Contention Resolution using Control Packet Buffering in Optical Burst Switched Networks

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***Abstract*—In this paper a novel contention resolution technique based on control packet buffering in OBS networks is proposed. This buffering is implemented in the electronic domain, thus avoiding complex optical domain solutions.**

I. Introduction

The aim of this paper is to add a new feature, namely the control packet buffering, to the MAC layer of the OBS network as a new contention resolution technique. This feature represents a new modification to the just in time (JIT) one way reservation protocol and does not depend on the medium access technique. Therefore, it can be implemented, for example above a WDM or OCDMA layer, to enhance the overall performance of the system. Thus decreasing the need for converters and hence simplifying the system. The key idea of this feature is that the CP that fails in reserving its required resource will not be dropped immediately, rather buffered for some threshold time X. This threshold time is determined by the system at the ingress node according to each burst duration. Meanwhile the required resource may be released and consequently immediately reserved for the new burst, otherwise the CP will be dropped, and the ensuing DB will be lost. This way *the per-node MAC layer burst loss probability* is decreased. Furthermore this saving process, like all CP processing operations, is added in the electronic domain and hence there will be no need to any complex optical devices. According to this proposal the burst offset time is modified to adjust the burst arrival.

II. System Description

According to our proposal, new functions must be added to the ingress and core nodes described in [1], as follows: In addition to its main job, the ingress node assigns to each CP prior to its transmission a threshold time that is directly proportional to its burst length. Furthermore it increases the burst offset time by $C \times$ *the assigned waiting time*, where C is a function of the expected number of congested hops on the expected path of each burst. This can be easily calculated at the ingress node based on the congestion statistics. Here it should be noticed that the increment in the offset time is not constant for all bursts, as the assigned waiting time and the function C differ from burst to burst. This variable offset time is necessary to help resolving the contention problem. On the other hand, a small size buffer at each core node is electronically implemented in order to save a control packet that finds the appropriate resource busy upon arrival.

Clearly, the proposed CP saving process will delay the burst delivery. However, it will reduce the burst blocking probability, thus the MAC layer delivery success will be more likely and there will be less number of DBs to resend. As a result, the overall delay will be relatively reduced. Moreover, the purpose behind having limited buffering time is that uncontrolled waiting time might cause intolerable delays and a waste of other resources already reserved in precedent nodes. In addition, it might be longer than expected and the DB might arrive before reserving the appropriate resources. Moreover the proportionality between the threshold time and the burst length implies that the burst loss probability will follow the burst length. In other words, it will be less likely to block bursts comprising larger number of packets.

III. Performance Analysis

In order to analyze the performance of the suggested system, we develop a mathematical model, which is based on a well known impatience concept in queuing theory named '*reneging*' [2]. In this model we assume an exponentially distributed service time with average rate μ and exponentially distributed random waiting time with average rate ν. Using this model for a buffer size m the per node burst loss probability $P_{Node-Loss}$, the MAC layer burst loss probability and the steady state system

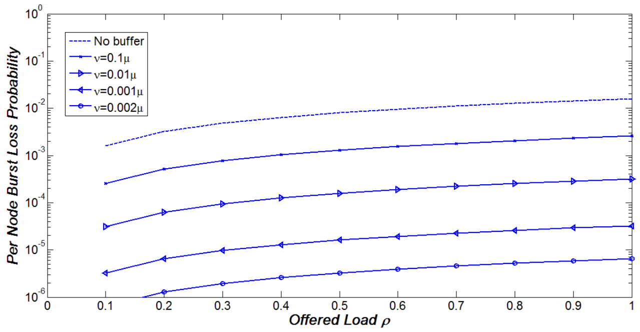

Figure 1. Semilog plot of the *per node burst loss probability* versus the offered load ρ with no buffer and with buffer under different values of ν.

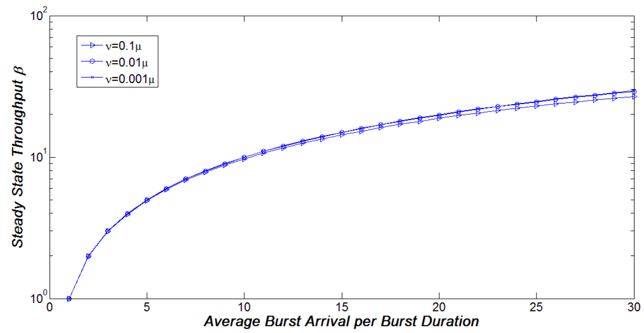

Figure 2. Semilog plot of the *steady state throughput* versus the offered load ρ under different values of ν.

throughput β can be written as follows:

$$P_{Node-Loss} = \pi_{m+1} + \sum_{i=1}^{m} \pi_i \times P(R_i), \qquad (1)$$

where π_m is the steady state probability that a CP finds m items upon arrival, while $P(R_i)$ is the probability that a core node discards a CP as its threshold waiting time has elapsed before reserving the required resource.

$$P_{MAC-Loss} = 1 - (1 - P_{Node-Loss})^H, \qquad (2)$$

where H is the maximum expected number of core nodes that the CP longest path can contain. This way we get the maximum MAC loss probability.

$$\beta = \lambda \times \mathit{Burst\ duration} \times (1 - P_{Node-Loss}), \qquad (3)$$

where λ is the average burst arrival rate.

IV. Results

In this evaluation, we assume an average burst length L_b= 100 Kbits, and apply this proposal to a WDM system with 62 channels and a bit rate of 100 Gbps for each single user. First, in Fig. 1 the per node burst loss probability is plotted versus the offered load under different values of ν. Clearly, decreasing ν improves the blocking probability. This is quite expected, as this decrease means that the CP is allowed to wait longer time in the queue before quiting.

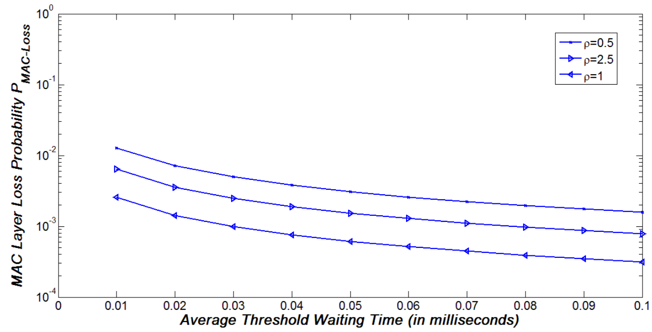

Figure 3. Semilog plot of the *per node burst loss probability* versus the average threshold waiting time.

Simply stated, it will be more likely for the required resource to be released before the core node discards the buffered CP.

Next, in Fig. 2 the steady state throughput is portrayed versus the average burst arrivals per average burst duration. Observing this figure, we find that the system throughput increases rapidly for small values of burst arrivals, then gradually as the number of arrivals grows up. It is also important to notice that this behavior improves with the increase in the average threshold waiting time.

Finally, the relationship between the MAC loss probability and the average waiting time is illustrated in Fig. 3. This figure indicates that the aforementioned improvement in the system behavior will be on the expense of the delay that the burst would experience, but this additional delay is justified as in case of burst loss the resending process can cause longer delay.

V. Conclusion

In this paper we have proposed a new solution to the contention problem in OBS networks by means of control packet buffering. This new modification to the JIT one way reservation protocol does not depend on the optical layer structure. Thus it can be easily implemented regardless of the optical layer nature. A descent proposal would be the implementation of this CP buffering to the WDM system with partial conversion proposed in [3]. This would boost up the system to outperform the complex SAC-OCDMA system without any additional complexity.

References

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