

Survey on Contention Resolution Techniques For Optical Burst Switching Networks

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Abstract

Optical Burst Switching (OBS) is a promising solution for allowing various size data burst to be transported optically over Dense Wavelength Division Multiplexing (DWDM) without optical/electronic/optical conversion. In OBS control packet called control burst is separated from data packet called data burst. A control burst is sent in advance, which configures the switches in the path for data burst. Due to lack of adequate contention resolution technique data burst loss is high in OBS. Contention occurs when more than one data burst try to reserve the same wavelength channel on outgoing link which is a main problem in OBS. In this paper, comprehensive review pertaining the classification of different contention resolution techniques for optical burst switched network has been presented.

Keyword s- OBS, CONTENTION, BLR, TAG, JIT, JET.

I. INTRODUCTION

Contention resolution is necessary when two or more bursts try to reserve the same wavelength of a link in same time. This is called external blocking. In packet switching, this is avoided by buffering the contending packets. In OBS, when two or more bursts contend for the same wavelength and for the same time duration, only one of them is allotted the bandwidth. In such case, one or a combination of the following three major options for contention resolution can be applied in addition to the option of dropping the unsuccessful bursts.

1.1 Wavelength Domain

By means of wavelength conversion, a burst can be sent on a different wavelength channel of the designated output line [1].

1.2 Time Domain

By utilizing an FDL buffer, a burst can be delayed until the contention situation is resolved. In contrast to buffers in the electronic domain, FDLs only provide a

fixed delay and data leave the FDL in the same order in which they entered [1].

1.3 Space Domain

In deflection routing, a burst is sent to a different output link of the node and consequently on a different route towards its destination node. Space domain can be exploited differently in case several fibers are attached to an output line. A burst can also be transmitted on a different fiber of the designated output line without wavelength conversion [1].

When there is no available unscheduled channel, and a contention cannot be resolved by any one of the above techniques, one or more bursts must be dropped. The policy for selecting which bursts to drop is referred to as the soft contention resolution policy and is aimed at reducing the overall burst loss rate, BLR, and consequently, enhancing link utilization [2]. Several soft contention resolution algorithms have been proposed and studied in earlier literature, including the shortest drop policy and look-ahead contention resolution. In burst segmentation, only that part of the burst, which is involved in a reservation conflict, will be dropped. The contention resolution policies are considered as reactive approaches in the sense that they are invoked after contention occurs. An alternative approach to reduce network contention is by proactively attempting to avoid network overload through traffic management policies [2].

II ARCHITECTURE OF OBS

Architecture of OBS network is shown in Fig.1. OBS network consists of two types of nodes: edge node and core node. Edge nodes are at the interface between electronic and optical domain. Edge nodes can be an ingress or egress node. Packets are assembled into bursts at ingress edge node, which are then routed through the OBS network and disassembled back into packets at egress edge node. A core node is mainly composed of an optical switching matrix and a switch control unit which are responsible to forward payload/data burst. A node in OBS network consists of both

optical and electronic components. The optical components are multiplexers (Mux), demultiplexers (Demux) and an optical switching network (OSN). The electronic components are input modules (IM), output module (OM), a control burst router (CBRT), and a scheduler. An optical burst switch control unit transfers an incoming data burst from an input port to its destination output port. When an edge node intends to transmit a data burst, it sends a control packet on the control wavelength to a core node. At core node, the control packet on the control channel is input to the corresponding IM, which converts the control packet into electronic form. The control fields are extracted from the control packet. The CBRT uses these control fields to determine the next outgoing fiber for the corresponding payload by consulting a routing table maintained locally. The control packet is scheduled for transmission onto the selected outgoing link by the scheduler and the control packet is buffered until the scheduled time. The scheduler maintains a control packet queue. The scheduler also reserves wave-length on the determined links for the upcoming payload. The control packet is then forwarded on the OM, which updates its control fields and transmits it to the selected outgoing fiber using the optical transmitter [2,6]. Just before the payload arrives, the switching element in the node is configured to connect the input port to the corresponding output port for the entire duration of the burst transmission. If the control packet is unable to reserve the wavelength then the control packet as well as payload is dropped. Fiber using the optical transmitter. Just before the payload arrives, the switching element in the node is configured to connect the input port to the corresponding output port for the entire duration of the burst transmission. If the control packet is unable to reserve the wavelength then the control packet as well as payload is dropped [2, 6].

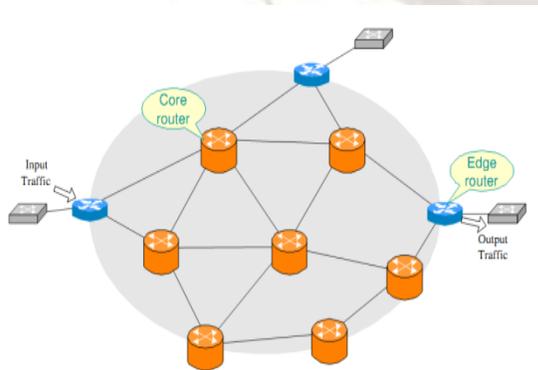


Fig.1: Architecture of OBS network

Edge node:

Edge node is at interface between the electronic and optical domain (can be ingress and egress). Packets are assembled into bursts at ingress node and disassembled into bursts at egress node.

Core node:

Core node composed of an optical switched matrix and switched control unit, Core node is responsible to forward data bursts.

III BURST ASSEMBLY SCHEMES

In OBS network, packets are assembled into burst at edge node. There exists two burst assembly schemes: threshold-based and timer-based [11]. In a timer-based scheme, a timer is started at the initialization of burst assembly. A data burst containing all packets in the buffer is generated when the timer exceeds the burst assembly period T_b . A large time-out value T_b results in a large packet and higher buffering delay at the edge node. On the other hand, a too small T_b results in too many small bursts and a high electronic processing load.

In a threshold-based scheme, a burst is created and sent into the OBS network when the total size of the packets in the queue reaches a threshold value L_b . The shortcoming of the threshold-based scheme is that it does not provide any guarantee on the assembly delay that packets will experience. The choice of burst assembly algorithms depends on the type of traffic being transmitted. Timer-based algorithms are suitable for time-constrained traffic such as real-time applications because the upper bound of the burst assembly delay is limited [2]. For a time-insensitive application such as file transmission, to reduce the overhead of control packets and increase OBS transmission efficiency, a threshold based scheme may be more appropriate.

IV WAVELENGTH RESERVATION SCHEME

Wavelength reservation refers to when and how the bandwidth is reserved and release. The reservation schemes in OBS network is adopted from ATM block transfer (ABT). There are two versions of ABT: ABT with delayed transmission and ABT with immediate transmission [9,13].

In an immediate transmission reservation scheme, an output wavelength is reserved for a payload immediately after the arrival of the corresponding control packet; if a wavelength cannot be reserved at that time, then the setup message is rejected and the corresponding data burst is dropped. In a delayed reservation scheme, the control packet and the payload are separated in time by an offset value in order to

accommodate the processing of the control packet. An output wavelength is reserved for a data burst just before the arrival of the burst bit of the data burst. If, upon arrival of the setup message, it is determined that no wavelength can be reserved at the appropriate time, then the setup message is rejected and the corresponding data burst is dropped. These two techniques have been adopted in OBS. Depending on bandwidth reservation, offset time and control management, three schemes for OBS implementation have been proposed: Tell-and-go (TAG), Just-in-time (JIT) and Just-enough-time (JET).

4.1 Tell-And-Go (TAG)

This is an immediate reservation scheme. In TAG, the control packet is transmitted on a control channel followed by a payload, on a data channel with zero or negligible offset. The payload is buffered using fiber delay line (FDL) while the control packet is processing at each intermediate node. If wavelength reservation is successful then the payload is transmitted along the reserved channel else the data burst is dropped and a negative acknowledgment (NAK) is sent to the source. The source node sends a control packet after transmitting the payload to release the reserved resources along the path.

The drawback of this scheme is availability of optical buffer. FDL can hold

packet is processed. Source transmits the payload after an offset time which is greater than the total processing time of control packet at intermediate nodes. If the resource is not available, the data burst is dropped. The difference between JIT and TAG is that in JIT the buffering of the payload at each node is eliminated by inserting a time slot between the control packet and the payload. The time slot is equal to the offset time. Since the bandwidth is reserved immediately after processing the control packet, the wavelength will be idle from the time the reservation is made till the burst bit of the payload arrives at the node. This is because of the offset between the control packet and the payload. An in-band-terminator is placed at the end of each data burst, which is used by each node to release the reserved wavelength after transmitting the payload [9,13].

Working of JIT is shown in Fig. 3. In this figure user A send a data burst to user B. Let t be the time a control packet arrives at some OBS node along the path to the destination. Let t_{setup} be the amount of time it takes an OBS node to process the control packet and t_{offset} be the offset value. The offset value depends on (i) the wavelength reservation scheme, (ii) number of nodes the control packet has already traversed, and (iii) other factors, such as whether the offset is used for service differentiation. t_{oxc} is the amount of time it takes the OXC to configure its switch fabric to set up a connection from an input port to an output port. Once, the processing of the control packet is complete at time $t + t_{\text{setup}}$, a wavelength is immediately reserved for the upcoming data burst, and the operation to configure the OXC fabric to switch the data burst is initiated. When this operation completes at time $t + t_{\text{setup}} + t_{\text{oxc}}$, the OXC is ready to carry the data burst.

Note that the data burst will not arrive at the OBS node until the time is $(t + t_{\text{offset}})$. As a result, the wavelength remains idle for a period of time equal to $(t_{\text{offset}} - t_{\text{setup}} - t_{\text{oxc}})$. Since the offset value decreases along the path to the destination, deep inside the network for an OBS node, will have shorter idle time between the instant OXC is configured and the arrival of burst bit of payload.

4.3 Just-Enough-Time (JET)

JET is a delayed reservation scheme. Here, the size of the data burst is decided before the control packet is transmitted by the source. The offset between control packet and payload is also calculated based on the hop count between the source and destination. At each node, if bandwidth is available, the control packet reserves wavelength for the upcoming data burst for a fixed duration of time. The reservation is made from the time when the burst bit of payload reaches the node till the last bit of payload is transmitted to the output

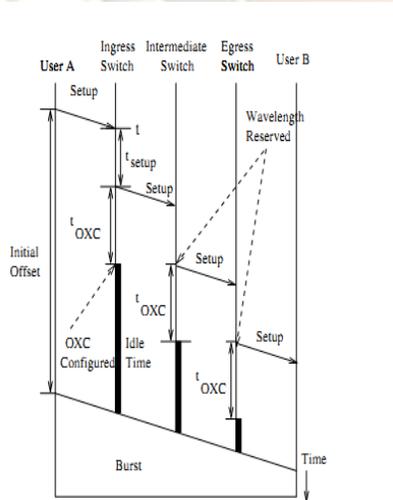


Fig. 2: Just-In-Time Reservation Scheme data only for a fixed duration and can not accommodate data burst of variable size. Furthermore, loss of control packet to release reserved resources result in wastage of bandwidth.

4.2 Just-In-Time (JIT)

This is also an immediate reservation scheme. Here, nodes reserve the resources as soon as the control

port. This eliminates the wavelength idle time. This is the basic difference between JET and JIT [14]. Since the wavelength is reserved for a fixed duration, there is no need for explicit release of reserved resources along the path. Since there is no wastage of bandwidth in this

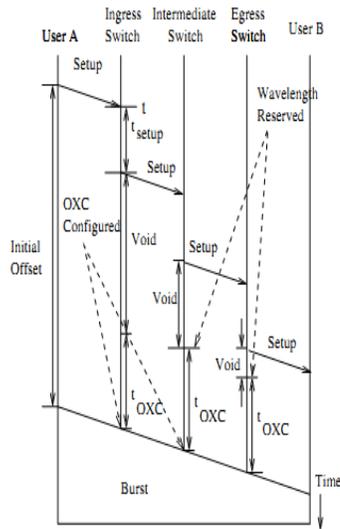


Fig. 3: Just-Enough-Time Reservation Scheme

scheme, channel utilization is higher than other schemes. However, scheduling process is complex compared to other schemes.

The operation of delayed reservation in JET is shown in Fig. 3. Let assume that a control packet has arrived at an OBS node at time t . Let the offset time is t_{offset} and the length of the payload is t_{burst} . The burst bit of the corresponding data burst is expected to arrive at time $t + t_{offset}$. After processing the control packet, the node reserves a wavelength for the payload starting at time $t + t_{offset} - t_{OXC}$ and ending at time $t + t_{offset} - t_{OXC} + t_{burst}$. At time $t + t_{offset} - t_{OXC}$, the OBS node instructs its OXC fabric to configure its switching elements to carry the payload, and this operation completes just before the arrival of the burst bit of the data burst. Immediate reservation protocols only permit a single outstanding reservation for each output wavelength, whereas delayed reservation schemes allow multiple setup messages to make future reservations on a given wavelength (provided these reservations, do not overlap in time). A void is created on the output wavelength between the time slot $t + t_{setup}$ to $t + t_{offset} - t_{OXC}$. In an attempt to use the voids created by the earlier setup messages, void-filling algorithms are employed in JET.

V CONTENTION RESOLUTION TECHNIQUES

Contention occurs when more than one data burst try to reserve the same wave-length channel on an outgoing link. In electronic network, contention is resolve by buffering the contending packets [12]. In OBS network when contention occur one of contending data burst is allowed to reserve the channel, for other data bursts one or a combination of the following contention resolution technique can be applied. If contention cannot be resolved then one of the contending data burst is dropped.

5.1 Using FDL

In optical network, fiber delay line (FDL) is currently the only way to implement optical buffering. To resolve contention using FDL, one of the contending data burst is passed through FDL. But it has several limitations. FDL are bulky and require over a kilometer of fiber to delay a single packet for 5 sec. provide only a fixed delay and data leave the FDL in the same order in which they entered [12]. Delay lines are commercially not viable due to the above drawbacks.

5.2 Wavelength Conversion

Wavelength conversion is the process of converting a wavelength on an incoming channel to another wavelength on an outgoing channel. To resolve contention using this method, a contending data bursts wavelength is shifted to another wavelength on the designated output link. Thus it increases wavelength reusability [15]. The concept of wavelength conversion is illustrated in Fig. 3. Assume that connections are required to be established between node pairs (C, D) and (A, D). Suppose both connections select the wavelength W_1 for lightpath establishment. At node B, both connections try for wave-length W_1 on link BD. Only one of the connections can be accepted. Let that the connection be (C, D). Since the wavelength W_1 is already used, the connection (A, D) would be dropped in case of wavelength continuity constraint. However in wavelength conversion, node B would convert an incoming wavelength W_1 to an available wavelength W_2 on the link B, D and the connection (A, D) would be established.

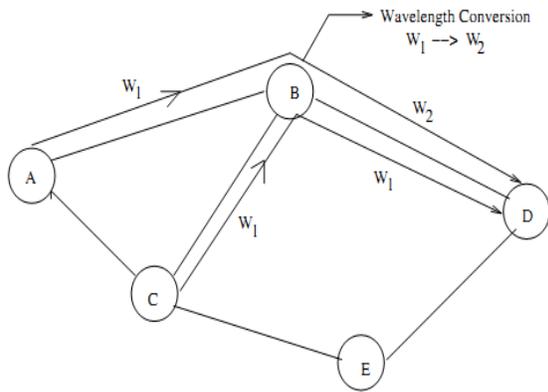


Fig. 3: Wavelength Conversion.

But, the technology is so far immature and is highly expensive for deployment in real network.

5.3 Deflection Routing

Deflection routing is another approach to resolve contention in OBS networks. In deflection routing one of a contending data burst is sent to a different output port and then follows an alternative route to the destination [16]. Working of deflection routing is explained below. We consider Fig. 4 for explanation. Suppose both nodes A and B are sending data bursts to node E. Before sending data bursts, nodes A and B send control packets (denoted as C(A, E) and C(B, E)) on control channels for bandwidth reservation for their respective data bursts. Assume, C(B, E) arrives at node C earlier than C(A, E). In this case, the output link CE is reserved by C(B, E). When C(A, E) arrives at node C, the link CE is not available. Without deflection, this data burst will be dropped. In deflection routing, node C checks other output links and selects the deflection link CD which is idle at that time. Then node D forwards B(A, E) on the link D → E and the connection between node A and E would be established.

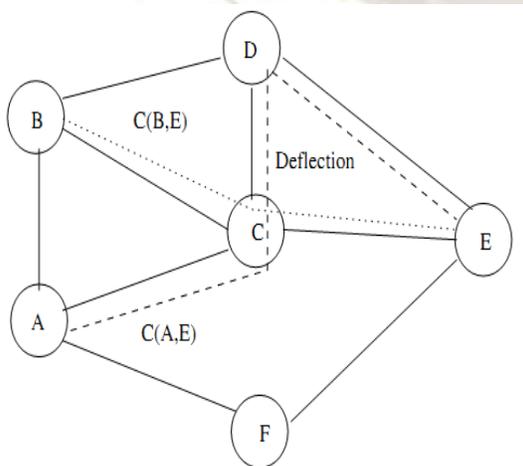


Fig. 4: Deflection routing.

It has several advantages. Like, it does not require any additional hardware so it can be easily implemented in existing network. But also has some drawbacks. Like end-to-end delay is high, due to follow deflected route which may not be always shortest route.

5.4 Burst Segmentation

Burst segmentation is a technique to reduce packet loss rather than burst loss. A data burst is composed of a number of segments. When two data bursts are contending, the overlapping segments of one of the contending data burst is dropped rather than the entire data burst [12]. The concept of burst segmentation is shown in Fig. 5. Burst segmentation gives good performance in terms of packet loss. But it requires a complex control handling to make it reality.

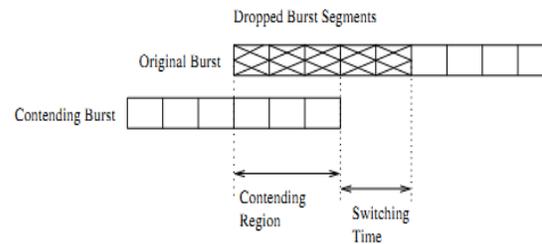


Fig. 5: Burst Segmentation.

TABLE I

Comparison of different contention resolutions techniques

Contention Resolution Technique	Advantage	Disadvantage
Wavelength Conversion	The most efficient solution	Immature and expensive
FDL Buffering	Simple	Increasing end-to-end delay
Deflection Routing	No extra hardware requirement	Out of order arrival
Burst Segmentation	Lower packet loss ration	Complicated control handling requirement

Table I gives a comparison between four contention resolution techniques. When there is no available unscheduled channel, and a contention cannot be resolved by any one of the above techniques, one or more of the contending data bursts are dropped. The policy for selecting which data bursts to drop is referred to as the soft contention resolution policy and is aimed at reducing the overall burst loss rate (BLR), and consequently enhancing link utilization. Several

soft contention resolution algorithms have been proposed in, including the shortest-drop policy and look-ahead contention resolution. These contention resolution policies are considered as reactive approaches in the sense that they are invoked after contention has occurred. An alternative approach to reduce network contention is by proactively attempting to avoid network overload through traffic management policies.

VI CONCLUSION

With the comparative study of wavelength reservation schemes, it is observed that TAG and JIT schemes are significant simpler than JET scheme since both schemes do not involve complex scheduling or void-filling algorithms. But JET scheme performs better than either JIT or TAG in terms of burst loss probability. All the contention resolution techniques were discussed and compared. They have their own limitations. FDL buffering is simple but increases end to end delay. Wavelength conversion is efficient but expensive. In deflection routing arrival of burst is out of order. In burst segmentation complicated control handling is required. In future a combination of all these techniques may be used.

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