Routing with Prioritization Based on Statistics in OBS Networks

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ABSTRACT
This paper introduces a new strategy to provide QoS in IP/OBS networks, using Routing with Prioritization Based on Statistics (RPBS). This proposal uses the feedback scheme in optical networks to provide statistical knowledge with the objective of finding a suitable route for reach each destination from a specific source node, with more chance of success. This yields a twofold outcome. First, the losses can be reduced due to the statistics. Second, the delays are also reduced compare with other methods based on feedback scheme. These two improvements allow better QoS provision, supporting class differentiation and more efficient resources utilization. The benefits of this proposal are compared against existent alternatives by simulation.
Keywords: OBS, Statistical Routing, WDM, QoS Provision, JET, RPBS

1. INTRODUCTION

Optical technology continues to provide an exponential growth in fiber transmission capacities at higher rate than IP traffic growth, allowing overcoming some trends as the bandwidth and quality of service (QoS) requirement in networks. In this paper, it's elaborated on these trends and show how they motivate *Optical Burst Switching* (OBS) as a new switching paradigm for future transport networks. [1]

Recently, OBS represents a balance between circuit and packet switching, has opened up some exciting new dimensions in optical networking. OBS can provide improvements over wavelength routing in terms of bandwidth efficiency and core scalability via statistical multiplexing of bursts.

OBS sent data burst, which is preceded by a control packet that contains the routing information that the burst must follow in the network. After the control packet is sent for a dedicate channel and without confirmation, the ingress node sends the data burst, following the path done for the resource reservation in a unique direction. In this technology the control plane and the data plane are strongly separated, allowing the optical data switching, using only the optical domain, meanwhile the resources accommodation is processed in the electrical domain. This is possible reserving an optical channel for the control information or having a parallel electrical network with this finality. The separation of both planes allows good flexibility, network management, scalability and adaptability. [2] In the other hand, in the Optical Packet Switching (OPS) approach, each packet is sent into the network with its own header, this header is going to be earthier electronically or all-optically processed at each intermediate node while the packet is optically buffered. Also OPS may be seen as both the natural choice and conceptually ideal for the future all-optical networks current optical technology is still immature and not able to overcome its exigencies. Finally, in order to provide optical switching for next-generation Internet traffic is a flexible yet feasible way, OBS paradigm was proposed. This paper contemplates the design of a new strategy to provide absolute QoS in IP networks which are based on optical switching under quality parameters, in order that can be taking as reference for new device creations and technology implementation.

OBS usually relies on one-pas resource reservation, implemented by means of the Just-Enough-Time (JET) protocol; this scheme uses a delay between transmission of the control packet and the optical burst transmission. This delay, named offset time (OT), can be set to be larger than the total processing time of the control packet along the path. This way, when the burst arrives at each intermediate node, the control packet has been processed and a channel on the output port has been allocated. Therefore, there is no need to buffer the burst at the node. This is a very important feature of the JET scheme, since optical buffers are difficult to implement.[3][4]

The adequate choice of the offset time is a key point in the design of an OBS network, since it has a huge impact on the final performance, measured in terms of delay and data loss. The class differentiation in OBS networks, based on JET scheme can be implemented by assigning an extra offset time to high-class bursts. [5]

JET-based OBS protocol can achieve good bandwidth utilization by using delayed reservation compared to other OBS protocol; but given the one-way reservation nature of JET, burst can be dropped due to contention in intermediate nodes, reason for what further improvement based JET scheme are been studied. Most of presents studies, shows how the use of a feedback scheme in optical networks can bring better performance n packet losses [6]. Reason to focus this work in study OBS technology, based on the JET protocol as reservation mechanism, to provide absolute QoS in optical networks, thanks that its performance allows isolation among classes, but combined with the feedback scheme in order to provide less losses in data burst, using a new introductory idea, which is the routing with prioritization based on statistics.

This paper continues as follows. Section 2 describes the proposed strategy. Section 3 describes the results and discussions. Section 3.1 presents the scenario under study. Section 3.2 analyzes the performance of the strategy against a related work based on feedback and the traditional JET protocol. Finally, in section 4, I draw up some conclusions and recommendations.

2. RPBS: Proposed Strategy

This section introduces the idea behind the RPBS scheme, which is followed by three phases: Assembling, Computing and Transmission, as explained follow:

2.1 Phase I. Assembling

In this phase, the electrical packets will arrive and will be transformed into bursts, these data bursts will be assembled according to the same CoS and destination node, also these will have a fixed size depending at which CoS belong. For the CoS_{k-1} the burst length will be $2 \times CoS_{k-2}$, where the higher priority *CoS* will be represented for CoS_0 and the lower priority for the CoS_{k-1}, the total number of classes will be $k \in [0, k-1]$.

2.2 Phase II. Computing

When a BCP packet arrives to an edge router, a route will be assigned and also an OT depending its *CoS.* Each edge router keeps information to all the available routes to reach other edge routers, these routes will be associated to a priority *P* between$[0,1]$, and an N_f value that will indicate the number of times that this route had been chosen, also an H value that indicates the number of hopes to reach the destination node. The routing table will be adjusted after a failure or success occurs in the network. When a success occurs the new P will be the same as the previous, meanwhile if a failure takes place, the new P and the N_f value for both cases will be calculated as shown in equation (1), which equations are extracted from [1].

$$P = \frac{P \times N_f}{N_f + 1} \quad \text{and } N_f = N_f + 1 \tag{1}$$

The chosen route will be the route with the biggest *P* value, if more than one route has the same value, the second parameter to take into account will be the smaller *H* value. When a route had been chosen, it's going to be introduced into the BCP packet, which contains also the information about the source edge router, destination edge router and the *CoS.* After the route is selected, the offset time must be calculated as shown in equation (2) and set, which will be carrying by BCP packets and will let know to the intermediate OBS nodes for how long they have to reserve the wavelength channel for its specific data burst.

$$OT_{CN} = \left(t_{bcp} + t_p + t_c + EOT_{CN}\right) \times h_i \qquad EOT_{CN} = \left(\sum_{i=0}^{k-1} BL_i - 2BL_{CN}\right) \times \frac{8}{b_{core}} \tag{2}$$

Where: OT_{CN} it's the offset time for each class number, t_{bcp} it's the delay time to transmit the *BCP* packet, t_p it's the delay time to process the *BCP* packet, t_c it's the matrix switching time, EOT_{CN} it's the extra offset time calculation for each class number, h_i it represents the number of jumps that the burst needs to do before to arrive to the i node, from the source node, BL_i it's the burst length size according to the CoS, b_{core} it's the output bandwidth for each wavelength channel and CN it's the number class, where $CN \in [0, k-1]$.

Knowing the OT for each *CoS* data burst it's possible to obtain the Time-to-Live (*TTL)* for each packet, which can be calculated with equation (3).

$$TTL = H \times \left[OT + \left(BL \times \frac{8}{b_{core}}\right)\right] \tag{3}$$

2.3 Phase III. Transmission

This phase is composed of two functional components: the Optical Switch Node (OSN) and the edge router.

2.3.1 The OSN Component: The feedback operation is composed by two phases, reservation and feedback.

Reservation: When a BCP packet arrives at an OSN, it attempts to reserve output bandwidth a time period in advance for the data burst that is expected to arrive a specific offset time later. If there is available wavelength for the period at the desire output port, the reservation is deemed successful. Otherwise, the reservation fails, and the second phase takes place.

Feedback: The OSN will send back a feedback packet, named NACK, to the source edge router of this data burst to initiate the transmission as corresponds if the number of feedback of this data burst doesn't exceed the maximum number of retransmissions. The NACK will contain information about the sequence number of the collision data burst and the source edge router's address.

2.3.2 The Edge Router Component: will be in charge of the transmission and retransmission operations.

Transmission: Each output unit maintains to queues, the *transmission queue* and the *waiting queue*. All data busts input into the output unit from the computing phase buffer are stored in the *transmission queue* and wait for transmission. This queue will performance a earliest deadline first (EDF) scheduling algorithm for scheduling the bursts, and the theory of this discipline is that the first burst to be sent will be the one which time to live is the earliest. This scheduling algorithm was choose in order to keep the *CoS* priority and also because it's often used in real-time operating systems. Once the bursts are scheduled, and the output link is idle, the burst will be sent to the optical network and a copy will be stored in to the *waiting queue* for a period of time, which is specified in the next section.

Retransmission: All the data burst that are sent to the optical networks are stored in the *waiting queue* for a period of time equal to the RTT from the source edge router to the destination edge router, plus a processing time. If the source edge router receives a feedback packet before the established time expires, the system takes this as a failure and the *waiting queue* will send the copy to the *transmission queue* and remove from its queue, this is done, after evaluates if its retransmissions number doesn't exceed the N_{max} parameter established. Otherwise, if the edge router doesn't receive a feedback packet in this period of time the system will consider that the data burst arrive to the destination node, and the *waiting queue* will drop its copy.

3. Results and Discussion

In this section, the performance of RPBS is evaluated in front of JET and other related work. With such purposes in mind, the QoS performance of these three models in a 3-class scenario, using the simulation as a calculation tool, in a 14-nodes NFSNET network.

3.1 Scenario under Study

With evaluation purposes the model is simulated using the 14-nodes NFSNET topology, assuming that each link carries 4 bidirectional wavelengths at 10Gbps. For the traffic characteristics, it's considered that uniformly distributed burst arrives following a Poisson process with rate 1/λ. Burst length packets have a length of 40kB, so the transmission time onto the link will be 32µs, where 20% of the traffic is from CoS1, 30% from CoS2 and 50% from CoS3.

Regarding hardware devices, it's assumed that OBS nodes are equipped with full wavelength conversion; a non-blocking matrix and enough number of add/drop ports. The BCP processing time and the matrix switching time were set to 10µs and 2.5µs respectively.

3.2 Evaluation of RPBS & the Other 2 Models

After the simulation was done, from the obtains results, the extracted were the number of packets that could be transmitted in this time period, the number of loss packets after the maximum number of retransmission is exceed in each class. The obtained results are shown in Table 1, being RPBS the proposed model, WS the related work that uses feedback and the last model standard JET. Being the received packets are the packets that could reach the destination, the lost packets are the packets that couldn't reach the destination and also are shown the calculated lost probability for each model. In Fig. 1 is possible to see the amount of packets send to the network per CoS and Model, meanwhile in Fig. 2 is possible to see the losses per CoS per model suffers in the network.

With these results it's possible to say that the packets sent to the network per model, follows the traffic characteristic, were almost 50% represent CoS3, 30% CoS2 and 20% CoS 1. Meanwhile with Fig. 2 could be seen that the losses are reduced in big amount with the proposal, which can be in more detail in Table 1, were it's possible to observe that with RPBS the losses are reduced almost 10% in comparison with the WS model. This is because thanks to the statistical route choose less packets need retransmission, so it add not just the improvement of less losses to the network, but also is able to attend more number of new packets and send to the network in the same amount of time.

Finally, in Table 2 and graphically represented in Fig. 3 it's possible to see the three models performance at different traffic loads, were can be noted that when the traffic load is small, the three algorithms converge towards the same loss probability, but as ρ increases, the loss probability for the three algorithms separates as RPBS always maintains the lower number of losses in the Network, being the crucial value when ρ=0,4. Based on these results and making a comparison with the paper referred in [6] is possible to say that the obtained results for the JET algorithm simulated in that paper, specifically shown in Fig. 3, were the standard JET was used for the BE class, follows the same performance on the same traffic conditions that were used in the simulation of this study; giving validation to their work and also to the obtained results for the three performances of this study.

Table 1. Loss probability for different traffic loads.

Model	Lost	Received	Loss Probability
RPBS	17824	17183021	1,04E-03
WS	170425	16784636	1,01E-02
JET	246790	17448603	1,39E-02

Table 2. Loss Probability per Model in the Network

Offered Load ρ	Loss Prob. RPBS	Loss Prob. WS	Loss Prob. JET
0,32	8,10E-06	1,73E-05	2,67E-03
0,40	9,81E-05	2,17E-04	5,27E-02
0,47	2,26E-04	7,59E-04	1,23E-01
0,57	3,38E-04	1,40E-03	1,76E-01
0,73	4,71E-04	2,00E-03	1,96E-01
0,84	5,32E-04	2,34E-03	2,13E-01

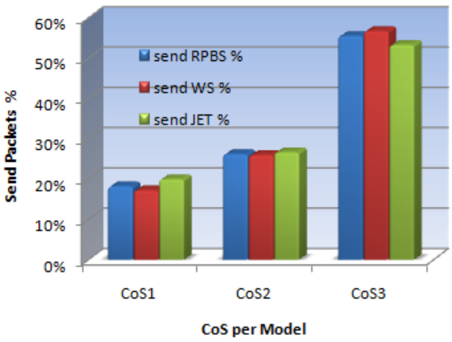

Fig.1. Percentage of the send packets to the network for the three models.

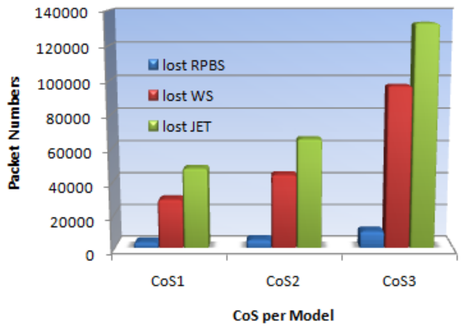

Fig. 2. Losses in the Network per model and CoS.

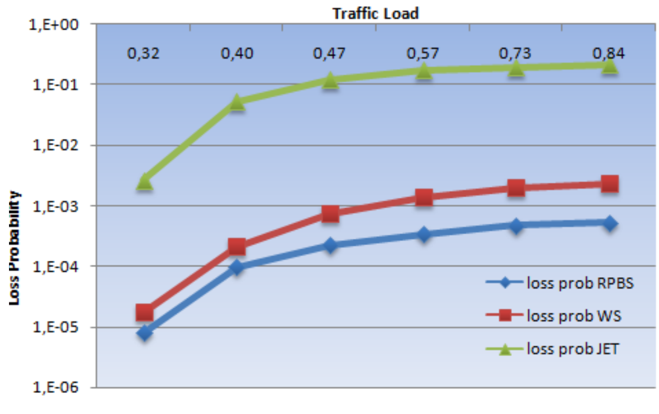

Fig. 3. Burst loss probability in a 3-class scenario.

4. CONCLUSIONS

In this paper, the RPBS model is presented as a strategy to provide absolute QoS in OBS networks, based on the JET signaling scheme and using feedback. The RPBS, standard JET and a model based on feedback were tested in different traffic loads, and it could be seen that with RPBS the losses in the network are reduced when the ρ increases, in comparison with the previous two models, being the crucial point ρ=0,4; being possible to conclude that using the statistical knowledge for choosing the different routes to reach the destinations.

Finally, it is possible to say, that with The RPBS model is able to provide absolute QoS in IP/OBS networks. It's noticed that the system works better in small environments; it can present increase in losses when the network grows. In this case, it would be necessary to define autonomous systems, keeping the delays small and not causing problems in the development of certain applications. That's why is recommended a strategy, were can be add functionality to internal nodes, were a better route to send the packets by themselves may be found, by using the feedback scheme. This way the source node should not be responsible of finding the whole route to reach the final destination.

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