Performance of Prioritized Service Discipline Based on Hop Count for Optical Burst Switched Networks

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Abstract

In this paper, we propose a new prioritized Optical Burst Switching (OBS) protocol based on a hop count, which can provide efficient utilization in optical networks. Under several legacy schemes, a switch drops the burst with the shortest time regardless of its traversed hop count. As a result, a dropped burst that have been traversed many hops might cause increased bandwidth waste compared to one that has traversed a few hops. To improve this problem, we propose the Just Enough Time (JET) with a hop counting scheme which can reduce the wasted bandwidth by prioritizing the burst traversed many hops over others. From the simulation result, it is proved, we show that the proposed scheme has advantages against legacy schemes in terms of the burst blocking probability and the link utilization.

I. Introduction

Recently, several optical switches have been proposed as the future generation optical Internet. To improve the bursty traffic efficiency, these switches employ Optical Burst Switching (OBS) capability with one-way reservation protocols, such as the Just Enough Time (JET) scheme or Tell-N-G (Tell And Go), in which a data burst follows a corresponding control packet without waiting for acknowledgements [1].

However, these optical burst switching scheme with a hop counting. over several switches. Thus, when a burst which has traversed several hops is dropped until it finally reaches its destination, the allocated bandwidth wastage over the path is severe. This bandwidth wastage becomes more severe as the number of hops increases. Therefore it is necessary to take the hop count into consideration and provide prioritized service to the burst traversing many hops [2][3].

In this paper, we propose the prioritzed optical burst switching scheme with regard to the hop count. When a switch receives a burst that has traversed many hops, it allows it to be buffered in the delay line block, in order to minimize the burst dropping. In simple words, the proposed scheme prioritizes the bursts that traverse many hops over others. From the simulation result, we made improvements on the burst blocking probability and the link utilization.

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We investigate the JET scheme in Section 2. In Section 3, the scheme proposed in this paper with FDL (Fiber Delay Line) will be described. In Section 4, we provide the new JET-With-Hop-Count scheme, and analyze the blocking probability for several traffic classes. Finally, we make conclusion in Section 5.

Ⅱ. Just Enough Time(JET) Scheme

OBS employs an out-of-band control channel besides the data transmission one. JET scheme for OBS has one unique feature, the use of DR (delay reservation). A source sends out a control packet, which is followed by a burst after a certain period of time called offset time. Burst is an assembly of data packets. In Figure 1(a), let δ be the processing delay of the control packet at each node for establishing the path, then T should be equal to δ *(H+1), where H is the total number of hops along the path.

As shown in Figure 1(b), a control packet arriving at a switch i is triggered to setup a data path before the corresponding main burst arrival, and the bandwidth on hop i is reserved from the time the burst is expected to arrive t until the moment it leaves the switch (t+l), where l is the burst length [3][4][5].

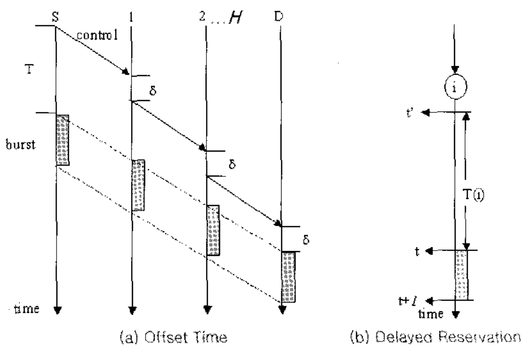

Figure 1. Basic Concept of JET

Ⅲ. Just Enough Time (JET) with Hop Count Scheme

In the JET scheme, when the collision between a burst with short offset time and a burst with long offset time occurs, the burst with short offset time may always be dropped. Therefore, the network bandwidth wastage increases when the burst traversed more nodes may be dropped by the one traversed fewer hops.

To remedy this problem, we propose a new prioritized Optical Burst Switching protocol based on the hop count. Proposed scheme allows a higher priority to the burst which has more traversed hops to escape from the risk of being abandoned without being set a channel in the intermediate node. The burst that receives the priority uses its priority to provide an additional delay time to avoid collisions among bursts. The additional delay time is chosen depending on different length of FDL in Delay Time Block (DTB).

For the proposed scheme we introduce two unique features: The Use of Delay Time Block and Reserve Channel with Control Packet, which are to be described in this section.

1. The Use of Delay Time Block

Using the delay time block, we can reduce the blocking probability of the burst which has more traversed hops.

In Figure 2, we show the JET-With-Hop-Count with Delay Time Block scheme, in which *T1_burst* has traversed more hops, while the *T0_burst* has a lower hop count. Delay Time Block (DTB) is based on Fiber-Delay-Line (FDL), which can be used as an output buffer. DTB has 5 different types of delay time with sizes increasing from 20% to 100% of burst length gradually by equal steps.

In Figure 2, when the *T1_burst* arrives at the region between *a* and *a'*, the burst offset time is recalculated by the delay time block. Proposed scheme gives the priority of DBT to *T1_burst* which has more hops when collision between *T1_burst* and *T0_burst* occurrs. Also *T1_burst* is given a higher priority for bandwidth reservation along with an additional offset time by DTB. For example, Figure 2 illustrates hop based additional offset time of bandwidth is useful to achieve an efficient bandwidth utilization. Using our proposed scheme, the bandwidth of the outgoing link is reserved from *T0*. When the *T1_burst* with a duration *a-a'* arrives at the area between *T1* and *T1'*, the bandwidth may be reserved until *a'*. Thus, if there is no buffer left for the burst using JET, the *T1_burst* will be dropped in intermediate node, denoted as *K* in Figure 2. However, proposed scheme will not drop the *T1_burst* as seen in Figure 2.

In Figure 2, where *T0* < *T1* < *T1'* + *T1'_off* , the *T1_burst* can be delayed at least *T1'* + *T1'_off*, so it need not to be dropped.

In proposed scheme, node *K* can determine whether it has sufficient FDL in DTB. After updating the offset time in the control packet, it transmits to the next intermediate node. Therefore, *T1_burst* which is abandoned in JET, can be transmitted to next intermediate node without collision in our proposed scheme.

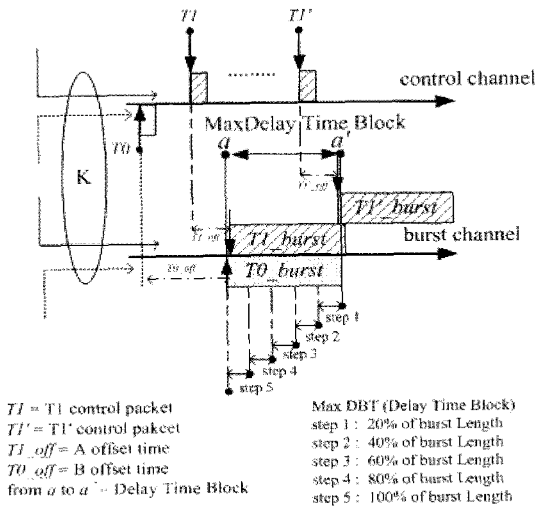

Figure 2. Proposed JET-With-Hop-Count Scheme

2. Channel Reservation with Control Packet

Figure 3 shows the operation process sequence in intermediate node. Intermediate nodes receive control packets from edge nodes or another intermediate node. They process bursts that arrive after the offset time. When control packets arrived at an intermediate node, the intermediate node synchronizes the timer with the one that it uses and checks if there is any channel available to process bursts which arrive after offset time. If any empty channel is remains, control packets update offset time and are sent to next intermediate node.

But if there is no channel to use, bursts which have least traversed hops among bursts which have already reserved a channel are searched. Then, if the arrived area of bursts which have more traversed hops is between *a* and *a'*, the intermediate node calculates offset time and send bursts to next intermediate node. If there is any burst which has already reserved a channel that has less traversed hops or the arrival time is not in DTB area(*a-a'*), the control packet can not reserve a channel. Therefore, bursts that arrive after offset time are abandoned.

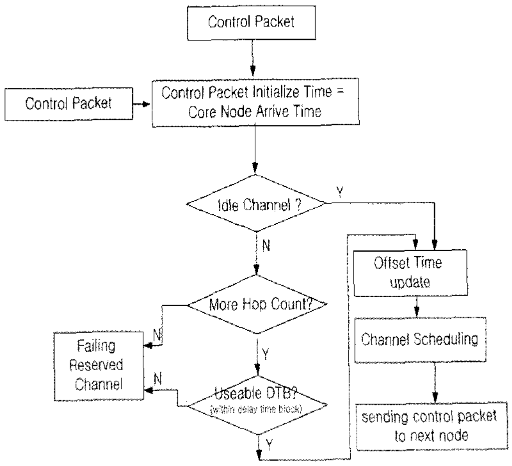

Figure 3. JET-With-Hop-Count Processing Sequence.

Ⅲ. Performance of JET scheme and proposed JET-With-Hop-Count scheme

In order to compare the blocking and link efficiency performance of JET with JET-With-Hop-Count, we use a network model as shown in Figure 4, and employs a object-oriented simulation language SIMULA. In the model, the total number of nodes is 8; 4 for edge nodes that generate bursts and 4 for intermediate nodes. The interval of generated bursts in each edge node follows the Poisson process. Bursts have a fixed length of 500Kbytes. The bandwidth of each edge node is 622Mbps (OC-12), and 2.5Gbps (OC-48) for each intermediate node [9].

Item	Value
Edge node number	4
Intermediate node number	4
Edge node generate rate (each a edge node)	155.5 packets/sec
Average burst length	500Kbyet
Edge node bandwidth	622Mbps
Intermediate node bandwidth	2.5Gbps

Table 1. Simulation Parameter

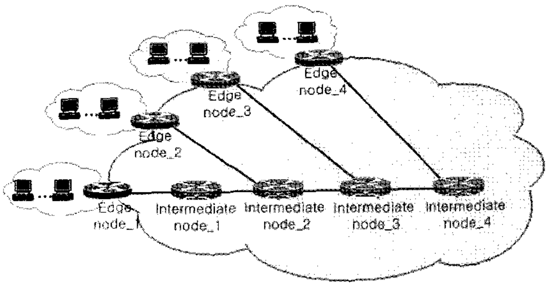

Figure 4. Scenario Model

Both Figure 5 and 6 show the blocking probability and link utilization of JET and JET-With- Hop-Count scheme. Note that the delay time is normalized by the burst length.

DTB Length \ Load	0.5	1
DTB_[20%]	14.2%	12.7%
DTB_[40%]	24.4%	23.5%
DTB_[60%]	35.2%	35%
DTB_[80%]	46.4%	47.4%
DTB_[100%]	57.6%	60.27%

Table 2. Blocking Probability by Delay Time Block

Table 2 shows the result of blocking probability. When 1.0 of traffic load is assumed and the delay time length is the same as the burst length(*DTB_[100%]*), the blocking probability of proposed scheme reduces to 60.27%. When the delay time is reduced to *DTB_[20%]*, the blocking probability of proposed scheme is reduced to 12.7%.

In this simulation, we use DTB to avoid collision in our proposed scheme. Bursts arrived in area between *a* and *a'* in Figure 2 which are abandoned in JET, but supposed scheme transmits the burst to the next intermediate node without collision.

Figure 5 shows the blocking probability according to each delay time. We separated the delay time into 5 areas and analyze the blocking probability of each intermediate node. The blocking probability decreases as the delay time increases.

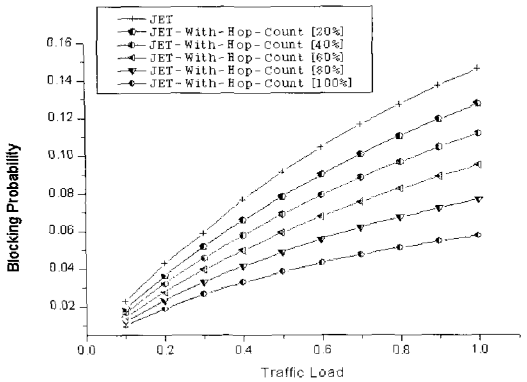

Figure 5. Blocking Probability by Delay Time Block

Table 3 is the result of link utilization between JET and proposed JET-With-Hop-Count. The delay time area is divided into 5 areas. If we compare with JET in *DTB[100%]* of delay time area and 1.0 of traffic load, the proposed JET-With-Hop-Count shows 4.3% improvement of link efficiency. And with *DTB_[20%]* of delay time area and 1.0 of traffic load, the proposed JET-With-Hop-Count shows 0.6% improvement. Thus, it shows that the link efficiency has relation with the delay time block.

In table 3, we compare the link efficiency between JET and our proposed scheme. We can verify that the link efficiency is improved along DBT. Because bursts arrived in area between *a* and *a'* in Figure 2 which are abandoned in JET are transmitted to the next node without collision.

Load / DTB Length	0.5	1
DTB_[20%]	0.4%	0.6%
DTB_[40%]	0.9%	1.4%
DTB_[60%]	1.4%	2.2%
DTB_[80%]	1.9%	3.0%
DTB_[100%]	2.4%	4.3%

Table 3. Link Utilization by Delay Time Block

Figure 6 shows the comparison result of link efficiency between JET and our proposed JET-With-Hop-Count. We separated the delay time into 5 areas and analyze the link efficiency of each intermediate node. The link efficiency increases as the delay time block.

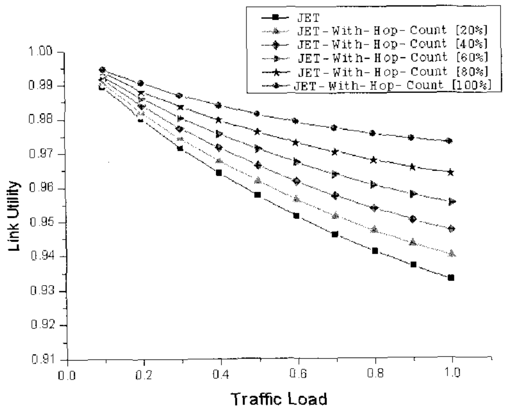

Figure 6. Link Utilization by Delay Time Block

Ⅳ. Conclusions

In this paper, the prioritized optical burst switching scheme with regards to the hop count is proposed. To prevent bursts that have traversed many hops from being dropped, we use the delay time block. We investigate the blocking probability and performance of link efficiency in terms of the size of delay time block and hop counts.

From the simulation results, one can find that the proposed JET-With-Hop-Count with delay time block can achieve lower blocking probability and higher link efficiency than JET. Specifically, when the size of delay time block increases, the performance is more improved.

Additionally, if our proposed scheme is added to the present OBS network a better service would be available.

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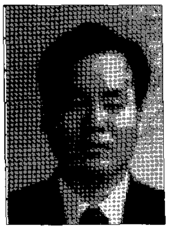

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