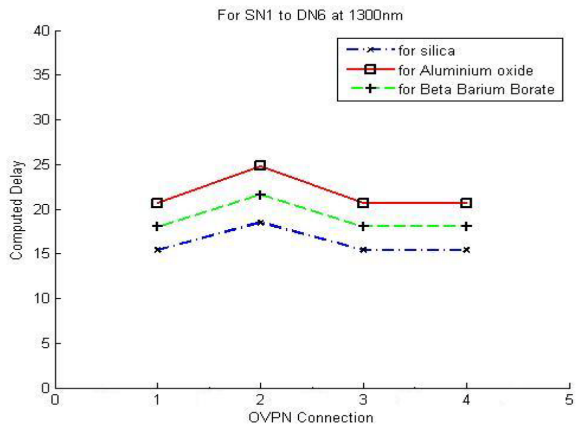


Figure 8.   Delay variation with OVPN paths for SN1 to DN6 at 1300nm for diff fiber material

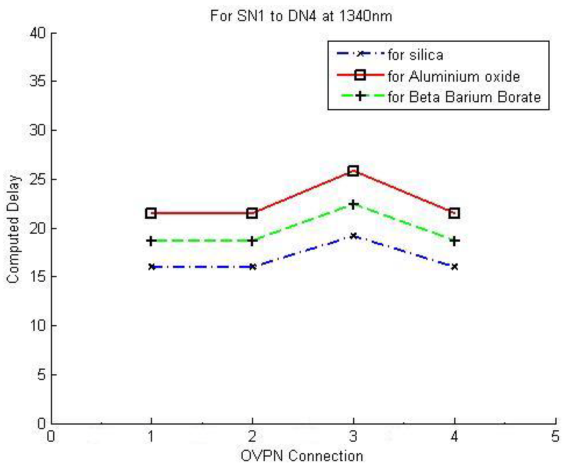


Figure 6.   Delay variation with OVPN paths for SN1 to DN4 at 1340 nm for different fiber material

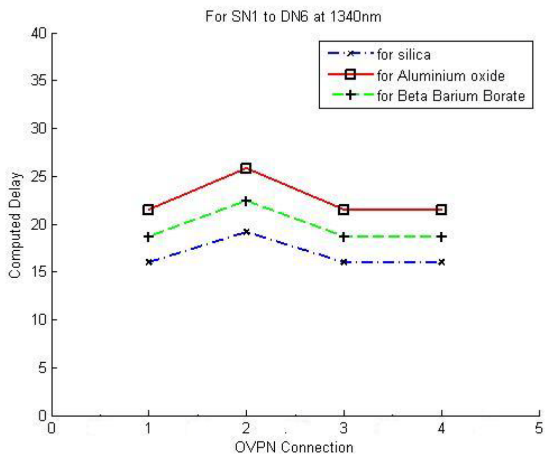


Figure 9.   Delay variation with OVPN paths for SN1 to DN6 at 1340nm for different fiber material

TABLE II. SIMULATION FOR BEST OPVN CONNECTION USING ALUMINIUM OXIDE

SN	DN	PC	CRN	DE	CRNA	RD	SOVPNC
1	4	1-2-3-4	1	20.30	2	21.6	2
		1-2-4	2	20	1		
		1-6-4	3	24.3699	4		
		1-5-4	4	20.3082	3		
5	3	5-6-3	1	20	1	21.6	3
		5-1-2-3	2	20.7003	3		
		5-2-3	3	24.36	4		
		5-4-3	4	20.7	2		
1	6	1-2-3-6	1	21.5029	3	21.6	3
		1-4-6	2	25.8035	4		
		1-5-6	3	21	1		
		1-2-6	4	21.5	2		

Note: PC = Possible Connection, CRN = Connection Reference Number, DE = Delay BOC = Best OVPN Connection, CRNA = Connection Reference Number in Ascending order, RD = Required Delay of OVPN Clients, SOVPNC: Selected OVPN Connection

The table II shows the simulation results for computation of overall delay, possible connection and the best OVPN connection. We have taken the affordable delay of 21.6 as the client requirement for all the source-destination pair and the corresponding best connection is shown in the table. For example, if a client has delay of 21.6 for the source destination pair (5, 3), then in accordance with the proposed algorithm, the best OVPN connection will be 5-1-2-3.

VI. CONCLUSIONS

In this paper we explore the motivation and a QoS based framework for OPVN connection setup over WDM/DWDM network. We formulate the delay model and its application for fiber material selection in-order to opt a suitable OVPN connection with minimum acceptable delay. We have presented an algorithm for fiber material selection based on delay computation as well as a method that determines the condition for the provisioning of an OVPN connection. Here we have considered delay as the quality parameter to provision a best suitable connection as per the client requirements of delay in-order to provide better QoS.

REFERENCES

[1] D. Simeonidou, "Optical Network Infrastructure for Grid", IEEE Journal on Lightwave Technology, Vol. 23, No. 10, pp. 3347-3357, 2005

[2] Y. Wang, “Joint scheduling for optical grid applications”, Journal of. Optical Networking, vol. 6, pp. 304-318, 2007

[3] Z. Sun, "Scheduling Algorithms for Workflow based Applications in Optical Grids", IEEE/OSA Journal of Lightwave Technology, Vol. 26, No. 17, pp. 3011-3020, Sept. 200

[4] X. Liu, “Task Scheduling and Lightpath Establishment in Optical Grids”, INFOCOM 2008, The 27th Conference on Computer Communications, IEEE, vol. no. , pp. 1966-1974, April 2008.

[5] T. Takeda, “Framework and Requirements for Layer 1 Virtual Private Networks”, IETF RFC 4847, April 2007.

[6] Z. Zhang, “An Overview of Virtual Private Network (VPN)”, IP VPN and Optical VPN, Photonic Network Communications, vol. 7, no. 3, pp. 213-225, May 2004.

[7] H. Ould-Brahim, “Generalized Provider-provisioned Port-based VPNs using BGP and GMPLS Toolkit”, draftouldbrahim-ppvpn-gvpn-bgpgmpls-03.txt, IETF Internet Draft, March 2003.

[8] Hamzeh Beyranvand and Jawad A. Salehi, “Multiservice Provisioning and Quality of Service Guarantee in WDM Optical Code Switched GMPLS Core Networks”, JOURNAL OF LIGHTWAVE TECHNOLOGY, vol. 27, No. 12, pp.1754-1762, June 2009.

[9] L. Georgiadis, R. Guerin, V. Peris, and R. Rajan, “Efficient Support of Delay and Rate Guarantees in an Internet”, SIGCOMM'96, Palo Alto, CA, Vol. 26, Issue 4, pp.106-116, October 1996.

[10] J. Glasmann, M. Czermin, and A. Riedl, “Estimation of Token Bucket Parameters for Videoconferencing Systems in Corporate Networks”, 8TH International conference on computer software, Telecommunication and Computer Networks, SoftCOM 2000, pp.10-14, October 2000

[11] S. Blake, D. Black, M. Carlson, E. Davies, Z. Wang, and W. Weiss, “An Architecture for Differentiated Services”, RFC 2475, December 1998.

[12] Ning Zhang,Hong Bao, “GMPLS Technology and Its Application in WDM Optical Network”, International Conference on Networking and Digital Society, Vol. 2, pp-48-51, May 2009.

[13] Jeong-Mi Kim, Oh-Han Kang, Jae-Il Jung, Sung-Un Kim, "Control Mechanism for QoS Guaranteed Multicast Service in OVPN over IP/GMPLS over DWDM", Journal of Communications, Vol 2, No 1, pp. 44-51, January 2007

[14] Lixia Zhang, Steve Deering, Deborah Estrin, Scott Shenker, and Daniel Zappala, “RSVP: A New Resource Reservation Protocol”, Communications Magazine, IEEE, Vol 14, issue 5, pp.116-127, May 2002.

[15] Zhi-Li Zhang, Zhenhai Duan, Lixin Gao and Yiwei Thomas Hou, “Decoupling QoS Control from Core Routers: A Novel Bandwidth Broker Architecture for Scalable Support of Guaranteed Services”, ACM SIGCOMM 2000, pp.71-83, August 28.

[16] Yang Qin, Krishna Sivalingam, Bo Li,” QoS for Virtual Private Networks (VPN) over OpticalWDM Networks”2000

[17] J. Strand, A. L. Chiu, and R. Tkach, “Issues for routing in the optical layer”, Communications Magazine, IEEE, Vol. 39, Issue 2, pp.81-87, February 2001

[18] Y. Miyajima, M. Ohnishi and Y. Negishi, “Chromatic dispersion measurement over a 120 km dispersion-shifted single-mode fiber in the 1.5 µm wavelength region”, NTT Electrical Communications Laboratories, Tokai, Japan, Electronics Letters,22 , Vol. 22, Issue 22, pp. 1185 - 1186, October 1986