Scheduling Algorithms for WDM Optical Networks

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***Abstract*—A Study of existing burst assembly schemes and scheduling algorithms for WDM optical networks has been done using the different performance metrics. Features of different scheduling and assembly algorithms for OBS network are compared. A study of existing scheduling algorithms using different parameters like bandwidth utilization, throughput, burst loss rate and end to end delay has been made. It has been found that architecture of optical burst switching (OBS) network which uses the ETLQF assembly scheme shows the better performance than other architectures with other assembly schemes. Improvement in network performance can be achieved using the different scheduling algorithms like VT-BA and CTBR. Also, new scheduling algorithm IWDs (Intelligent Water Drops) is proposed to improve the performance of OBS network.**

Keywords: WDM, OBS, Scheduling Algorithms, IWDs, ETLQF, VT-BA, CTBR, Assembly Schemes.

I. Introduction

Optical burst switching (OBS) is one of the promising optical network technology for increasing demand of internet traffic. OBS helps in better utilization of network resources as compare to optical packet switching (OPS) and optical circuit switching (OCS) [1], [2]. Optical circuit switching and optical packet switching have some limitations for WDM optical networks [3]. Limitation of circuit switching is that it is not efficient in term of bandwidth and limitation of packet switching is that there is use of optical buffer at each intermediate node [4]. OBS networks have the nodes which are linked with each other using the network technology called wavelength division multiplexing (WDM). In WDM, fiber bandwidth is distributed among a number of wavelength channels. There is no overlapping between wavelength channels so that bandwidth can be used efficiently and terabit networks can be realized. Each wavelength channel is operating at its individual speed. Firstly, packets that require to be forwarded for the same destination are aggregated in the ingress node (entry edge node). The aggregated packets are called data burst. When the data burst arrives at the egress node (exit edge node). Finally, it is disassembled and its constituent packets forwarded to their destination [5]. A burst is made up of two things: burst control packet and data burst. Some offset time is always there between the control packet (CP) and the data burst so that the core nodes in OBS network have enough time for establishing their switching paths and have enough time for reserving the channel for the coming data burst. A burst header packet (BHP) is transmitted from source node to the core node before the transmission of data burst for reserving the required resources in core nodes [6], [7]. When the core node receives BHP it sends the BHP-R ACK (BHP received acknowledgment) and after the reception of BHP-R ACK, data burst is forwarded. In this way, burst loss probability is reduced and the network quality of service is improved. In this research work, we study QoS provisioning in order to improve the network performance in data burst transmission. Table1 shows the real-time application that uses OBS and burst switching technology. Firstly, we investigate offset time since it plays a significant role in optical networks. However, existing approaches have been considered predetermined offset time so we obtain high burst loss probability due to low offset time. Similarly, high offset time can cause high delay for single burst transmission. To mitigate such issues intelligent water drops algorithm is proposed.

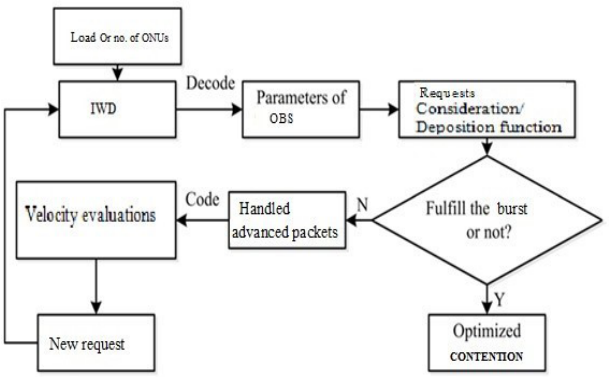

Fig. 1: IWDs Figuring.

The IWDs technique uses OBS network parameters and deposition function to determine whether the burst is properly transferredor not as shown in figure 1. The Intelligent Water Drops (IWDs) algorithm coordinates to discover better arrangements as shown in fig. 1

The drawback of this intelligent water drops algorithm is that it increases complexity and it does not consider burst priority.

Table 1: Real-time Application Sample (Multimedia Video Transmission)

Video Data	Supported Technology	Data Rate
4K UHD/3D and UHD	OBS, Burst Switching	>1 Gbps

Burst contention occurs when several data bursts attempt for transmission to the same core node. This is one of the major limitations of the OBS networks. Different content resolution techniques have been proposed at core nodes such as fibe delay lines (FDL), deflection routing and wavelength conversion [8], [9]. These strategies are increases processing time on the core node, which highly cause delay for sensitivedata transmission. Still, the contention avoidance research is emerging to determine an optimal amount of resources required at the core node for the contention resolution [10]. In latest available unscheduled channel with void filling (LAUC-VF) scheduling algorithm, void intervals are used for scheduling the data bursts. With LAUC-VF, the latest available unused data channel can be used for coming burst [11]. Also, burst assembly algorithm known as variable time burst assembly (VT-BA) may be used in which burst loss rate and end to end delay varies with the variation of traffic in the network. There is compatibility between Constant time burst resequencing (CTBR) and VT-BA for most of the parameters which are considered here for the analysis. Assembly of packets into burst at ingress node is also one of major issue in OBS network. Several burst assembly techniques are there based on threshold and time. In assembly scheme which are based on threshold, a threshold parameter is set which tells count of packets to be assembled in a burst. In timer- based burst assembly scheme, a timer is used which starts counting from the arrival time of first packet and counts until count reaches a pre-defined value. Timer-based assembly schemes are: Just in time (JIT) assembly technique and Just enough time (JET) assembly scheme. Estimated traffic based longest queue first (ETLQF) is threshold based burst assembly scheme. Also, burst loss rate can be reduced by combining best burst scheduling algorithms and best burst assembly scheme.

II. Review of Literature

The performance of LAUC-VF scheduling algorithm is better than the horizon algorithm in terms of bandwidth utilization and burst loss rate. It has been found that architecture of OBS network in which we are using a novel burst assembly algorithm, fiber delay lines and dynamic route selection technique is more effective than other architectures using other assembly algorithms [12]. When we are using ETLQF burst assembly scheme, throughput and burst loss rate is improved [13]. When we are using CTBR scheduling algorithm network performance is improved in terms of parameters like burst loss rate and end to end delay [14]. Concepts of both VT-BA and CTBR algorithms can be combined to get a better solution for the coming generation of OBS networks. Also, Intelligent Water Drops(IWDs) algorithm can be a better solution for coming generation of OBS networks. We can declare OBS a practical solution, after finding the best combination of the burst scheduling algorithm and the burst assembly scheme.

III. Analysis

Table 2. gives the overview of different burst scheduling algorithms. When we are using LAUC-VF burst scheduling algorithm, end to end delay is negligible but there is high burst loss rate. When we are using VT-BA, there is increase in both burst loss rate and source end to destination end delay with the increase in traffic load. When we are using CTBR, there is decrease in the burst loss rate. Also source end to destination end delay lies in feasible range when we are using CTBR. Concept of VT-BA and CTBR can be combined and network performance can be improved. Setting the parameters such as line rate 10 Giga bits per second per wavelength and fixed offset time around 30 seconds, variation in burst loss rate and end to end delay for different scheduling algorithms is as shown in table2:

Table 2: A Comparison of Existing Burst Scheduling Algorithms.

Scheduling Algorithm	Burst Loss Rate	ETE Delay(s)
LAUC-VF Algorithm	0.80-0.85	0.004
VT-BA Algorithm	Increases with the increase in traffic load	Increases with the increase in traffic load
CTBR Algorithm	0.55-0.60	Lies in acceptable range

Table 3. gives the overview of different existing burst assembly schemes. Using JIT assembly technique there is a less utilization of bandwidth and high value of blocking probability in comparison to other assembly schemes. With the help of JET assembly technique, improvement

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in blockingprobability and throughput can be made. With the help of ETLQF, more utilization of bandwidth and more throughput can be achieved with respect to other techniques. When we are using ETLQF assembly scheme blocking probability is less in comparison to other schemes. Setting switching time between nodes = 12 microseconds, propagation delay time on the link = 0.2 milliseconds, the average burst length = 90 microseconds, processing time of burst =2.5 microseconds, performance parameters bandwidth utilization, blocking probability and throughput are as shown in table 3:

Table 3: A Comparison of Existing Burst Assembly Schemes.

Burst Assembly Scheme	Bandwidth Utilization	Blocking Probability	Throughput
JIT Assembly Scheme	Less than 50 %	0.1 to 0.5	Low value
JET Assembly Scheme	Less than 50 %	0.01 to 0.05	Medium value
Novel Burst Assembly Scheme (ETLQF)	More than 50 %	< 0.01	High value

IV. Conclusion

A study of existing burst scheduling algorithms taking parameters burst loss rate and end to end delay has been done. Also, study of existing burst assembly schemes taking parameters bandwidth utilization, blocking probability and throughput has been done. All the scheduling algorithms are compared and it has been found that, the CTBR scheduling algorithm gives better results in terms of burst loss rate and source end to destination end delay Also, study of existing burst assembly schemes has been done. All the burst assembly scheme are compared and it has been found that, the ETLQF burst assembly scheme gives better results in terms of parameters like utilization of bandwidth, throughput and blocking probability etc. More research work can be done to find out more efficient technique by combining existing burst scheduling algorithms and existing burst assembly schemes. CTBR burst scheduling algorithm and ETLQF burst assembly scheme can be combined for achieving better results. Also, IWDs burst scheduling algorithm and ETLQF burst assembly scheme can be combined for achieving better results.

V. References

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