Configuration of Offset Time in Optical Burst Switching Networks for Delay Sensitive Traffic

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***Abstract*— In Optical Burst Switching (OBS), the Burst Header Packet (BHP) is sent prior to the burst payload. The time gap between the BHP and payload is referred as offset time. The initial offset value is set by the ingress node and depends upon the processing time of BHP at core node and number of hops between ingress and egress pair. As the BHP propagates through the intermediate nodes, the offset value reduces at each hop by the amount the BHP spends at each node. This offset value is kept sufficiently large in order to allow the intermediate nodes to configure themselves before the burst arrival. The decision for the optimum offset value is not trivial and is important parameter for delay sensitive traffic. The small offset values result in burst loss due to insufficient remaining time between BHP and burst arrival to configure the switch while large offset values reduces the burst loss but increases the average packet delay. In this paper we study the effect of offset value on burst loss probability. The input and output queuing delay for BHP at core nodes effects the burst loss probability and is crucial factor for computing the offset value at an ingress node as these values vary with traffic intensity.**

***Index Terms*—Optical burst switching; Burst header packet; Fiber delay lines;**

I. INTRODUCTION

An enormous growth in internet traffic in recent years has been the reason for increased network capacity. The need for large bandwidth demanded new high speed transmission and switching technologies. WDM has emerged as a most viable transmission technology to cater to the demand of increasing network capacity. WDM supports large number of high speed channels on a single fiber, thereby offering enormous bandwidth at the physical layer. The large mismatch in electronic switching technologies and optical transmission has been the bottleneck in effectively utilizing the advantages of WDM. To overcome this bottleneck optical switching technologies like optical circuit switching, optical packet switching and optical burst switching were proposed.

A. Optical Circuit Switching

This is implemented by establishing all-optical lightpaths between the pair of ingress and egress nodes using wavelength routing capability of the optical layer [1]. The establishment of lightpath involves several tasks like topology and resource discovery, routing wavelength assignment, and signaling and resource reservation. However, it gives efficient utilization of bandwidth only if transfer of data happens for longer time duration than the set-up time of lightpath.

B. Optical Packet Switching

Packets are switched and routed independently throughout the network without O/E/O conversion [2]. At intermediate nodes, packets are kept in optical domain alongwith the conversion of tapped copy of header to electronic domain to take appropriate routing decisions. Optical packet switching offers greater degree of statistical multiplexing gain than optical circuit switching (OCS) and is better suited for bursty traffic. Unfortunately there are certain crucial limitations to its implementation. One major challenge is the non availability of optical RAMs. The payload needs to be buffered for the time taken by the header processing and switch configuration. The only way to achieve optical buffering is fiber delay lines (FDLs) which can only provide limited delay because large lengths of fiber are needed for more delay. This degrades the signal quality and also requires more space to house the fiber. Another major challenge is the synchronization which is difficult to achieve. Also the increase in traffic increases the processing overhead as more headers need to be processed per unit time.

C. Optical Burst Switching

To cope up with the electronic bottleneck and implement all-optical switching Optical Burst Switching (OBS) which combines OCS and OPS was proposed. OBS avoids buffering and packet processing in the optical domain and reserves bandwidth on demand [3].

Optical Switching Paradigm	**Bandwidth utilization**	**Setup Latency**	**Switching Time**	**Processing/ Synchronization Overhead**	**Traffic Adaptivity**
OCS	Low	High	Slow	Low	Low
OPS	High	Low	Fast	High	High
OBS	High	Low	Medium	Low	High

II. OBS NETWORK ARCHITECTURE

The OBS network consists of core network and client network as shown in figure 1. The edge routers lie on the boundary of core network and act as an interface between core network and client network. The main tasks of edge routers are packet aggregation, burst assembly, formation of burst header packet (BHP) and scheduling of bursts [4]. The nodes in the core network are known as core routers and are responsible for switching of burst in all-optical domain and handling contentions.

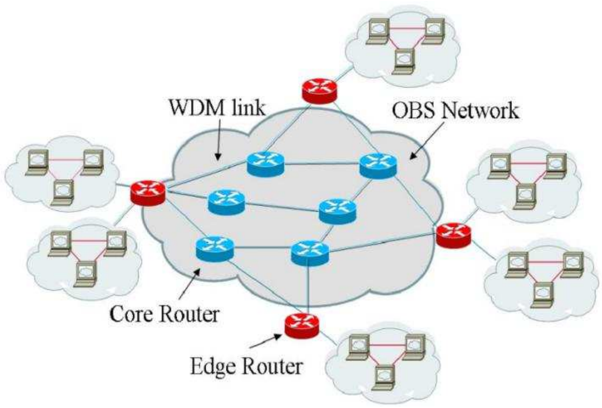


Figure 1. OBS Network Architecture

In an OBS network, at the *ingress* node, the packets arrive from different traffic sources. The packets which are destined to the same *egress* node are aggregated into a single data burst which is transmitted entirely in optical domain. To avoid buffering and processing of optical data bursts at the intermediate *core nodes*, a Burst Header Packet (BHP) with the information about the corresponding data burst is sent in advance. At the egress node, the received data bursts are disassembled into IP packets and are forwarded to their respective destination client networks.

The implementation of OBS network infrastructure involves following major tasks.

- Burst Assembly
- Burst Scheduling
- Contention Resolution
- Signaling Scheme

BURST ASSEMBLY

Burst assembly determines when and how to assemble the incoming data packets into burst. The assembly schemes can be broadly classified into timer based scheme and size based scheme [5]. In timer based scheme data bursts are created after the assembly timer value of the ingress node expires. The BHP's are sent into the network at periodic intervals. The burst length depends upon the timer value and traffic load. In size based schemes the bursts are formed when burst length reaches the particular threshold set by the ingress node. The BHP's are sent at non-periodic intervals and the bursts from an ingress node are of fixed length.

BURST SCHEDULING

Burst scheduling occurs at ingress node as well as core node. Scheduling involves assignment of data wavelength to the burst on an outgoing link. The scheduling algorithm searches the suitable channel and allocates it for the burst. The scheduling algorithms are mainly classified as void filling such as HORIZON and non void filling algorithms such as LAUC-VF [6].

BURST CONTENTION

Contention occurs when more than one burst are destined to the same output port on same wavelength channel at the same time. There are various policies to resolve the contention [7].

A) *Optical Buffering*
   The incoming burst is buffered using fiber delay lines (FDL's) until the channel is available for the burst.
B) *Wavelength Conversion*
   The contending bursts are scheduled on different data wavelengths. All optical wavelength conversion is assumed at nodes.
C) *Deflection routing*
   The contending bursts are routed to different output ports following different routes.

SIGNALING SCHEMES

The reservation of resources and configuration of switches for a burst depends upon signaling scheme implemented. Signaling scheme can be broadly classified into one-way and two-way signaling. In one-way signaling bursts are sent following the BHP without waiting for acknowledgment. In two-way signaling the ingress node sends the burst after receiving the positive acknowledgment from the egress node. The BHP informs the intermediate node along the route, about the bursts arrival and request for resource reservation. In TAG the resources are reserved as soon as the BHP arrives and bursts are buffered at each node for the processing of BHP. In TAW BHP reserves the resources along the route and if the reservations are successful at each intermediate node then a positive acknowledgment is sent back to ingress node. The ingress node sends the burst after receiving the acknowledgment otherwise it attempts for retransmission. Depending upon the time when the reservation is made for the burst the signaling is classified as immediate reservation or delayed reservation. In immediate reservation such as JIT resources are reserved immediately after the arrival of BHP [8]. In delayed reservation scheme such as JET reservation is made just before the burst arrival [9]. In JET there is time gap between BHP and burst sending known as offset time as shown in Fig 2.

Figure 2 Offset Time in JET signaling Scheme

The offset time is set in such a way that processing of BHP is complete at all the nodes and connection between the desired input and output port is established before the arrival of corresponding burst. Thus bursts are transmitted without buffering them at intermediate nodes [10].

In this paper, the study of impact of offset time is carried out.

III. CONFIGURATION OF OFFSET TIME

The offset time depends upon number of hops between ingress and egress nodes, processing time at each core node and switch configuration time.

$$T_{offset} \geq (N_{hops} * T_{PROC}) + T_{OXC}$$

The processing time of BHP (T_{PROC}) comprises of O/E/O conversion time, burst scheduling time and queuing time at input and output of the switch. The queuing time of BHP varies with traffic intensity. Thus T_{PROC} time also varies with traffic load at each node.

The average packet delay in case of timer based assembly scheme is $D_{TA} = (T/2) + T_o$ where T is assembly time and T_o is offset time. For size based scheme the average packet delay is $D_{SA} = (S/2\lambda) + T_o$.

The average packet delay depends upon offset time. For delay sensitive traffic such as video traffic, VOIP etc. the average packet delay should be kept as minimum as possible.

The large offset time increases the packet delay while short offset time results in burst losses due to insufficient offset time as shown in Fig. 3.

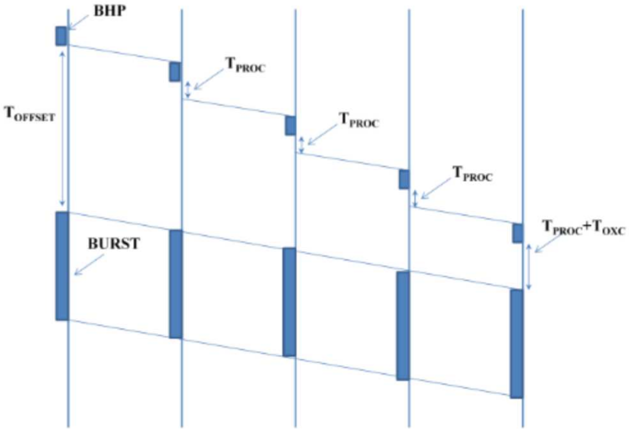


Figure 3 Offset value for successful Burst Transmission

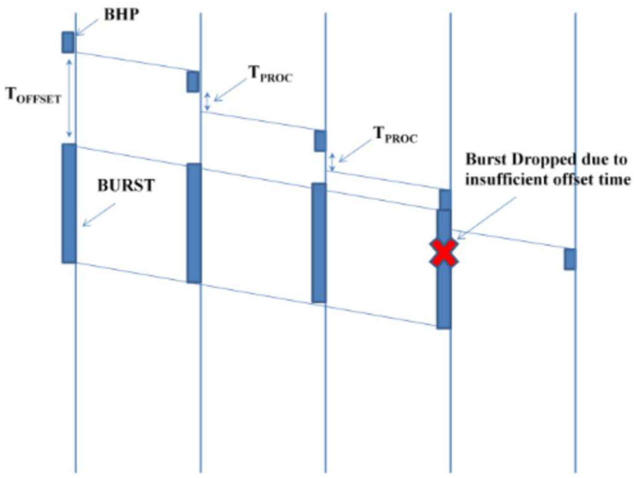
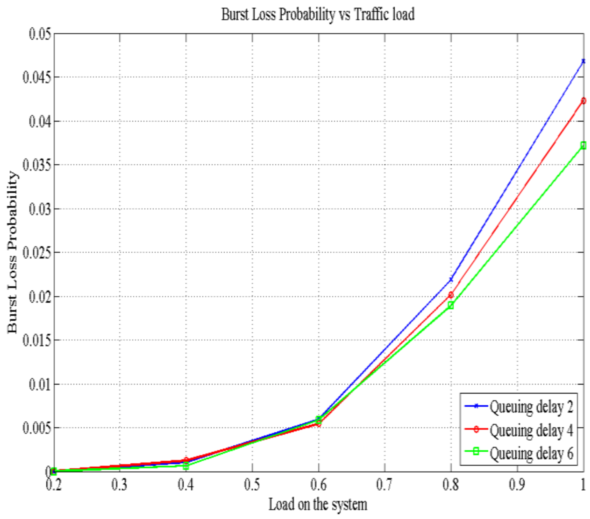


Figure 3 Burst Dropping due to Insufficient Offset time

For delay sensitive traffic large packet delays are not desirable thus there is a tradeoff between burst losses and average packet delay if fixed value of offset value is applied in all traffic scenarios.

IV. Results And Discussion

In this section the simulation results are presented that shows the burst loss probability for different offset time values. NFSNET topology of 14 nodes was used for the simulation. Our simulation model assumes that 4 data wavelengths are available at each node having 2X2 ports and each port has a 1Gbps transmission rate. Three different values of offset times were used having queuing delays of 2, 4 and 6 time slots. Fig 3 shows the blocking probability versus offered load. It is seen that blocking of bursts due to insufficient remaining offset time at higher load is reduced by increasing the offset time.



V. Conclusion

In this paper the study carried out shows the effect of offset time configuration on burst blocking probability. The burst blocking probability decreases at higher load values if offset values are large. The offset values need to be increased at ingress node due to increase in queuing delay at higher load values. Instead of fixed value, dynamic offset time values for various traffic scenarios need to be considered which will result in different average packet delays for different traffic scenario. A study on various other factors that influence the burst blocking probability and average packet delays such as assembly time, scheduling time will be considered in our future research work.

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