A New Contention Avoidance Scheme in Optical Burst Switch Network

M. Nandi[#1], A. K. Turuk[#1], B. D. Sahoo[#1], D. K. Puthal[#1], S. Dutta[#2]
Department of Computer Science and Engineering[#1]
Department of Electrical Engineering[#2]
National Institute of Technology, Rourkela, Orissa-769008, India
Email: {mrinal.nandi, akturuk, bdsahoo, hal.css, saibal.13}@gmail.com

Abstract*-Optical burst switching (OBS) is developed as an alternative switching technology, which combines advantages of both Optical circuit switching (OCS) and Optical packet switching (OPS) and avoids the disadvantages. In OBS control packet called control burst is separated from data packet called data burst. A control burst is sent in advance, which configures the switches in the path for the data burst. Due to lack of adequate contention resolution technique data burst loss is high in OBS. Schemes such as fiber delay line (FDL), wavelength conversion, deflection routing are the solution to prevent network congestion. But they have their own limitations. So a contention resolution technique is needed in OBS. In this paper we propose a scheme to minimize contention and to control traffic flow in the network. The proposed scheme logically divides a given network to clusters and selects a node as cluster head from each cluster. Cluster head keeps track of the resources available in the network and exchange the status of the resources among themselves to maintain up-to-date information. A node within a cluster that wishes to send a burst make request to its cluster head for a available wavelength on the path to destination. If a unused wavelength is available on the path to its destination, then it send a reply message with the available wavelength else send a reply no wavelength is available. Node after receiving a reply from the cluster head send a control burst followed by data burst on the wavelength that it has received from cluster head. If the reply says no wavelength is available then it waits for some specified time and sends another request. Since the cluster heads maintain the status of the resources at any time, t, it will minimize the contention of bursts. We made a comparison between the different techniques using simulation. Our simulation result shows propose method gives lower burst loss.

I. Introduction

Contention resolution is necessary when two or more bursts try to reserve the same wavelength of a link in same time. This is called external blocking. In packet switching, this is avoided by buffering the contending packets. In OBS, when two or more bursts contend for the same wavelength and for the same time duration, only one of them is allotted the bandwidth. In such case, one or a combination of the following three major options for contention resolution can be applied in addition to the option of dropping the unsuccessful bursts.

B. Wavelength domain

By means of wavelength conversion, a burst can be sent on a different wavelength channel of the designated output line [1].

B. Time domain

By utilizing an FDL buffer, a burst can be delayed until the contention situation is resolved. In contrast to buffers in the electronic domain, FDLs only provide a fixed delay and data leave the FDL in the same order in which they entered [1].

B. Space domain

In deflection routing, a burst is sent to a different output link of the node and consequently on a different route towards its destination node. Space domain can be exploited differently in case several fibers are attached to an output line. A burst can also be transmitted on a different fiber of the designated output line without wavelength conversion [1].

When there is no available unscheduled channel, and a contention cannot be resolved by any one of the above techniques, one or more bursts must be dropped. The policy for selecting which bursts to drop is referred to as the soft contention resolution policy and is aimed at reducing the overall burst loss rate, BLR, and consequently, enhancing link utilization [2]. Several soft contention resolution algorithms have been proposed and studied in earlier literature, including the shortest drop policy [3] and look-ahead contention resolution [4]. In burst segmentation, only that part of the burst, which is involved in a reservation conflict, will be dropped [5]. The contention resolution policies are considered as reactive approaches in the sense that they are invoked after contention occurs. An alternative approach to reduce network contention is by proactively attempting to avoid network overload through traffic management policies [2]. In this paper we proposed a method by which network traffic can be controlled so burst loss will be minimum. The paper is organized as follows in section 2 the proposed method is discuss, section 3 is for analysis the performance of the proposed method, section 4 is for conclusion.

II. Proposed Method

In this section first propose an algorithm to create clusters. Since the backbone network is fixed, so the clusters are fixed.

A. Procedure to Create Cluster

Let n be the number of nodes in a given n/w.
$N = 1, 2, 3, \ , n$ be a set, representing the nodes in the n/w.

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$D = d_1, d_2, d_3, \ , d_n$ be a set representing the degree of nodes in the n/w, where the element d_i of the set D, represents the degree of node i.

1) Functions: Delete_Node (X, i) - Deletes the ith element from the set X.

Max_Index (X) - Return the element having maximum value in the set X.

Cluster^i*:* Is a set representing the number of element in the cluster i.

2) Algorithms for Formation of Clusters:

1: For a given n/w find the set D.

2: while ($N! = \varphi$) {

3: Find a node having maximum degree in the set N. Let it be called *Node_MaxDegree*. So *Node_MaxDegree* = *Max_Index* (D)

4: Delete the maximum degree node from the set N and its corresponding entry in the set D.

Delete_Node (D, *Node_MaxDegree*)

Delete_Node (N, *Node_MaxDegree*)

5: Increase the value of i by 1 and form $cluster^{\,i-1}$ as described below.

a. Mark the Node_MaxDegree found in Step 3 as the head node of $cluster^{i-1}$ and include it in $cluster^{i-1}$.

b. $\forall i \in N$, if i is adjacent to head node then do the following:

I. Include i in $cluster^{i-1}$.

II. Delete node i from the set N. *Delete_Node* (N, i).

III. Delete the entry corresponding to node i from the set D. *Delete_Node*(D, i).

}

Cluster formed in step 5, may contain single node. We are interested in forming cluster with minimum of four nodes. Our algorithm will form cluster around the head node. If a cluster contains fewer than 4 nodes, such clusters are deleted and the nodes in the cluster are added to other clusters.

I. Sort the clusters formed in Step5 according to the number of elements in the cluster, such that number of elements in $cluster^i \leq$ *number of elements in* $cluster^{i+1}$.

II. For all $cluster^i$ do the following.

III. If the number of elements in $cluster^i < 4$.

{

While ($cluster^i ! = \varphi$) {

remove an element form $cluster^i$. Let this element be Z. Delete this element from $cluster^i$, *Delete_Node* ($cluster^i$, Z). Include the node Z in $cluster^j$ for which the distance between the node Z and head node of $cluster^j$ is minimum

}

Delete $cluster^i$.

}

According to the previous algorithm final clusters of Fig. 1 is:

$Cluster^1 = \{6, 3, 5, 10, 13, 2, 4, 7\}$

$Cluster^2 = \{9, 8, 12, 14, 1, 11\}$.

B. Contention Avoidance Scheme in Optical Burst Switched Networks

1. First create the clusters of the given network.

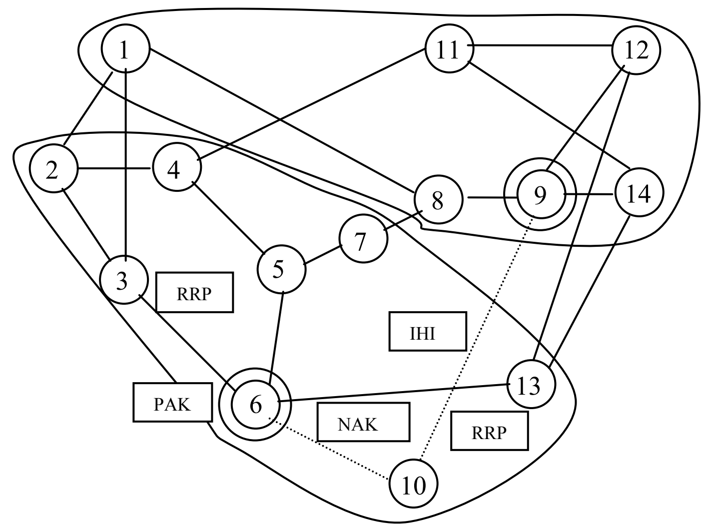

Figure 1. A clustered NSFNET.

2. Setup a light path between the head nodes of the clusters.
3. Head nodes keep all resource information in the network.
4. A source node has to request for free wavelength to the cluster head before sending control burst.
5. After receiving a request from source node, head node checks its database for a free wavelength. If such wavelength is available head node will reply that wavelength to the source node, which is treated as a positive acknowledgement. At that same time informs other head nodes about that wavelength reservation.
6. If no such wavelength found then head node sends a no wavelength reply to that source node.
7. After receiving a positive reply source node send a control burst followed by data burst on the wavelength.
8. If the reply is negative then it makes another request to head node.
9. After getting a control burst from other head node, a head node updates its own database.

C. Signaling Issues

Here we are using some special type of packets with OBS control burst these are as follows:

1) Route request packet (RRP): Source nodes send this type of control packet for a wavelength. The information within the RRP packet is as follows:

1. Two bits (00) are used to represent that this is RRP packet.
2. Address of the source node.
3. Address of the destination node.
4. Size of the burst.

2) Positive Acknowledgement (PAK): Cluster head find out wavelength information form it database and send the information to the source node. This is called positive acknowledgement (PAK). The information within the PAK is as follows:

1. Two bits (01) are used to represent that this is PAK packet.
2. Address of the source node.
3. Address of the destination node.
4. Wavelength that can follow the burst.

3) Negative Acknowledgement (NAK): If no free wavelength is available then the head node will send a negative acknowledgement (NAK). The information within the NAK packet is as follows:

1. Two bits (10) are used to represent that this is NAK packet.
2. Address of the source node.
3. Address of the destination node.

4) Inter header information (IHI): If a head node finds a free wavelength it sends a PAK to the source node and Inter header information (IHI) packet to others head nodes. It is used to inform other head nodes about the reservation wavelength. The information within the IHI packet is as follows:

1. Two bits (11) are used to represent that this is IHI packet.
2. Address of the source header node.
3. Address of the destination header node.
4. Currently scheduled wavelength's information.

D. Communication Procedure

Here we have given the communication procedure as follows:

1. Begin
2. if (*any burst is present to an edge node*) *then*
3. *Send an RRP packet to the corresponding cluster head node.*
4. if (*path is available from that source to destination*) then
5. Send PAK packet
6. else
7. Send NAK packet
8. *if* (*packet is PAK*) *then*
9. *send the control burst.*
10. *else*
11. *Stop some specified time duration after that send the control packet.*
12. *End if*
13. *End*

Consider the Fig. 1, here a lightpath is established in between the head nodes 6 and 9 through the node 10. Now suppose node 3 want to send burst to node 7. So according to propose method node 3 will send RRP packet to cluster head node 6. After checking the request the head node 6 will send PAK packet (depending upon the availability of wavelength) to node 3, then node 3 send control burst followed by data burst on the wavelength.

Again consider the Fig. 1, node 13 want to send burst, so it send RRP packet to head node 6, but from the Fig. 10 we can see due to unavailability of wavelength the head node is sending NAK packet. So the node 13 will stop to send control packet for some specified time after that made another request. Also see from Fig. 1 that two head nodes 6 and 9 are sending IHI packet in between them to keep up-to-date information.

III. Performance Analysis

Performance of the propose contention avoidance scheme is measured here. NS2 [6] and OBS-ns [7] simulators have used for simulation. NSFNET and an ARPANET is taken as topology. Assuming *eight* wavelength channels per link, *six* channels for data burst and *two* channels for control channel, with capacity of 5Gbit/s per each channel. The input traffic has taken as Selfsimilar type. Offset time is taken 0.00004ms, burst time out is taken 0.5s, and control burst processing time is taken as 0.000001ms. We are comparing propose scheme with deflection routing and no deflection scheme. Fig. 2 shows overall burst loss ratio in Cluster-base, Deflection routing and No deflection. It is observed from Fig. 2 that overall BLR is high in No deflection and low in our propose scheme. Due to drop of contending bursts BLR is high in No deflection. In Deflection routing contending bursts follow alternate route before drop, so BLR is less than No deflection scheme. Fig. 3 shows End-to- End delay in burst transmission. It shows End-to-End delay is high in proposed scheme, due to communicating head node before sending control burst. Delay is increases with increases of load in deflection routing, due to increases in the number of bursts to follow deflected route. Fig. 4 shows the average number of hops traveled vs. intended number of hops. This shows that in deflection routing average number of hops increases with increases in intended number of hops. Since, the bursts with larger hop counts have higher chance of getting blocked than bursts with smaller hop counts. In deflection routing contending burst follow alternate routes, which are not always shortest route. In no deflection and propose scheme contending bursts are dropped so average number of hops traveled is same as intended number of hops.

To check the topology dependency of the proposed scheme, we have taken ARPANET. Fig. 5 and Fig. 6 shows the results in ARPANET, which can be explained as like as NSFNET.

IV. Conclusion

Proposed scheme gives better result in case of burst dropping probability, but the end-to-end delay is comparatively high at low load, due to due to communicating head node before sending control burst. So it can be used where delay is not that much important but drop is much more important.

Acknowledgment

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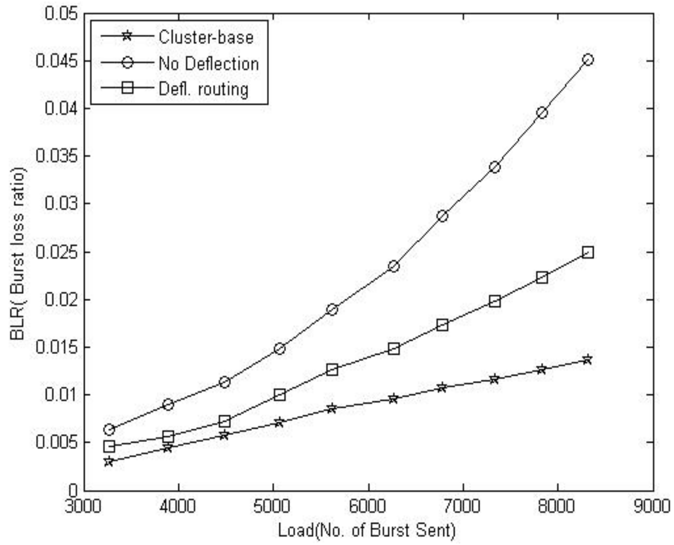

Figure 2. Burst loss ratio vs. load in NSFNET.

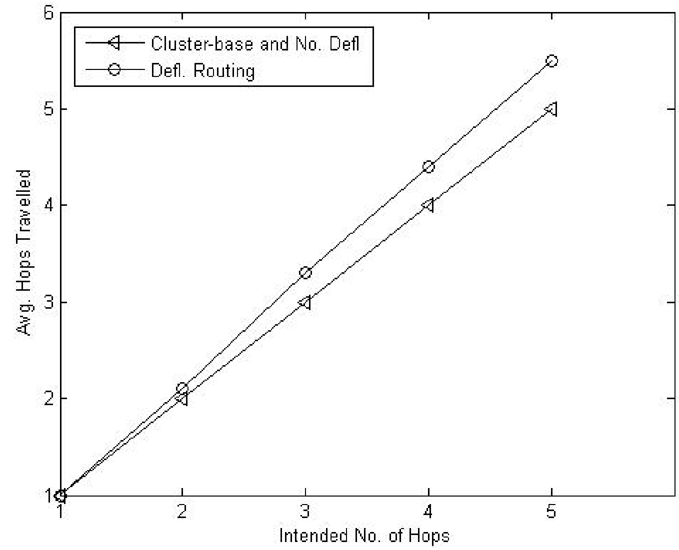

Figure 4. Average number of hops traveled vs. intended number of hops.

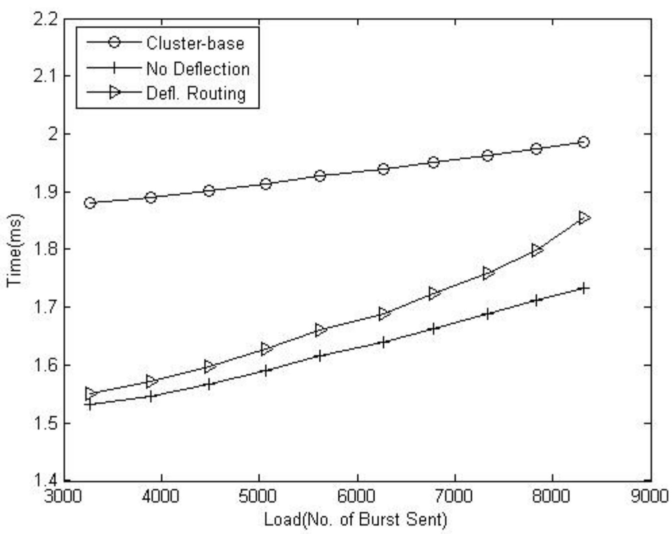

Figure 3. End-to-End delay vs. load in NSFNET.

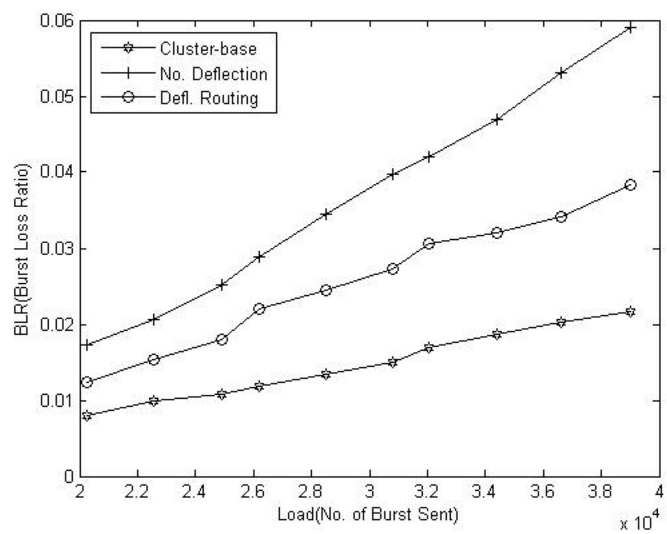

Figure 5. Burst loss ratio vs. load in ARPANET.

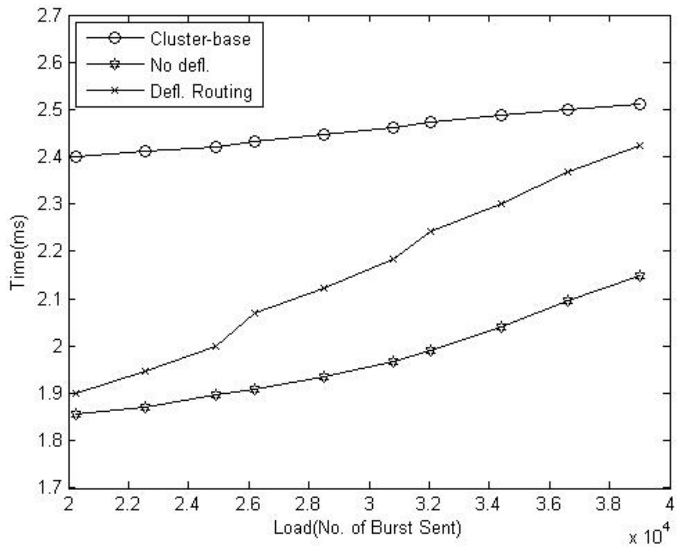

Figure 6. End-to-End delay vs. load in ARPANET.