A survey of Reservation Schemes for Optical Burst Switching (OBS)

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Abstract: - Optical Burst Switching (OBS) is an efficient switching method to building very high capacity routing switches based on all optical burst data and electronic processing for the control data. OBS combines the benefits of circuit switching and packet switching while taking into consideration the limitations of the current all-optical networks. In this paper we introduce the concept of OBS network and examine the various OBS reservation schemes. A comparison amongst the different reservation schemes is made in terms of admission, delay, delivery, and QoS.

Key-Words: - Optical Burst Switching (OBS), Quality of Service (QoS)

1 Introduction
The candidate technology for high Internet traffic is Wavelength Division Multiplexing (WDM), a technology that is capable to multiplex a number of optical channels in a single optical fiber. There are three switching methods for WDM networks: circuit switching, packet switching and burst switching. Currently applications of WDM use optical circuit switching (OCS) which takes the form of the wavelength routing. However, the limited number of available wavelengths makes circuit switching WDM non-flexible for implementing IP over WDM. Every node cannot set up a dedicated wavelength to every other node. Another approach is the optical packet switching (OPS), which provides better flexibility, functionality, and granularity. The drawbacks of this method are the absence of the optical random access memory (RAM), and the request of the synchronization between multiple packets and between the header and the burst data of a packet. An alternative switching technique that provides optical transparent networks is the Optical Burst Switching. OBS transmits transparent in a purely optical domain the data, while the control packet converted and processed in electronic domain. OBS will require no buffering of the data at intermediate nodes as in circuit switching and achieve efficient bandwidth utilization when supporting burst traffic as in optical packet switching (OPS). OBS is seen as a transmission technology for the next generation optical backbone [1]. In IP over OBS-WDM networks, the Internet traffic requires to support different types of services, to provide QoS and traffic engineering capabilities and to allocate the network resources in order to optimize the overall routing and performance of the networks. However, many times the IP over OBS-WDM network has to sustain limited sources and the routing problems is an inevitable phenomenon. OBS is a promising method for overcoming the low speeds of switching in the electrical domain, avoiding opto/electronic conversion and thus making the most of the high transmission speeds of optical media. There are three main components to set-up a connection for each burst data using the OBS method. The first one is the signaling procedure, which consists of creating the control in the edge node and sending it an offset time ahead of its corresponding data burst. The other two components are the routing and the wavelength allocation (RWA) for each data burst.

This paper is organized as follows: In Section 2, the Optical Burst Switching (OBS) technique is briefly introduced. In Section 3, a general topology of optical burst switching (OBS) networking is presented and in Section 4 the OBS protocols are introduced. Section 5 describes the functionality of OBS reservations schemes and Section 6 compares them in terms of admission, delay, delivery, and QoS.

2 Optical Burst Switching
In optical networks the traffic exhibits a high degree of bursty packet. The existing switching methods such as circuit and packet are not the most appropriate methods to handle packet traffic with bursts. A good alternative switching method for bursty traffic is the OBS. OBS keeps data in the
optical domain but separates control information that allows sophisticated electronic processing. So it makes the efficient use of resources required, operating in the optical level without having buffering as a prerequisite. OBS is considered suitable for sending data requiring a high bit-rate and a low latency but having a short duration compared to the end-to-end propagation delay of the network.

OBS can be thought of as an intermediate of the traditional circuit-switching and packet switching techniques. It ensures a path capable of transporting an optical burst from its source to its destination, but does not use any complicated two-way reservation mechanism. At the same time, it provisions for traffic in some granularity larger than the packet (a burst) without reserving a circuit for the whole duration of a transmission. OBS is designed to achieve a balance between the coarse-grained circuit switching and the fine-grained packet switching.

In the OBS switching method, a control packet is firstly sent on a dedicated wavelength channel to establish the connection. Then the bursty data are transmitted without receiving an acknowledgment on successful reservation. The advantage of this method is that the source node can switch bursts of packets using only one control packet. Thus, bursts of packets may be released into the network despite the fact that there may not be enough resources available. On the other hand, this yields extremely low latencies as propagation delay usually dominates in WAN networks. Packet and circuit switching use store-and-forward method while OBS uses different wavelength channels to transmit the bursty payload and its header compares the different switching methods. Table [1] compares the different switching methods:

<table>
<thead>
<tr>
<th>Switching</th>
<th>Circuit</th>
<th>Packet</th>
<th>Burst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>LOW</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
<tr>
<td>Set-up</td>
<td>HIGH</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>Optical Buffer</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Sync Overhead</td>
<td>LOW</td>
<td>HIGH</td>
<td>LOW</td>
</tr>
<tr>
<td>Traffic/Fault</td>
<td>LOW</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
</tbody>
</table>

Table.1 Comparison of Switching Methods

3 OBS Networks
OBs networks uses two types of nodes: edge routers and core nodes, as shown in Fig. 1.

![Fig.1: Optical Burst Switching Network Topology](image)

Edge nodes are electronic devices and are connected to the optical core nodes to provide burst assembly/disassembly functions. An edge node is composed of an electronic router and a burst assembler. The traffic format at the edge router is bursty, consisting of multiple packets. These packets are assembled into a larger data units the burst and then are routed through the network. A burst is composed of data (payload) and a control packet (burst header). The data are sent after the control packet reserves a free wavelength channel in the intermediate nodes. The one-way reservation is done without having to wait from the destination node an acknowledgment that contains all the necessary routing information to be used by the core node. OBS networking can achieve high bandwidth utilization with lower processing than the original pure packet switching. Hence, the preference to be used in IP networks with bursty traffic. Moreover, it provides end-to-end transparent optical paths by transporting data bursts. An optical core node is composed of an optical switching matrix and a control unit, and it uses transparent DWDM or WDM technologies.

4 OBS Design Protocols
The design of protocols for OBS is depended on the reservation mechanisms and the supported QoS. The burst switching is a hybrid approach, which separates the data information from the control
packet. The data information remains in the optical domain while the control packet experiences sophisticated electronic processing. The goal in the burst switching is to switch bursts of packets without extensive process. To achieve this, some control information containing reservation requests is necessary to be added at every bursty transmission. The main challenge in OBS networking is the reservation schemes for the data channel bandwidth. There are two schemes, the SCDT (separate control delay transmission) and the non-SCDT. SCDT is very similar to optical burst switching because it is based on the separation of data information and control packet. Non-SCDT schemes are very similar to packet or circuit switching where the control packet is attached to data information. This paper focuses on SCDT schemes. SCDT schemes are divided according to two different types of reservation: one-way reservation and two-way reservation. One-way reservation is based on source nodes. A source node sends a data burst following with the corresponding control information without waiting an acknowledgment of the destination node. Such proposed one-way protocols are: Just-Enough-Time (JET) [2,3], tell-n-go (TAG) [4,5], Fast Reservation Protocol (FRO) [6] and ATM block transfer with immediate transmission (ABT-IT) [7]. Two-way reservation is applied to circuit switching optical networks during the connection setup. Proposed two-way protocols are: Just-In-Time (JIT) [11], Tell-And-Wait (TAW), also known in ATM as ABT-DT delayed transmission. The above differentiation of the protocols is based on how a burst of packets is transmitting over an optical link. Dolzer, Spath, and Bodamer [8] have proposed another approach for SCDT reservation mechanism. Particularly their study introduces two types of reservation mechanisms: a RLD (reserve-a limited-duration) and a RFD (reserve-a fixed-duration) mechanism.

In RLD method the source indicates the length of the burstiness by means of the control packet. When the source requests a reservation the control packet takes the available wavelength channel and it reserves it to the end of the burst. The only information that is stored within the nodes is the availability of the wavelength channel. If there is not any available channel then the request is aborted and the burst is lost. This method exhibits some disadvantages when in the same wavelength channel there are different bursts. A wavelength channel is allocated for a limited duration of time. When a new burst requests a reservation with starting time earlier than the finishing time of an existing allocated burst then the request is accepted. It is observed that the offset interval of a new burst may overlap the previously accepted burst. Typical RLD mechanism is the Horizon proposed by Turner [9]. With the second RFD approach, the reservation does not start immediately with after request but after one delay through the basic offset. Qiao and Yoo [2] proposed the RFD method named as Just-in-time (JET). This method gives the starting and finishing times of all accepted bursts. Also, it detects situations where the starting time of a new burst is earlier than the finishing time of the already accepted burst. That means a new burst can be transmitted between two accepted bursts.

5 OBS Reservation Mechanisms

The choice of the reservation mechanisms is manly depended on the way of how to allocate the burst length into a WDM channel. The previous section presented the types of OBS protocols associated with the reservation of the bandwidth. In this section, the proposed reservation mechanisms over an OBS network are discussed.

5.1 Just-Enough-Time (JET) method

The basic concept of JET method is the following: A reservation request is sent in a separate control packet on a different channel while the actual transmission of the data burst is delayed by a certain offset. This basic offset enables the intermediate nodes to process control information and prepare themselves for accommodating the data burst that will arrive there shortly. Fig. 2 illustrates the basic concept of the JET method.

![Fig.2 JET Method](image-url)
Better utilization and more precision is achieved with a further improvement of JET, resources are reserved at the optical burst switch from the time the burst arrives at the switch, rather from when the control packet is processed of the switch.

5.2 Horizon method
The burst packet consists of a burst header cell (BHC) and the burst data, which follow the BHC after an offset. The main characteristics of this method are: for each wavelength channel a horizon is maintained which determines the available channels and selects the best. It has the simplest hardware implementation and it gives good results for small offset variables.

In Horizon scheduling the controller for a link maintains a time horizon for each of the channels of an outgoing link. The horizon is defined, as the earliest time after which there is no planned use of the channel. The horizon scheduler assigns arriving bursts to the channel with the latest horizon that is earlier than the arrival time of the burst, if there is such a channel. If there is no such channel, the burst is assigned to the channel with the smallest horizon and is directed to the burst storage area where it is delayed until the assigned channel is available. Fig. 3 illustrates the basic concept of the horizon method.

5.3 Tell and Go (TAG) method
Qiao [10] was proposed the TAG method, which a burst sent along with its header. While the header is being processed by an intermediate node, either all optically or electronically, the burst is buffered at the node in the optical domain.

5.4 Just in time (JIT) method
In this method, called JIT [11] there is no information about burst length in the control packet and a wavelength channel is immediately allocated if available, upon arrival of the control packet. The wavelength channel remains allocated until burst transmission has finished. The only information that has to be kept record of in network nodes is whether a wavelength channel is currently available or not. This simple information makes the JIT method less complex in both edge and core nodes. The drawback of this method is exhibited when there are different bursts on the same wavelength channels.

5.5 Wavelength routed OBS (WR-OBS)
The WR-OBS method by M.Duser and P.Bayel [12] was proposed and combines the OBS approach with the dynamic RWA. In the WR-OBS architecture, packets are buffered in edge routers, according by their destination and class of service for burst aggregation. In this method two parameters are introduced, the bandwidth utilization, and the wavelength channel re-use. Summarizing WR-OBS represents a fast circuit-switching scheme that can provide low burst dropping probability and low end-to-end delays. WR-OBS can also provide differentiated series and QoS.

6 Comparison of OBS mechanisms
OBS is a switching method where all the electronic processing is performed at the edge nodes and the routing at the core nodes is used for transporting DWDM technology. OBS is used in IP networks where IP traffic is dynamically varying and therefore QoS is not assured a priority. Table 2 [12] compares the reservation mechanisms in terms of the admission, delay, and QoS.

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>JET</th>
<th>Horizon</th>
<th>JIT</th>
<th>WR-OBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission</td>
<td>Full</td>
<td>Full</td>
<td>Full</td>
<td>Limited</td>
</tr>
<tr>
<td>Delay</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Deterministic</td>
</tr>
<tr>
<td>Qos</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 2. Comparison of Reservation Mechanisms

From the above table the most important parameter is the QoS and it is achieved only from JET and WR-OBS methods.
References:


