Adaptive Data Burst Assembly in OBS Networks

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***Abstract*— To perform an Optical Burst Switching (OBS) network, a lot of challenges are faced that have to be solved. The edge node has to manage burst offset time and burst assembly technique. The core node has to reserve resources to send the data burst, schedule the control packet and data burst and contention resolution strategy. In this paper, we discuss the burst assembly mechanisms and their disadvantages which we will overcome using a new and simple algorithm for data burst generation which relies on changing some characteristics in queuing model in OBS network by taking into consideration the presences of Quality of Service (QoS) for multiple data priorities. The OBS network simulation using our algorithm shows that it adaptively changes the data burst size according to the offered load. So, it can offer high data burst utilization, limits the maximum end to end delay and reduces burst drop rate for high priority packets.**

Keywords* — *Optical Burst Switching; Contention; Burst Assembly; Burst Drop Rate.

I. INTRODUCTION

The upsurge growth of the Internet is resulting in an increased instance for higher transmission rate and faster switching technologies. Switching in core optical telecommunications networks is performed using high speed electronic or all-optical switches. Switching with high speed electronics requires optical-to-electronic (O/E) conversion of the data stream making the switch a probable bottleneck of the network as the transmitting node converts electrical data into optical signal (E/O) conversion and sends it on the optical fiber link. Then, the receiving node converts the optical signal back into electrical domain (O/E) conversion for electronic processing [1, 2].

On the other hand, the all-optical switching is divided into three methods which are Optical Circuit Switching (OCS), Optical Packet Switching (OPS) and Optical Burst Switching (OBS). The optical circuit switching depends on the presence of line of sight light path between the transmitter and the receiver. So, it is not able to keep up with the bursty nature of internet traffic in a functional manner [3]. In optical packet switching, the packets are switched and routed through the network in the optical domain without conversion back to electronics at each node. But, since network resources are not reserved in advance in optical packet switching, packets may experience contention in the network [4].

The third method for all-optical switching is Optical Burst Switching (OBS) which made a revolution in optical networks. In OBS, a control packet is sent first to configure a connection by reserving an appropriate amount of bandwidth and configuring the switches along a route, then a burst of data is sent without waiting for an acknowledgement for the connection establishment. To reduce the burst contention, one has to choose a suitable offset time between control packet and data burst transmission and a suitable data burst size [5].

There are three types of assembly algorithms: timer-based, burst-length-based, and mixed timer-burst-length. In the timer based algorithm, the timer starts at a new assembly period after a fixed time, T. Packets arriving at the egress are aggregated into a burst. The timeout is set with care as long timeout will result in high packet delay and short T will produce many small bursts which lead to overhead in network. For a burst-length-base scheme, the length of the already queued packets surpasses the minimum length. In this strategy, there is not prediction for assembly delay time. The third algorithm mixes between time based and burst-length based algorithm by choosing proper length and time to reduce the delay and overhead on network [6, 7].

In the present work, a new and simple algorithm overcomes the disadvantages of the ordinary bursting algorithms. When the ordinary algorithms yield small bursts, this causes high overhead network processing, and when yield large bursts, this increases the network contention. On the other hand, the proposed algorithm makes the data burst size adaptive to the offered load in the presence of minimum and maximum size thresholds. The proposed algorithm is also characterized by taking into consideration the presence of Quality of Service (QoS) for multiple data priorities. So, in case of high offered load, this algorithm will reduce the end-to-end delay and increase the data burst utilization for high priority packets.

II. CONCEPT OF ADAPTIVE BURST ASSEMBLY FOR SEVERAL PRIORITY CLASSES

The three mentioned algorithms of data burst assembly which are timer based, burst length based and mixed algorithms have a common disadvantage because they depend on fixed time or fixed burst length without taking the offered load and varying in priority classes in consideration which lead to high contention and low burst utilization [8].

In our proposed algorithm, the adaptive burst assembly puts a minimum (BS_{min}) and maximum (BS_{max}) length for data burst as the minimum length does not lead to many small bursts and the maximum length does not lead to high delay. We applied this algorithm to enhance the transmission of high priority packets in the presence of low priority packets in the same fiber link. So, in the edge node, we create two queues: one for the high priority packets (Class 1) and the other is for low priority packets (Class 0). For low priority queue, a mixed-timer-length based assembly algorithm is applied on it and the adaptive burst assembly algorithm is applied on the high priority packets in case of high offered load.

Two transitions are created, Q_{low} which is the minimum number of packets in queue to create a burst and Q_{high} the number of packets queue which can be increased in case of high offered load. The cross-over count number is the common factor between the queue size and the burst size. If the packets in queue reach Q_{high}, the cross-over count number is increased by 1 as shown in Fig.1.

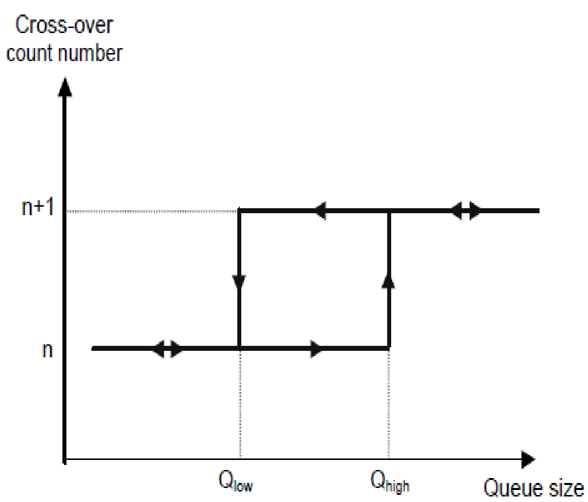

Fig.1 Characteristics of cross-over count number transitions.

To monitor the arrival of input traffic, the data burst-size should be modified accordingly. The burst size is decided either discretely or continuously. Because the function of the control is critical in optical burst switching. We adopt a discrete type burst-size decision algorithm that uses a simple transition method to relax the data burst size adaptation process for arrival input traffic. Figure 2 shows that, when the cross-over count number reaches its upper limit, the burst size in increased by one step [9, 10].

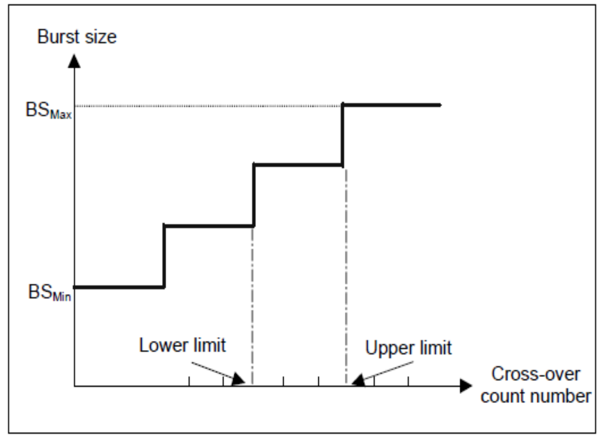

Fig.2 Discrete type burst size decision scheme.

The overall flow diagram for the adaptive data burst assembly algorithm is illustrated in Fig. 3.

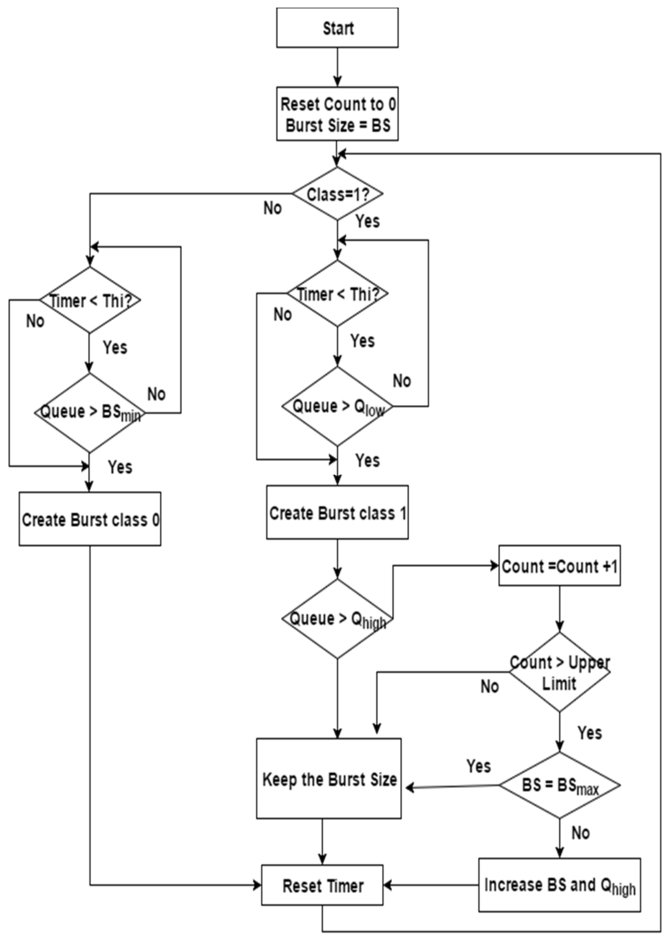

Fig.3 Flow diagram for adaptive burst assembly.

The procedure can be explained as follow.

- A timer starts as soon as the first packet arrives at the queue. Then, it starts to classify the priority of the incoming packet.
- If the packet's priority is low (Class 0) and if the timer value reaches the threshold value, (Thi) or if the timer value is smaller than Thi and the queue size is greater than the minimum burst size, a new burst including class 0 packets is created.
- If the packet's priority is high (Class 1) and if the timer reaches the threshold value (Thi) or if the timer value is smaller than Threshold and the queue size is greater than Q_{low}, a new burst including class 1 packets is created.
- For the high priority packets queue, if the queue size is greater than Q_{high}, the counter number is increased by 1.
- The cross-over count number is compared with the upper limit. If it crosses over the upper limit, the burst size is increased by one step, otherwise, it is not changed.
- Reset the timer to 0 and go back to step 1.

  By this way, the burst size is adaptively changed according to the input traffic to enhance the data burst utilization.

III. SIMULATION RESULTS AND DISCUSSION

A. Simulation Parameters

To evaluate the effect of adaptive burst assembly algorithm, we simulated the algorithm by using NS2 software. We generated TCP traffic from two different sources. The first source generates high priority packets and the second source generates low priority packets with an average value of 800 Byte packet lengths. In the ingress node, we set the default values for BS_{min} and BS_{max} to 50 KB and 800 KB, respectively for high priority packets (Class 1). Q_{low} is set to be the minimum data burst length and the initial value for Q_{high} is 200 KB. After that, it will be variable according to the offered traffic. We set a default value for minimum data burst size for low priority traffic to 50 KB and we assumed that the threshold time is 50 ms for both priority classes as in case of low traffic load. This time will be the maximum time for data burst creation.

To get several and different simulation results, simulation is carried out with different three cases:

- The traffic includes 80% high priority and 20% low priority.
- The traffic includes 50% high priority and 50% low priority.
- The traffic includes 20% high priority and 80% low priority.

We simulated these three cases with several throughputs 20%, 50% and 80% of the fiber link and with two different step sizes for data burst adaptation:

- Step size is equal to 20% of data burst minimum size.
- Step size is equal to 50% of data burst minimum size.

Figure 4 declares the network topology which consists of two transmitter electronic nodes, two optical nodes connected with a fiber link and two receiver electronic nodes.

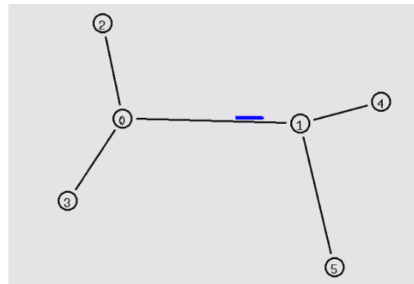

Fig.4 Optical network topology.

B. Simulation Results

The obtained simulation results declare the differences in burst drop rate average number of packets in burst and average end-to-end delay for three simulated cases.

Figures 5-7 show the differences in burst drop rate for simulated cases. As shown, the low priority traffic suffers from high burst drop rate more than the high priority traffic. For high priority traffic, one can notice that in high offered load, Fig.5, the step size cannot make a difference in burst drop rate as both low and high priority suffer from same average burst drop rate. But, when the traffic of high priority decreases, Fig.6, it is found that when the step size is equal to 20% of BS_{min}, the traffic suffers from a burst drop rate slightly more than the traffic which using a step equals 50% of BS_{min}. This is expected because the adaptive burst assembly algorithm which is applied on the high priority traffic reduces the burst contention and hence, the burst drop rate reduces. So, the adaptive data burst assembly algorithm is reliable in applications which need low data drop.

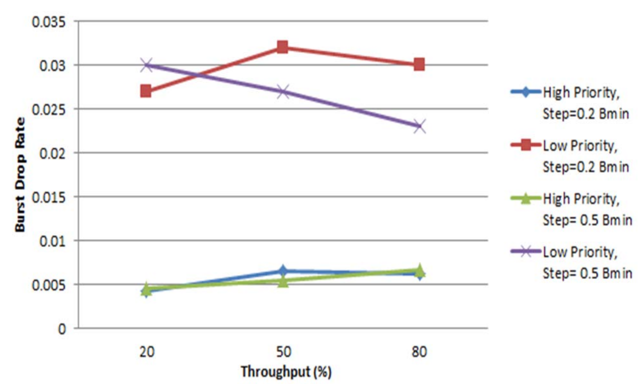

Fig.5 Burst drop rate for a traffic of 80% high priority and 20% low priority.

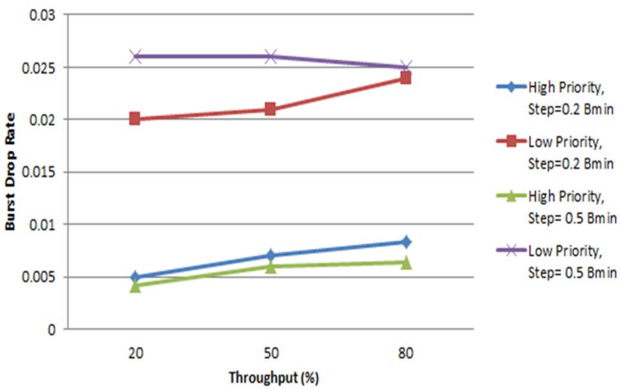

Fig.6 Burst drop rate for a traffic of 50% high priority and 50% low priority.

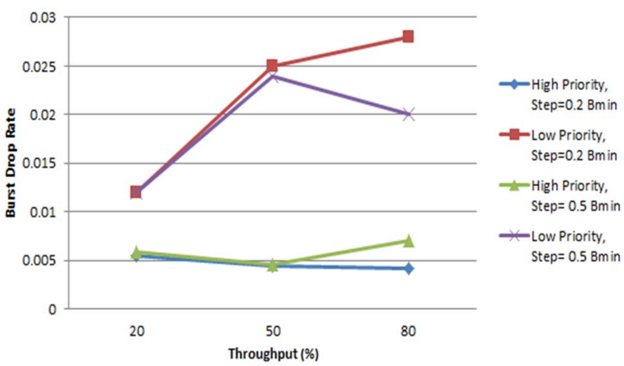

Fig.7 Burst drop rate for a traffic of 20% high priority and 80% low priority.

Figures 8-10 compare the average number of packets in the burst.

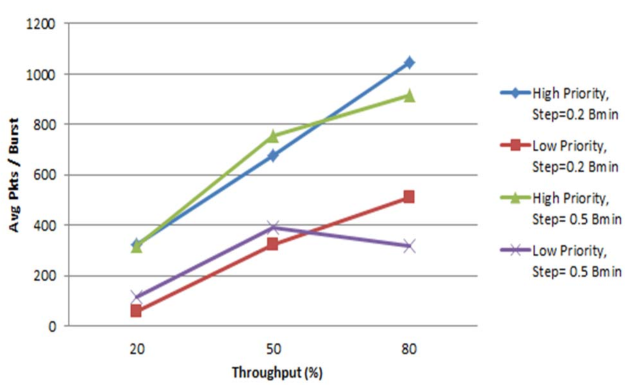

Fig.8 Average number of packets in burst for a traffic of 80% high priority and 20% low priority.

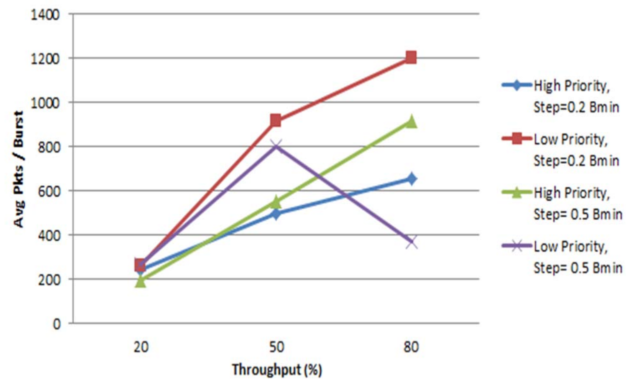

Fig.9 Average number of packets in burst for a traffic of 50% high priority and 50% low priority.

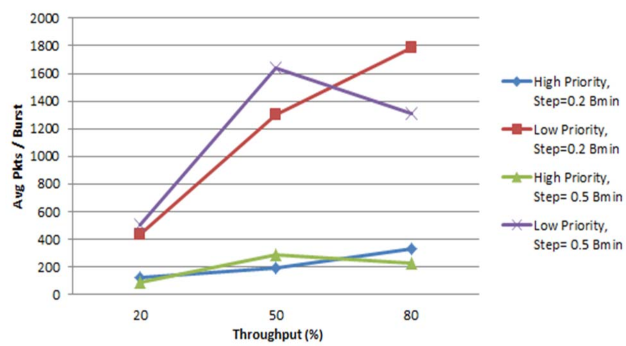

Fig.10 Average number of packets in burst for a traffic of 20% high priority and 80% low priority.

It is clear that, the number of packets in the burst increases with the throughput for the high priority traffic. But, for low priority traffic, in some cases, the number of packets in burst decreases with the throughput due to the time-burst-length-based assembly algorithm which is applied on the low priority traffic. Also, the average number of packets for low priority traffic reaches a high number of packets more than the high priority traffic. As an example, low priority traffic in case throughput 80% of the fiber link reaches 1790 packets per burst but the high priority traffic reaches 1000 packets per burst at the same throughput. This is due to the presence of BS_{max} for high priority traffic to limit the burst length to reduce burst contention.

The average end-to-end delay for the three simulated cases is compared in Figs. 11-13. It is noted that, the low priority traffic has high end-to-end delay in all cases which reaches to 27 ms in case of the traffic that includes 20% high priority traffic and 20% low priority traffic with a step size of 50% of BS_{min}. Also, for high priority traffic, one can notice that the traffic which depends on step size 50% of BS_{min} suffers from high delay more than the traffic which depends on step size 20% of BS_{min}.

So, the adaptive data burst assembly algorithm can be used with lower step size for applications which need low end-to-end delay as voice over IP (VoIP) or video streaming. This is because these applications especially VoIP requires a maximum end-to-end delay of 150 ms. If we have an optical network topology that consists of ten core nodes by maximum end-to-end delay 13 ms per node as shown in Fig. 12, one gets about 130 ms end-to-end delay which is acceptable.

It is also clear that, the adaptive data burst assembly algorithm reduces the burst end-to-end delay for high priority traffic in all simulated cases. This is because this algorithm not only depends on the time threshold and burst length threshold but also depends on the offered load. So, the high priority packets do not wait a lot of time waiting burst creation.

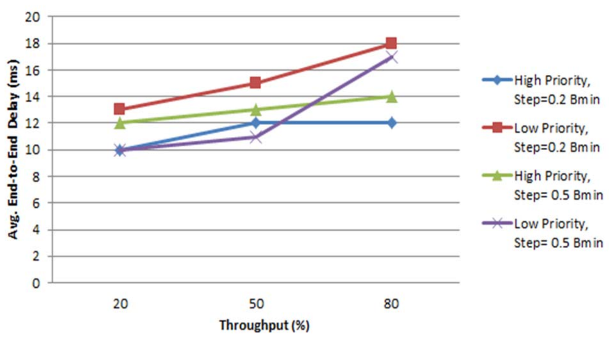

Fig.11 Average end-to-end delay for traffic of 80% high priority and 20% low priority.

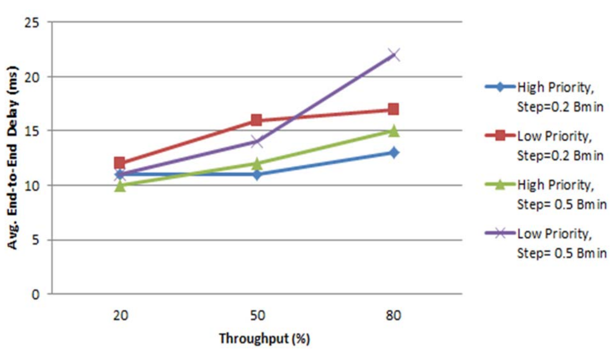

Fig.12 Average end-to-end delay for traffic of 50% high priority and 50% low priority.

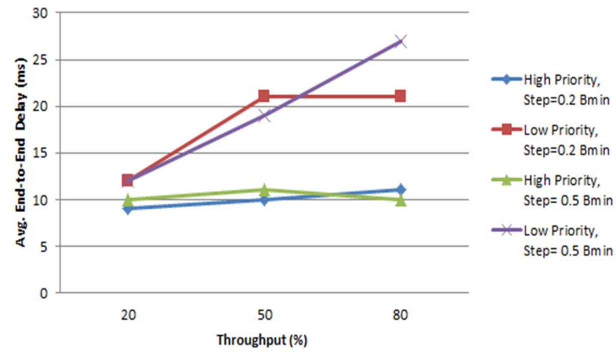

Fig.13 Average end-to-end delay for traffic of 20% high priority and 80% low priority.

IV. CONCLUSION

In this paper, we discussed the core concept of OBS and presented the tasks of ingress, edge and egress nodes. A data burst assembly algorithm is proposed that depends on data burst size adaptation according to the offered load by taking into consideration the QoS for multiple priority classes. We simulated this algorithm with different throughputs and several priority classes with different step adaptation sizes.
Comparing all simulated cases, it is verified that our proposed algorithm changes the data burst size according to the offered load leading to an increase in the data burst utilization. It also reduces the burst contention leading to a decrease in the burst drop rate. Finally, our new algorithm proves that it limits the end-to-end burst delay, increases the data burst utilization and decreases burst drop rate by decreasing burst contention go high priority traffic. So, our proposed algorithm can be used for applications which require low end-to-end delay and low packets drop like voice over IP (VoIP) or video streaming applications.

References

[1] K. Christodoulopoulos, E. Varvarigos, and K. Vlachos, “A new burst assembly scheme based on the average packet delay and its performance for TCP traffic,” Optical Switching and Networking, vol. 4, no. 3-4, pp. 200–212, 2007.

[2] J. P. Jue and V. M. Vokkarane, Optical Burst Switched Networks, New York: Springer, 2005.

[3] V. Kavitha,“New burst assembly and scheduling technique for optical burst switching networks,” Journal of Computer Science, vol. 9, no. 8, pp. 1030-1040, 2013.

[4] D. Veeravanitha, R. Nandhini, and U. Sathya, “Avoid congestion using control packet buffering in optical burst-switched networks,” International Journal of Scientific & Technology, vol. 2, pp. 69-73, 2013.

[5] P. Tuan and M. Hiroyuki, “Performance analysis of optical burst switched networks with limited-range wavelength conversion,

ISBN: 978-1-4673-7503-0 ©2016 IEEE

retransmission and burst segmentation," vol. 52, no.1, pp. 58-74, 2009.
[6] S. Waheed, "Comparing optical packet switching and optical burst switching," Daffodil International University Journal of Science and Technology Daffodil Int Uni J Sci Technol, vol. 6, no. 2, pp. 22-32, 2011.
[7] M. Nasir, S. Habib, and Z.Haroon, "Optical burst switching (OBS): the future switching technology," International Journal of Advanced Research in Engineering and Management, vol. 1, pp.10-15, 2015.
[8] R. Lamba, A.Kumar, "Survey on contention resolution techniques for optical burst switching networks," International Journal of Advanced Research in Computer Science and Software Engineering, vol. 2, no. 1, pp. 956-961, 2012.
[9] S. Y. Oh and M. Kang, "A data burst assembly algorithm in optical burst switching networks," Optical Fiber Communication Conference and Exhibition, vol. 24, no. 4, pp. 311-322, 2002.
[10] J. A. Hernandez, J. Aracil, L. D. Pedro, and P. Reviriego, "Analysis of blocking probability of data bursts with continuous-time variable offsets in single-wavelength OBS switches," J. Lightwave Technol., vol. 26, no. 12, pp. 1559-1568, 2008.