A Novel Burst Algorithm of OBS Metro Ring Networks

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Abstract

This paper studies the impact on burst length and time-out assembly algorithms under guard time effect for variable-size packets in OBS Metro ring networks. The simulation results scales well geographically for metro applications.

***keywords*—CSMA/CA, Burst Assembly, and OBS.**

1 Introduction

As Internet traffic grows rapidly the need for a transmission medium with the bandwidth capabilities for handling such huge amount of information is paramount. Optical communications support up to several hundred channels and the total bandwidth of an optical fiber has reached to several Tb/s. In order to efficiently use the bandwidth at WDM layer, it requires developing the corresponding frameworks and protocols at the high layers.

As IP-oriented data services grow exponentially, fast optical switching has become an important issue. Besides, the switching technology is also an important topic in optical network, and it can be divided into Optical Circuits Switching (OCS), Optical Burst Switching (OBS), and Optical Packet Switching (OPS). OCS is a coarse switching technology; the number of the available wavelength is constrained and the wavelength routing is not the ideal switching paradigm to realize All Optical Networks (AON). To date, many studies of OPS have been carried out, yet some technical obstacles remain to be overcome. OBS was proposed with its advantages and feasibility for practical applications. It is a switching technique that occupies the middle of the spectrum between the circuit switching and packet switching paradigms, borrowing ideas from both to deliver a completely new functionality. In an OBS network, incoming IP traffic is first assembled into bigger entities called bursts. Bursts, being substantially bigger than IP packets are easier to switch with relatively small overhead. This paper will specifies how to design the high performance of OBS Metro ring networks under different guard-time effect based on burst assembly size and time-out assembly algorithms for variable length packets was reported.

2 Experiment

We consider *N* nodes organized in a unidirectional OBS. The ring can be a metropolitan area network (MAN) serving as the backbone that interconnects a number of access networks. Each fiber link between two consecutive OBS nodes in the ring can support *W* wavelengths. Of these, *W* wavelengths are used to transmit bursts, and the control channel is not necessary in our architecture. Bursts travel as optical signals along the ring, without any electro-optic conversion at intermediate nodes. The input packets from LAN are divided into classes for aggregation into bursts. Classes are defined based on destination, class of service, or other criteria. In this study, the classification is done on basis of destination and assumed the packets are uniformly distributed among seven possible destinations.

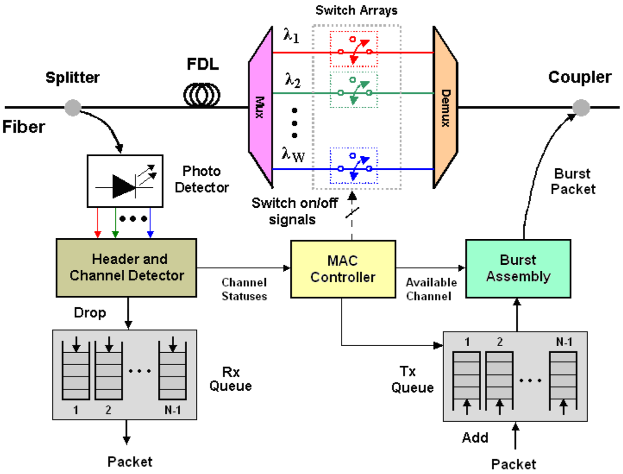

Fig. 1. The OBS node architecture.

Signaling protocol is one of the most important issues for OBS network. Just-Enough-Time (JET) and Just-In-Time (JIT) are two feasible signaling protocols that have been proposed to date [1]. The JIT protocol is adopted in our system because it is relatively simple and easy to be implemented. This article proposes an OBS switching node (Fig 1.) which puts optical burst packets on the ring by using a CSMA/CA [2] MAC protocol, and the contention on the optical burst packet domain is avoided. Each node has *one* tunable transmitter and *W* fixed

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receivers to transmit or receive data on any channel. When the optical signal arrives at FDL, it will be delayed a fixed interval for the address recognition processing, and then may be dropped by adjusting the SOA switching if necessary. The guard time (T_g) distance between two neighboring burst packets should be long enough to cover the maximum switching time of switch (T_s) [3] or the wavelength time (T_w) of tunable transmitter [4] for avoiding burst packet collision when burst packet was added or dropped.

- Burst Assembly Algorithm

Two challenges in designing an OBS network are the burst assembly size and the burst assembly time, which reduces the switching burden and overheads at the optical layer. A typical IP packet is too small to efficiently process for optical networks. The necessary overhead would lead to very low bandwidth utilization. Therefore, incoming packets have to be grouped into bigger burst packet, but the impacts on the burst assembly size at heavy load and the burst assembly time at light load are worthy to study for variable-size packets. Packets wait for transmitting are organized into transmit queues according to their destination. In this paper, the transmit queues are served in longest queue first (LQF) that the highest priority is given to the longest burst queue. Although the burst assembly can reduce the switching burden and overheads at the optical layer, but two possible problems occur in light load and heavy load. First, the burst assembly may be too long before the burst reaches its minimum size limit B_{min} at light load. It can be improved by using the time-out scheme. Second, bursts will be smaller than the maximum burst size limit B_{max} at heavy loads when time-out T_{max} is too small. Therefore, in this paper, we propose a novel to solve above two problems. First we study maximum throughput (P_{max}) based on burst assembly size to find burst ranges B_{min} to B_{max} at heavy load a timeout T_{max} can be used to avoid a long packet delays at light load based on B_{max} that burst assembly sizes cannot smaller than the B_{max} size at heavy load. So, we defined the timeout T_{max} as follow:

$$T_{\max} = \frac{B_{\max}}{(N-1)\times P_{\max}} \tag{1}$$

where

P_{max}: the average maximum throughput per node at heavy load

Therefore, in order to improve the bandwidth under guard time effect. In this paper, the FDL length must to be equal B_{max}+T_g.

$$FDL = B_{\max} + T_g \tag{2}$$

- Simulation and Results

The simulations are done by the SIMSCRIPT II codes. The parameters of simulation are listed in Table 1. The queue length of transmit queues is finite. In all simulations, we assume that:

(1) The P_{max} selected a turning point of simulation curves shown as fig. 2. This turning point represents high performance and low transmission delay.

(2) The packets arrive according to a Poisson process and the arrival rate of the packets at each node is the same. Variable-size packets with a cumulative distribution function measured at Intel data center [5], but the packets would be fragmented when the packet's length larger than 1500 Bytes. Therefore, the mean packet size for this distribution is 353.8 Bytes.

All P_{max} in fig. 3 are approached to 8.47 Gb/s under the condition T_g =0~100ns with W=4 and N=8, and the P_{max} will be 10 Gb/s when W=N=8 except the worst-case of T_g=100ns and B_{min} or B_{max} too short as shown in fig. 4.; in the case, P_{max} approaches to 9.4 Gb/s only. The results show the proposed burst algorithm provides excellent performance. By the above simulations, the upper bound of B_{min} and the lower bound of B_{max} under different T_g had found in Table 2. Afterward, the length of FDL and T_{max} can be calculated in Table 3 by formula (2). Furthermore, more simulations using the FDL in table 3 obtained the average end-to-end transmission delay (T_d) under different T_g with W=4 and N=8, and the results are shown as in fig. 5. The figure shows that T_d has a large value at lighter load; hence the table 4 is derived by formula (1) to solve the problem. In fig. 6, the T_d had decremented at lighter load, and did not affect T_d at heavy load.

Table 1. The simulation parameters.

Node Architecture : TT-FR^W	
Number of Nodes	8 (Fixed)
Number of Channels	4, 8
Light Velocity	$2\times10^8 m/s$
Ring Network Length	100 km
Channel Speed	10 Gb/s
Queue Length	10^5 Bytes
Guard-time (i.e. T_g)	0ns, 4ns, 10ns, 100ns
B_{min}	40~1,000 Bytes
B_{max}	1,000~30,000 Bytes

Table 2. The $B_{min,up\text{-}bound}$ and $B_{max,low\text{-}bound}$ under different T_g with W=4 and N=8.

T_g	0ns	4ns	10ns	100ns
$B_{min,up\text{-}bound}$ (Bytes)	40	280	340	800
$B_{max,low\text{-}bound}$ (Bytes)	22500	25500	27000	28500

Table 3. The superior FDL length based on $B_{max,low\text{-}bound}$ under different T_g with W=4 and N=8.

T_g	0ns	4ns	10ns	100ns
FDL $_{\text{Superior}}$ (Bytes)	22500	25505	27013	28625

Table 4. The T_{max} based on $B_{max,low\text{-}bound}$ under d kg ifferent T_g with W=4 and N=8.

T_g	0ns	4ns	10ns	100ns
T_{max}(ns)	3035.9	3441.4	3645.9	3862.4

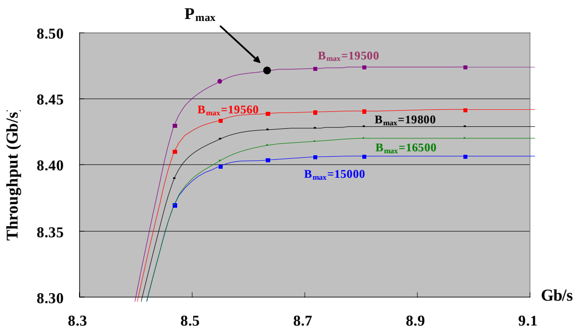

Fig. 2. Throughput per Node with T_g=0ns, B_{min}=200 Bytes.

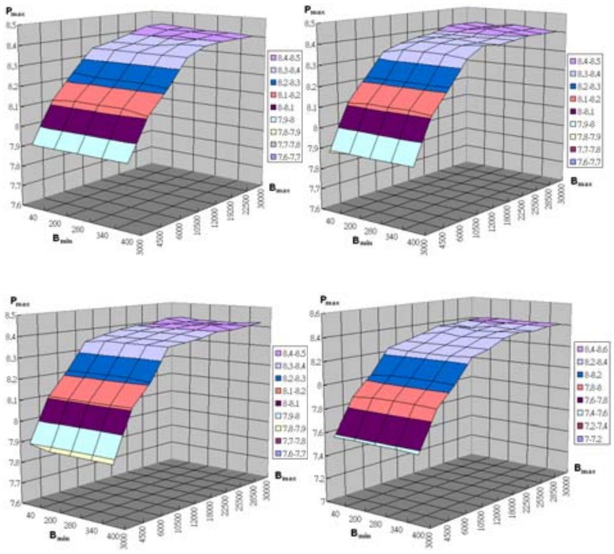

Fig. 3. The relationship of P_{max} between B_{max} and B_{min} under different T_g values with W=4 and N=8.

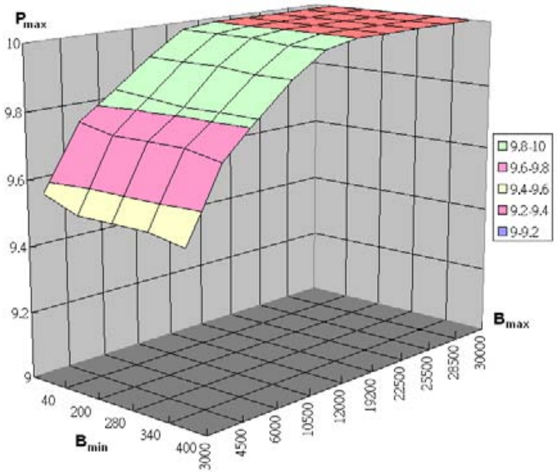

Fig. 4. The relationship of P_{max} between B_{max} and B_{min} under different T_g values with W=8 and N=8.

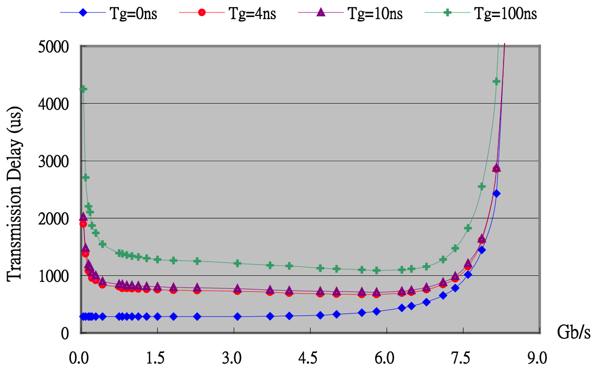

Fig. 5. The average transmission delay under different Tg with no time assembly scheme.

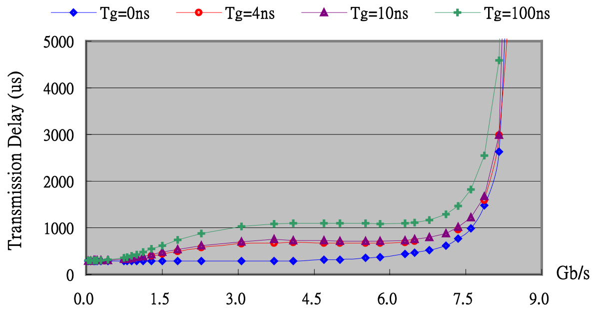

Fig. 6. The average transmission delay under different Tg with added time assembly scheme.

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