Limited Deflection Routing with QoS-Support

HyunSook Kim¹, SuKyoung Lee², and JooSeok Song¹

¹ Dept. of Computer Science, Yonsei University, Seoul, Korea,

² Graduate School of Information&Communications, Sejong University, Seoul, Korea,

Abstract. In this paper, we propose a Limited Deflection Routing with Wavelength Conversion (LDR with WC) technique which decides alternative paths adaptively according to data burst's priority. Furthermore, this technique is extended to support multiple QoS. Performance is evaluated in terms of burst blocking probability as a performance metric. The proposed LDR with WC enables us to support various QoS in optical burst switching networks while still maintaining good performance.

1 Introduction

In Optical Burst Switching (OBS) networks, most of the research on contention resolution has focused on one particular method (e.g. wavelength conversion, deflection routing, Fiber Delay Line). Recently, however, several different methods have been integrated and hybrid approaches have emerged. Our scheme considers whether to use wavelength conversion on alternative future paths according to the QoS priority of each burst, when the alternative path for limited deflection routing is selected. Unlike traditional deflection routing, our proposed scheme determines a node with a wavelength converter to be over an alternative path on the basis of a certain performance metric, as well as includes limited deflection routing. Considering that generally, only some nodes are capable of converting a wavelength into different one or deflection routing in OBS networks, our scheme has a benefit of reducing the cost of wavelength conversion and the overhead due to unnecessary deflection routing in the overall network. In practice, as we use more highly efficient functions in switches such as deflection routing, wavelength conversion, and optical buffering, the overall network performance will gradually improve, but at a very high cost. To reduce this cost, we assume that only some nodes have the ability to convert wavelengths, otherwise try to find a cost-efficient alternative path that includes the nodes with wavelength converters selectively according to the QoS level of the contending burst.

2 Limited Deflection Routing with Wavelength Conversion

In OBS, important approaches for resolving contentions include deflection routing and wavelength conversion[1]. If all core nodes have these functions, the system cost becomes very high. Therefore, we consider the case in which just

Fig. 1. Node with wavelength converter and deflection routing function

some nodes have the capability of resolving contentions using the function of wavelength conversion or deflection routing. There are different kinds of nodes within a network as follows : a node which has a wavelength converter, a node which can perform deflection routing in the event of a contention, a node which can both convert wavelengths and do deflection routing, and a node which is a normal node without wavelength conversion or deflection routing capability. Each core node has a statistical database which has the information of the network state including the network topology, the mean length of a burst, the average blocking rate over a path, and so on. With the burst blocking rate as a performance metric, each node tries to resolve contentions according to its node type. To support QoS, we modify the limited deflection routing scheme proposed in [2] as can be seen in Figure 1. This procedure checks whether the burst is generated in the congested node by sender check function, and then it tries wavelength conversion before starting limited deflection routing. To apply our integrated scheme to OBS, it is assumed that the fields of control packet include burst priority, offset time, burst size, and so on. When bursts and control packets are generated at an ingress node, the values of these fields in each packet are determined.

3 QoS-Support Algorithm of LDR with WC

In this section, we describe how LDR with WC supports various QoS. Since LDR with WC can choose an optimal alternative path flexibly, it satisfies the QoS while providing several ways of selecting an alternative path. It is very simple to select the shortest path among the various alternative paths. However, we aim to choose an cost-efficient path depending on the QoS class of the burst,

which includes nodes with or without a wavelength converter. We assume that c_i^{wc} is zero for any node without a physical wavelength converter. Conversely, a node with a wavelength converter has a value that is proportional to the number of available wavelengths.

- Step 1: We collect the paths for which the value of C^{wc} , the sum of the wavelength conversion cost at each node, c_i^{wc} , is greater than zero. This means that we select some paths from the deflection routing database, on which the deflected burst can pass by one or more wavelength converters.
- Step 2 : For each candidate path gathered in Step 1, we compute the standard deviation of the number of available wavelengths per path. If the standard deviation of any path is smaller than a given threshold, the number of available wavelengths at each node on the path does not differ significantly. Although one path has several nodes with wavelength converters, if the number of available wavelengths is concentrated at one node, there is a high possibility of further blocking. Therefore, we do not consider the average number of available wavelengths, but the standard deviation of the number of available wavelengths.
- Step 3 : We examine the mean blocking probability on each candidate path gathered in Step 1. Since one of the important and challenging issues in optical networks is to reduce burst loss, we use the burst blocking probability as a QoS parameter.
- Step 4 : According to the priority of the burst, we must find a path by minimizing the difference between the respective value of the wavelength conversion cost, the standard deviation of the path, and the mean blocking probability, and threshold value.
- Step 5 : The alternative paths obtained by this process are stored in a deflection routing table at each node. Information necessary to compute the paths is also provided from the OAM control packet and the control packet for each burst. This process of updating the deflection routing table is also periodic, but the frequency is low. If it is high, it will deteriorate the performance of the whole network. That is, frequent updates of information about network status and the overload of exchanging control packets are always a trade-off.

4 Performance Evaluation

Simulations are carried out on NSFNET topology with 14 nodes where the number of wavelengths per link is 6, the average burst length is 1Mb and link bandwidth is 1Gbps. The type of node is determined randomly and the pairs of source and destination nodes are also selected randomly. At every ingress node, we assume a Poisson burst arrival with a mean rate of λ . When two or more bursts collide at the same node, one of the following policies is applied : No Conversion and No Deflection routing (NCND), Only Wavelength Conversion (WC), Only Deflection Routing (DR), LDR with Wavelength Conversion (LDRWC). Next, we define some QoS classes similar to [3] and the requested blocking probability

Fig. 2. Loss rate vs. Traffic load

as a QoS parameter is respectively 10^{-1} , 10^{-2} , 10^{-3} , and 10^{-4} . It is assumed that a burst is randomly generated with one of the four QoS classes at the edge router. Performance is evaluated in terms of loss rate and throughput.

Figure 2 shows that the mean loss rate is smaller in LDR with WC than in WC or DR. In addition, we observe that LDR with WC is more efficient at high loads because the difference between the performances at low and high loads is less than that in the other schemes. That is, the other schemes have a deteriorated performance at high load compared to that at low load. Accordingly, LDR with WC can be considered to provide a uniform performance consistently in the overall network, irrespective of traffic fluctuations. Our algorithm is also simulated with different QoS classes. Mean burst loss rate obtained from our simulation is 0.98×10^{-1} , 1.01×10^{-2} , 1.13×10^{-3} and 1.29×10^{-4} compared with the required mean burst loss rate for each class: 10^{-1} , 10^{-2} , 10^{-3} and 10^{-4} , while respectively keeping throughput of 0.90%, 0.98%, 0.99% and 0.99%. This result reveals that if we use the LDR with WC algorithm, we can isolate a specific QoS class and adequately support the QoS in terms of blocking probability.

5 Conclusions

Simulation results indicated that the proposed LDR with WC scheme achieves a lower loss rate than existing contention resolution schemes. Moreover, it was shown that the LDR with WC satisfies the burst loss rate required for each class while still keeping good throughput. Finally, the LDR with WC is more efficient in a large network environment with high traffic load.

References

1. S. Yao, B. Mukherjee, S.J.B. Yoo and S. Dixit: A Unified Study of Contention-Resolution Schemes in Optical Packet-Switched Networks. *IEEE Journal of Light-wave Technology*, Vol. 21, No. 3, March 2003, p. 672-683.

2. H.S. Kim, S.K. Lee and J.S. Song: Optical Burst Switching with Limited Deflection Routing Rules. IEICE Trans. on Commun., Vol. E86-B, No. 5, May 2003, p. 1550-1554.
3. W.H. So, H.C. Lee and Y.C. Kim: QoS Supporting Algorithms for Optical Internet Based on Optical Burst Switching. Photonic Network Communications, Vol. 5, No. 2, March 2003, p. 147-162.