A Study on a Deflection Routing Method in Optical Burst-Switched WDM Networks

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Abstract. One of the key problems in the application of optical burst switching is the handling of burst contention when two or more incoming burst are directed to the same output line. Various techniques for resolving contention problems have been examined and generally classified as wavelength translation, buffering, and deflection routing. Deflection routing is simply a multipath routing technique that allows the contention problems to be solved with reasonable savings in hardware volume and cost. However the decision of offset time for idle optical link results in increased burst blocking probability. Therefore, in this paper a deflection routing algorithm is proposed to solve these problems.

Keywords: DiffServ, Marking policy, TCP, Deflection routing, WDM network

1. Introduction

Recently, Optical Burst Switching (OBS), which leverages on the advantages of OCS and OPS, was proposed. It is being actively discussed as a practical way to build an optical internet. In OBS, data is transmitted in the optical domain and control packets are processed in the electrical domain. There are different WDM channels for data bursts and BCPs (Burst Control Packets). The technique guarantees data transparency by performing channel allocation for data bursts in advance by first processing BCPs.[1-5]

As the optical burst network uses a one-way type of reservation, a contention would occur if two bursts that arrived at different times are transmitted at the same time on the same wavelength. There are many techniques available for addressing this, such as using a wavelength converter, deflection routing, and using an optical buffer. Although using a wavelength converter is efficient, it also involves increased cost, and optical buffering is still difficult to apply due to limitations in the length of optical fibers that make up the fiber delay line (FDL). Lastly, deflection routing, or routing data bursts to different output links, can be used simply without additional hardware.[6-7]

In the proposed algorithm, when a burst contention occurs, only a certain ratio of bursts is re-routed in order to reduce delay. In addition, a priority system is used for channel reservation so that as small number of bursts as possible are re-routed. Accordingly, the proposed algorithm can deal with rapid increases in the amount of data transmitted over the network. Its performance was analyzed using a computer simulation.

2. Proposed deflection routing algorithm

The core router is made up of the electrical control unit for control packets and the optical switcher which performs transparent data burst switching without photoelectric conversion. The Core Router Control Unit (CRCU), which is the electrical control unit, reserves output channels for data bursts based on receive/transmit addresses, burst length, input wavelength, and label information for OLSP, which are control information of BCP. The processing time for this is used in determining the base offset time. Therefore, depending on the CRCU structure and performance, the performance of the OBS-style optical switching system is determined.
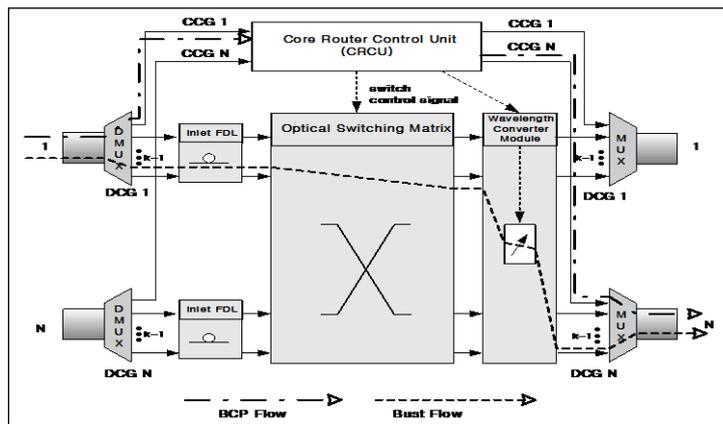

Fig. 1. Core router structure

The contention resolution algorithm proposed in this paper uses a deflection routing technique. As re-routing is done when a burst contention occurs, a wavelength converter module like the one shown in Figure 1 doesn't need to be added. Although using deflection routing can reduce costs for the OBS core node, there are also additional delays from offset time when re-routing is done, and there can be rapid increase in traffic due to increase in re-routing of data bursts. In order to address these shortcomings, this paper considered the following two items.

First, when a burst contention occurs, bursts were classified into two and processed: those that can be re-routed, and those that get discarded. By doing this, the

average delay that results from additional offset time can be reduced, and the shortcoming of excessive re-routing of bursts can be mitigated.

Second, in the burst reservation process, priority order was given to BCP processing. Examining the currently-used burst reservation process, the buffer shared by BCPs is used to process BCPs in the order they arrive at the core node (FIFO). But, if a wavelength of some BCP has already been reserved and a contention occurs, bursts that can be re-routed are rerouted, but those that can't are immediately discarded. Therefore, efficiency can be increased by processing bursts for which re-routing is not possible first and processing bursts for which re-routing is possible later.

3. Simulation results

The OBS network structure used to simulate the contention resolution algorithm. There are a total of 32 wavelength channels for each of the links of the OBS network - one OCG channel and 31 DCG channels. Poisson process was used to create the bursts, and OSPF algorithm was used as the routing algorithm. Paths are searched in a OBS network when a contention occurs in the IER where bursts are initially created and in the core router, and re-routing has to be done. Different path searching algorithms were used. For IER, one that finds the optimal path according to the link status was used, and for the core router, the one that finds the optimal path based on hop count was used. Additional offset time, which is an important parameter of the re-routing algorithm, is 2ms. As this is twice the BCP processing time in the core node, when re-routing takes place the number of core nodes that are passed through cannot be larger than the number of core node that are passed through for the original BCP, plus two.
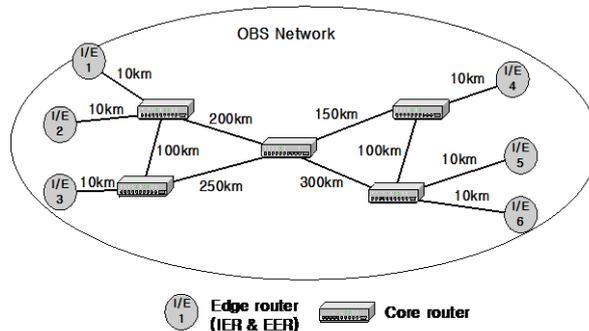

Fig. 2. Simulated OBS network

In the simulation, the following four cases were performed, according to the input load. The '*re-*' technique used a shared buffer, and the '*pre-*' technique used a priority buffer: ① No: Technique that doesn't do re-routing. ② Re: Ratio of burst for which re-routing is possible: 100%. ③ Pre-08: Ratio of burst for which re-routing is possible: 80%. ④ Pre-05: Ratio of burst for which re-routing is possible: 50%.

For each of the above cases, overall success rate, burst transmission delay, high priority burst success rate, low priority burst success rate and re-routing success rate were analyzed. The re-routing success rate is the proportion of bursts that were successfully transmitted, among those for which re-routing was attempted.
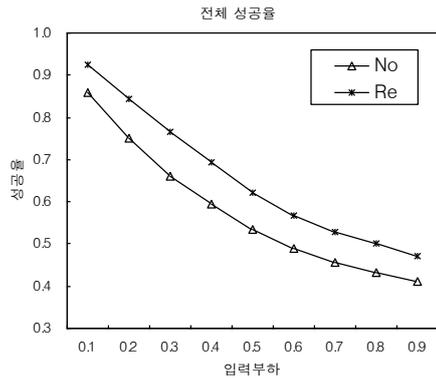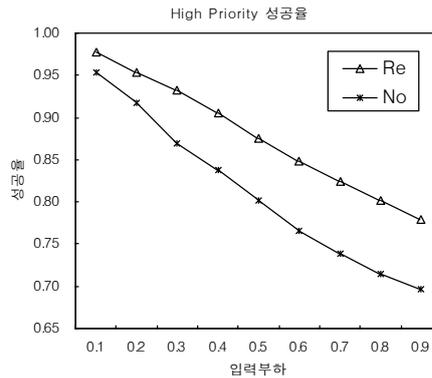

Fig. 3(a) Overall success rate (No & Re)

Fig. 3(b) High priority success rate(No & Re)

Figure 3(a), 3(b), 3(c), and 3(d) show the results of the simulation of the burst contention resolution algorithm that uses a re-routing technique. It can be seen that the overall burst success rate has been improved by about 10% on average. There are differences in the amount of improvement in the success rate from re-routing according to the burst priority order. Improvement for bursts with high priority is much greater than for bursts with low priority. This can bring about differentiated service because of the high success rate for bursts of high priority. Figure 3(d) shows the average transmission delay. When re-routing techniques are used, it is 2ms more on average, which is due to the additional offset time needed for re-routing.
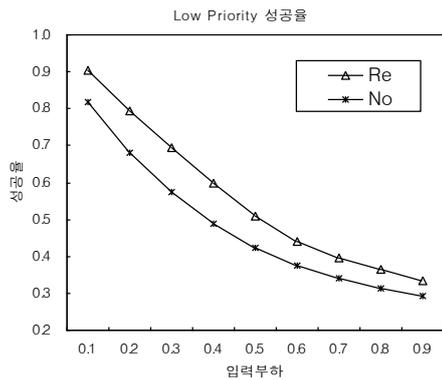

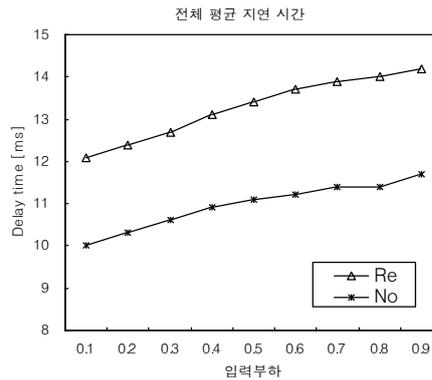**Fig. 3(c)** Low priority success rate (No & Re)

Fig. 3(d) Average transmission delay time

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Figure 4(a), 4(b), and 4(c) shows the results of the simulations according to the ratio of burst for which re-routing are possible. When the ratios were 50%, 80%, and 100%, the overall success rates were 100%, 80%, and 50% respectively, the re-routing success rates 50%, 80%, and 100% respectively, and the average transmission delays 100%, 80%, and 50% respectively.
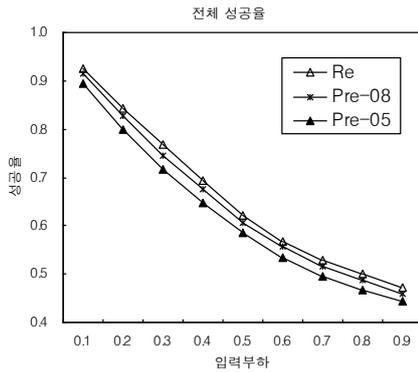

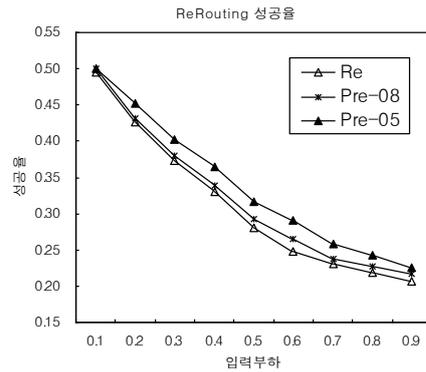**Fig. 4(a)** Overall success rate
(Re & Pre-08 & Pre-05)

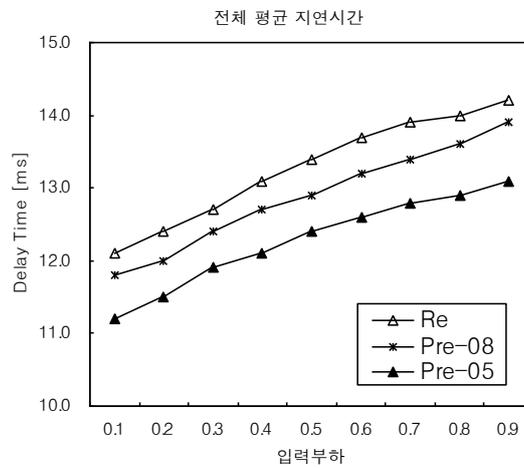**Fig. 4(b)** Re-routing success rate
(Re & Pre-08 & Pre-05)

Fig. 4(c) Average delay (Re & Pre-08 & Pre-05)

When the ratio that re-routing is possible is increased, success rate is increased. However, there are the following shortcomings when this is done: increase in the BCP processing load for re-routing at a core node; increase in the average burst transmission delay; and decrease in the re-routing success rate. Therefore, it is important to use a suitable ratio in order to reduce the BCP processing load when re-routing is done at a core node, and to reduce the burst transmission time. There were

almost no differences in the success rates when the re-routing ratio was 80% versus when it was 100%, while the average transmission time was reduced by about 0.5ms for the former.

4. Conclusions

In this paper, a computer simulation was done in various ways in order to analyze the performance of a burst contention resolution algorithm that uses a re-routing technique. The resolution algorithm can improve the performance of an OBS network without the need to add a wavelength converter to the core node. Simulation results showed that the algorithm improved the burst success rate by about 10% on average. However, the kind of approach has its shortcomings: it increases the average burst transmission delay, and when the load is increased, there is rapid increase in traffic. To address these problems, in this paper the algorithm was modified so that the ratio of burst for which re-routing is possible can be set. By doing this, the average transmission delay of burst can be reduced, and rapid increase in traffic can be mitigated. The simulation compared when the ratio was 80% versus when it was 100%. The success rate for the former was about 1% less than the latter, and the average burst transmission delay was about 0.5ms less. Also, by using a priority buffer for BCP processing at a core node, burst success rate could be improved by about 1%.

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