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# Contention and Scheduling Algorithms in Optical Burst Switched Networks

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*Abstract*---- **Optical Burst Switching (OBS) is a potential switching mechanism for future backbone networks because of its ability to perform fast switching and the processing time is reduced as well. It avoids the deficiencies found in Optical Packet Switching (OPS) and Optical Circuit Switching (OCS). OBS adopts the good features of both the optical technologies OCS and OPS. It has certain issues like Burst Assembly mechanism, Scheduling Algorithms and Contention. As a result of contention between two bursts at any core node, one of the burst which is utilizing more resources is deliberately dropped. This causes unfairness for hundreds of aggregated packets assembled from different client access networks. This paper mainly focuses on Contention and its proposed solutions in literature. The second issue discussed is Scheduling Algorithms.**

***Keywords---Optical Burst Switching, Contention Resolution, Deflection Routing, Segmentation, Scheduling Algorithms, Latest Available Unscheduled Channel***

## 1. Introduction

The use of multimedia services like online games, Video on Demand, Video Calls etc, are putting much burden on the backbone network. The network engineers need to cope with this ever growing demand. The bottleneck is the switching technology which converts data from Optical domain into Electrical for processing purpose and then reconverts it into Optical domain for transmission on optical link. To reduce the switching time and keep the data mostly in optical domain Optical Burst Switching (OBS) was proposed [1-4]. It not only keeps the data burst in optical domain but reduces the control overhead. The data is never dropped due to unavailability of the control channel [5]. There are some issues in OBS [6] in which the Contention [7] is the hot topic. Actually when two or more bursts tend to opt for same output at same time, contention happens. This inheritance problem reduces the network throughput. There are some of the proposed schemes in literature to resolve contention. The other issue is of scheduling algorithms. There are many proposed algorithms which are discussed later.

## 2. Contention in OBS

Contention occurs, when two or more bursts try to reserve the same wavelength at same time for same output port as shown in Figure 1. Contention is an inheritance problem with OBS technique [8]. If contention is not resolved then incoming burst is dropped.

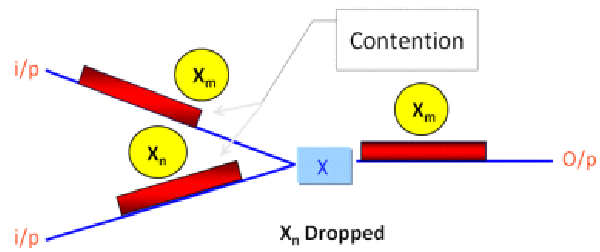


Fig. 1: Contention in OBS

### 2.1 Contention Resolution

Following are few of the proposed techniques in literature for contention resolution in OBS network [9, 10, 11, 12].

Fiber Delay Lines (FDL)

Deflection Routing

Wavelength Conversion

Segmentation based dropping

#### 2.1.1 Fiber Delay Lines (FDL)

FDL was proposed in [13]. It is a time domain contention resolution scheme where a contending burst is delayed for a predefined amount of time using FDL to overcome contention as depicted in Figure 2.

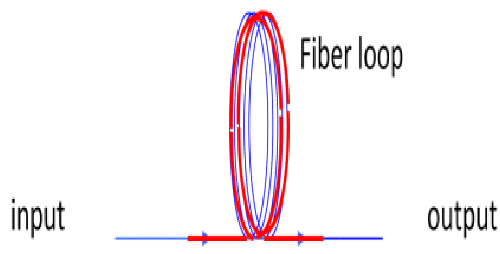


Fig. 2: Fiber Delay Lines (FDL)

As presently we are lacking with Optical RAM, therefore due to dynamic nature of light it is delayed (using FDL) rather than storing it like electronic signal. However FDL is a very costly solution. That's why it is not so effective and efficient. The other main issue is how to achieve synchronization using FDL buffer.

### 2.1.2 Deflection Routing

Deflection routing [14, 15]in Figure 3 is a space domain contention resolution scheme where a conflicting burst is tried to schedule using another physical path to the same destination. So the physical medium is used as a source of storage for conflicting burst to overcome the contention.

This contention resolution approach is feasible for large network sizes i.e. there are more physical paths available between two edge nodes. The main limitations of deflection routing are the increase of complexity in managing the deflected burst on the reflected node. Different flavors of deflection routingare also discussed in literature as [16, 17]; Deflection routing, Reflection routing, etc.

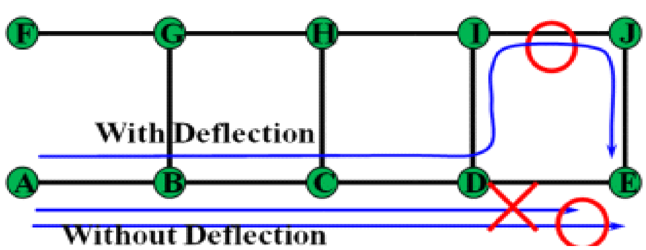


Fig. 3: Deflection Routing

### 2.1.3 Wavelength Conversion

In this scheme, wavelength converters [18] are used in order to convert one wavelength to another. In case of contention, core node uses wavelength converters to assign a different wavelength to one of the contending burst. In they are expensive; but many scheduling algorithms assume full wavelength converters.

### 2.1.4 Segmentation

During contention, bursts overlap in time domain. Instead of dropping the whole burst, this scheme is proposed where only overlapping part of contending burst is dropped [19].

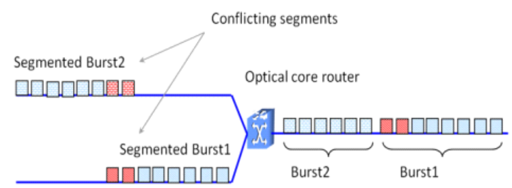


Fig. 4: Segmentation dropping

Advantage of segmentation based scheme as shown in Figure 4 is improved network throughput. However this scheme also suffers from complicated control in managing the acknowledgment of drop segments to source node and drop segments regeneration mechanism.

Below table 1 shows the comparison of different contention resolution techniques.

Table 1: Comparison of Contention Resolution Scheme

| Contention **Resolution Scheme** | **Advantages** | **Disadvantages** |
|---|---|---|
| ***Wavelength Conversion*** | ***Low burst loss*** | ***Immature and expensive*** |
| ***Fiber Delay Lines*** | ***Mature Technology*** | ***Bulky FDLs; more voids; Extra Delay; Limited Storage*** |
| ***Deflection Routing*** | ***No extra hardware required*** | ***Late arrivals; Endless Loops*** |
| ***Burst Segmentation*** | ***Improved Throughput*** | ***Complicated Control*** |

## 3. Scheduling Algorithms in OBS

During burst transfer at each intermediate node, the scheduler inspects for the requested wavelength at output port. If this wavelength is available at that time instant it is assigned to the burst for output port. In a case when requested wavelength is not available, the wavelength converter is used to schedule burst on free wavelength. Scheduling algorithm will decide which wavelength to be scheduled for output port. Since the arrival of bursts is dynamic, fast and efficient scheduling is highly desirable for avoiding the burst loss and better bandwidth utilization. Some existing scheduling algorithms and their outcomes is presented in the Figure 5. Here five channels namely Channel 0, Channel 1, Channel 2, Channel 3 and Channel 4 are shown. The comparative analysis of these techniques in [20], illustrates that all void filling algorithms have higher link utilization and less burst loss ratio as compared to Horizon-based algorithms without void filling [21].

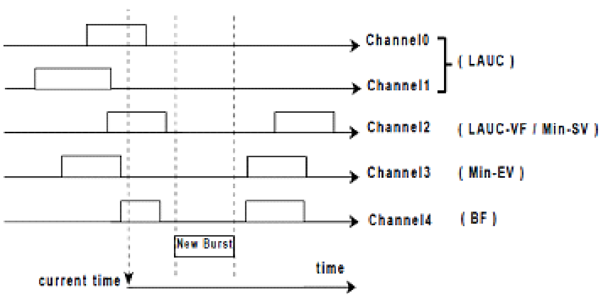


Fig. 5: Scheduling Algorithm in OBS

3.1 Latest Available Unused Channel (LAUC) Algorithm

In LAUC [22], each new arriving data burst is scheduled by selecting the latest available unscheduled data channel. In this algorithm, a scheduler keeps information of horizon (time after which no reservation has been made on that channel is called horizon). On the basis of this information, LAUC searches the most suitable wavelength on each channel.

The scheduler assigns each arriving new burst to the data channel in such a way that minimum void is created on that data channel. By using this technique, Channel 0 or Channel 1 will be selected as shown in the Figure 5.

LAUC algorithm is simple in terms of implementation. However it has less efficiency due to ignoring the voids created between already configured wavelengths.

3.2 Latest Available Unused Channel with Void Filling (LAUC-VF) Algorithm

In order to utilize the existing gaps (unused channel capacity) between already scheduled burst in LAUC algorithm, the void filling algorithm is proposed. Latest Available Unused Channel with void filling (LAUC-VF) was presented in [23]. This algorithm keeps the start time and end time information of voids along with the horizon. In the above Figure 5, using LAUC-VF algorithm, Channel 2, Channel 3, and Channel 4 are available for burst scheduling.

3.3 Best-Fit (BF) Algorithm

In this algorithm proposed in [24], scheduler keeps the information of horizon and void for each channel. Scheduler tries to assign a more optimal void to newly burst request. This assignment of voids is done in such way that newly created void is the smallest void before and after scheduled burst. In Figure 5, using Min-SV algorithm, channel 4 will be selected.

3.4 Minimum Starting Void (Min-SV) Algorithm

Minimum Starting Void (Min-SV) algorithm was proposed in [25]. It is similar to LAUC-VF, except it tries to decrease the newly created void in such a way that newly created void is the smallest void after scheduled burst. In above Figure 5, using Min-SV algorithm, channel 2 will be selected.

3.5 Minimum Ending Void (Min-EV) Algorithm

Minimum Ending Void (Min-EV)algorithm was proposed in [26]. It is similar to LAUC-VF, except it tries to decrease the newly created void in such a way that newly created void is the smallest void before scheduled burst. In Figure 5, using Min-SV algorithm, channel 3 will be selected.

Here is a comparison of different above discussed scheduling algorithm summarized in table 2 below:

Table 2: Comparison of Different Scheduling Algorithm

| Scheduling Algorithms | Time Complexity | State Information | Bandwidth Utilization |
|---|---|---|---|
| ***LAUC*** | ***O(W)*** | ***Horizoni*** | ***Low*** |
| ***LAUC-VF*** | ***O(Wlogm)*** | ***Si,jEi,j*** | ***High*** |
| ***BF*** | ***O(Wlogm)*** | ***Si,jEi,j*** | ***High*** |
| ***Min-SV*** | ***O(logm)*** | ***Si,jEi,j*** | ***High*** |
| ***Min-EV*** | ***O(logm)*** | ***Si,jEi,j*** | ***High*** |

Where W: No. of wavelengths at each output port

m: Maximum number of reservation for data burst

Horizon i: horizon of ith data channel

Si;j and Ei;j: start and end time of jth reservation for burst on channel i

From the above comparison we can conclude that the void filling scheduling algorithm better utilizes the available bandwidth and reduces the burst loss rate as compared to LAUC. However its execution time and complexity also increases.

## 4. CONCLUSION

This paper summarizes need of Optical Burst Switching and its issues. The hot issues are Scheduling Algorithms and Contention Resolution. To better utilize the bandwidth, burst placement is very important and scheduling algorithms are responsible for it. This paper discussed these schemes all at once in the OBS literature. To mitigate the Contention, different schemes are proposed in literature and this paper discussed those schemes like FDL, Wavelength Conversion, Deflection and Segmentation. This paper clearly provides directions for researchers in the fields of Scheduling Algorithms and Contention Resolution Techniques. The pros and cons are also discussed to provide a better understanding of the schemes proposed.

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