Optical Burst Switching (OBS): A New Area in Optical Networking

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***Abstract*—** **The Optical Burst Switching (OBS) is a growing result to the technology issue that could achieve a feasible network in future. They are featured with the ability to meet the bandwidth requirement of those applications that demand intensive bandwidth. There are more domains opening up in the OBS that clearly shows their advantages and their capability to face the future network traffic. However, the concept of OBS is still far from perfection facing issues in case of security threat. The transfer of optical switching paradigm to optical burst switching faces serious downfall in the fields of Burst aggregation, routing, authentication, dispute resolution and quality of service (QoS). Optical Internet has become the main conduit for all types of virtually sharing communications around the world as it continues its phenomenal growth of in traffic volumes and reaches using dedicated optical routers. Optical burst switching (OBS) is a predominant switching technology for Optical network to cater the huge bandwidth demand.**

Keywords*— *Jet-Enough-Time (JET), Jet-In-Time (JIT) Buffering of Optics, Conversion of wavelength.

I. INTRODUCTION

Today's internet requires huge bandwidth for accessing and downloading data. Optical network supports huge bandwidth and provides transmission of data at a faster rate than the conventional networks. But we need to exploit the fiber's huge bandwidth. This can be achieved through Time Division Multiplexing (TDM), Code Division Multiplexing (CDM) or Wavelength Division Multiplexing (WDM). CDM chip rate and TDM bit rate are very high when compared to electronic processing speed of an end user's network interface. Therefore WDM is more attractive than CDM and TDM because of no such requirement. For long haul communication, WDM is the current favourite multiplexing technology in Optical communication networks. Wavelength Division Multiplexing (WDM) divides the available wavelength of a fibre into number of non overlapping wavelength channels each operating at electronic speed. Using the WDM technology, multiple WDM channels from different end-users may be multiplexed on the same fibre.

II. OBS ARCHITECHTURE

In optical burst switching (Figure 1), IP packets with the same destination are buffered in the edge routers to form a data burst. Then edge routers will generate the control burst for the corresponding data burst. The control packet is sent prior to its corresponding data burst. The time difference between control packet and data burst is called as offset time. The offset time is used for reservation and utilization of the required resources. In transmission of data, control burst is responsible for signalling and forwarding its corresponding data burst. If the control burst and data burst are using the same wavelength for transmitting the data, it is named as in-band signalling (Figure 2). If the control burst and data burst uses different wavelength it is named as out-of-band signalling.

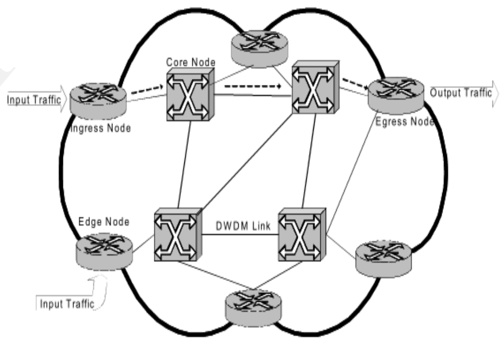

Fig 1: Optical Burst Switching Architecture

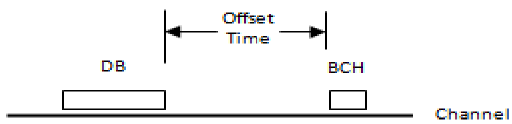

Figure 2: In-Band Signalling

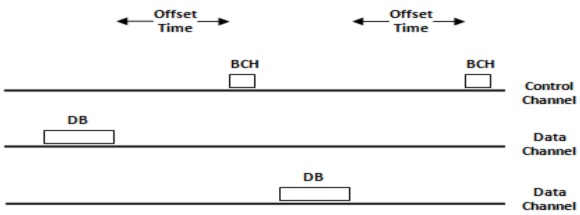

Figure 3: Out-of-Band Signalling

There are two kinds of burst assembly process named as timer and threshold based. In timer based approach, a timer will be started in the source ingress node. All the IP packets which are collected and reach the same destination are formed as data burst. Once the timer gets expired, a control burst will be generated and sent ahead of data burst. In a threshold based, a burst is created and sent into the Optical Burst Switched network when the total size of the IP packets reaches a threshold value. Wavelength reservation scheme is followed to reserve the wavelength for data burst. The three popular wavelength reservation methods are tell and go, just in time and just enough time. In tell and go method, data burst will be transmitted after the control burst with a small offset. Just in time is a direct reservation method. Here, nodes reserve the resources as soon as the control signal processing gets over. Just enough time is a delayed reservation method. Here, the size of the data burst is decided before the control signal is transmitted by the source. The offset between control signal and data burst is also calculated based on the hop count between source and destination. In OBS network, there is a degree of security vulnerability exists which is explained in the next section.

III. ANALYSIS OF KEY ISSUES

A. Just-Enough-Time (Jet)

This protocol is used in the optical burst switching for sending a packet from origin node to delivery node comes under the delayed reservation scheme. It is meant for Two-way reservation protocol and has some unique characteristics such as delayed reservation (DR) and the ability of combining delayed reservation with the help of fiber optical delay lines (FDL) based buffered burst multiplexers (BBM). In the late eighties, the TAG protocol was used for the optical burst switching and it lacks these features of JET protocol because it is a one way reservation mechanism.

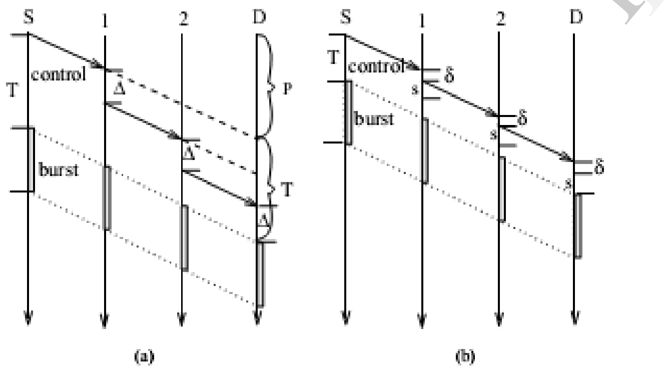

Figure 4 Optical Burst Switching using JET protocol

The Figure 4 explains the basic concept of Jet Enough Time (JET). The source node contains a burst to send to the destination. At first, the protocol JET helps the source node to send the control packet through the physical/static links between the IP entities. In order to maintain the routing table, topology (structure of the network) and the information about the source node and destination node, packet switching supports the JET protocol between the contiguous IP entities. The control packet reserves the path for the burst to reach destination based on the IP addresses of the links by composing all the optical switches along their path. After that, burst can be reached to the destination without passing through the IP intermediate nodes. From this way the JET protocol supports the Optical burst switching by depreciates the latency and the processing load in the IP layer [2]. Once the burst passed through the particular link, the wavelength used by the burst on the particular link will be released automatically or by an explicit mode. Due to this feature, the burst can reserve the bandwidth of the similar wavelength on a particular link from different source to different destination node. If control packet fails to set aside a bandwidth for the burst in any node, then the burst will be blocked or dropped from in a specific node. So, the negative response is sent to the respective source node for retransmission. The OBS should have some applications protocols for the retransmission action. Sometimes the OBS sends data automatically to the destination node with the help of upper application layer protocol like transmission control protocol (TCP) [2]. Because of this retransmission, there will be some wastage of bandwidth takes place. In order to avoid that, the blocked burst must be stored in an electronic buffer after the two conversions takes place. They are optical to electronic conversion and electronic to optical conversion based on the respective destination. The use of fiber delay lines in OBS is to create delays at intermediate nodes. It is not mandatory but it support OBS to eliminate the bandwidth waste and accelerate the performance of quality of service in the network.

B. Just-In-Time (Jit)

This is another protocol used in the optical burst switching comes under immediate reservation scheme. The source node sends the control burst for wavelength reservation to the upcoming data burst. Once the wavelength is set aside or utilized, the control burst processing is over in the network. The data burst from the source node is transported to the intended delivery address over the path of the control burst. It takes place when the transportation of the burst after a delay (Offset time) should be greater than the control burst's processing time in the network. When the control burst reaches closer to the destination node, the offset time decreases and the idle time of the reserved wavelength also decreases. It means that the data burst in the particular path will get transmitted after some time.

There are two protocols (JIT and TAG) under the immediate reservation scheme. In JIT, there will be time gap or time line between the control and data burst because of that buffering is avoided at each node and wavelength is reserved until the first bit of the data burst arrives at each

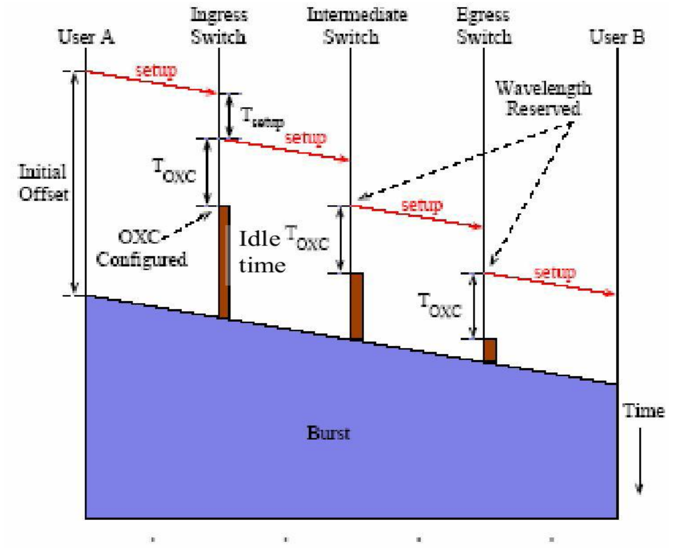

Figure 5 Optical Burst Switching using JIT protocol

And every node in the link. The reserved wavelength will be released after the data burst passes through the link by using the in-band terminator. Figure 5 explains how the control burst and data burst coordinates in the optical burst switching. There are few things to explain in the figure. They are- It represents the total time taken by both the bursts to reach destination node from source node in the optical burst switching.
T Setup-Total time taken by the optical burst switching to process the control burst in the source node Offset- The total time taken between transmission of data burst and the Control burst + T Setup- At this point, the wavelength is reserved for the particular data burst. Amount time taken for the Control burst transmission from source to destination. T Oxc- Total time taken to configure switches form an input port to an output port.

IV. RESLOUITON SCHEME

A. Buffering of Optics

The concept of optical buffering is done by using the Fiber delay lines (FDL). Fiber delay lines are Used in optical buffering because of less memory in optical RAMs. The buffer can hold the data to delay sometime in the particular node. The buffer size in the optical buffering is precise and controlled compared to the other schemes. This is due to the concern of signal quality and also physical space in the optical RAM. Mostly .This reservation scheme contains two phases. They are in output port, the wavelength should be reserved and in optical fiber, the fiber delay lines (FDL) must be reserved. The scheduler searches for a more apt wavelength in the output port, in the first phase of the reservation scheme. If the needed wavelength is idle ($t + \Omega$) then it will be reserved immediately for the data burst. Sometimes, the required wavelength would not available in the path node for certain period of time. The data burst should wait for Minimum amount of time W to reserve the required Wavelength to reach the destination node. There are two conditions for this wavelength reservation In first case, the minimum amount of time W should be greater than the fiber delay line to discard the specific burst (W > D).In second case, for reserving the required wavelength the condition should be (W< D) i.e., the minimum amount of time should be less than the fiber delay (D).The reservation time period should be the current available time until then fiber delay lines will hold the data burst through the reserved FDL. FDL transmits the data burst through the required wavelength to the output port when the waiting time reaches the minimum amount of time (W). There are lots of limitations in this reservation scheme. They are

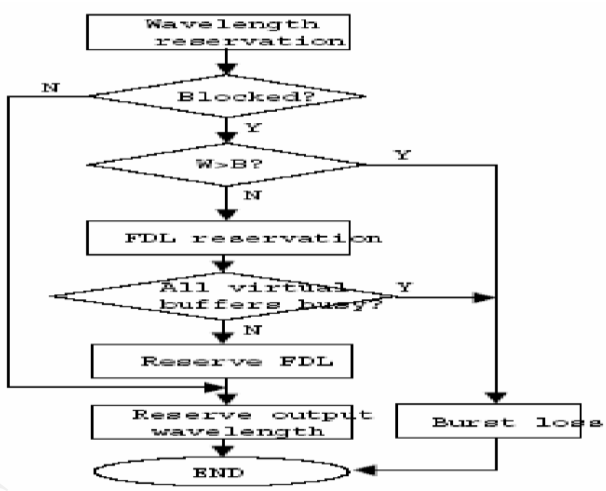

Figure 6 Optical buffering using Fiber Delay Lines

1. Controlled Physical size of optical (RAM)
2. It is not applicable for large scale deployment because of Signal dispersion and attenuation in the node.

B. Conversion of Wavelength

This is the next resolution scheme to carry bursts from origin node to intended delivery node. Whenever there is a situation of no route or lack of common wavelength in the link from origin node to intended delivery node is faced then this scheme can be used. The light paths are necessary for carrying the messages in the wavelength routed networks. For this, there are conditions to be met.
A successful communication is the one that is able to satisfy the constraint condition for wavelength continuity in the network. When the incoming channel converts the wavelength to the different wavelength on the outgoing channel is called as Wavelength conversion. There are two classifications for this scheme. They are Optical-electronic conversion and Electronic-optical conversion. The process of wavelength conversion is explained in the bellow figure 7. Consider the task is to establish the connection between the node pairs (A, D) and (C, D). The nodes A and C looking for the same wavelength W1 to complete the task i.e., to reach the destination node D. so, the nodes A and C approaches the node B to form the link
Called BD. Unfortunately, the link BD has wavelength W2 to form the link.

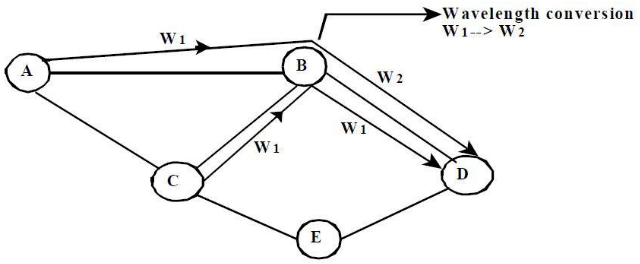

Figure 7 Wavelength conversion methods

Let's assume that the link passage (A, D) is satisfied the wavelength continuity constraint to form the link between B and D and the node C fails to meet the constraint. So, it has neglected in the network. The wavelength converter is used to convert the wavelength from W1 to W2 to reach the destination node called D by forming the link BD. The reuse values are high of about 10% to 40% when availability of wavelength is limited by using the wavelength converters .Now days, wavelength
Conversion algorithms are used in the network to reduce the wavelength converters. This method is really expensive in real networks deployment.

V. OBS CHALLENGES

A. Burst Segmentation in Practical System

Challenges when implementing burst segmentation in practical systems were:

- *Switching time*

Since the system does not implement buffering or any other delay mechanism, the switching time is the number of packets lost during reconfiguring the switch due to contention. Hence, a slower switching time results in higher packet loss. While deciding which burst to segment, we consider the remaining length of the original burst, taking the switching time into account. By including switching time in burst length comparisons, we can achieve the optimal output burst lengths for a given switching time.

- *Segment boundary detection*

In the optical network, segment boundaries of the burst are transparent to the intermediate nodes that switch the burst segments all optically. At the network edge nodes, the burst is received and processed electronically. Since the burst is made up of many segments, the receiving node must be
Able to detect the start of each segment and identify
Whether or not the segment is intact. If each segment consists of an Ethernet frame, detection and synchronization can be performed using the preamble field in the Ethernet frame header, while errors and incomplete frames can be detected by using the CRC field in the Ethernet frame included in the header processing time, at each node.

- *TCP over OBS Challenges*

It is quite normal to employ OBS as core architecture under TCP as it constitutes almost 90% of the current internet traffic and thus when an optical core network, i.e.., Optical Burst Switching is considered there would be number of challenges
Namely:

○ OBS experiences Bandwidth Delay Product (BDP), thus suffers from speed mismatch with TCP. Even if the TCP Scaling option is employed to reach congestion window to 4MB from 64KB longer time would be consumed.
○ The Delayed ACK must be used in TCP over OBS as in reality all TCP segments cannot be included in a single burst which causes further delay. .
○ High Speed TCP (HSTCP) was proposed for high BDP networks that offers bad throughput for Burst losses.

VI. CHALLENGES IN CONTENTION RESOLUTION STRATEGIES

_ A burst can reside in an optical buffer only for a
Specified amount of time unlike electronic buffers.
_ Wavelength conversion produces linear effects like 'noise' and it is costly.
_ In tail dropping segmentation scheme, the header
Contains the total burst length even if the tail is dropped and thus downstream nodes are unaware of truncation. This is called "*Shadow Contention*".
_ In head dropping segmentation scheme, there will be more out-of-order delivery in contrast to the tail
dropping policy where the sequence is maintained.
_ Long bursts passing through different switches
Experience contention at many switches.
_ Bursts of bigger lengths cannot be stored at the "Fiber Delay Lines".
_ Burst deflection routing dynamically deflects the Bursts in an alternate path due to contention in the primary path and is usually longer than the primary path. Thus it increases the propagation delay.
_ The deflected bursts might also loop multiple times wasting network bandwidth

VII. OBS ISSUES

In a TCP over OBS network is considered. The Throughput of various implementations of TCP namely TCP Tahoe, Reno and New Reno are done. An experimental study represented results of throughput of TCP source variants, Tahoe, Reno and New Reno. The network parameters such as, Bandwidth, packet size, congestion window size and queue limit were considered for this experiment. In, a performance evaluation of an OBS router was done. It was said that OBS with LPI can reduce energy consumption up to 60% at low loads.

VIII. CONCLUSION & FUTUER SCOPE

Optical Burst Switching is an efficient architecture to utilize the enormous bandwidth provided by the optical fiber and cater communication at the network cores with minimal The authors would like to thank the anonymous reviewers and the Editor – in – Burst losses. OBS suffers from a phenomenon called as contention as it cuts-through switches unlike other architectures where the data is stored and forwarded. Various contention resolution mechanisms were discussed along with the Challenges thus faced when these resolution policies are used and hence concluded that OBS has attracted lot of researchers due to its ability to achieve dynamic and on-demand bandwidth allocation that offers improved network economics and enables control and management integration.

Along with finding the new solutions to overcome from the main two major issues in terms of Security and QoS in OBS. The QoS issues were due to contention or QoS issues due to Bit Error Rates. At the industrial level, commercial products were very rarely made based on OBS and the only company that offers this product is "Matisse networks" as the technology is still immature. To model or design an OBS node, there is a requirement of test beds or simulators. Few of the OBS simulations were implemented on test beds. These OBS network test-beds would not be imported to most Asian countries like India, Sri Lanka, and Pakistan etc. So, these researchers are forced to a single option namely, implementing on a simulator.

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