Sindh Univ. Res. Jour. (Sci. Ser.) Vol.49 (004) 773-778 (2017)

http://doi.org/10.26692/sujo/2017.12.0056

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Novel Composite Burst Assembly for OBS-Networks

S. SARWAR, F. ZEESHAN*, L. ASLAM, M. M. YOUSAF, W. U. QOUNAIN

Punjab University College of Information Technology (PUCIT), University of the Punjab, Lahore,

Received 7th December 2016 and Revised 1st July 2017

Abstract: Multiple priority packets are aggregated together to form a composite data-burst in an optical burst-switched network. The tail of the composite data-burst contains low-priority packets. It assumes that contention between data-bursts can be resolved by clipping and dropping the tail of data-burst which contains low-priority packets that result in quality-of-service (QoS) differentiation. This mechanism requires implementation of complex preemption-based scheduling scheme which employs increased signaling on the control channel. Further, it fails to handle several contention and scheduling scenarios especially when a data-burst contends at head- and tail-ends, simultaneously. Furthermore, in order to provide maximal class isolation, it has been identified that the best approach is to safeguard the high-priority packets by dropping low-priority packets. Thus, we propose a novel scheme for assembling a composite data-burst in which the packets having high-priority are placed at the tail-end. It has been learnt from the results of simulation that our proposed scheme guarantees maximum class isolation between traffic classes having low and high priority. Furthermore, class isolation is investigated for several percentage of class-0, highest priority, packets in a composite data-burst.

Keywords: Optical Burst Switched (OBS) Networks; Burst Assembly; Class Isolation; Segmentation-Based Partial Burst Dropping

I. INTRODUCTION

Behind the paradigm shift from circuit switching (CS) to packet switching (PS), the primary motivation was to design a network that can survive the switch/router failure without losing the communication in progress. In response to that, the community proposed packet switched networks by combining the payload and control information in a single data unit, also known as packet. That made every packet independently switchable. Thus, in case a node or link fails, the packets can take the alternative route, second shortest path, without losing the communication in progress. However, this comes at a price of processing every single packet on the entire intermediate routing nodes. On receipt of a packet, the router performs store-and-forward procedure for every packet in order to find the IP address of next hop on the path (from source to destination). All the processing is done electronically.

The fiber optic links offer enormous amount of bandwidth to transport data between the network routers. In order to improve the utilization of the link bandwidth the router has to deal with huge data in very short time, usually couple of *nano-seconds*. To meet the strict deadlines for processing packets, almost entire computational power of CPU is utilized those results in heat dissipation. Excessive cooling is used to keep the temperature within the permissible limit. It is evident, electronic devices are unable to cope the processing requirements due to excessive heat dissipation. Thus, high-speed optical network technologies can conserve energy by providing switching facility, without hefty cooling units. Ideally speaking, the data would stay in optical domain and can cut through the intermediate nodes without involving electronic storage and processing. The proposed optical circuit switched (OCS) networks are unable to provide bandwidth at fine granularity and also, entails two-way signalling. On the other side, optical packet switched (OPS) networks can take benefit of statistical multiplexing of the bandwidth, offering the finest granularity of bandwidth. But, the OPS networks are still far from reality in the absence of optical counterpart of electronic RAM. The middle ground opted between the OCS and OPS networks is optical burst switched (OBS) networks. The OBS-network carries advantageous parts of both OCS and OPS networks.

The OBS-network is highly energy-saving due to its unique characteristics. To this end, separation of control plane and data plane enables resource reservation through one-way out-of-bound signaling on the control channel. First, a burst header is sent. Afterwards, the corresponding data-burst is sent with a gap of an offset time. The control information in a burst header is used to reserve the wavelength data channel to establish light-path across OBS routers, for soon-to-arrive data-burst. Resultantly, a data-burst cuts-through the OBS routers without being buffered and inspected. The separation of payload and control information

++Corresponding Author Email, s.sarwar@pucit.edu.pk
*University of Engineering and Technology (UET), Taxila.

relaxes the requirements of buffering the payload and eliminates the per-packet next-hop look up at OBS routers. The reduction in overhead of packet processing corresponds to number of packets being aggregated in a data-burst. The reduced processing results in significant energy-saving by dissipating fewer amounts of heat resulting in significant drop in cooling requirement. Furthermore, the expensive electro-optical (E/O), and vice versa, conversion of signals is eliminated, which was required for sending and receiving data over optical communication links between electronic routers.

An OBS-network comprises of two types of nodes a) edge-node and b) core-nodes. In this paper, the terms OBS router and core nodes are used interchangeably. The edge node aggregates multiple packets into a data-burst, that forms the payload of OBS-network. Subsequently, over the OBS edge nodes, the data-burst is all-optically transported across the OBS-network to reach the egress node, unlike the notion of store-and-forward.

The control information in a burst header is used to reserve the wavelength data channel to establish light-path across OBS routers, for soon-to-arrive data-burst. The wavelength is assigned according to the arrival-time of the data-burst. The phenomenon of delayed reservation is also known as just-enough-time (JET). For transmission time of data-burst, JET assigns the data channel wavelength. The individual packets are recovered by disassembling the data-bursts. Then, the packets are handover to the upper network layer.

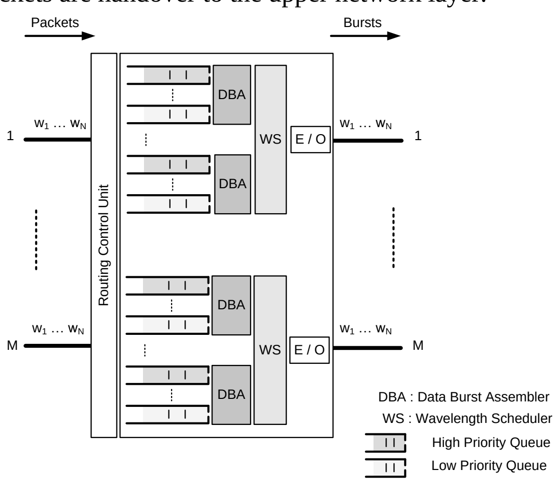


Fig.1.The layout of OBS edge node.

The OBS edge node is comprised of three components that are routing control unit, data-burst assemblers, and wavelength scheduler. The **(Fig. 1)** depicts the architecture of an ingress edge node. The routing control unit separates out arriving packets into the pertinent priority queues with respect to similar properties, such as priority and destination address. Further, in the data-burst assembly module, packets are aggregated into a data-burst which belong to a single class and are destined to the same destination egress node. According to the data-burst scheduled transmission time, the generated data-burst is transmitted on the output port.

The data-burst assembly algorithms significantly affect the Packet Loss Probability (PLP). The OBS research community has proposed many data-burst assembly mechanisms. These mechanisms are categorized as time-based [Cal00], length-based [Har02], or hybrid [Oh02, Che02] algorithms. It has been shown, that the criterion for the data-burst assembly effects length of burst and inter-arrival time of the data-burst. A comparison of the data-burst assembly criterions has been presented in **(Table 1).**

Table 1: Comparison of data-burst assembly mechanisms

Data-burst Assembly Criterion	**Burst Length**	**Burst Inter-arrival-time**	**Traffic Load**	
			Low	**High**
Length-based	Fixed	Huge variation	Takes too long to create a data-burst	Data-burst inter-arrival time is small
Time-based	Huge variation	Fixed	Small burst	Long burst
Hybrid	Low variation	Low variation	Burst assembling is stopped when timer expires	Burst is assembled when the specified length of burst is met.

Primarily, the OBS core node is composed of three major components for instance a) processing unit of burst header, b) switch controller, and c) non-blocking switch fabric. A forwarding table is maintained by the switch controller. Upon the receipt of the burst header, the processing unit processes electronically in order to find out the destination of the burst. Afterwards, the switch controller does the forwarding table look up to choose the output port of the OBS core node. If the required wavelength is available at output port, the switch controller sets up the switch fabric allowing the scheduled data-burst to cut through.

In case of contention, the decision of configuring the switching fabric is made according to the scheduling policy and mechanism for resolving the contention. The wavelength scheduler may employ one or more contention resolution techniques; that include buffering payload optically [Cho07], conversion of wavelength [Ram98], and hot-pot routing [Wan00]. The effectiveness of time- and wavelength-domain solutions is limited to the availability of the additional expensive hardware resources, for instance, wavelength converters and fiber delay-lines (FDL).

In the following text, a discussion is presented about the wavelength scheduling algorithms and contention resolution mechanisms in an intuitive way instead of analytical. Also, the discussion does not engage priority of traffic unless it is explicitly mentioned.

It is trivial to assess, the wavelength channel scheduling algorithms are designed to achieve higher utilization of resources and to reduce PLP by minimizing the void between two adjacent scheduled data-bursts, on a wavelength data channel. In literature several void-filling and partial dropping-based algorithms are proposed (Xiong, *et al.*, 2000). (Tancevski, *et al.*, 1999) (Vokkarane, *et al.*, 2003). The scheduling algorithms have been developed in order to support segmentation-based (Vokkarane, *et al.*, 2002) partial dropping of overlapping parts of the contenting data-burst, in preemptive fashion (Vokkarane *et al.*, 2005). (Using the partial burst dropping schemes is beneficial for resolving the contention and achieving lower packet loss. But paying the price of increased complexity of implementation and downstream signaling. If the high-priority burst is scheduled by preempting, fully or partially Kaheel and Alnuweiri. 2003) the allocated wavelength channel from the low-priority data-burst, that requires additional signaling to downstream core nodes for dropping that reservation of data channel for the preempted data-burst. Thus, the usage of non-preemptive scheduling algorithms is recommended; such as non-preemptive (NP) version of void-filling based minimum channel overlapping (Vokkarane, *et al.*, 2003).

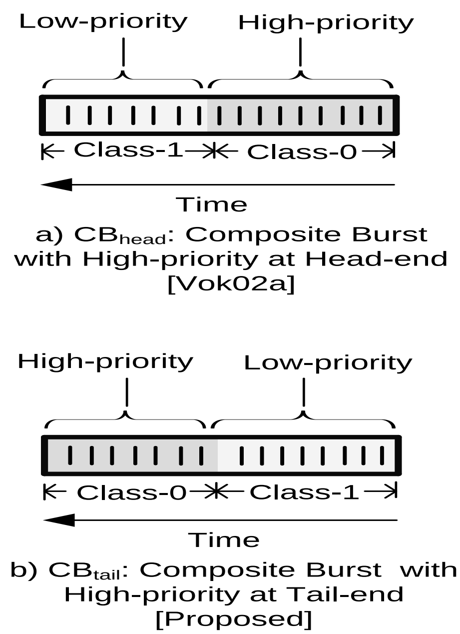
It has been presented in literature that shorter data-burst length and longer off-set time helps to reduce the probability of packet loss. However, in this study we are not attempting to verify these claims.

The paper contains different sections as follows. An overview has been presented for the proposed composite data-burst assembly mechanism in Section II. Section III presents the simulation model and numerical results with particular focus on PLP. Section IV concludes the discussion and presents topics for research.

2. COMPOSITE DATA-BURST ASSEMBLY

In recent times, a lot of Internet protocol (IP) based real-time interactive applications have been developed for example video-on-demand (VoD), IP-based audio and video telephony, multimedia online gaming, emergency and mission critical services, and telemedicine applications. It is likely that several classes of traffic would coexist in the Internet, simultaneously. For the sake of intuitive argument, the traffic classes are broadly categorized in high-priority and low-priority traffic class, which are denoted by Class-0 and Class-1, respectively. In the literature to deal with priority of the traffic, different composite data-burst assembly techniques are proposed (Vokkarane *et al.*, 2002).

A composite data-burst assembly technique has been introduced in (Vokkarane *et al.*, 2002) that suggests to aggregate packets in a single burst having diverse priority classes. Such a composite data-burst contains packets of Class-0 and Class-1. The **(Fig. 2)** shows, the Class-0 and Class-1 packets placed at the head-end and tail-end of the data-burst, respectively. Let this scheme is denoted by CB_{head} because data-burst contains Class-0, high-priority, packets at the head.



Fig, 2. Composite data-burstassembly a) high-priority at head (CB_{head}) [Vok02a]b) high-priority at tail (CB_{tail}) [Proposed]

However, CB_{head} technique assumes that contention between data-bursts would be resolved by clipping and dropping the tail of data-burst which contains low-priority packets that would results in quality-of-service (QoS) differentiation. In case of preemptive scheduling, such mechanism drops the packets of low-priority from the tail of the scheduled data-burst and still the truncated data-burst, containing high-priority packets, can be transmitted (Vokkarane *et al.*, 2002) In this way, the QoS differentiation comes at the increased cost of downstream signaling to drop the previously made wavelength reservations. Moreover, an important observation can be made that wavelength contention between arriving and scheduled data-bursts may not always be on the tail-end of the data-burst. The contention can also be more often on the head-end of the data-burst. Based upon the two observations a) preemptive scheduling requires additional signaling and b) contention can be on any end of the data-burst; head-end, tail-end, or both. Furthermore, in order to provide maximal class isolation between Class-0 and Class-1 traffic, we have identified that the best approach is to safeguard the high-priority packets as much as possible against losing packets having low-priority.

We propose a novel composite assembly scheme, the Class-0 packets are placed at the tail of data-burst. The **(Fig. 2 (b))** elaborates the proposed scheme denoted with CB_{Tail}. We expect an improved performance in comparison to CB_{head}. The Section III contains the numerical results for PLP (PLP) and PLP ratio.

3. SIMULATION MODEL AND NUMERICAL RESULTS

A network topology comprised of two ingress, core, and egress nodes each has been created. Each of the two ingress nodes maintains numerous first-in, first-out (FIFO) queues. A queue is maintained for each priority-class of traffic destined to the same egress node, as shown in **(Fig. 3).**

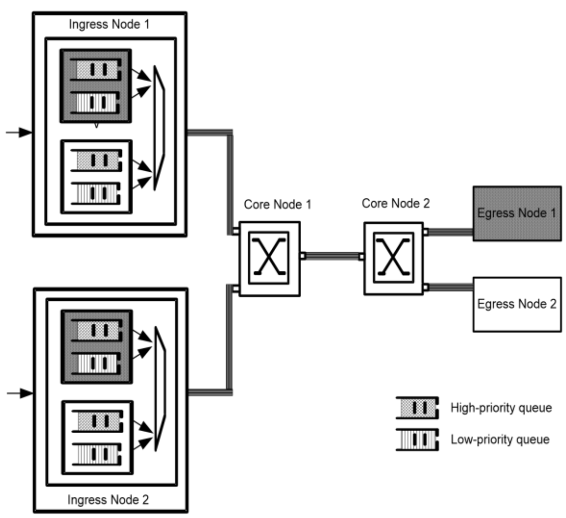


Fig. 3. Network topology

Each communication link has one control channel and three data wavelength channels and transmission rate is 1 Giga-bit per second (Gbit/s). At the core nodes, it is assumed that full wavelength converter is available allowing any-to-any wavelength conversion, if required. Also, it is assumed that wavelength channel would be reserved for transmission time of a burst, which is featured by just-enough-time (JET) signaling scheme (Yoob and Qiao, 1997). Also, NP-MOC-VF is used as scheduling algorithm (Vokkarane *et al.,* 2005) In this study, the performance of conventional and proposed, CB_{head} and CB_{tail}, composite data-burst assembly mechanism has been evaluated and compared. It is assumed, the length of packet is distributed negative exponentially having the mean value of 1 Kilo-Byte (KByte). It is assumed that packet's arrival process is Poisson. In this study, the incoming traffic is comprised of class-0 and class-1, respectively. At the ingress node, the composite data-bursts are created by aggregating arriving packets, destined to the same egress node, using the length-based data-burst assembly. The length of aggregated composite data-burst is 300 KByte. The arrivals of data-bursts are distributed uniformly for all sender-receiver pairs of ingress and egress nodes. The offset time is fixed for egress nodes EN_1 and EN_2as 0.05 and 0.055 second, respectively. The configurations and parameters of simulation setup have been summarized in the **(Table 2).**

The characteristic performance metrics are measured are at core node CN_1. The CN_1 receives composite data-bursts destined for egress nodes EN_1 and EN_2. Subsequently, the CN_1 schedules these data-bursts on the wavelength data channels of connecting output link between CN_1 and CN_2.

Table 2: Configurations and parameters of simulation setup

Item	Specification
Packet	Arrival process is Poisson
	Packet length is distributed negative exponentially with mean packet size of 1 Kilo Byte (KB)
Traffic Classes	class-0
	class-1
Composite Data-burst Assembly Mechanism	CB_{head}: HP packets at head-end of data-burst
	CB_{tail}: HP packets at tail-end of data-burst
Percentage of high-priority	10, 25, 33, 40
Data-burst	Length-based burst assembly
	Fixed burst length is 300 Kbyte
	Offset time is 0.050 and 0.055 seconds
Transmission Rate	1 Gbit/s
Scheduling Algorithm	NP-MOC-VF [5]
Reservation Protocol	Just-enough-time (JET) [8]
Wavelength Conversion	Full wavelength converter

Let, B_0 and B_1 represents PLP of high-priority (class-0) and low-priority (class-1) traffic, respectively. The simulations have been run for four high-priority percentages in a composite data-burst that is 10%, 25%, 33%, and 40%. For both schemes, the composite data-burst are presented in the **(Fig. 4).**

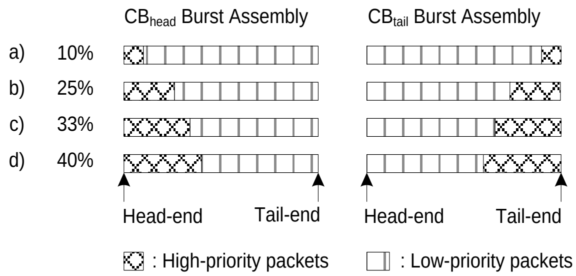


Fig. 4. Composite data-bursts with different percentage of class-0 traffic.

For the two composite data-burst assembly mechanisms, the packet loss probabilities, B_0 and B_1, have been plotted against the normalized load with 10- and 40-percent of high-priority packets, as shown in **(Figs 5(a) and (b)).** The premise of this study is that CB_{head} mechanism unjustifiably results in higher blocking of the class-0. As shown in Figs. 5(a) and (b), it is observed that the CB_{head} mechanism offers higher blocking to class-0 traffic in comparison to class-1 traffic, which is not a desired case. Hence, the premise of our study has been proved. Additionally, it is observed that the proposed mechanism CB_{tail} has improved the situation in the favor of class-0, which faces less blocking than that of class-1, $B_0 < B_1$. The justification is simple; class-0 packets are placed at the tail-end of a data-burst that faces only fewer and smaller contentions with other data-bursts.

Let the PLP ratio (PLPR) is given in Eq. 1.

$$PLPR = \frac{B_1}{B_0} \tag{1}$$

The PLPR results of CB_{tail} mechanism have been plotted against the normalized load for various percentage of class-0 traffic, as shown in Fig.6. It has been observed that higher percentage of class-0 traffic, that is 40%, leads to the highest class isolation, see the Fig.6. It is also observed that the relationship given in the Eq. 2 holds true.

$$\mathrm{PLPR}_{10} < \mathrm{PLPR}_{25} < \mathrm{PLPR}_{33} < \mathrm{PLPR}_{40} \tag{2}$$

The lowest and highest class isolation is offered by 10% and 40% of class-0 traffic, respectively. The proposed composite data-burst assembly ensures better class isolation (CI)in case of contention, by allowing dropping of packets having low-priority from head-end of data-burst, by the wavelength channel scheduler of OBS core node. Please note, the reduction in PLP of class-0 traffic is achieved by paying the price of increased blocking of class-1 traffic.

Fig. 6 shows that the PLPR of different percentages of class-0 traffic under heavy load is almost the same. However, it is interesting to note that still PLPR> 1, please refer to **(Fig. 6)**. The reason for this behavior is that high offered load results in increased burst collisions, which yields higher loss of packets and differentiated service cannot be offered to the class-0 traffic.

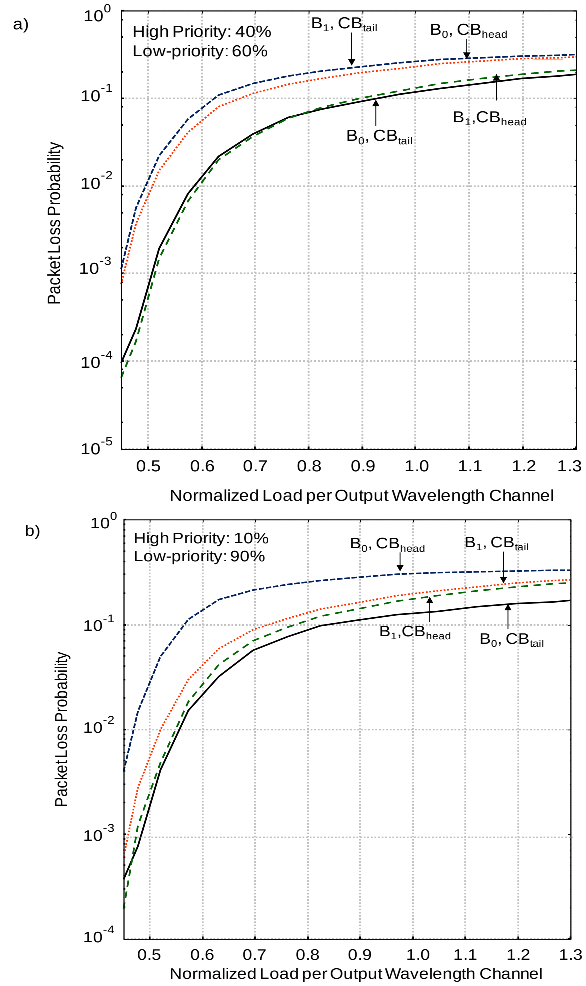


Fig.5. Offered load against probability packet loss a) 40% Class-0traffic b) 10% Class-1 traffic

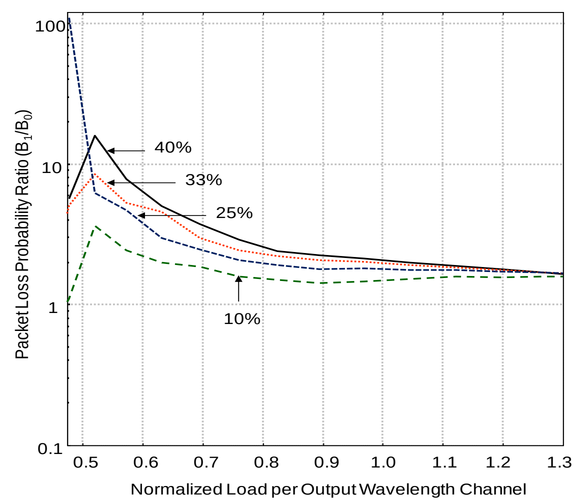


Fig. 6. Packet loss probability (PLP) ratio (B_1/B_0) versus normalized load

4. CONCLUSIONS

In this study, it has been established that placing high priority packets at the tail of the burst reduces the loss of high priority traffic. Further, the proposed scheme holds true for arbitrary percentage of classs-0 data-burst packets. Additionally, our proposed scheme ensures the class isolation higher than one, PLPR>1. However, the class isolation increases with the increase in percentage of high-priority packets on account of less protection available at the ends of the data-burst.

During the course of this study, we have identified three topics for the future research that include a) generalized composite data-burst assembly schemes b) novel scheduling algorithm targeting to achieve low loss of high-priority traffic, and c) partial burst dropping-based contention resolution mechanisms which must be the best suited to the proposed data-burst assembly scheme for further increase in the PLPR.

REFERENCES:

Kaheel A. and H. Alnuweiri. (2003) A Strict Priority Scheme for Quality-of-Service Provisioning in Optical Burst Switching Networks. 8th IEEE International Symposium on Computers and Communication (ISCC 2003), vol. 1, 16–21.

Tancevski, L., A. Ge, G. Castanon, and L. Tamil, (1999) “A New Scheduling algorithm for Asynchrounous, Variable Length IP Traffic Incorporating Void Filling,” Proc. Optical Fiber Communication Conference (OFC), vol. 3, 180-182, San Diego (USA).

Vokkarane, V. M. G. P. V. Thodime, V. U. B. Challagulla, and J. P. Jue, (2003) “Channel Scheduling Algorithms using Burst Segmentation and FDL for Optical Burst-Switched Networks,” IEEE ICC 3, vol.2, 1443-1447, Seattle, WA.

Vokkarane, V. M., J. P. Jue, and S. Sitaraman. (2002) Burst Segmentation: An Approach for Reducing Packet Loss in Optical Burst Switched Networks. IEEE International Conference on Communications (ICC), New York, USA, vol. 5, 2673–2677.

Vokkarane V. M. and J. P. Jue, (2005) “Segmentation-Based Nonpreemptive Channel Scheduling Algorithms for Optical Burst-Switched Networks,” Journal of Lightwave Technology, vol. 23, no. 10, 3125-3137.

Vokkarane, V. M., K. Haridoss, and J. P. Jue. (2002) Threshold-Based Burst Assembly Policies for QoS Support in Optical Burst-Switched Networks. SPIE Optical Networking and Communications Conference (OptiComm) , Boston, USA.

Xiong, Y., M. Vanderhoute, and H.C. Chankaya, (2000) “Control Architecture in Optical Burst-Switched WDM Networks,” IEEE Journal on Selected Areas in Communications, vol. 18, no. 10, 1835-1851.

Yooq M. and C. Qiao, (1997) “Just-Enough-Time (JET): A High Speed Protocol for Bursty Traffic in Optical Networks,” Proc. IEEE/LEOS Conf. on Technologies for Global Information Infrastructures 26-27,