IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 6, No 3, November 2011
ISSN (Online): 1694-0814
www.IJCSI.org

A Review of Burst Scheduling Algorithm in WDM Optical Burst Switching Network

R.P.Adgaonkar [1] and S.N.Sharma [2]

[1] Department of Computer Engineering, G.S. Mandal's Marathwada Institute of Technology (M.I.T.) Aurangabad, M.S., India

[2] Department of Computer Engineering, G.S. Mandal's Marathwada Institute of Technology (M.I.T.) Aurangabad, M.S., India

Abstract

Optical Burst Switching (OBS) has proved to be an efficient paradigm for supporting IP-over-WDM networks. The growth of a variety of applications which transmit voice, data, video and multimedia, has necessitated the need to provide Quality of Service (QoS) over OBS networks. One of the key factors in OBS is the scheduling algorithm that is used in the switches to allocate the incoming bursts to a wavelength. Since the arrival of bursts is dynamic, it is highly desirable that the scheduling is done as quickly as possible. In this paper, a survey of various existing burst scheduling algorithm that provide QoS and reduce burst dropping probability is presented and compare different algorithm.

Keywords: WDM, Optical Burst Switching Network, LAUC

1. Introduction

A WDM technology has the enormous amount of bandwidth available in fiber cable. In WDM system, each carries multiple communication channels and each channel operating on different wavelength. Such an optical transmission system has a potential capacity to provide Tera bytes of bandwidth on a single fiber. WDM technology has the capability to provide the bandwidth for the increase in the huge on traffic demand of various applications like audio, video and multimedia, which needs the QoS over the network [1].

The currently existing switching techniques can be broadly classified into optical circuit switching (OCS), optical packet switching (OPS) and OBS techniques [1], [2]. In OCS, an end-to-end optical light path is setup using a dedicated wavelength on each link from source to destination to avoid optical to electronic (O/E/O) conversion at each intermediate nodes. Once the light path is setup, data remain in optical domain throughout transmission of data. OCS is relatively easy to implement but main drawback of OCS is circuit setup time and improper holding time of resources like bandwidth. On other hand, no circuit setup is required in OPS but packet header need to be processed in the electronic domain on hop-by-hop basis. Due to which data payload must wait in optical buffers like fiber delay lines (FDLs), which is very complex and challenging task in high speed optical networks. To do this task, OPS require optical buffers, O/E/O converters and synchronizers. The new switching technology, which combines the merits of coarse gained OCS and fined gained OPS was proposed and called as OBS [1], [2], [3], [4].

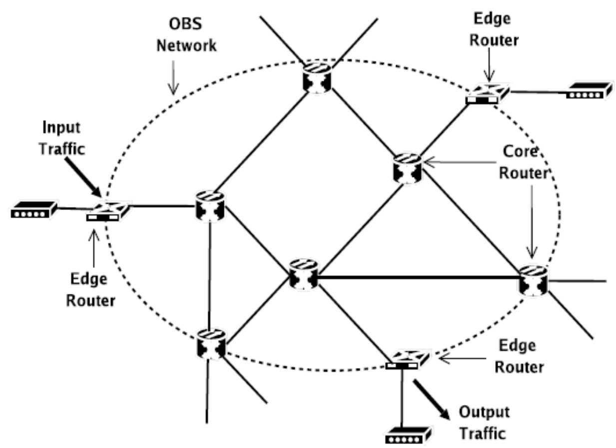

Fig 1: OBS Network Model

In OBS network model, as shown in the Fig. 1 [5], there are two types of routers, edge and core router, which are connected by WDM links. Various type of client's data with same destination are aggregated at the edge router in a data burst. The data could be IP/SONET/SDH/ATM cell or combination of all packet type.In OBS, edge router is responsible for burst assembly/ disassembly, scheduling of burst, transmission of burst, deciding the offset time, generation of burst control packet (CP) functions. Core router will forward the burst to its destination node [6],

[7]. In OBS, a burst consist of header and payload called data burst. A burst header is called as CP. Typically; CP contains information about burst size and burst arrival time. The CP and payload are send separately on different channels called as control and data channel respectively as shown in Fig. 2 [8]. The burst is preceded in time by a CP, which is send on separate control wavelength. The preceded time is called as "offset time".

After a burst is generated, the burst is buffered in the queue at edge router for an offset time before being transmitted to give its CP enough time to reserve network resource along its route. During offset time, packets belonging to that queue may continue to arrive. These extra packets are dropped [9].

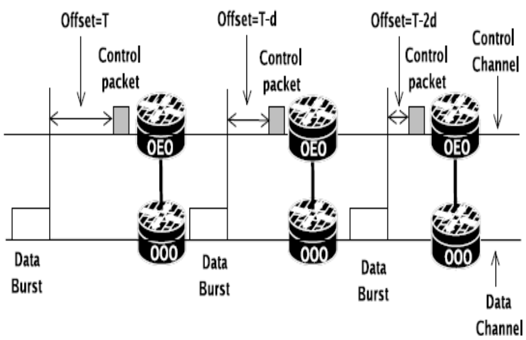

Fig 2: Separate Transmission of data and control signals.

At each intermediate node, CP undergoes O/E/O conversion to get it processed electronically. The time taken for processing a CP is called as the "processing time" [9], [10], [11]. Depending upon CP information wavelength is reserved for the incoming burst for that duration by core router [4], [6],[7], [8].

Basically, there are three different assembly schemes, namely threshold-based, timer-based and hybrid-based [9], [10].

In a timer-based scheme, a timer is started to initialize the assembly process. A burst containing all the packets in the buffer is generated when the timer exceeds the burst assembly period [9]. While in a threshold-based scheme, a burst is created and sends into the OBS network when the total size of the packets in the queue reaches threshold value [9].

Hybrid assembly scheme is the combination of both threshold-based and timer-based assembly scheme [9]. In the hybrid assembly scheme, a burst can be sending out when either the burst length exceeds the desirable threshold value or the timer expires.

In OBS network, different wavelength reservation schemes are used for reserving the wavelength. One is called as Tell-And-Wait (TAW). In TAW, when source has the burst to send, it first reserve the wavelength along the route by sending "request" message. If the wavelength is granted by intermediate nodes along its route, a positive acknowledgment (PACK) message returns to source from the destination; otherwise negative acknowledgment (NACK) is received at source [4], [12],[13], [14].

Second scheme is called Tell-And-Go (TAG), in which two reservation schemes has been proposed. They are Just-Enough-Time (JET) and Just-In-Time (JIT). In JET, reservation is made by using CP information. The reservations made for the duration of data burst. The resources are reserved and released implicitly. In JIT, the resources are reserved as soon as CP is received and hold resources until burst departure time. The resources are released explicitly by sending another control message and which results in bad resource utilization. Due to this the wavelength holding time to that node is larger than burst transmission time [4], [12], [13], [15].

2. Burst Scheduling Algorithm

Another important factor which affects the network traffic is scheduling algorithms used to schedule burst. Arrival of bursts at OBS node is dynamic. Scheduling technique must schedule arrival burst on the available wavelengths for the entire duration of burst transmission. Scheduling technique must schedule burst efficiently and quickly. Scheduling algorithm should be able to process the CP fast enough before the burst arrives to the node. It should also be able to find proper void for an incoming burst to increase channel bandwidth utilization. Following are proposed burst scheduling algorithms in the literature.

2.1 Latest Available Unused Channel (LAUC) Algorithm [16],[17].

In LAUC, burst scheduling is done by selecting the latest available unscheduled data channel for each arriving data burst. In this algorithm, a scheduler keeps track of horizon for each channel. Horizon is the time after which no reservation has been made on that channel. LAUC searches the wavelength by using horizon information on each channel. The scheduler assigns each arriving new burst to the data channel with minimum void formed by that burst on data channel. For example, in Fig.3, wavelength $C2$ and $C3$ is unscheduled at the arrival time t of the new burst. Wavelength $C3$ will be selected for the new burst because the generated void (t-$t3$) on wavelength $C3$ will be smaller than the void (t-$t2$) that would have been created if wavelength $C2$ was selected.

LAUC algorithm is simple and has a good performance in terms of its execution time. However, it results in low bandwidth utilization and a high burst loss rate.

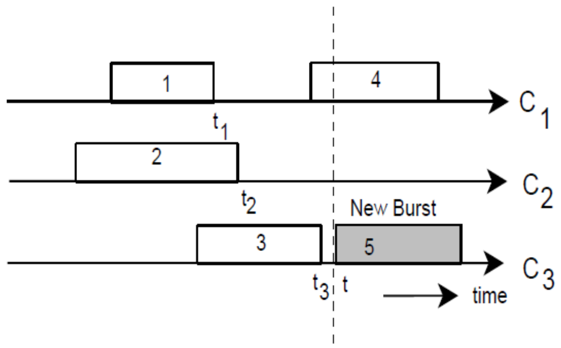

Fig 3: Illustration of LAUC data scheduling algorithm.

2.2 Latest Available Unused Channel with Void Filling (LAUC-VF) Algorithm [16],[17].

In LAUC, the voids are created between two data burst assignment on the same data channel. This is termed as unused channel capacity. LAUC-VF is variant of LAUC. In this algorithm, a scheduler keeps track of horizon and voids for each channel. LAUC-VF maintains start and end time of void for each data channel. LAUCVF searches for the void such way that newly formed void is very small compared to other voids. An example of LAUC-VF algorithm is illustrated in Fig. 4. New data burst with duration *L* arrives at time *t* to the optical switch, the scheduler first finds the outgoing wavelengths that are available for the time period (*t*, *t*+*L*). Wavelengths *C*1, *C*2 and *C*5 are available for the coming data burst. Wavelengths *C*2 is chosen to carry the new data burst because the void that will be produced between the bursts and coming data burst is the minimum void.

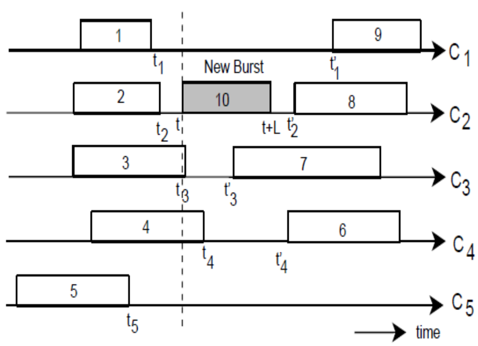

Fig 4: Illustration of LAUC-VF data scheduling algorithm

Implementation of LAUC-VF has a much longer execution time than the LAUC scheduling algorithm, especially when the number of voids is significantly larger. However, it result in high bandwidth utilization and a low burst loss rate.

2.3 Best-Fit (BF) Algorithm [16].

In BF, a scheduler keeps track of horizon and void for each channel. It also maintain start time and end time of void for each data channel. Scheduler tries to search for a void such way that newly created void is the smallest void before and after scheduled burst. An example of Min-EV algorithm is illustrated in Fig. 5.

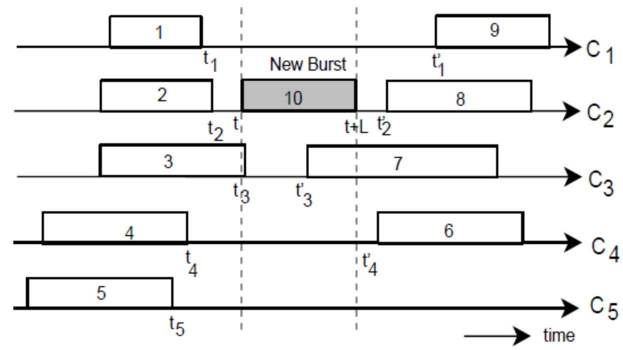

Fig 5: Illustration of BF data scheduling algorithm

New data burst with duration *L* arrives at time *t* to the optical switch, the scheduler first finds the outgoing wavelengths that are available for the time period (*t*, *t*+*L*). Wavelengths *C*1, *C*2, *C*4 and *C*5 are available for the coming data burst. Wavelength *C*2 is chosen to carry the new data burst because the starting and ending void that will be produced between the bursts and coming data burst is the minimum void. Implementation of BF has a much longer execution time than the LAUC scheduling algorithm, especially when the number of voids is significantly larger. Also it achieves a loss rate which is at least as low as LAUC-VF, but can run much faster. However, it results in high bandwidth utilization and a low burst loss rate.

2.4 Minimum Starting Void (Min-SV) Algorithm [16], [17].

In Min-SV, a scheduler keeps track of horizon and void for each channel. It also maintains start and end time of void for each data channel. Scheduler tries to search for a void such way that newly created void is the smallest void after scheduled burst. An example of Min-SV algorithm is illustrated in Fig. 6. New data burst with duration *L* arrives at time *t* to the optical switch, the scheduler first finds the outgoing wavelengths that are available for the time period (*t*, *t*+*L*).Wavelengths *C*1, *C*2 and *C*5 are available for the coming data burst. Wavelength *C*2 is chosen to carry the new data burst because the starting void that will be produced between the burst and coming data burst is the minimum void.

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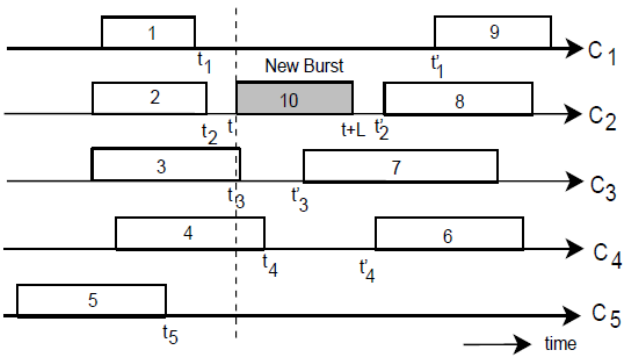

Fig 6: Illustration of MIN-SV data scheduling algorithm.

Implementation of Min-SV has a much longer execution time than the LAUC scheduling algorithm, especially when the number of voids is significantly larger. Also it achieves a loss rate which is at least as low as LAUCVF, but can run much faster. However, it results in high bandwidth utilization and a low burst loss rate.

2.5 Minimum Ending Void (Min-EV) Algorithm [16],[17].

In Min-EV, a scheduler keeps track of horizon and void for each channel. It also maintain start and end time of void for each data channel. Scheduler tries to search for a void such that newly created void is the smallest void before scheduled burst. An example of Min-EV algorithm is illustrated in Fig. 7. New data burst with duration *L* arrives at time *t* to the optical switch, the scheduler first finds the outgoing wavelengths that are available for the time period (t, $t+L$). Wavelengths *C*1, *C*2, *C*4 and *C*5 are available for the coming data burst. Wavelength *C*4 is chosen to carry the new data burst because the ending void that will be produced between the bursts and coming data burst is the minimum void. Implementation of Min-EV has a much longer execution time than the LAUC scheduling algorithm, especially when the number of voids is significantly larger. Also it achieves a loss rate which is at least as low as LAUCVF, but can run much faster. However, it result in high bandwidth utilization and a low burst loss rate.

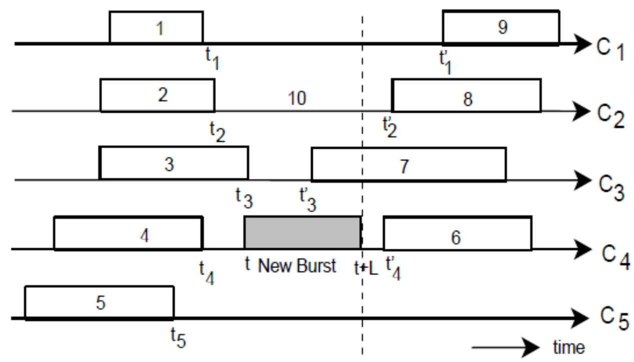

Fig 7: Illustration of MIN-EV data scheduling algorithm.

BF, Min-SV and Min-EV algorithms are the variant of LAUC-VF algorithm. All the void filling scheduling algorithm yields better bandwidth utilization and burst loss rate than LAUC algorithm. But all the void filling scheduling algorithm has a longer execution time than LAUC algorithm.

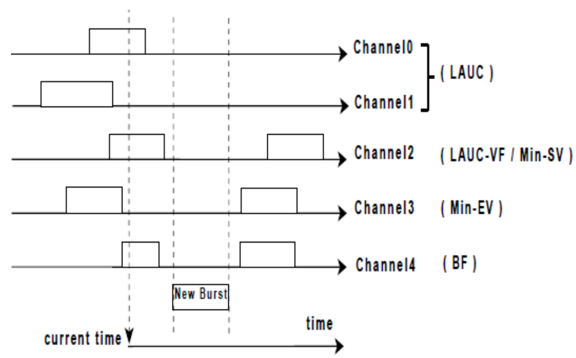

Fig 8: An example showing how a new burst is scheduled by using different scheduling algorithm.

Table I shows the comparison of different scheduling algorithm [16].

Table 1: Comparison of Different Scheduling Algorithm.

Scheduling Algorithms	Time Complexity	State Information	Bandwidth Utilization
LAUC	O(W)	$Horizon_i$	Low
LAUC-VF	O(Wlogm)	$S_{i,j}E_{i,j}$	High
BF	O(Wlogm)	$S_{i,j}E_{i,j}$	High
Min-SV	O(logm)	$S_{i,j}E_{i,j}$	High
Min-EV	O(logm)	$S_{i,j}E_{i,j}$	High

Table I summarizes the above discussion using the following notations:

- W : Number of wavelengths at each output port.\
- m : Maximum number of data bursts(or reservations) on all channels.
- *Horizoni* : Horizon of the *ith* data channel.
- *Si;j* and *Ei;j* : Starting and ending time of *jth* reservation on channel i.

3. Conclusions

OBS provides a cost-effective solution for switching in the next-generation optical Internet. Various Internet applications such as multimedia, voice-over-IP, ecommerce and web conferencing have different resource requirements and differ in how much they are willing to pay for the services. In this paper, a survey of burst rescheduling algorithms in OBS is presented along with advantages and disadvantages of this algorithm.

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First Author Sanjay N. Sharma has Received B.E. (Computer Engineering) degree in 1992. M.B.A. in (Marketing Management) in 1995.Currently pursuing M.E (Computer Engineering) from Aurangabad. He has more than 18 years of experience in teaching. Currently working as Assistant Professor in Computer Engineering at Thakur College of Engineering, Kandivali East, Mumbai, INDIA.His areas of interest are Image Processing and Computer Networks.

Second Author Dr. R.P. Adgaonkar has received B.E. (Hons.) from Government College of Engineering, Aurangabad in 1968, M.Tech from IIT Bombay in 1970,and Ph.D.in 1980.