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Variable Offset Time for Composite Burst Assembly with Segmentation Scheme in Optical Burst Switching Networks

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Abstract— Optical burst switching (OBS) is one of the major paradigms of optical switching networks along with optical circuit switching and optical packet switching. It combines the advantages of the other two paradigms and avoids their limitations. Hence, optical burst switching networks are seen as the best candidate for next generation optical networks. Since OBS networks are expected to be the backbone for different types of applications, a suitable quality of service (QoS) algorithm is necessary to handle the task. One of the open issues in these networks is assigning appropriate offset time value, especially in the case of composite burst assembly. Composite burst assembly scheme suggests the generation burst may consists of different classes of services. Generally, low priority packets are placed in location where contention may occurs. The limitation of this technique is that, as the number of high priority packets increases in the generated burst, loss increases. On the other hand, variable offset time QoS scheme suggests adding more offset time to bursts with high priority which allows more time for the burst header to reserve the required resources. The limitation of this technique is the increased delay for high priority traffic. In this study, variable offset time for composite burst assembly with segmentation scheme is deployed. The proposed scheme is evaluated by the way of comparison with the two previously mentioned schemes. The proposed scheme suggests that after receiving the traffic at the ingress node, the transmitted packets are filtered and high priority packets are placed at the tail of the burst. In the case of bursts contention, head dropping burst segmentation is deployed as a resolver. The simulation results show that the proposed scheme performs better than composite burst assembly with segmentation and variable offset time QoS schemes in terms of loss with improvement of 50% and 55% respectively, and delay with improvement of 40% over variable offset time scheme.

Keywords— Optical Burst Switching (OBS), Quality of Service (QoS), composite burst assembly, offset time, burst segmentation.

I. INTRODUCTION

Optical burst switching (OBS) was proposed as a compromised solution that combines the advantages of optical circuit switching (OCS) and optical packet switching (OPS) and avoids their limitations [1]. In OBS the basic transmission unit -unlike OCS and OPS that use packet- is called burst. The burst is composed of a number of packets that are assembled in the source (ingress) node and destined to the same destination (egress) node. A packet called burst header packet (BHP) will be sent to reserve resources prior to the arrival of a burst. The interval time between sending the BHP and its related burst is called the offset time which eliminates the need for fiber delay lines (FDLs) in the core node to buffer the contending bursts. OBS offer better bandwidth utilization than OCS, and evades the technological limitations in the case of OPS. Recently, a determined effort was accomplished by the researchers in the field of optical switching networks to study the possible ways of providing quality of service in OBS networks. Different types of QoS mechanisms were proposed to satisfy the requirements of each kind of traffic in the OBS network [2]. However, several issues need to be considered before optical burst switching can be deployed in the working networks. These issues are burst assembly, signaling, scheduling, contention and service differentiation.

A burst assembly scheme is required to determine how packets are assembled into burst. When assembling a burst, issues like the number and the type of the packets to include in a burst should be considered. The burst assembly scheme will affect the burst length as well as the amount of time that packets must wait before being transmitted. Trigger criterion of the burst is a very important factor in burst assembly because it has a direct effect on the arrival time and loss in the core nodes. Time-based and size-based algorithms are usually used in assembling the burst using a specific threshold [3]. Since resources must be reserved in advance before burst arrives to the core node, a signaling scheme must be available to achieve such task. In general, there are two signaling mechanisms in OBS, two way signaling mechanism and one way signaling mechanism. The most common signaling scheme that uses two way reservation method is Tell And Wait (TAW) [4], while several signaling schemes use one way reservation methodology like Tell And Wait (TAG), Just In Time (JIT) and Just Enough Time (JET) [5].

After BHP arrives to the core node, a channel scheduling mechanism handles the issue of assigning the burst to one of the available channels. The characteristics of a good scheduling algorithm are low Burst Loss Probability (BLP), fast burst scheduling, low complexity and the ability to minimize the voids in the channels which leads to better bandwidth utilization. A void on a wavelength is the gap between scheduled bursts. Scheduling algorithms are usually classified

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based on their ability to fill these voids to void filling and non void filling algorithms. Two of the most important scheduling algorithms are First Fit Unscheduled Channel (FFUC) which schedules the burst to the first available channel and Latest Available Unscheduled Channel (LAUC) which schedules the burst to the channel that offer minimum gap with the preceding burst [6].

Since OBS networks usually apply one way reservation mechanism, more than one burst may contend for the same resource at the same time. This may cause increasingly loss of the bursts, so a contention resolution policy must handle this problem. The most important contention resolution approaches are optical buffering, wavelength conversion, deflecting routing and burst segmentation.

As a promising and efficient network, OBS supposes to sustain a vast scope of applications with different service requirements. Consequently, providing Quality of service in OBS network is considered one of the hottest topics in this field. Differentiation can be executed in various parts in the network, at edge node like in burst assembly, offset time assigning process, signaling scheme and traffic routing, or at core node like in scheduling algorithm and contention resolution mechanism. There are two basic models for QoS in OBS, the relative QoS model and absolute QoS model. In the relative QoS, each class is defined relatively to other classes. For example, a burst of high priority is guaranteed to experience lower loss probability than a burst of lower priority. However, the loss probability of high-priority traffic still depends on the traffic load of lower-priority traffic; and no upper bound on the loss probability is guaranteed for the high-priority traffic. The absolute QoS model provides a worst-case QoS guarantee to applications, from a service provider's point of view, the absolute QoS model is preferred in order to ensure that each user receives an expected level of performance [2].

The rest of the paper is organized as follows. Section 2 describes QoS techniques in optical burst switching networks. Section 3 reviews some of the related works. Section 4 describes the methodology of the proposed QoS scheme. Simulation results are presented in Section 5 followed by conclusion in Section 6.

II. QoS Techniques in OBS Network

One of the desirable features in any type of networks is providing QoS, but this is a challenging task in OBS networks because of the absence of buffers at the core nodes. Lack of buffers makes the loss ratios for different classes of traffic greatly relies on the traffic attributes formed at the edge nodes. For example, shorter bursts with long offset time have low probability of being dropped. The existence of number of separate queues at the edge nodes assist in the process of service differentiation that satisfy the requirements of each class [7]. Three types of QoS schemes that related to the proposed scheme are discussed as follows:

A. Composite Burst Assembly:

The fundamental concept of this technique is to assemble a burst using packets aggregated from multiple traffic classes with different priorities. Higher priority packets placed in location where it's low likelihood to conflict with other burst. For example, in the case of deploying tail dropping scheme to resolve a contention, data with high priority is inserted close to the head of the burst and the data with low priority is put near the end. The number of traffic classes and the number of priorities supported by the network will have impact on the composite burst assembly algorithms. The task of the composite burst assembly algorithm is to determine how to select packets from different traffic classes for a composite burst and how to map the composite burst to different priorities supported by the network [8].

B. Offset-based Mechanisms:

For networks that deploy JET signaling scheme, an extra offset time suggested to be added to high priority classes. Consequently, high priority burst will suffer less contention due to the virtue of early reservation. The amount and assigning method for the additional offset time varied among different proposed algorithms based on the numbers and types of classes [9].

C. Burst Segmentation:

A burst segmentation can be implemented to drop only the overlapping segments instead dropping the whole burst. Obviously, in the case of more than one class existed, the segments of lower priority class will be dropped. In the case of contention between two bursts belong to the same class; the larger burst will win the contention to increase the overall throughput of that class.. Some drawbacks of using burst segmentation are out of order traffic transmission, virtual contention and excessive loss in lower classes of traffic [10].

III. Related Works

The proposed algorithm in this work is composed of combination of three relative QoS schemes, these are composite burst assembly scheme, offset time-based scheme and burst segmentation scheme. These three techniques are considered the building blocks of the suggested algorithm which offers merging the benefits of these schemes while leave their limitations behind.

One of the first schemes that suggest offering QoS in OBS networks using composite burst assembly is proposed in [11]. After assembling high priority packets towards the head of the burst, a combination of burst segmentation with tail dropping and burst deflection were used to resolve contention. So, high priority burst can preempt low priority burst with noticeable enhancement on overall packet loss and delay. According to [12], a composite burst assembly with segmentation was proposed to provide QoS by assembling the high priority packets at the middle of the burst and the low priority packets at the edges. Such scheme offers low delay since no extra added and it decreases the probability of contention between two high priority bursts since contentions occur mainly at the burst edges. The problem in such scheme is the increasing loss in high priority packets when their numbers in the burst increase. Also, using head and tail dropping techniques lead to the existence of out of order traffic and virtual contention problems.

In many works related to OBS, fixed amount of offset time was suggested to all classes of traffic in the network. However, some schemes proposed assigning unique offset time for each class since offset time has a direct effect on the blocking probability at the core nodes. Hence, assuming fixed offset time will ignore some important issues like the probability of queuing the burst header packet at the core nodes, time required to find voids and variable burst length. An extensive analysis and evaluation for these factors is presented in [13] to study the causes of burst blocking probability in a single wavelength with a continuous-time variable offset values. The authors in [14] proposed a variable offset time scheme to provide QoS by assigning 10 times offset time for high priority traffic more than low priority traffic. Such scheme allows BHP for high priority traffic to reserve more resources in advance which offer better resource management. Also, the arisen of early arrival issue will decreased since the time gap between BHP and the burst increased. On the other hand, adding more offset time will increase the delay for high priority traffic. Also, this scheme may cause excessive loss in low priority traffic since the contention probability among bursts of low priority increase.

IV. Methodology of the Proposed Scheme

The process begins with receiving the transmitted data at the ingress node. A filtration process initialized where packets with the same priority and class are placed in a separate queue. After that, the burst assembler starts creating the burst by placing the high priority packets at the tail of the burst and low priority packets at the head of the burst. The process of the composite burst assembly is depicted in Figure 1.

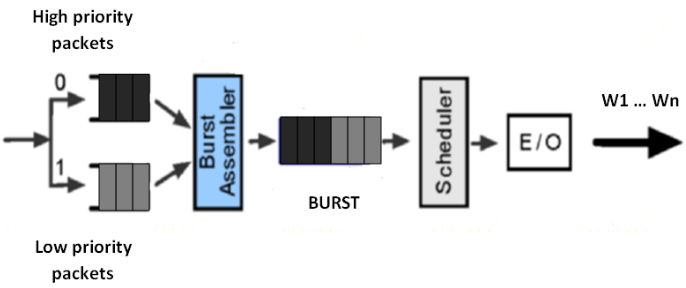

Fig. 1 Composite Burst Assembly

With the completion of the first phase, the process of assigning the appropriate offset time begins. The number of high priority packets in the burst is counted, and based on that the proper offset time is assigned. The more high priority packets the burst has, the more offset time it gains. The standard way to calculate offset time for the burst is using the following equation:

$$T = h.\ (\delta + ts) \qquad (1)$$

Where T is the offset time, h is the number of nodes the burst pass through between the source and the destination, δ is the time required to process the BHP, and ts is the time needed to configure the switches. The novel method of calculating offset time proposed in this work is:

$$T = h.\ (\delta + ts) + (Ex.R) \qquad (2)$$

Where Ex is the extra time added to the burst and R is the percentage of high priority packets in the burst. Using equation 2 allow the edge node to assign the appropriate offset time for each burst in such a way that accommodate with the content of that burst. Then, the burst forwarded to its destination, passing through the network core nodes. In the case of scheduling the burst with no contention at the core nodes, then the burst delivered successfully to the destination. Otherwise, when two or more bursts contend for the same resource, a contention resolution policy is recruited. The third phase is launched when a contention between two bursts resolved using burst segmentation. After truncating the head of the contending burst, the BHP of that burst modified to inform the rest of core nodes about the modification. In the case of completing the segmentation process successfully, both original and contending bursts resume their trip towards the destination. Otherwise, the contending burst is simply dropped. Figure 3 describes burst head dropping.

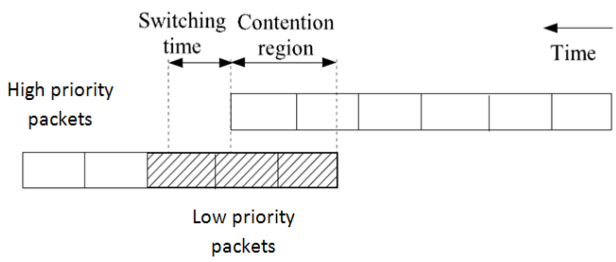

Fig. 2 Burst head dropping

V. Simulation Results and Discussion

For the purpose of evaluating the proposed scheme, a simulation model is developed using NCTUns 6.0 network simulator. The used network topology is NSFNET which is considered as one of the main topologies in the field of OBS.

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JET is the signaling scheme while FFUC is the channel scheduling method. The transmitted data are classified into high and low priority traffic. Input traffic ratio is 50% for each class, with variable number of packets inside the burst based on the arrival rate for each class. Numbers of data channels are three, one for control packets and two for data packets with a maximum transmission rate of 1 Gbps. The packet length is 1000KB while the burst length is set to 10000KB. The offset time is variable based on the packets number of high and low priority. The contention resolution method is head dropping segmentation with no wavelength conversion, burst deflection or FDLs. The range of the tested traffic load lies between 0.2 and 0.8. Comparisons among QoS schemes in OBS are applied, these QoS schemes are Variable Offset Time (VOT) scheme, Composite Burst Assembly with Segmentation (CBAwS) scheme and the proposed scheme Variable offset time for Composite burst assemble with Segmentation (VCS) scheme. The comparisons test the loss and delay in high and low priority traffic in those three schemes.

As shown in figure 3, a comparison of loss probabilities between high and low priority traffic is presented. The simulation results revealed that high priority packets experience less loss ratio than low priority packets. This is occurs because of two main reasons. First of all, low priority packets will work as a shield that protect high priority packets since the latter were assembled at the tail of the burst and head dropping segmentation is applied. Secondly, more offset time will be assigned to the burst with the increasing number of high priority packets which enhance the chance of successful reservation.

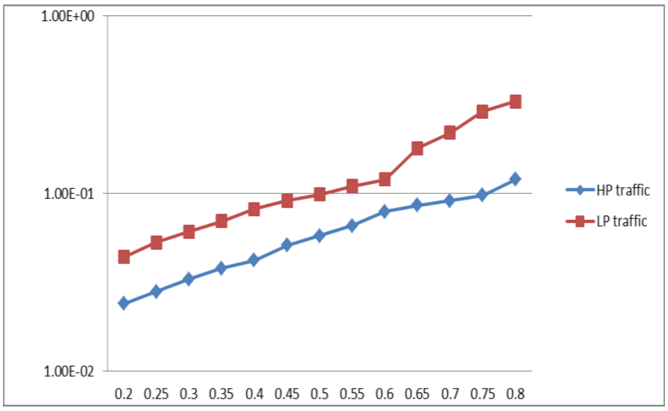

Fig. 3 Loss ratio in VCS scheme

The results of comparison among VOT, CBAwS and VCS schemes regarding overall traffic loss ratio are shown in figure 4. VOT has the lowest performance because of the excessive low priority packet loss. Also, the slightest contention between bursts will lead to drop one of them since no burst segmentation is used to resolve the contention. In the case of CBAwS scheme, low priority packets suffer less loss than previous scheme thanks to burst segmentation and better sources reservation opportunities. The main problem with this scheme is the increasing loss ratio of high priority traffic especially when the load of this class is increased. This happens because of all bursts have a constant offset time value regardless the number and the type of the included packets. The proposed scheme has the best performance since it combines the good features of the other two schemes and avoids their problems. Low priority packets experience less loss ratio after being tagged together with the high priority packets at the same burst with the existence of burst segmentation. While the bursts that includes high percentage of high priority packets will obtain more offset time. This offers better network resource management method.

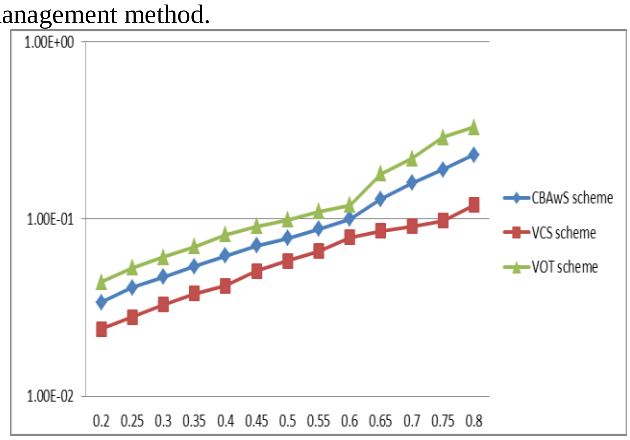

Fig. 4 Overall traffic loss ratio

Regarding delay, obviously CBAwS scheme has the minimum delay for both high and priority traffic since no extra offset time added in this scheme. In the case of VOT scheme, high priority traffic experience higher delay than low priority because the extra offset time will be completely assigned to high priority traffic while low priority gets none. This time gab difference is mitigated in the proposed scheme by integrating high and low priority packets together. As shown in figure 5, delay in micro second (μs) in high and low priority traffic is presented for both VOT and VCS.

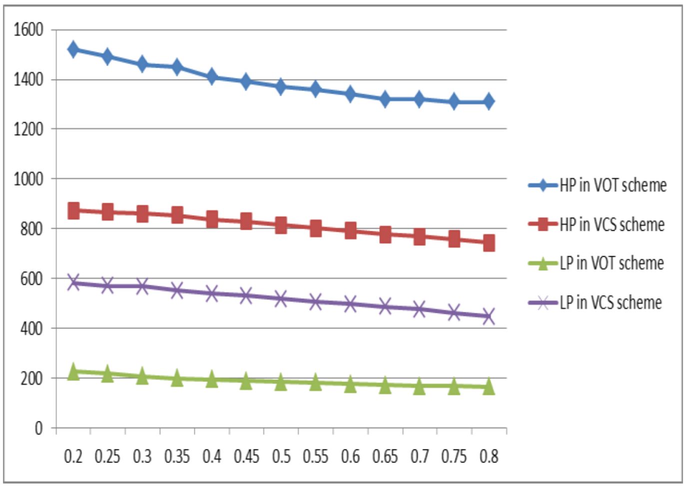

Fig. 5 Delay in VOT and VCS schemes

VI. Conclusions

In this study, a variable offset time for composite burst assembly with segmentation is proposed to provide QoS in OBS networks. After assembling the high priority packets at the tail of the burst and low priority packets at the head of the burst, a novel mechanism of assigning offset time for each burst is utilized. Each burst will be given more offset time with the increase number of high priority packet in it. This scheme decreases delay for high priority traffic compared to other variable offset time algorithms. The contention between two high priority bursts will decrease since the high and low priority packets are tagged together in the same burst. Also, the problem of virtual contention is eliminated by using only head dropping mechanism. Finally, increasing the load of high priority packets in the burst will not cause excessive loss for these packets since the burst will assigned more offset time. The expected limitations for this scheme are the increasing complexity in the offset time assigning process at edge nodes because this process occurs in a non systematic manner. Also, this scheme may cause poor bandwidth utilization when the majority of transmitted traffic is composed of high priority.

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