The Novel Effective Hybrid Contention Resolution Scheme for Optical Burst Switched Network

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***Abstract* — the Optical Burst Switched (OBS) Networks is buffer less and thus contention among the bursts is unavoidable fact. Many Burst retransmission schemes have been proposed in the literature to deal with burst contention. Burst retransmission gives better throughput performance for higher layers. At high network load, the random retransmission mechanism often leads to unprecedented increase in network load. In many cases, retransmission of lost burst beyond allocated time offers no benefits. Also, the existing retransmission scheme fails to capture the effect of load variation in each retransmission attempt and cannot be adaptive to retransmission requirements for different traffic conditions. Therefore, we propose an Adaptive Hybrid Burst Retransmission and Wavelength Conversion Scheme. Which adaptively balance between the number of retransmission attempts and wavelength conversion in contention scenario. Thereby effectively manage the increase in the network load. The propose model is evaluated with various parameters like path blocking probability and burst loss probability to measure the associated benefits and its impact on the network performance. The simulated results of our scheme are compared with existing retransmission scheme. The results show that the proposed hybrid mechanism provides adaptive selection and thus perform better than the existing contention solving schemes.**

Index Terms—Burst retransmission; Burst loss probability (BLP); Path blocking probability; Optical burst switching

I. INTRODUCTION

In the networking scenario, the Optical Burst Switched (OBS) network is consider as most mature all-optical architecture [1]. The burst is created for transmission of user data and it is pass through entire optical route in optical domain without undergoing optical to electrical conversion. For each generated burst, the control burst packet is transmitted in advance and it undergoes the electrical conversion process at each intermediate node along the route from source to destination. The separation of data plan and control plan leads to flexibility and scalability of OBS network. The dynamic nature of OBS network is more appropriate for handling bursty internet traffic [2]. Due to buffer less and connectionless nature of OBS network, the burst may face contention at intermediate nodes. The contention is generated if more than one burst arrives at a time on single node and asking for the same output link or port.

The fiber delay lines (FDLs) is used for buffering the signal and thus reducing the contention. In FDL, the light is stored through delaying the optical signal by using very long fiber [3]. With burst segmentation scheme [4, 5], during contention the overlapping burst portion is divided into smaller segments and it is again transmitted. It results into lower burst loss ratio. Another scheme known as deflection routing used for contention resolution. Wherein, the data burst is transmitted to another route than the original route in contention scenario. It results into poor network performance [6] as it creates long looping of data bursts. The performance comparison of these schemes has clearly shows that above proposed scheme have its own technical and economical limitations [7, 8]. For contention resolution, these schemes only give partial temporary solution as they cannot entirely remove the end-to-end burst loss due to contention. Therefore, the retransmission is proposed as long term solution for contention at the OBS layer [9]. Another contention resolution scheme is wavelength conversion, wherein wavelength of input port can be converted to different wavelength [10] at the output port. The equipment wavelength converters switched an incoming signal's wavelength to any of the outgoing wavelength, thus increasing reuse of wavelength, i.e., the single wavelength channel may be reused to transmit the different data burst in different fiber links in the network. A wavelength converter provides a 10 to 40 percentage increase in reuse values when wavelength availability is small [10-11]. The optical wavelength conversion has been tested in research laboratory and the following are the available different types of possible wavelength conversion alternatives:

Full conversion: Any incoming wavelength can be switched to any outgoing wavelength.

Limited conversion: Wavelength switching is limited, so that not all incoming wavelengths can be connected to all outgoing wavelengths. The restriction on the wavelength switching will reduce the expense of the switch but increases blocking.

Fixed conversion: This is a deterministic form of limited conversion, wherein each incoming wavelength may be connected to one or more pre-determined outgoing wavelength channels.

Sparse wavelength conversion: The few nodes in the network have the facility of full, limited, fixed, and no wavelength conversion.

There are many wavelength conversion algorithms to minimize the number wavelength converters [11]. In our work we are using the wavelength conversion with data burst retransmission to crate optimum solution to ever present issue of burst contention. In retransmission scheme, the ingress node stored a copy of the burst [12] and the stored burst is released when the burst retransmission is successfully completed. The existing retransmission schemes [12, 13] effectively retransmit the lost burst due to contention but it result into increase in network load with retransmission. Also, these schemes fail to provide a solution to control the extra load generated due to retransmission. This paper presents an Adaptive Hybrid Burst Retransmission and Wavelength Conversion Scheme for contention resolution. Also, it provides a mechanism for evaluation of increase in network traffic and controlling the retransmission rate. The rest of the paper is organized as follows. Section II covers a comparative brief about the related work. Section III describes the proposed mechanism with new retransmission parameters and wavelength selection scheme. The proposed model is validated with simulations and the performance of the network is investigated in details in the Section IV. Finally, section V concludes the paper.

II. Related Work

For reducing the end to end burst loss, the retransmission mechanism [9] has been proposed. The performance studies of retransmission scheme reveal that burst loss probability (BLP) improved as lost TCP packets are retransmitted from its source [12, 13]. The partial burst retransmission scheme with burst segmentation have been presented in[12] and its results shows improvement in BLP as only discarded segments packets are retransmitted. Even through, burst retransmission gives better BLP performance but it also generates extra load in the OBS network. In OBS network contention is natural fact, just static retransmission without any discrimination leads to a radical increase in the network traffic, BLP and thus the sidetrack the very goal of burst retransmission. The current random retransmission approaches [5, 12] fail to provide relationship between the improved end-to-end BLP and extra load generated with retransmission attempts. They do not provide any upper bound to generated load [14] due to retransmission and it result into poor delivery rate and drastically increase the storage capacity at ingress node. Therefore, to overcome the issue associated with burst retransmission, we have consider the hybrid alternative of combining the wavelength conversion with retransmission.

A novel efficient burst retransmission is presented in this paper. This approach effectively handles rapid increases in the network traffic. It considers new retransmission parameters that provide upper bound on traffic due to retransmission. These parameters efficiently control the number of burst need to be retransmitted and again retransmitted when the burst is lost during transmission attempts. The model present the definite relationship between extra loads generated due to dynamic retransmission and improvement in the BLP. In addition, the efficient wavelength assignment and conversion scheme is introduced and it effectively handles the contention when the burst retransmission gives degradation at varied value of load in the OBS network. It is expected that the proposed hybrid scheme combing the burst retransmission and wavelength conversion gives better BLP performance compared to simple retransmission or wavelength conversion.

III. Proposed Adaptive Hybrid Scheme

In this section, we present the proposed hybrid scheme into two subsections, the burst retransmission and wavelength conversion.

A. Burst Retransmission

At the OBS layer, it is critical to carefully study the effect of burst retransmissions on the generated extra network load and burst loss. In many practical applications, the burst retransmission may not be always required for successfully sending the lost burst to its destination like ARQ method. TCP based transmission many retransmission attempts would be useless if the timer expire. Furthermore, some application needed certain loss rate and thus the retransmission of bursts can be determined to fulfill the loss rate criteria. Therefore, it is not required to retransmit all the lost burst. Focusing on this different traffic scenario, we propose adaptive burst retransmission approach which can effectively control the rate of burst retransmission.

Unlike, existing work [15] proposes a probabilistic model having two different probabilities to retransmit the lost, we set different values to each retransmission attempts. Our propose scheme facilitate to measure behavior of the load variation in each retransmission attempt and could be adaptive to the retransmission needs for different types of traffic scenario. In our proposed scheme, we consider a P_i (i =1, 2…N) as the retransmission probability having total N number of retransmission attempts for lost data burst during process of transmission or retransmission. Besides retransmission P_i enable effective retransmission of lost bursts, we introduce parameter N known as number of retransmission attempts for controlling an upper limit of traffic entering to core OBS network. The proposed work presents a smooth mechanism which can adopt the different value of retransmission probability (P_i) and measure performance based on it.

The redefined ingress node has two addition block, the copy of burst (COB) block and the burst scheduler (BS) block. The COB block is used for maintaining the copy of transmitted burst and BS block is used to retransmit the lost bursts with appropriate time and to access acknowledgements from the destination node. Once the burst is transmitted and it is lost because of contention then we need to retransmit the burst with selected values of probability of P_i from COB. When retransmission is not desirable for the lost burst then the copy of burst is eradicated from the COB block. Also, the BS maintain acknowledgement up to one cycle of round trip time for all the bursts and then it simply discard the burst from COB. The burst generated by various assemblers are assigned unique number for each source and the destination pair. When a burst is generated from assembly unit, it is sent to all the main scheduler, BS and the COB.

B. Wavelength Conversion

In OBS network, each WDM fiber link contains several wavelengths to establish the link between two nodes or switches. This multiple wavelengths can be exploited to minimize contentions along with propose retransmission. When two data bursts are requesting to go the same output port at the same time then it results into contention of data burst. However, using wavelength conversion process both the data bursts can be easily transmitted on two different wavelengths. This process drastically reduces the burst contentions, considering the fact that the number of wavelengths supported on a single fiber increases continuously. In WDM based optical network, configure physical path and allocate wavelengths to establish light paths is very significant for successful transmission of information. The wavelength is assign for every new connection request [10] and it is critical to handle.

Routing and wavelength assignment (RWA) problem compute the required routes and assign appropriate wavelengths from the set of available wavelengths to establish the light path. The wavelength converters have great ability in term of reducing the burst contention and it supports various types of traffic to be effectively transmitted in buffer less OBS network. This paper focuses on the wavelength assignment (WA) with wavelength converters. As far as routing is concern, the routes are selected from the set of shortest-paths and we are shortest path algorithm in our work [16]. The different types of wavelength assignment schemes [11] are presented below:

1 First fit (FF) wavelength Scheme

FF algorithm always selects the lowest indexed wavelength from the set of free wavelengths and allocates it for making light path connection. Upon completing data transmission process, the connection released and again the used wavelength is enter in the set of free wavelength.

2 Random fit (RF) wavelength Scheme

Random fit algorithm selects the number of available free wavelengths and then selects one of the wavelength on random basis from the set of free wavelengths.

3 Most used (MU) and least used (LU) wavelength Scheme

In Most used wavelength scheme, upon receiving the light path request for setting the connection a free wavelength that is used for maximum number times different fiber link in network is allocated. When more than one wavelength has the same maximum usage, then the wavelength that has a specific index is selected.

Least used wavelength assignment scheme is very much similar to the most used wavelength strategy, however the least used wavelength is allocated in this scheme. The first fit scheme result into improvement in network performance, the overhead process generate contention loss because it uses the lower indexed wavelengths first than the higher indexed wavelengths. The RF assignment severely affected due to lack of predefined approach for wavelength allocation and thus it gives very poor performance.

4 Round robin (RR) wavelength Scheme

The wavelengths are indexed in Round robin wavelength assignment scheme. When the first request for creating light-path is made, the first indexed wavelength is assign or allocated to that particular request. Similarly, for every number of requests, the switch or node selects the next indexed numbered wavelength and so on.

The first allocated wavelength is use again after all the wavelengths from the set of indexed wavelength have been allocated to light paths requests and this scheme is continues in round robin fashion. This approach drastically decreases the contention in OBS network as all the wavelengths are being utilized uniformly. In this paper, we are using RR scheme along burst retransmission to analyze the performance our hybrid scheme.

In addition to proper wavelength assignment scheme, the wavelength converters further reduce the contention among bursts in buffer less the network. We are using the uniform placement of converters algorithm and it closely match with our vBSN topology. Based on work of [15], the analysis can be carried out for a node with wavelength conversion by adding change in the blocking probability. A node with full wavelength conversion ability with B wavelengths, the blocking probability can be calculated by Erlang B equation [10],

$$Q_C = E(\rho_C, B) = \frac{\frac{\rho_C^B}{B!}}{\sum_{a=0}^{B} \frac{\rho_C^a}{a!}} \;..(1)$$

Where the Q_C is the blocking probability and ρ_C is the actual load at node *C*. The load at particular node can be easily computed by taking the average value of arrived traffic to the service rate to arrived traffic. By using equation (1), we can compute the total load in network against the increase in extra load due to burst retransmission.

IV. SIMULATION & RESULT ANALYSIS

The vBSN topology is consider for the core OBS network with three source nodes and three destination nodes connected fig. 1. We have developed C++ code for simulation work. We are using 32 wavelengths for each link and extra 4 control wavelengths. The 10 Gbps of transmission rate selected on each wavelength. In our work, the MTTAS algorithm, JET protocol and LAUC-VF scheduling algorithm is used [17]. The packets are generated randomly between the all pair of ingress-egress node with random start times. The network performance was carried out for main two parameters, the throughput and improvement in BSR. The BSR measures the ratio of total number of bursts successfully transmitted over number of data bursts send into OBS core network. We compare the results of proposed work with existing retransmission scheme [15] and network without retransmission option.

As the number of retransmission attempts *N* increases the extra load in the generated in network and it result into higher BLP with missing the very purpose of burst retransmission. We limit the optimum value of *N* in such way that it offer the best BLP and improved BSP. The results reveal that when *N* is beyond four the performance improvement in BSR and in BLP is nil. Therefore, we limit *N* = 4 as optimum value in our work.

For with wavelength conversion, the fig.2 shows the result of path blocking probability (PBP) against load. Compared to existing retransmission scheme, our scheme provides extremely improved results even at very high load with higher P_1 and P_2. However, in the existing scheme, the higher values of P_1 and P_2 results in rapid increase in PBP and it further increases with increase in network load. Obviously, when retransmission option is not used, the PBP drastically reduced as shown in figure 2.

For with wavelength conversion, the fig.3 shows the result of BLP against load. We set the value of P_1 is 0.4 for single retransmission and value of P_2 is 0.5 for next three retransmission attempts. Compared to existing scheme, our proposed model gives better results even at high load. The observation reveals that with higher P_1 and P_2 values we get very small BLP. Regardless of retransmission values, the BLP increase with the higher value of load but intensity of rapid increase in BLP become steady with higher values of P_1 and P_2. With increases in P_2, the reduction in BLP and rapid increases in path blocking is more prominent compared to result of increase in P_1. The main reason is that P_2 is the probability of three burst retransmission attempts where as P_1 is just one time retransmission and thus has higher effect on generated network traffic than P_1.

Next, the effect of proposed hybrid scheme on the network performance is considered. We observed the improvement in Burst Success Ratio against varied value of *N*, P_1 and P_2. The network throughput is also measured.

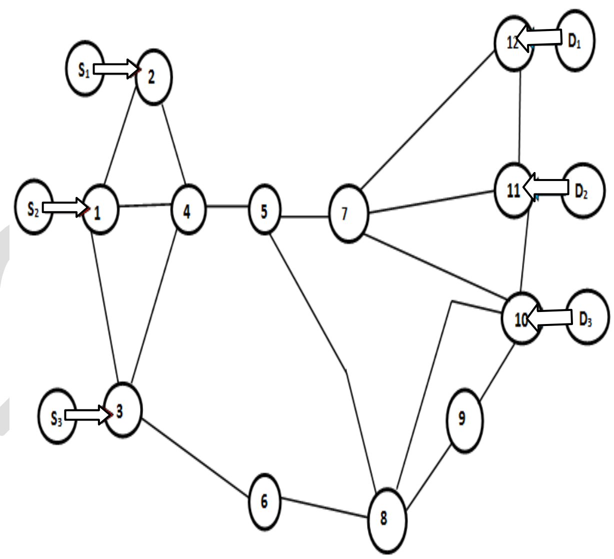

Fig - 1 The core OBS vBSN topology with connected three source nodes (S_1, S_2, S_3) and three destination nodes (D_1, D_2, D_3).

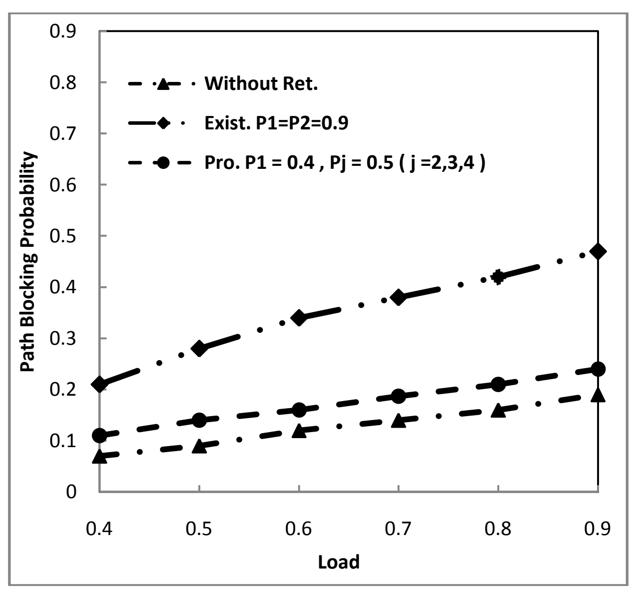

Fig- 2 Path blocking probability against normalized load with wavelength conversion facility

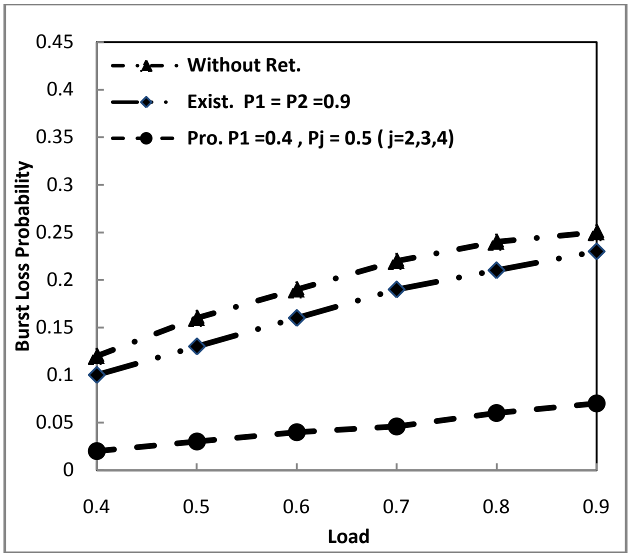

Fig -3 BLP against normalized load with wavelength conversion

The graph in fig.4 shows total improvement in BSR against varied values of retransmission attempts, P_1 and P_2. We have taken the N is four at $P_1=0.4$, P_2 = 0.5 for three consecutive attempts. We observed that our proposed scheme provides drastic improvement in BSR compared to existing scheme at high load. This is due to fact that our hybrid scheme performed effective wavelength assignment and converter during heavy contention period than simply retransmissions. The value of BSR is reduced at very high load (above 0.7) in existing scheme and there is constant increase in BSR in our proposed scheme. When network load become very high, the benefits associated with our scheme is clearly visible than the constant increases in path blocking in case of existing scheme even at lower values of N. Thus, by observing the results carefully the optimum combination of P_1, P_2 and N can be dynamically selected for achieving improved BSP and path blocking in buffer less OBS network.

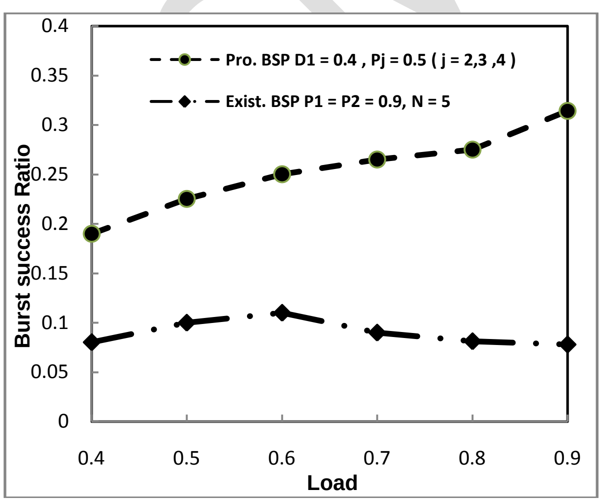

Fig. 4 The improvement in BSR for a network with wavelength conversion.

The fig. 5 shows the variation in the throughput against increasing load for varied P_1 and P_2. At high value of load, the throughput gradually reduces due to extra load in network but it increases because improved BSR associated with higher retransmission probabilities. In our scheme the

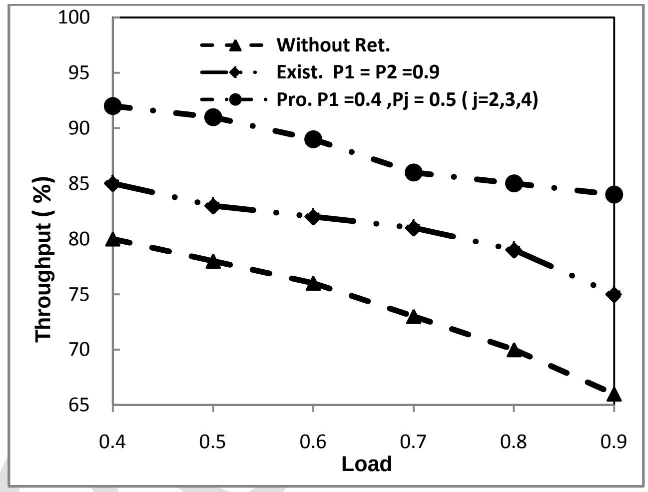

Fig. 5 Over all throughput in a network at N = 4.

throughput slightly fall rather than rapidly with increased in load. Thus, concept of proposed adaptive hybrid proves to be very effective in term of effectively handling the contention loss in OBS network.

CONCLUSION

In general, the retransmission of the lost bursts improves the contention loss. But, the random burst retransmission generates extra load and BLP with missing the very aim of retransmission. To effectively handle burst contention, the adaptive hybrid burst retransmission and wavelength conversion scheme proposed and analyzed. It includes retransmission probabilities that can dynamically control the rate of burst retransmission and extra load in the network. The investigated results clearly show that the value of P_1, P_2 and N can be selected for reducing the network load associated with burst retransmission and thus BLP. Also, the benefits associated with proposed scheme and their effect on overall network performance is observed. The outcome of our work suggest that even at high load, the scheme with higher values of P_1 and P_2 offers better perform for improved BSR and throughput.

Our proposed scheme is validated against vBSN network topologies and its results compared with no retransmission scheme and existing retransmission scheme. Ours proposed hybrid model can be potentially utilized wherein the retransmission probabilities can be dynamically selected for achieving minimum BLP and improved path blocking against extra load generated due to retransmission.

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