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Performance Analysis of Optical Burst Switching (OBS) Network

Sagar H. Sodhatar[1], R. B. Patel[2] and V. J. Dave[3]

[1] **Electronics and Communication Department, L. D. College of engineering**
Ahmedabad-380015, Gujarat, INDIA
sagar.sodhatar@gmail.com

[2] **EC Department, U. V. Patel College of Engineering**
Kherva-382711-Mehsana, INDIA
rbp_ec@yahoo.co.in

[3] **Electronics and Communication Department, L. D. College of Engineering**
Ahmedabad-380015, Gujarat, INDIA.
prof_jvdave@hotmail.com

Abstract

Optical Burst Switching (OBS) is a promising switching paradigm for all-optical WDM networks. It combines advantages of both Optical circuit switching (OCS) and Optical packet switching (OPS) and avoids the disadvantages. Optical Burst Switching (OBS) is a new paradigm where the use of modeling and simulation tools is very important. In OBS there is strong separation between control packet called control burst and data packet called data burst. A control burst is sent in advance, which configures the switches in the path for the data burst. Due to lack of adequate contention resolution technique data burst loss is high in OBS. In this paper we present a complex topology. NS-2 is used as simulation software in this parametric study. The result shows the significant reduction in the BLR.

Keywords: *Optical Burst Switching (OBS), Wavelength Division Multiplexing (WDM), Burst Loss Ratio (BLR), Network Simulator version-2 (NS-2).*

1. Introduction

There has been a phenomenal increase in the demand for bandwidth-hungry applications and services. The increase in demand for bandwidth over the years due to rapid growth in the number of Internet users and increase in bandwidth intensive applications such as voice-over-IP, video conferencing, interactive video on demand, and many other multimedia applications [1]. To meet the ever growing demand of bandwidth, copper cables were replaced by optical fibers in both the access networks as well as in the backbone networks [2].

Optical data communication has been acknowledged as the best solution to meet the present bandwidth requirement of users and supporting future network services. This is because theoretically optical fiber has the ability to support bandwidth demand up to 50 THz. Light wave has higher frequency and hence shorter wavelength, therefore more bits of information can be contained in a length of fiber versus the same length of copper. Apart from this, optical fiber provides extremely low bit-error rate of the order of 10^{-12}. Optical signals are immune to electrical interferences. Fiber cables are much more difficult to tap than copper wires, so there is a security advantage in optical communication.

The first generation optical networks, fibers were used as point-to-point connections. The entire bandwidth available for transmission was not fully exploited. This is because electronic equipments operate at an order of gigabits per second, whereas the fiber has a bandwidth of terabits per second. This mismatch between electronic speed and the optical bandwidth is called electronic bottleneck. Representative of first generation optical networks are SONET/SDH. In second generation Wavelength Division Multiplexing (WDM) technology were deployed to overcome the problem of electronic bottleneck. WDM is the optical version of frequency division multiplexing (FDM). WDM divides the available bandwidth of a single fiber into a number of non-overlapping wavelength channels. Each of the wavelength channels operate at the electronic speed. Several signals are transmitted at different wavelengths in a single fiber at the same time. Thus, WDM encapsulates many virtual fibers in a single fiber. The main advantages of WDM technology are transparency, scalability and flexibility.

2. OBS Fundamentals

To carry IP traffic over WDM networks three switching technologies have been studied: optical circuit, packet switching and burst switching. Optical circuit switching and packet switching have their own limitations when applied to WDM networks [3]. Circuit switching is not

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bandwidth efficient unless the duration of transmission is greater than the circuit establishment period. It is shown that establishment of circuits (lightpaths) in optical networks is an NP-hard problem [4-6]. On the other hand packet switching is hop-by-hop store and forward scheme and needs buffering and processing at each intermediate node [7]. It is flexible and bandwidth efficient. However, technology for buffering and processing in optical domain is yet to mature for this scheme to be commercialized [8, 9]. Fiber delay lines (FDL) have been proposed in literature to provide buffering. However, FDL have limited buffering capability and support only for a fixed duration [10]. In this context optical burst switching (OBS) [11-15] is emerging as the alternative switching techniques, which combines the advantages of both circuit switching and packet switching. OBS needs no buffering and ensures efficient bandwidth utilization on a fiber link by reserving bandwidth only when data is actually required to be transferred through the link.

In OBS, a burst is the basic switching entity. Burst is a variable length data packet, assembled at an ingress router by aggregating a number of IP packets, which may be received from a single host or from multiple hosts belonging to the same or different access networks. A burst has two components: control and payload [16, 17]. The control packet carries the header information. Thus, the control component incurs an overhead, referred to as control overhead. Payload is the actual data transmitted. In OBS control and payload is decoupled. Control is sent on a control channel and payload/ data on data channels. Control packet is sent first followed by the payload on a separate wavelength channel after an offset time equal to the processing time of control packet at intermediate node. Control packet is processed electronically at each intermediate node and reserves resources for a period starting from the time the payload/ data burst is expected to arrive at the node until the transmission is completed. If reservation is successful the control packet is transmitted to the next node on the path, else it is dropped at the node. For a successful reservation, switches are configured by the time payload/ data burst arrive at the node. Hence the data burst remains in optical domain from source to destination. OBS uses one-way reservation schemes. We summarized the important properties of OBS as below.

- Payload (data burst) and header (control packet) are transmitted on different channels.
- Data bursts are of variable length.
- Payload follows the header after an offset time equal to the sum of processing delay of control packet at each intermediate node.
- Header undergoes optical-electronic-optical (O-E-O) conversion at each intermediate node.
- Payload remains in optical domain from source to destination.
- Uses one-way reservation scheme.
- Resources are reserved for a fixed duration and are release implicitly.
- No buffering of payload at intermediate nodes.

Comparison of switching technology is given Table-1 [18].

TABLE-1

Switching	Bandwidth Utilization	Optical Buffering	Overhead	Adaptively
Circuit	Low	Not required	Low	Low
Packet	High	Required	High	High
Optical burst	High	Required	Low	High

A major concern in OBS networks is high contention and burst loss due to output data channel contention, which occurs when multiple bursts contend for the same outgoing wavelength at the same time. Contention is inevitable for an OBS network, which assumes that there is no optical buffer in the core nodes. The contention can affect the network performance dramatically in terms of loss ratio and delivery rate. Each discarded burst causes a wasted bandwidth and decreased throughput. Contention is worsened when the traffic becomes bursty and when the data burst duration varies and becomes longer. In this paper we present a complex topology. We reduced the BLR to a significant level by changing the simulation parameters.

3. Proposed Algorithm

Bandwidth greedy multimedia applications are being developed continuously [19], such as e-health, e-education, e-administration, IPTV, video conference, and others. OBS is the promising technology to meet these high demands. However, OBS still suffers from performance problems. Therefore, in this paper, we propose a scheme in which BLR is reduced in OBS networks. Figure 2 depicts the flowchart of the proposed solution and it is briefly described as follows:

- Create a topology having more than 7 nodes.
- Place the nodes in X-Y Plane according to your topology.
- Establish connection between the source and destination nodes.
- Attach the agent to node which will communicate on the behalf of particular node.
- Attach traffic source to node which will generate the real time load (or data).

- Start the simulation process. Start and stop time of the simulation process is defined by the user.
- When the simulation process is complete, NAM and TRACE file has been created by the software.
- NAM file provides the visualization of the topology created.
- TRACE file provides the real time statistical data of the topology created.
- We will collect data in appropriate form using AWK file in store it in text file.
- Plot the data stored in text file using XGRAPH or GNUPLOT function.
- Change the simulation parameter of the topology created and gets the results.
- Compare the results of same topology with different parameter.

4. Simulation Scenario

To evaluate the proposed scheme, ns-2 simulator is being used where our constraints and parameters are to be integrated. The network to be simulated is depicted in Figure 1. This network, we are proposing having 12 nodes. The nodes are connected by duplex links. We attach TCP agents to the transmitting node and TCPSink agents to the receiving nodes. The TCP sender sends data to TCPSink agent and processes its acknowledgments. The TCP agent does not generate any application data on its own; instead, the simulation user can connect any traffic generation module to the TCP agent to generate data. Two applications are commonly used for TCP: FTP and Telnet. FTP represents a bulk data transfer of large size, and telnet chooses its transfer sizes randomly from tcplib. These applications work by advancing the count of packets available to be sent by a TCP transport agent. The actual transmission of available packets is still controlled by TCP's flow and congestion control algorithm. To produce congestion we transmit data from two different nodes and receive data at the same node. In this network, we have two nodes which face congestion. These nodes are node-0 and node-4. Node-1 and node-2 are transmitting data to node-7 via node-0 at the same time node-3 and node-5 transmitting data to node-6 via node-4. Hence, congestion is inevitable at both of these nodes. So, we monitor the link between node-0 and node-7. Simulation time is taken 5.0s. Traffic source attached to nodes 1, 2, 3, and 5 start transmitting data at 0.1s and stop at 4.0s of the simulation time.

The bandwidth of the links between n0-n1, n0- n2, n0-n3, n1-n2, n1-n3, n2-n3, n2-n5, n3-n4, and n5- n4 is 500Mb. We are interested in the bandwidth of the link between the nodes n0-n7 and n4-n6. Another parameter, we are interested in is "window size" of the transport agent. TCP implements a window based flow control mechanism.

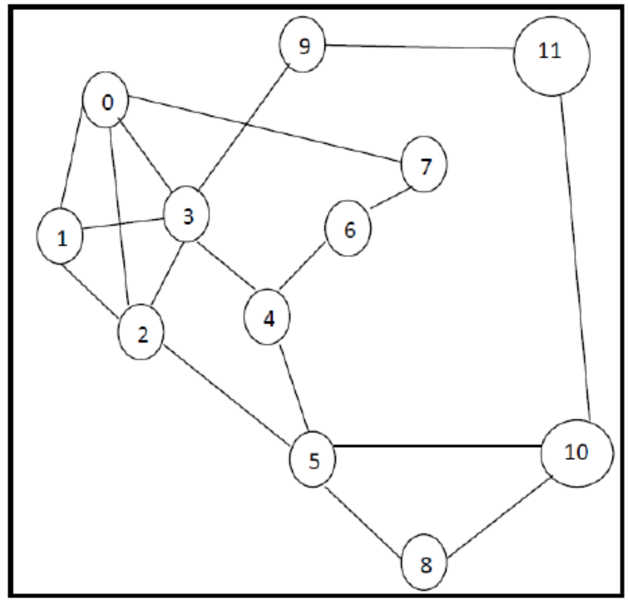

Fig. 1 Simulation network diagram

Roughly speaking, a window based protocol means that so called a strict upper bound on the amount of unacknowledged data that can be transit between a given sender-receiver pair. We get the faithful results after changing the bandwidth of the link between nodes n0-n7 and the window size of transport agent connected to node n1 or node n2. We continue the discussion in the following section.

5. Numerical Results

As discussed in previous section, in this simulation study we change the bandwidth and the window size of the transport agent. We define a parameter BLR as the ratio of packets dropped to packets received. Aim of this paper is to reduce the BLR. We first consider the bandwidth of link between the nodes n0-n7 is 100Mb. The simulation results have been shown below. Fig. 3 shows the graph of BLR v/s Packets received. Now, we change the bandwidth of the link. We increase the bandwidth to 300Mb. BLR is reduced to significant level.

It is quite obvious that as we are increasing the bandwidth, the numbers of received packets are also increased. Hence, the BLR is reduced. The result is also supported by the other two graphs. The first one is Packets dropped v/s Time and second one is packets received v/s Time. The

BLR is also reduced by reducing the window size of the transport agent.

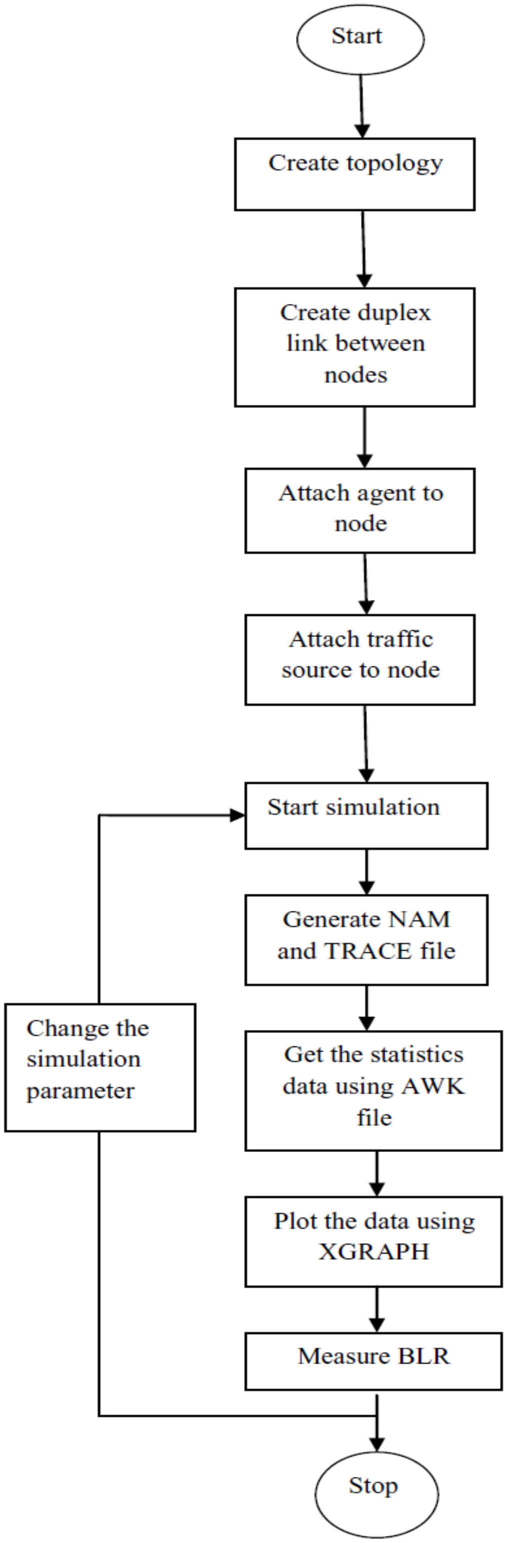

Fig. 2 Flow Chart of the Proposed Algorithm

We are considering two different values of window size. First we take window size as 100. As we already discussed that window size is concerned with the amount of unacknowledged data. Hence, higher the value of window size results in higher number of dropped packets. So, BLR also increased. Opposite to that if we decrease the window size, the number of dropped packets decreased and BLR also decreased. The simulation results have been shown below.

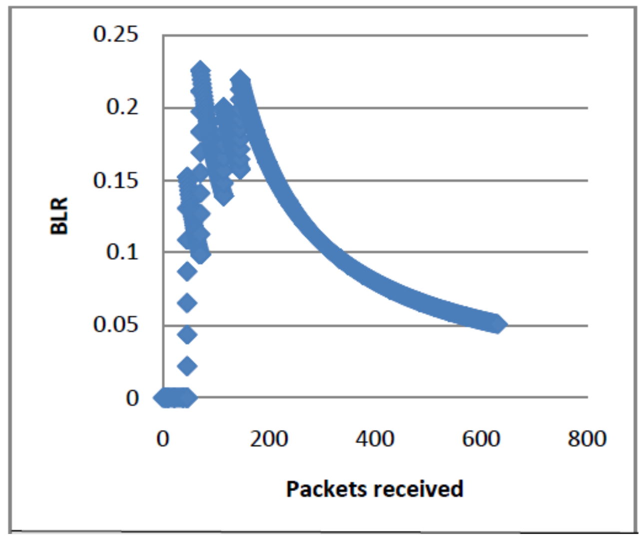

Fig. 3 BLR v/s packets received with bandwidth 100Mb

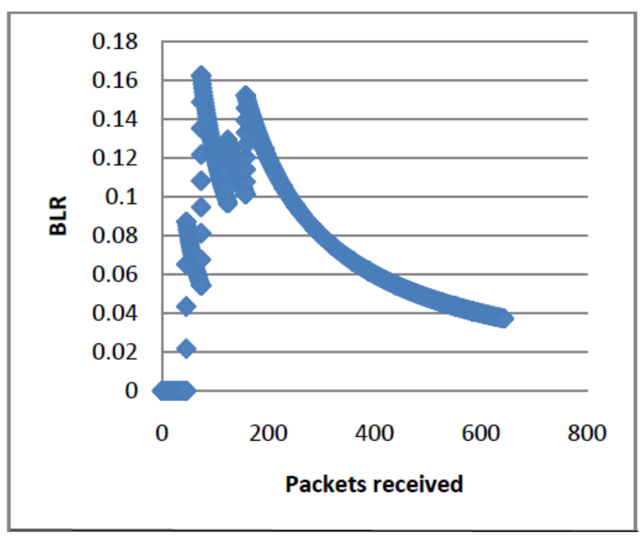

Fig. 4 BLR v/s packets received with bandwidth 300Mb

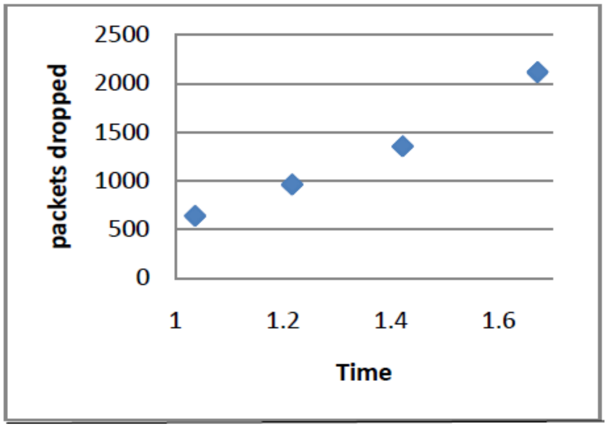

Fig. 5 packets dropped v/s time with bandwidth 100mb

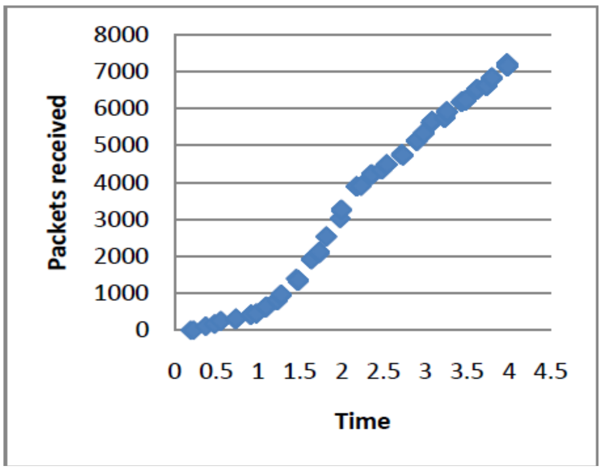

Fig. 6 packets received v/s time with bandwidth 100mb

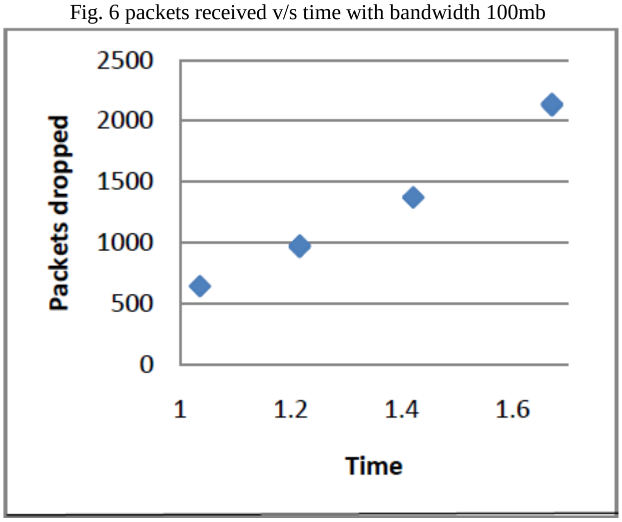

Fig. 7 packets dropped v/s time with bandwidth 300Mb

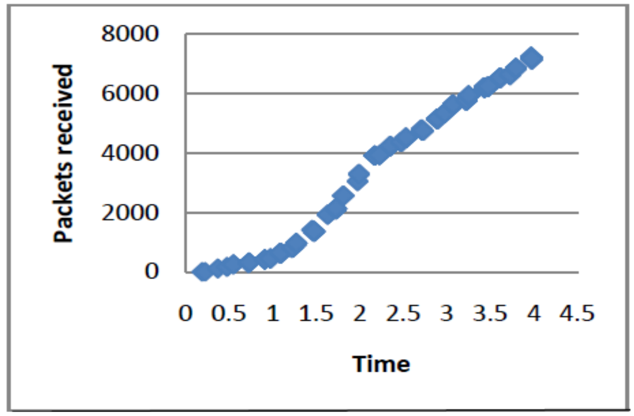

Fig. 8 packets received v/s time with bandwidth 300mb

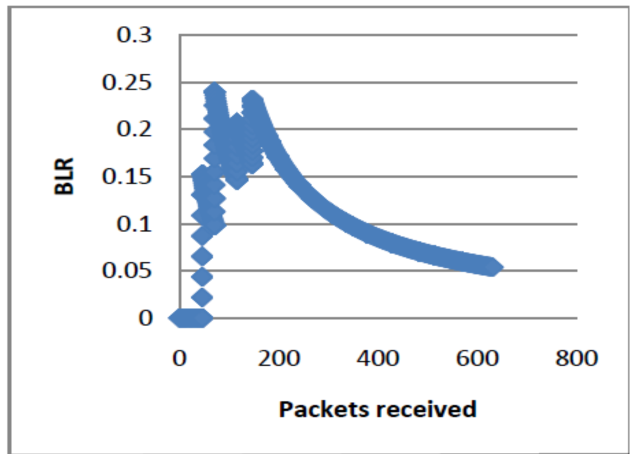

Fig. 9 BLR v/s packets receivd with window size 100

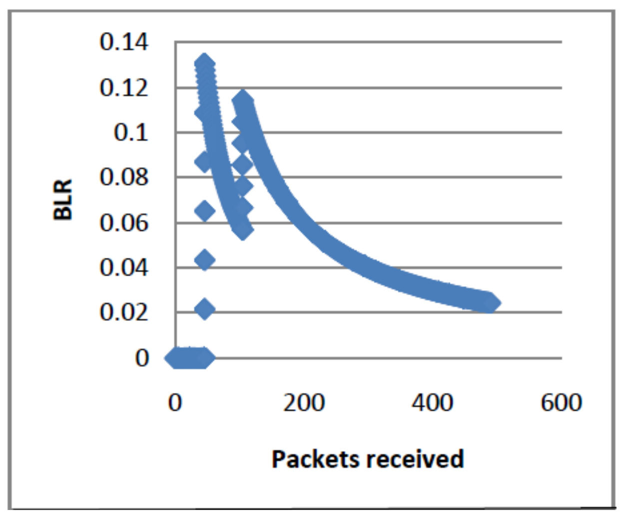

Fig. 10 BLR v/s packets received with window size 30

6. Conclusions

In this paper, we propose an algorithm in which BLR is reduced in OBS network. Results show that BLR is reduced to 72% by changing the bandwidth of the congested link from 100Mb to 300Mb and change in the window size of the transport agent of node n1 and node n2 will result in the reduction of the BLR up to 55% in the OBS network.

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Sagar H. Sodhatar has completed has B.E. (E. C.) in 2009 from, A. D. Patel Institute of Technology, Sardar Patel University, Vallabh Vidhya Nagar. He is pursuing his M. E. (CSE) in Communication System Eng. From L. D. College of Eng., Ahmedabad, Gujarat Technological University. His area of is Optical Burst Switching.

Rohit Patel is Associate Prof at U. V. Patel College of eng. He has more than 5 years of teaching experience. He has completed his M.tech (Laser Technology) form IIT-KANPUR. His area of interest is Optical Communication and Telecommunication.

Prof J. V. Dave is principal of Government Eng. College, Gandhinagar. He has more than 30 years teaching experience. He has held various positions like advisor at GUJCOST, Chairman of IETE, Ahmedabad centre. He has guided more than 100 P.G. students. His area of interest is Optical and Microwave Communication.