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An Efficient Way to Enhance Throughput in Egress Routers of Optical Burst Switching Networks

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Abstract

To transfer variable size data bursts directly over dense wavelength division multiplexing links Optical burst switching (OBS) is used vastly in recent days. But burst-scheduling algorithms implemented in OBS must be able to use the available wavelengths efficiently, and operate fast enough with the burst incoming rate. In this paper we proposed a new burst scheduling algorithm to avoid burst overlapping in the egress router of OBS network, which will improve the quality of service (QoS). We considered TAG (tell-and-go) protocol where many lightpaths pass in a given link and burst overlap may occur. For intermediate node forwarding to only one outgoing link and receiving from many incoming links, we found the conditions for the burst controls. For low traffic loads we showed that burst blocking can be made zero. For higher traffic loads there is burst blocking, which can be reduced using different sets of fiber delay lines (FDLs) and also shown relation stating the burst blocking and the requirements of FDLs. For both the traffics we used, time-based assembly algorithm in an assembly node to build the burst. Analysis on throughput depending on burst size, inter-arrival time, and sizes of FDLs, is made and improvement of throughput using FDLs is shown.

Keywords: Optical burst transport (OBT), quality of service (QoS), fiber delay lines (FDL$_s$), throughput (Th).

1. Introduction

Data traffic in internet and communications have been increasing day by day. In order to fulfill the ever-increasing demand for data various technologies have been developed, optical circuit switching (OCS) is used to fulfill the increasing demand of traffic in data and communications. But OCS provides problems for fluctuations in data traffic. Optical packet switching (OPS) method was developed where statistical method of bursty traffic of packets in which a buffer in the electrical domain was required. But implementing it in optical domain is too immature. By combining the advantages of OCS and OPS a new technology is developed, Optical burst switching (OBS) which has advanced switching technology to utilize the benefits of optical communications. It supports internal protocol (IP) over Wavelength Division Multiplexing (WDM) multiplexing.

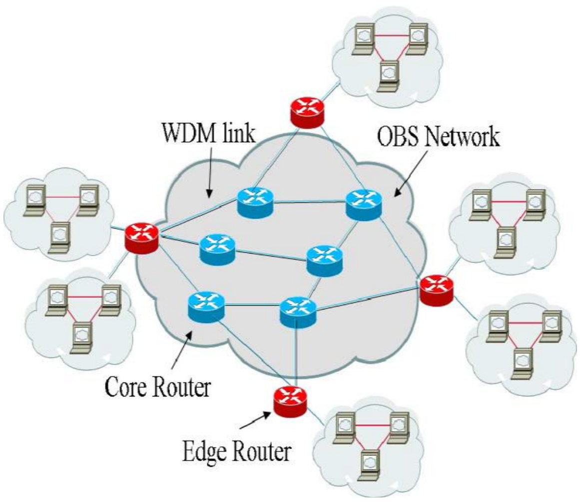

Figure 1: OBS router architecture

Fig.1 shows the OBS architecture. After assembling in the access the packets in the electrical domain as burst of packets, OBS sends bursts with burst header/label over light paths between end-end users. IP router or layer-2 switches are to be used to groom traffic in optical networks to connect optical link with high speed routers.

An OBS networks has many interconnected OBS nodes in which an ingress nodes assembles packets from local access networks in to bursts and sends them in respective control packets (CP). Based on the data traffic at the assembly queue,the electronic buffer changes the characteristics of the data traffic. The packet traffic in a queue has an exponentially distributed inter arrival time with a mean value.

2. Burst Assembly Process and Traffic Load

The long range dependency of the Internet traffic exists in traffic processes and there may be increased data loss and large delays both in low and heavy traffic loads, which degrades network performance and decreases network utilization. In access networks, the algorithm for data packet aggregation into burst will be timer based, and the optical burst is sent when a limit time $t = B/b_e$ is reached, B is the average burst length and b_e=C/G is mean input electrical bit rate. C is output optical bit rate, known as the capacity of the fiber link where G is rate gain factor, and the wavelength holding time t_w=t/G. We consider here time-based assembly algorithm of low and heavy traffic loads [8].

2.1. Low traffic Load ($0 <\rho< \rho_L$)

Actually, in the low traffic load, when one burst is sent out, the assembly queues are always empty and the next burst is started to create after the previous burst is sent out. In the network of packet transport, delays are due to queuing, propagation and transmission. A larger burst having multiple packets may have longer delays due to queuing at the node. In an assembly node, the processing time of a burst includes the time to schedule and transmit the burst. Therefore the delay of the present burst will not be affected by the previous bursts because the traffic statistics only change within the assembly time period. For the larger burst length B (packets/sec) having P_{n+k} number of packets containing in the burst is equal to mxP_{n+k} and the corresponding delay will be T2. Thus, in the lower traffic load region, delay T increases with the increase of burst length B or its equivalent time.

Again, for the relatively lower traffic load, assemble time or delay in burst assembling will automatically increase for the same burst lengths B_1 and B_2. Thus, the delay T_L for burst assembling in the lower range of traffic load may be assumed as given in Eq.(1), where k_1 is constant and B is burst sizes in k-bytes.

$$T_L = k1\ B\ (1- \rho)/C \qquad (1)$$

2.2. Higher traffic Load ($\rho_H < \rho <1.0$)

In the heavy traffic load, when one burst is sent out the assembly queues will not be empty for the next burst to assemble, for which there is delay of the packets . Here the burst size becomes large and its processing time is relatively large compared to the burst inter-leaving time. Thus the departure time of the following burst and the queuing process in the electronic buffer will further change the assembled burst traffic from Gaussian distributed to an almost constant rate process so long there are enough arriving packets in the buffer. Then the assembled traffic may become more like a constant rate and may be followed the similar queuing process of the standard queuing theory. Thus the delay T_H in assembling the burst for higher traffic loads can be written as in Eq.(2). Where $1/\mu$ is the mean packet size in bits, C is the capacity in bps, λ is the mean flow in packets/sec. k_3 is constant and the value is near about unity. S is the assignable lightpaths as servers.

$$T_H = 1/(\mu C-\lambda) = 1/\mu C(1-\rho) = k_2B/C(k_3-\rho)S \qquad (2)$$

3. Burst Reservation Process

Having various burst reservation protocols [4], [7], and in general there are two burst-level control mechanisms for asynchronous transfer mode (ATM) in the exiting protocols for OBS networks, namely tell-and-wait (TAW) and TAG. In TAW, for one burst to transfer from an edge node, it first enquires to reserve the bandwidth of one wavelength from source to destination by sending a request. If all the links along the path becomes free to send the burst, the destination node will send acknowledgment (ACK) to the source to send out the burst immediately; otherwise, a negative acknowledgment (NAK) will be returned to the source and request for retransmission of the burst after a back-off-time and taking the previous bandwidth reservation. In TAG, the source transmits bursts without any bandwidth reservation in advance. An NAK is sent back to the source for any failure of reservation at intermediate node to initiate the retransmission after a back-off time. In comparison of two burst reservation protocols

TAW is suitable over TAG when the propagation delay in the networks is negligible with respect to the burst length time. However, TAG performs better when the propagation delay is significant compared with burst length.

4. Analysis of Throughput in Egress node with multi-inputs and one output channels

For an OBS network with TAG protocol, there may be more than one OBS path passing the bursts in an egress node. For simplicity we consider here three input paths A, B, and C, coming from the core routers 2, 3, and 7, respectively, and the bursts from all the channels will pass in the output path O in OBS core router node number 6 connected by WDM links (Fig. 1). In the optical domain there may be hundreds of WDM channels in all the paths A, B, and C. In the output path all the input bursts coming from paths A, B, and C may pass or some bursts may overlap depending on the burst sizes. Fig.2 shows the trend of bursts of three input channels of sizes B_{1i}, B_{2j}, and B_{3k}, and interarrival time t_{1i}, t_{2j}, and t_{3k}, for the channel-1 (CH-1), channel-2 (CH-2), and channel-3 (CH-3), respectively. And pd_{12} and pd_{13} are the path differences between the first two bursts B_{11} and B_{21}, and B_{11} and B_{31} respectively.

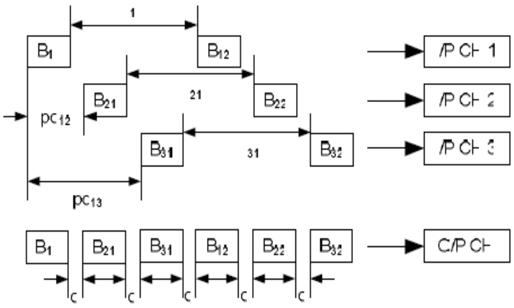

Figure 2: Input burst trends B_{1i} of CH-1, B_{2j} of CH-2, and B_{3k} of CH-3.

So the condition of no burst loss at the one output channel O without FDLs is given in Eq.(3) – (7). Where d is the minimum time gap required between two successive bursts as guard at the output path O, FDL_{12} and FDL_{13} are the required time delays of the fiber used for initial mismatch between B_{11} and B_{21}, and between B_{11} and B_{13}, respectively. FDLs is a set of fiber delay lines or one fiber delay line known as FDL_{max} having number of taps [8]. For the requirement of no burst loss with the condition of Eq.(3) - (5), the Eq.(6) shows that if $pd_{12} < B_{11} + d$, then we require FDL12. Similarly, considering Eq.(7), if $pd_{12} < B_{11} + B_{21}+2d$, then we require FDL_{13}, and $FDL_{13} = 0$ at $pd_{13} = B_{11} + B_{21}+2d$.

$$t1i \geq B2j + B3k + 3d \quad (3)$$
$$t2j \geq B1i + B3k + 3d \quad (4)$$
$$t3k \geq B1i + B2j + 3d \quad (5)$$
$$FDL12 = B11 + d - pd12 \quad (6)$$
$$FDL13 = B11 + B21 + 2d - pd13 \quad (7)$$

5. Simulation Results

In this section we discussed the simulation results.

Table 1. Throughput results for different number of bursts

Total no of bursts (2n)	No of pass bursts (p)	No of lost bursts (l)	FDL_{max} (µs)	Throughput (T_h)
2000	1000	1000	5	0.551724
2000	1000	1000	10	0.571429
2000	1334	666	15	0.711372
2000	1334	666	20	0.727521
2000	1334	666	25	0.7442
2000	1500	500	30	0.8
2000	1500	500	35	0.813559
2000	1600	500	40	0.827586
2000	1600	400	45	0.85333
2000	1600	400	50	0.864865

Table.1 shows the variation of Throughput (Th) for different number of lost bursts and the required FDLmax, when total number of bursts equal to 2000. Where p is the number of bursts passing at the output channel before one burst is blocked or controlled in the server of the electrical domain or in the router of the optical domain at egress node in order to avoid the loss of bursts. Fig.3 shows the simulated results between Path difference (pd_{12}) and maximum values of fiber delay lines (FDL_{max}).

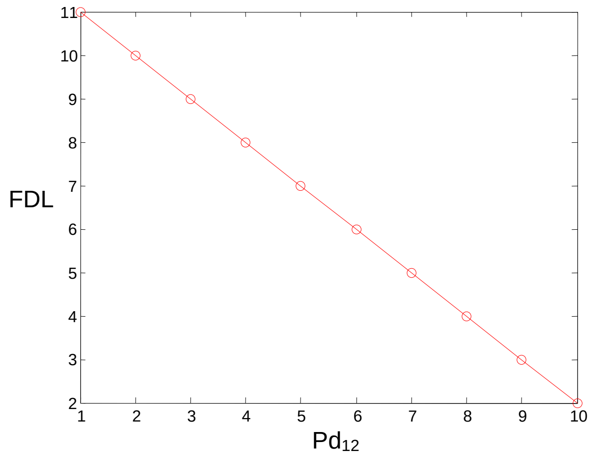

Figure 3. Path difference (Pd_{12}) versus maximum values of fiber delay lines (FDLmax).

Fig.4 shows the simulated results Throughput against the continuous values of FDL_{max}, for two different values of total number of bursts. It clearly shows a very small variation exits for higher values of total number of bursts.

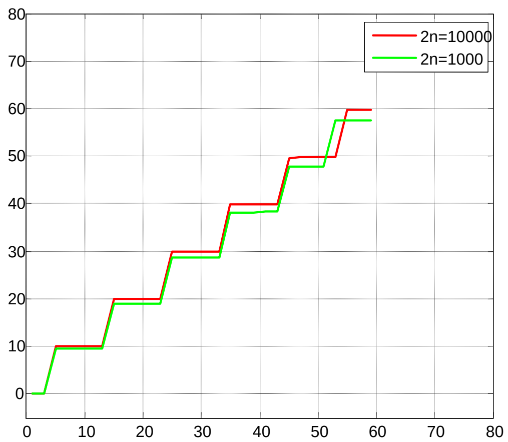

Figure 4. Throughput (T_h) versus maximum values of fiber delay lines (FDLmax) for two values of input burst number.

For channel forwarding to only one channel and receiving from many channels of a core router, there will be priority of input channels. This priority input channels can be obtained by controlling the number of passing bursts (p). For a three inputs and one output node, p=3 and p=4 will execute uniform priority at the input channel. For p=3, one burst will be blocked or controlled in the server of the electrical domain after passing 3 bursts from each input channel of the core router. For p=4, one burst will be blocked or changed the lightpath at the core router after passing 4 bursts from each input channel. Again, p=2 means the blocking of all the bursts in the third input channel and passing all the bursts from the first and second channels. Passing of all the bursts from the first and second channel, but after alternate passing of burst from the third channel occurs for p=5.

So number of passing bursts can be controlled by the parameters of burst size B, inter-arrival time t, and the fiber delay lines FDLs. Fig.5 shows number of passing bursts versus inter-arrival time for different values of FDL with the constant values of B, pd12, pd13 and d =5 µs. The solid lines represent the passing of bursts is repeated whereas the dotted lines are the non-repeated burst trends. Fig.5 shows that the values of p can be changed by t, FDL, and B. Fig.6 shows p versus FDL for two values of B with the constant values of t, pd12, pd13, and d =5 µs. Fig.6 shows that the values of p can be changed by FDL and B.

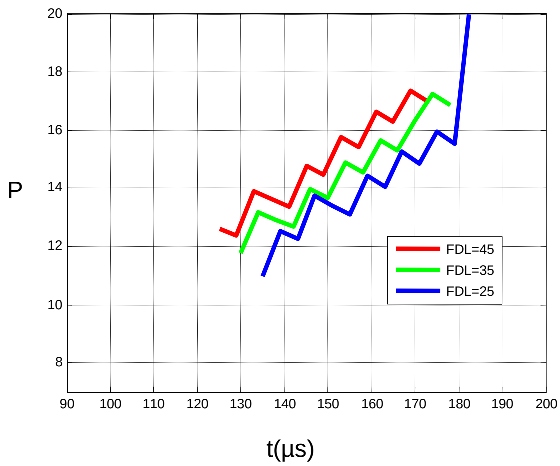

Figure 5. Passing of burst p in the input channels versus inter arrival time t for different values of fiber delay lines (FDL).

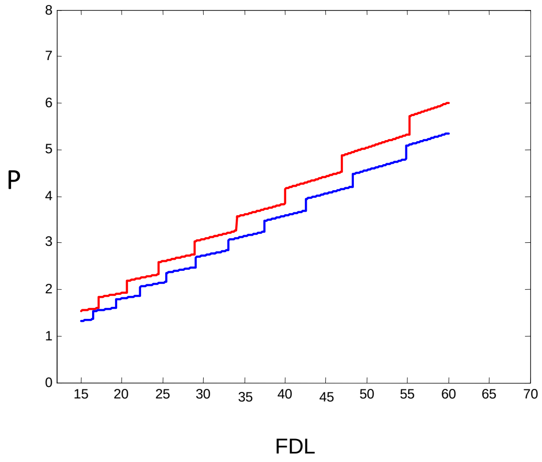

Figure 6. Passing of burst p in the input channels versus fiber delay lines (FDL) for two burst sizes B.

Also we showed that by using different sets of FDLs and with minimum usage of wavelengths burst loss can be reduced. Analysis of throughput with respect to burst size, inter-arrival time, and sizes of fiber delay lines (FDLs), is showed. Improvement of throughput using FDLs is shown. Control of passing of burst in the input channel and hence the priority of the channel depending on the parameters of burst size B, interarrival time t, and the fiber delay lines FDLs is shown.

6. Conclusion

In this paper we showed an algorithm to remove burst overlapping for egress router of optical burst switching (OBS) network at low traffic loads with a TAG protocol. In an egress node of optical domain, for an intermediate node forwarding to only one link and receiving from three links we found the conditions for the burst controls by either passing of all bursts or blocking of some bursts. We found a relation for the burst loss and the throughput depending on burst size, interarrival time, and sizes of FDLs.

7. References

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