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Novel Contention Prevention Scheme-based on Delayed Reservation for QoS Enforcement in Optical Burst Switched Networks

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***Abstract*—**Contention resolution mechanism for QoS provisioning is considered as a significant issue in optical burst switching network. Further, optical burst switching network necessitates a mechanism for contention resolution and service differentiation for enabling support in internet traffic. In this paper, a Novel Contention Prevention Scheme-based on Delayed Reservation for QoS Enforcement (NCPS-DRE-QoS) in optical burst switching network. This NCPS-DRE-QoS approach allocates the wavelength based on the available wavelength information obtained along the forward path by means of PROBE packet in the backward reservation. Further, the information gathered by PROBE packet are outdated due to the link propagation or processing delay, since the possibility remains of request is blocked by the utility of PROBE based inspection. The performance of NCPS-DRE-QoS are exhaustively studied through ns-2 simulations with the aid of evaluation parameters such as Jitter, Packet delivery ratio, Burst loss ratio and average goodput. From the simulation results obtained, it is transparent that NCPS-DRE-QoS successfully reduces the burst loss probability when compared to the other delayed reservations based contention resolution oriented QoS provisioning mechanisms available in the literature.

***Keywords*—**Delayed Reservation, Contention Resolution, Just-in-Time Provisioning, Forward blocking , PROBE packet, Wavelength prediction table, Wavelength topology ring.

I. INTRODUCTION

The needs of fast growing traffic on the internet can be furnished by introducing the optical network. This growth can be dealt by means of high bandwidth applications. This indispensable need of the internet can be upgraded by using wavelength division multiplexing. Wavelength Division Multiplexing is a multiplexing technique in which the signals are multiplexed with a unique wavelength under a required minimal amount of space. Moreover, WDM is similar to Frequency Division Multiplexing [1]. If the multiplexing is done in the optical carrier, then it is called WDM and if it is in a radio carrier then it is called as FDM. The benefits picked out of doing WDM prevails over even though multiplexing and demultiplexing introduces more complexity. The IP-over –WDM can be formed by bringing the presence of IP in the internet and use of WDM technique which makes high bandwidth applications together. Every optical switching and end to end optical path can be provided by IP-over WDM. It also provides the benefits of protocol independence. IP packets encapsulated the traffic from every protocol and WD can be done on the packets. Since IP layer is responsible for routing and WDM layer is from end to end transmission, the network become simple and efficient.

Optical Burst Switching (OBS) is a networking technique that allows switching of the data. It was suggested as a candidate transport solution for next-generation optical internet. OBS is a compromise between Optical Circuit Switching (OCS) and Optical Packet Switching (OPS). Hence the OBS model plays an important role in next-generation network framework considering Quality of Service (QoS) as an essential feature[2]. In this paper, the traffic patterns are examined and the constraint problem in terms of link failure is dealt in order to satisfy the receiver in network by providing Quality of Service (QoS).
In this paper, the major contributions are:

1) Implementation of PROBE packet based wavelength assignment mechanism for the OBS network which improves the degree of QoS provisioning under the data dissemination.

2) Incorporation of an opportunistic routing algorithm that chooses the best available wavelength for routing when there is a loss in transmitting the video signal Rest of the paper is organized as follows. A comprehensive level of literature review is presented in Section 2. The network design used for formulating a Delayed Reservation based Contention Resolution Scheme for QoS provisioning (NCPS-DRE-QoS) in optical burst switching network is discussed in Section 3. An algorithm for Delayed Reservation based Contention Resolution Scheme for QoS provisioning is discussed in Section 4. Results from a extensive simulation study and the discussion of its results are presented in Section 5. Section 6 concludes the paper.

II. Related Work

In this section, the literature review of the recent QoS enforcement schemes that resolves contention prevention based on the establishment of asynchronous and synchronous path is discussed with the merits and limitations. In general, the existing mechanism proposed for QoS enforcement in optical burst switching network is classified into Just Enough Time, Just-In-Time, Tell-And-Go Enforcement and Path-based QoS Enforcement approaches.

In the Just Enough Time-based QoS enforcement scheme, the data burst size is influenced by the degree of offset [5]. The degree of offset in turn depends on the number of control packet and the type of payload that aids in the measurement of the hop count that are more essential in the process of QoS Enforcement. Further, each and every individual node reserves the wavelength for each burst of data by transmitting control packets over a predefined period of time. This approach of reservation is initiated during the time from which the first bit of the payload is realized at each node of the optical network and terminates when the last bit reaches the output port of the optical node [6]. This Just Enough Time-based QoS enforcement scheme prevents the idle time incurred during the process of wavelength reservation. The inessential utilization of bandwidth is also eliminated in this approach under channel utilization on par with other categories of QoS enforcement scheme. In the Just-In-Time approach, the nodes are incorporated with the potential for resolving the issues by utilizing excessive control packets that are used in the reservation. In this approach, the source initiates the payload within a predefined offset period, which is greater than the time actually essential in the process of resolving issues that arise during the transmission of control packets through the intermediate router points. In this scheme, the data burst is prevented from forwarding when the actual resources are not available. The wavelength reservation is utilized till the last bit is destined in the route due to the existence of offset that lies between the control packet and the payload. This Just-In-Time approach also involves a in-band- terminator which is suitable for policing the data burst such that the wavelength reserved during transmission is released after the period of utilization.

In the Tell-And-Go Enforcement scheme, the control packet is always transmitted by embedding the payload under its communication in the control channel [7]. In this scheme, the payload is buffered based on the utilization of Fiber Delay Line that control the process of packet policing in each and every node of the optical burst network. The wavelength reservation approach of the Tell-And-Go Enforcement scheme is facilitated only when the payload is forwarded in the channel [8]. In case of the NAK packet transmission, the data burst is discarded when the burst of transmission reaches above the threshold of data transmission. In addition, this Tell-And-Go Enforcement scheme allows the source to transmit the control packet along the routing path only when the payload is released into the reserved path of quantified wavelength such that the reliability of data is protected. The core merit of the Tell-And-Go Enforcement scheme lies on the average availability rate of buffer incorporated in the process of FDL-based data burst accommodation [9]. In Path-based QoS Enforcement approaches, the QoS are always facilitated based on asynchronous and synchronous path transmission such that the number of possible paths and wavelength count is made available in order to avoid any kind of overlapping that might exist between the reserved paths during the process of data burst data transmission. In the synchronous path transmission, the restricted number of wavelengths is made to overlap through the maximum of a single link that is essential in the process of data transmission.

Initially, the method of PQP is proposed for facilitating reliable audio and video signal over the network [10]. This method of PQP uses the method of Just-Enough-Time Provisioning under which the data burst size is synchronized through the degree of offset controlled through the integrated delayed reservation process. In PQP, the degree of offset is fundamentally computed using the transmission of payload and control path that is reliable in the assessment of hop count. This mechanism involves the control packet for wavelength reservation at each and every individual optical node for a predefined period of time and this process of reservation is initiated when the first bit of data reaches the output and gets terminated until the reception of the last bit of optical data burst. This PQP prevents the idle time incurred during the process of wavelength reservation and prevents the degree of bandwidth wastage for ensuring higher channel utilization at the expense of the control packet. Then Path Stability-Based Contention Prevention Scheme (PSBCPS) is contributed as an opportunistic routing process based on the determination of hop count under the process of data transfer facilitated between the source and destination optical ports [11]. In PSBCPS, the local knowledge is exploited for determining the optimal successor hop node that is predominant among the neighbor optical nodes of the network by eventually sharing the messages between them.

Extract of the Literature:

The literature review carried out on the existing work available for QoS provisioning in optical burst networks have the following shortcomings, they are:

A mechanism which greatly allocates wavelength by incorporating dynamic exchange of wavelengths and time slots for resolving burst switch over a problem which has not been much explored to the best of my knowledge.

A mechanism which could deal with the issues and impacts of forward blocking and backward blocking for QoS provisioning is not available in the literature.

These shortcomings of the literature were the motivational factors that lie behind the devision of a Delayed Reservation based Contention Resolution Scheme for QoS provisioning (NCPS-DRE-QoS) in optical burst switching network that allocates the wavelength based on the available wavelength information obtained along the forward path by means of PROBE packet through the backward reservation scheme formulated for QoS provisioning in optical burst networks for enhancing the process of reliable transmission of data.

III. THE PROPOSED NCPS-DRE-QOS SCHEME

Traditionally, the optical burst switching techniques depends on the inherent methodology utilized in the network for reserving the resources.One specific category of the Asynchronous Transfer Mode (ATM) in optical burst network is the method of ATM Block Transfer (ABT) mechanism that provides better data transmission under dynamic usage of control packets. This ATM-based ABT process utilized in the proposed NCPS-DRE-QoS Scheme is divided into delayed transmission process and immediate transmission process. The main differences between the two lies in the minimization of limited time gap that exists between the data and control burst. The remaining moderate scheme corresponds to the Tell-And-Go Enforcement scheme and the Just-Enough-Time approach, while Just-in-Time is the most delayed process. Thus, the Just-Enough-Time approach possesses maximum advantages on par with the benefits of the other reservation schemes considered for investigation. The main advantages are, a) the process of allocation is always done prior to the transmission of control burst, b) the source of data burst is also concluded before the wavelength reservation process, c) the number of hops are computed based on the offset that is always determined between the data burst and the control burst and d) the method of reservation in wavelength is always facilitated when the initial bit of data packets reaches the desired location such that much of the wavelength is not made idle.

Further, the proposed approach uses the optical burst switching network that possesses edge nodes and core nodes for optimal wavelength reservation [12]. In the utilized architecture, the edge nodes play the vital role as the interface point between the electronic and optical components considered for reservation. The packets are always assembled and disassembled in the egress node and ingress node respectively [13]. Furthermore, the core node is responsible for synchronizing the actions performed at the ingress and egress nodes. In addition, the network architecture is designed such that they handle the process of organizing, analyzing, administrating the operations of the optical networks such that essential degree of services are extended in the optical networks without delay in any potential time [14]. The used architecture does not possess any centralized controller and hence they contribute towards the establishment of a distribute network such that the is accessible and non idle during the process of wavelength reservation enabled between the source and destination nodes. This approach used PROBE packet for extracting data related to the currently utilizing wavelength along the forward path using the process of backward wavelength reservation.

Furthermore, the proposed NCPS-DRE-QoS Scheme is classified into Backward blocking and hence the probability of data burst blocking is estimated based on Equation (1)

$$B_{p(i+1)} = F_{b(i)} + (1 - F_{b(i)}) B_{p(i)} \quad (1)$$

Where $F_{b(i)}$ and $B_{b(i)}$ relates the forward and backward blocking probability of packets in the proposed NCPS-DRE-QoS Scheme.

In addition, the value of $F_{b(i)}$ and $B_{b(i)}$ are comparatively high and hence the process of wavelength reservation is not maximized. Thus the process of forward blocking is again incorporated for enhancing the proposed approach based on the utilization of wavelength convertor in the process of optimal packet route selection. This proposed NCPS-DRE-QoS Scheme also eliminates the maximum use of PROBE packets since their utilization incurs maximum cost. Thus the proposed NCPS-DRE-QoS is proved to be better than the existing wavelength reservation schemes of the literature in terms of the goodput, blocking probability and communication overhead.

IV. ALGORITHM-PROPOSED NCPS-DRE-QOS SCHEME

The detail of the proposed NCPS-DRE-QoS algorithm is described as follows:

(1) Initially, monitor the activity facilitated by the source node of the architecture
1.1 If the destination node receives the connection establishment request .
1.2 Initiate the possibility of generating PROBE packet.
1.3 investigate the degree of the available wavelength of the successor link.
1.4 Compute the primary wavelength from the topological ring.
1.5 Choose an initial wavelength from the topological order in a random manner. .
1.6 Transmit the PROBE packet between the source and destination.
(2) Facilitate the process of observing intermediate node.
2.1 When the PROBE packet is received by the intermediate node.
2.2 Analyze the wavelength reserved for transmission.
2.3 Peep into the wavelength prediction table in the

predecessor and successor Field.

If prediction wavelength is obtained, Wavelength is in a deadlock.

Else: Go to next step.

(3) Iteratively enable the process of revising the wavelength topology.
3.1 If a wavelength is in deadlock delete the wavelength from the topology.
3.2 Reorder the wavelength topology.
3.3 If the selected-λ window has modified: update the wavelength prediction table by checking the wavelength topology.
(4) Modify wavelength prediction table by reordering the wavelength topology.
(5) Relay the PROBE packet towards the downstream node.

Behavior of the Destination node :(DS1) Receive the PROBE packet through the intermediate node.(DS2) Check for wavelength availability. (DS3) Check for wavelength prediction table.

- The wavelength is available, then discard the frequency range.
- Otherwise, proceed to the next step.
  (DS4) Modify the wavelength topology.
  (DS5) Return the reply packet to the source node.

In the proposed NCPS-DRE-QoS, initially the source node activity is monitored by the first node which receives the connection establishment request for generating the PROBE packet. After generating, the available wavelength of the succeeding link is analyzed and then the primary wavelength of the wavelength topological ring is estimated. From the estimated topological list the initial wavelength is randomly chosen. Finally the PROBE packet is relayed. The intermediate node monitoring is done by receiving the PROBE packet. Then the available wavelength is analysed and look into the wavelength prediction table in the predecessor and successor link. If the prediction wavelength is found , the wavelength is in deadlock otherwise new step has to be proceeded. The wavelength topology is always revised when the wavelength is in deadlock. In addition the wavelength from the topology gets deleted, and then the reordering of the wavelength is done.

The wavelength prediction table is updated by checking the wavelength topology when the selected-λ has modified. The wavelength prediction table is modified by reordering the wavelength topology, by which the PROBE packet is relayed towards the down stream node. The behavior of the destination node can be determined by receiving the PROBE packet through the intermediate node. Now checking the wavelength availability are performed on the wavelength prediction table. If the wavelength is available then discard the frequency range otherwise proceed to the next step. Finally the wavelength topology is modified and the reply packet is returned to the source node.

V. RESULTS AND DISCUSSION

NCPS-DRE-QoS is extensively simulated through ns-2 simulator, with the help of the NSF network. The NSF network topology contains 30 nodes and 25 links with JIT signaling protocol as the base protocol. The simulation is done by making the most loaded link of the NSF network to fail for identifying the role of NCPS-DRE-QoS for wavelength reservation and contention resolution in regaining the required QoS. The comparison of NCPS-DRE-QoS with PSEMQoS (Path Stability Based Enhancement Mechanism for QoS Provisioning) and OBSRWA [15] (Optical Burst Switching Reservation and Wavelength Assignment approach) which reduces the wavelength required to assign a different wavelength to each path with a set of overlapping paths (asynchronous PQP). Further, the traffic pattern variations are analyzed for all the schemes considered in measuring the performance of proposed technique with parameters such as burst loss probability, jitter, average goodput and packet delivery ratio.

Other assumptions considered in carrying out the simulations are:
a) All the physical links in the network are considered as a bidirectional, allocating 40 wavelengths per link.
b) The burst arrival process for the Optical Burst Switching Reservation is considered to be modeled through the Poisson burst duration process.

Performance metrics

PSEMQoS is compared with NFRMOBS and OBSRWA. Based on the following evaluation metrics, the exhaustive comparative analysis is made.

1.Packet Delivery Ratio:

The ratio of total number of packets received by the destination (receiver) node to the number of packets generated actually by the source (sender) node.

2.Jitter:

It is defined as the variation of latency which is measured over time by varying the packet latency across the burst switching network.

3.Burst loss probability:

The ratio of number of burst packets lost to the number of burst packets obtained during a link failure of burst switching network.

4.Average goodput:

The ratio of maximum size of the transmitted file to the time required for transferring that particular file.

Each and every result of the simulations is obtained through batch mean method with 95% of confidence. Here, the fault detection rate and update time for the simulation are approximated as 20ms and 250 ms respectively. All the results of the simulations are obtained with 95% of confidence through batch mean method. The fault detection rate and update time for the simulation are considered to be 20 ms and 250 ms respectively.

Performance Evaluation of Delayed Reservation based Contention Resolution Scheme for QoS provisioning (NCPS-DRE-QoS) based on Load:

The performance of NCPS-DRE-QoS is evaluated through comparative analysis with PSEMQoS and OBSRWA based on jitter, Burst loss probability, packet delivery ratio and Average Goodput by varying the load from 0.2 to 1.2 in increments of 0.2.

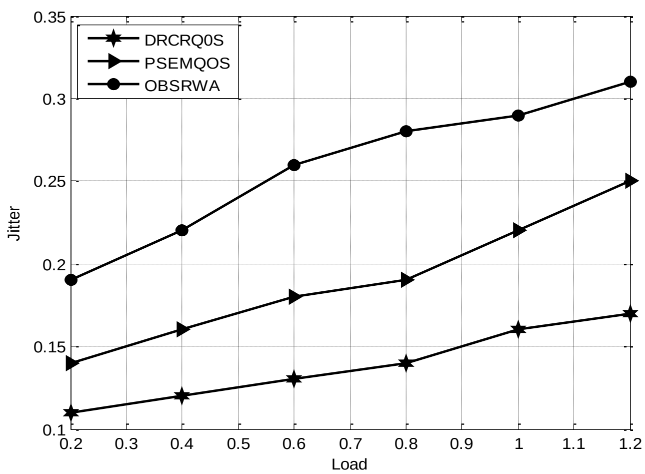

Figure 1: NCPS-DRE-QoS-Jitter-varying the load

Figure 1 and Figure 2 presents the Comparative analysis for NCPS-DRE-QoS based on varying load with respect to Jitter and Packet delivery ratio. From the simulation results obtained, it is transparent that NCPS-DRE-QoS decreases the amount of jitter from 25% to 32% when compared to PSEMQoS and from 36% to 42 % when compared to OBSRWA.This is due to the incorporation of efficient contention resolution and wavelength allocation scheme by NCPS-DRE-QoS.

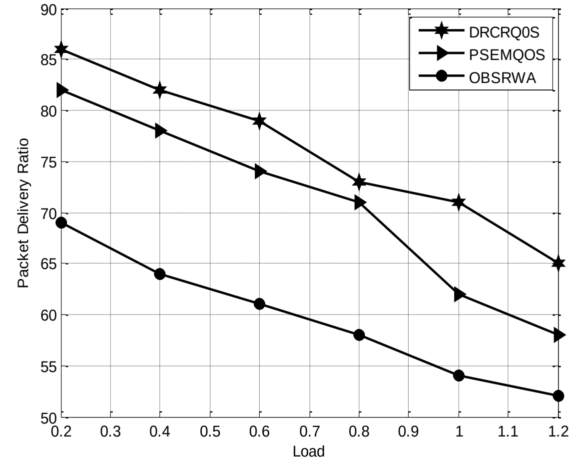

Figure 2: NCPS-DRE-QoS-Packet Delivery Ratio-varying the load

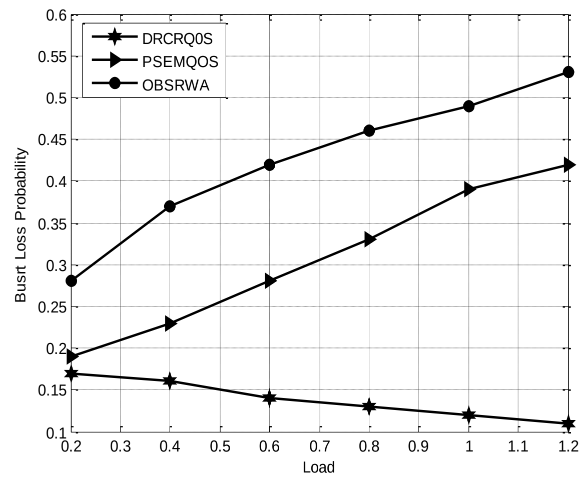

Figure 3:NCPS-DRE-QoS-Packet Delivery Ratio-varying the load

In contrast, NCPS-DRE-QoS improves the packet delivery ratio from 24 % to 32 % when compared to PSEMQoS and from 32% to 38% when compared to OBSRWA. Thus, in an average NCPS-DRE-QoS decreases the amount of jitter by 32% while increasing the packet delivery ratio by 27%. Likewise, Figure 3 and Figure 4 present the Comparative analysis for NCPS-DRE-QoS on varying load with respect to Burst Loss probability and Average Goodput. From the simulation results obtained, it is evident that NCPS-DRE-QoS decreases the amount of Burst Loss Probability from 21% to 28% when compared to PSEMQoS and from 32% to 38% when compared to OBSRWA.This is because NCPS-DRE-QoS utilizes fast restoration process when compared to PSEMQoS and OBSRWA.

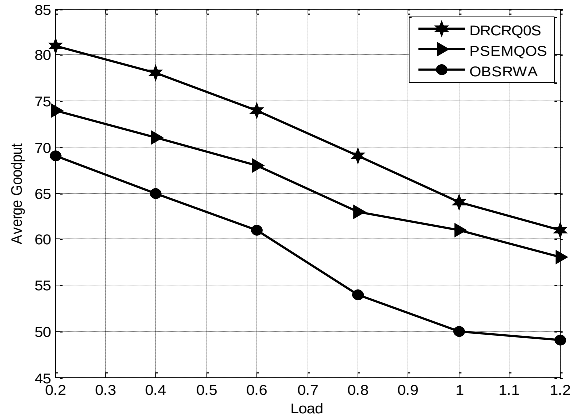

Figure 4: NCPS-DRE-QoS-Average Goodput-varying the load

In contrast, NCPS-DRE-QoS improves the Average Goodput from 29% to 37% when compared to PSEMQoS and from 39% to 45% when compared to OBSRWA.Thus, in average NCPS-DRE-QoS decreases the bust loss probability by 28% while increasing the Average Goodput by 36%.

Performance Evaluation of Delayed Reservation based Contention Resolution Scheme for QoS provisioning (NCPS-DRE-QoS) based on Burst block probability.

The performance of NCPS-DRE-QoS is evaluated through comparative analysis with PSEMQoS and OBSRWA based on packet delivery ratio and Average Goodput by varying the Burst loss probability from 0.1 to 0.8 in increments of 0.1.

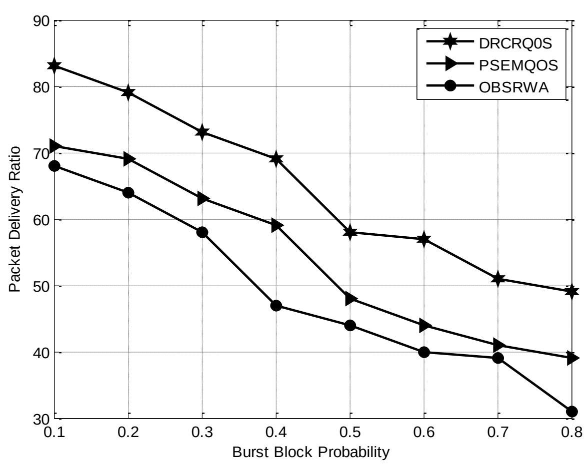

Figure 5: NCPS-DRE-QoS-Packet delivery ratio-burst block probability

Figure 5 and Figure 6 presents the Comparative analysis for NCPS-DRE-QoS based on varying Burst Block Probability with respect to the packet delivery ratio and Average Goodput. From the simulation results obtained, it is transparent that NCPS-DRE-QoS increases packet delivery ratio from 31% to 38% when compared to PSEMQoS and from 40% to 43% when compared to OBSRWA.

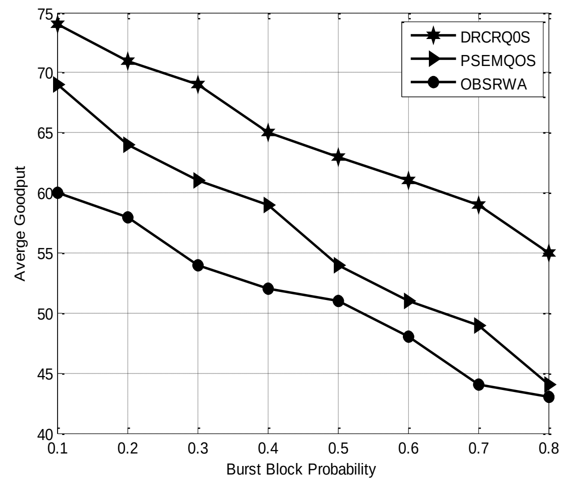

Figure 6: NCPS-DRE-QoS-Average Goodput-burst block probability

Similarly, NCPS-DRE-QoS improves the Average Goodput from 26% to 33% when compared to PSEMQoS and from 29% to 36% when compared to OBSRWA. Thus, in average PSEMQoS improves the packet delivery ratio by 16% and Average Goodput by 32%.

Performance Evaluation of Delayed Reservation based Contention Resolution Scheme for QoS provisioning (NCPS-DRE-QoS) based on Propagation time.

The performance of NCPS-DRE-QoS is evaluated through comparative analysis with PSEMQoS and NFRMOBS based on blocking probabilities by varying the propagation delay from 0.2 to 1.2 in increments of 0.2. Figure 7 presents the Comparative analysis for NCPS-DRE-QoS based on varying propagation delay with respect to blocking probabilities. From the simulation results obtained, it is transparent that NCPS-DRE-QoS decreases the blocking probability from 29% to 22% when compared to PSEMQoS and from 33% to 39% when compared to OBSRWA.

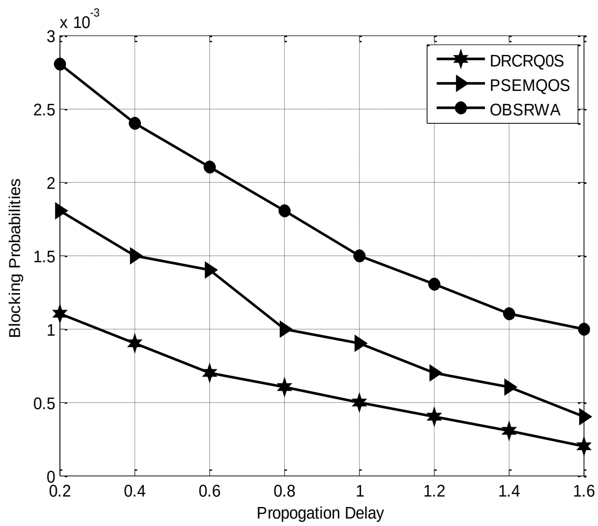

Figure 7: NCPS-DRE-QoS - Blocking probability- propagation delay

IV. CONCLUSION and Future Scope

In this paper, we present a Delayed Reservation based Contention Resolution Scheme for QoS provisioning (NCPS-DRE-QoS) that effectively and efficiently allocates the wavelength based on the available wavelength information obtained along the forward path by means of PROBE packet incorporated for the backward reservation scheme. Further, this mechanism is more effective since it utilizes the information gathered by PROBE packet that is outdated due to the link propagation or processing delay. This novel opportunistic wavelength assignment chooses the best optimal wavelength for transmitting the video signal and also maintains the wavelength assignment parameters that optimally prevents the illegal use of services from the server to the user. Furthermore, the proposed concept of multipath mechanism reduces the amount of the link failure that could occur when the router takes the alternating path to the server. Finally the results of simulations show that video signals can be transmitted at less jitter, minimum loss probability and high packet delivery ratio.

REFERENCES

[1]Wayne D. Grover. Mesh-Based Survivable Networks: Options and Strategies for Optical, MPLS, SONET, and ATM Networking. Prentice Hall, August 26, 2003.

[2]D. Sou and S. Subramanian. Survivability in optical networks. *IEEE Network*, 14(6), Nov. /Dec. 2000.

[3]I. Baldine, George N. Rouskas, Harry G. Perros and Dan Stevenson. Jumpstart: A Just-in-Time Signaling Architecture for WDM Burst-Switched Networks. *IEEE Communication Magazine*, 40(2), Feb. 2002.

[4]Y. Chen, C. Qiao and X. Yu. Optical burst switching: A New Area in Optical Networking Research. *IEEE Network Magazine*, 18(3), May/June 2004.

[5]T. Battistilli and H. Perros. An introduction to optical burst switching. *IEEE Communication Magazine*, 41(8), Aug. 2003.

[6] A. Halim Zaim, Ilia Baldine, Mark Cassada, George N. Rouskas, Harry G. Perros and Dan Steven- son. Fault Management with Fast Restoration for Optical Burst Switched Networks. *Optical Engineering*, 42(2), Feb. 2003.

[7]David Griffith and SuKyoung Lee. A 1+1 protection architecture for optical burst switched networks. *Journal of Selected Areas in Communications*, IEEE, 21(9), Nov. 2003.

[8]A. Sengupta, J. Qu and S. Bandyopadhyay. Fault management in burst switched optical WDM networks *Proc. of Terabit Optical Networking*, SPIE, 2000.

[9] J-D Shin, Saravut Charcranoon, Hakki C. Cankaya, and Tarek S. El-Bawab. Operation and maintenance issues in optical burst-switched networks. *Proc. of Optical Transmission Systems and Equipment for WDM Networking*, SPIE, 2002.

[10] Yufeng Xin, Jing Teng, Gigi Karmous-Edwards, George N. Rouskas, and Daniel Stevenson. Fault Management with Fast Restoration for Optical Burst Switched Networks. *Proc. of BroadNets*, IEEE, 2004.

[11] J. Xu, Chunming Qiao, Jikai Li, and Guang Xu, "Efficient Channel Scheduling Algorithms in Optical Burst Switching Networks," In Proceeding of IEEE INFOCOM, vol. 3, pp. 2268-2278, 2003.

[12] V. M. Vokkarane and Jason P. Jue, "Segmentation-Based No preemptive Channel Scheduling Algorithms for Optical Burst- Switched Networks," Journal of Lightwave Technology, vol. 23(10), pp. 3125- 3137, October 2005.

[13]B. Ramamurthy and B. Mukherjee, "Wavelength Conversion in WDM Networking," IEEE Journal on Selected Areas in Communications, vol.16(7), pp. 1061-1073, September 1998.

[14]Abdeliouab Belbekkouche, Abdelhakim Hafid, Michel Gendreau and Mariam Tagmouti, "Path –Based QoS Provisioning for Optical Burst Switching Networks", Journal of Light wave technology, Vol. 29, No. 13, 2011.

[15]Yufeng Xin, Jing Teng, Gigi Karmous –Edwards, George N.Rouskas, Daniel Stevenson, "A Novel Fast Restoration Mechanism for Optical Burst Switched Networks", IEEE 2011.

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