Ingress traffic classification versus aggregation in video over OBS networks

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***Abstract*—Optical Burst Switched (OBS) networks may become a backbone technology for video-on-demand providers. This work addresses the problem of dimensioning the access link of an ingress node to the optical core network in a video over OBS scenario. A video-on-demand provider using an OBS transport network will have to deliver traffic to a set of egress destinations. A large part of this traffic would be composed of video streaming traffic. However, in a real network there would be also a fraction of non video traffic related to non video services. This work studies the decision whether it is better to gather all traffic to the same destination in a joint burst assembler or separate video and general data traffic on different burs assemblers. The later may increase burst blocking probability but also allow for better tuning of OBS parameters that help improve video reception quality. Result show that this tuning of parameters is not enough to compensate the drop probability increase and thus it is better to aggregate video and general data traffic.**

I. Introduction

Optical Burst Switched (OBS) networks offer an optical backbone for high capacity data transport. This would benefit video streaming providers that need network infrastructures to accommodate a growing service. The present work addresses the dimensioning of ingress nodes for a streaming service over an OBS backbone. The behavior of the output port in the ingress node is studied. This service is already being offered by Internet Service Providers (ISPs) as part of their triple or quadruple play offerings. Nowadays, the video flows are being transported over traditional ATM/SONET/MPLS networks. However, they are clear candidates to take advantage of the high transmission speeds offered by the new all-optical networks as their bandwidth consumption grows with user population and video quality (High Definition Television).

In an OBS network, the workload to the control plane is reduced by switching bursts with a large number of packets in a single operation. The packets from legacy networks are buffered at the ingress nodes and aggregated into bursts in what is often called a *burstifier*. These bursts are optically switched by the core nodes in the network and disassembled at the egress node in order to be relayed to the destination.

The performance of edge nodes in OBS networks has been studied in several works [1], [2], [3]. The case of transport of video flows over OBS networks has received less attention. In [4], video transmission is simulated over an OBS network, describing the effect of time- and size-triggered burstifiers. In [5], the authors study the effect that the burst losses in the OBS network have on the decoding of video frames when the edge node uses a timer-based burstifier. Our own works at [6] and [7] address blocking probabilities at an OBS ingress node in a video over OBS scenario but assuming always that there was just video traffic present on the network.

Nevertheless in a realistic scenario the OBS transport backbone will not be used to send just video traffic but there will be an amount of other application's data as well. The nature of video-on-demand service may benefit from receiving special treatment. The popularity of video distribution may cause a large part of transport network traffic being video related but an appropriate video and non-video traffic mixing method must be used. This work address the problem of accommodating both kinds of traffic at the edge of an OBS transport network.

The rest of the paper is structured as follows. Section II presents scenario and parameters under study and explains the simulation setup. Section III shows simulation results and discuss them and section IV provides conclusions.

II. Scenario and methodology

The scenario under study is the network of a video on demand provider. As seen on figure 1, the provider network contains a set of video servers located in a legacy network connected through an OBS ingress router to the OBS core. At the ingress node a mix o video and non-video traffic is offered to be delivered through the backbone to the clients on remote access networks. The ingress traffic has to be classified at least in enough burstifiers as remote egress nodes. In that limit case every packet traveling to the same egress node would be put

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in the same burstifier, regardless of being video related or not. It was suggested in our previous work [7] that keeping the lowest number of burstifiers at the ingress node helps to reduce burst blocking probability.

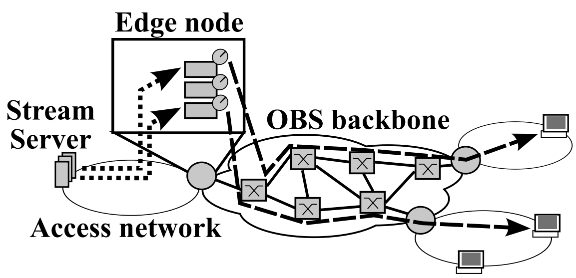

Fig. 1: Video over OBS scenario

However in the core network of an IPTV provider a significant amount of traffic corresponds to video flows and it may be useful to separate these streams to a different burstifier so as to apply some tunning based on the knowledge that traffic served by a given burstifier is just video flows traffic. For example, given that video distribution is not so dependent on one way delay, the video burstifier timeout can be increased so as to enhance the video reception quality of experience (as seen on [5]). This increase of timeout value beyond hundreds of milliseconds would not be tolerated by generic data traffic that may include packets from interactive applications. However, this separation may have an impact on the burst blocking probability because a larger number of burstifiers comes into play.

Thus, separation of video and non video traffic at the edge of the OBS core would on one hand increase overall burst drop probability (of video and data bursts) reducing received video quality. On the other hand, separation permits the application of specific video over OBS optimization techniques, namely increasing timeout to reduce impact of losses on video. Quantifying the net impact of both effects and studying the design parameters that allow network designers optimize received quality is the objective of this work.

To study the previous tradeoff and decide whether it is interesting to segregate video traffic, a video over OBS ingress node is simulated in both situations. The number of data wavelengths in the access link is set to $c = 16$ and $c = 32$. The system is simulated with a custom event driven simulator written using OMNeT++ [8]. A given input traffic load, composed of 20% generic data traffic and 80% video flows traffic is fed to an OBS edge node that injects traffic into the OBS network for k different destination egress nodes. Values of $k > c$ are considered so that blocking probabilities are not 0. Several values are simulated although results shown in section III correspond to the case $k = 40$ and $c = 16$.

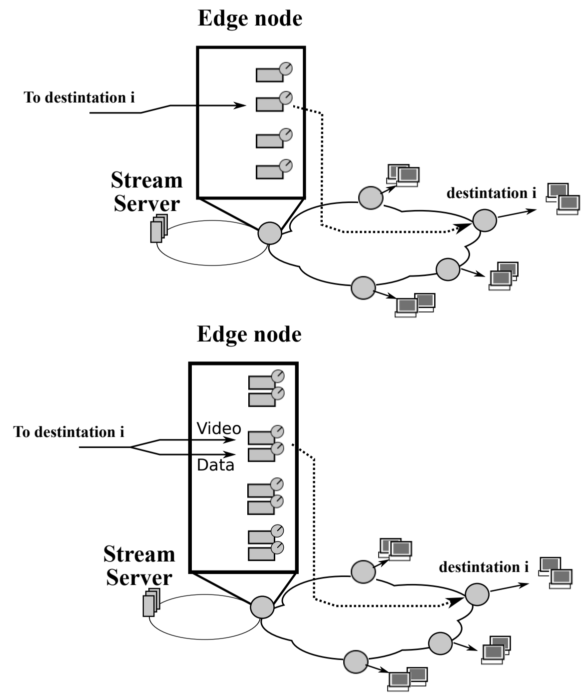

Fig. 2: Simulated scenarios

The input traffic is assumed to be uniformly distributed over destinations and video and data traffic are present in the same composition traveling to each destination. The first scenario considers that every traffic to the same destination is gathered in the same burstifier, giving a total of k burstifiers (see figure 2 (up)). Burstifiers are time triggered with a timeout value of $T_{out} = 10ms$ in order not to increase the latency of interactive traffic.

In the second scenario considered there are two burstifiers per egress detination. The first burstifier will gather only the video streaming traffic and the second one will accumulate the rest of the traffic (Figure 2(down)). Both burstifiers are timeout triggered. The one fed on video traffic will have a timeout value T_{out}^{video} that can be tuned and will be an input parameter of this study. The second one is set to $T_{out} = 10ms$ like in the previous case for the benefit of potential interactive traffic.

The video traffic is obtained by multiplexing traces of MPEG4 video made available from [9] to use in research. For this study a trace of Tokyo Olympics (coded with G16B7 GoP structure) is used. An arrival process of video flow requests is generated with a Poisson process with chosen rate to achieve the desired link utilization.

The generic data traffic is synthetized with a Gaussian sized burst generator with the needed rate for target utilization and a coefficient of variation set to $c_v = 0.2$.

This value of c_v is observed in high rate real traffic traces such as shown in [10].

For comparison purposes the scenario is simulated also for the same input load but with traffic composition of 50% video and 50% non video.

III. Results

Figure 3 shows the Burst Loss Probability (BLP) in the scenario of joint burstifiers for video and non video traffic (the case of k total burstifiers). Burst drop probability is shown versus the utilization factor of the link to the OBS core network. The curves shown were obtained for $T_{out} = 10ms$, $c = 16$ and $k = 40$. Similar results are obtained for different traffic composition and different values of number of destinations, wavelengths and timers.

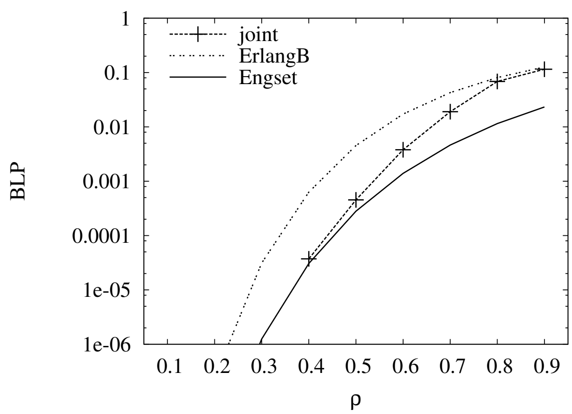

Fig. 3: BLP in the one burstifier per destination scenario

Loss probabilities are compared to values given by Erlang-B formula which would model the losses of an M/G/c/c system with infinite population. They are also compared to values of Engset formula which models an M/G/c/c/k system with a maximum of k sources given that just k burstifiers are used. It can be observed that actual burst loss probabilities obtained fit between those values that can be used as an approximation of high and low bounds. Thus, in the case of a joint burstifier for video and data traffic, with c wavelengths at the access link, fed by k joint burstifiers for k egress destinations and working at an utilization factor of ρ, a higher bound for burst loss probability will be given by $ErlangB(c, c\rho)$. A lower bound for the same scenario will be $Eng(c, \frac{c\rho}{k}, k)$.

On the other hand, for the scenario of video and generic data sources gathered in separate burstifiers, burst blocking probabilities are shown in figure 4 (for the case of 80% video composition) and figure 5 (for the case of 50% video and data). Same values of c and k are presented. Several burstifier timeout values for video burstifiers are used ($T_{out}^{video} = \{40, 80, 240, 480ms\}$) in order to observe the effect of bursts with low number (2 or 3) of video frames and also with more frames (8 or 15) per burst. The same $T_{out}^{data} = 10ms$ is kept in the non video traffic burstifier for interactivity purposes.

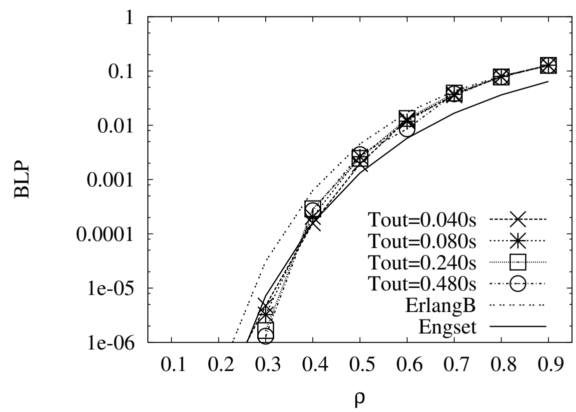

Fig. 4: BLP in the two burstifier per destination scenario with 80% video traffic

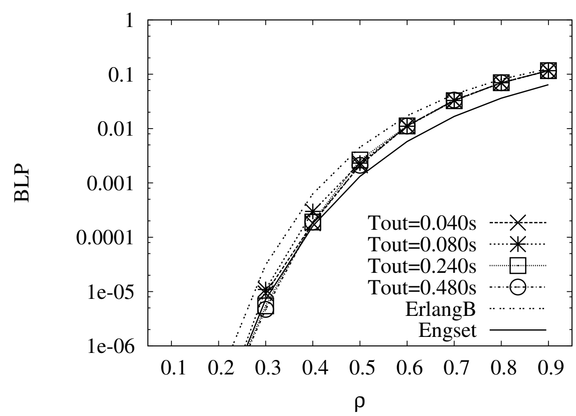

Fig. 5: BLP in the two burstifier per destination scenario with 50% video traffic

Again, simulation values are compared to theoretical ones. Notice that a higher bound is given by the same value $ErlangB(c, c\rho)$ because Erlang-B formula is independent of the number of sources. However, with $2k$ burstifier sources the lower bound given by $Eng(c, \frac{c\rho}{2k}, 2k)$ increases. This causes a higher BLP than in the common video and data burstifier scenario. This is regardless of traffic mix with more or less video presence (see figures 4 and 5). The implication is that burst blocking probability increases when video is separated in its own burstifier because as the number of independent sources grow with the same load, Engset formula is increasing towards Erlang-B value. $(Eng(c, \frac{c\rho}{k}, k) \xrightarrow[k \to \infty]{} ErlangB(c, c\rho))$

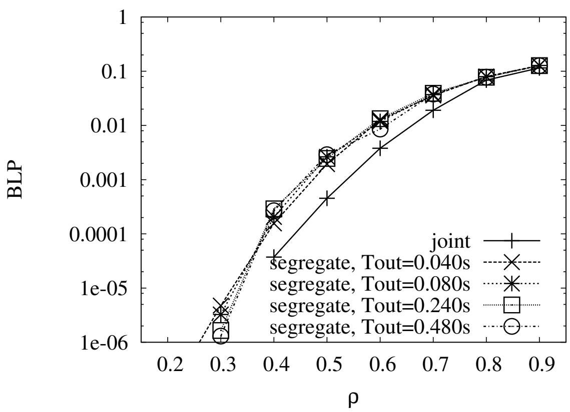

Fig. 6: Joint and segregated video scenarios comparison

This is further shown in figure 6 where burst loss probabilities for both scenarios are plotted for the same load, c and timeout values. The comparison of joint and separate video cases clearly shows lower drop probability with more wavelengths as expected and an increase in burst drop probability when video is separated. Thus, it seems that segregating video does not provide a benefit regarding burst blocking probabilities. However, burst loss rate does not translate directly to frame loss rate due to interdependence of frames that cause a higher amount of non decodable frames. As seen on previous work [5] a better parameter to represent received video quality is Frame Starvation Ratio (FSR) or the rate of frames that are not decoded due to being lost or to depend on other frames that are lost. The FSR can be computed from burst loss rate and depends on the average number of frames in a burst. Thus, FSR depends strongly on the burstifier timeout value. On figure 7 this dependence is shown plotting the FSR for videos with different codification versus the number of frames lost in a burst (which is linear with T_{out}^{video}). It can be seen that the FSR value falls with the number of frames but the rate of decay depends on the video codification parameters. So video codification parameters are an important tuning point in a video distribution service as suggested in [5]. Nevertheless the effect of increasing burstifier timer value is always decreasing FSR for the same burst loss probability, but this decreasing only takes place each time the timer grows over an integer multiple of the video inter frame arrival time.

Regarding this approach FSR is calculated at the scenarios under study and BLP of figure 6 is translated to FSR. The FSR comparison in the two scenarios is shown in figure 8. It can be observed that the effect of video burstifier timeout value decreasing reduces frame loss

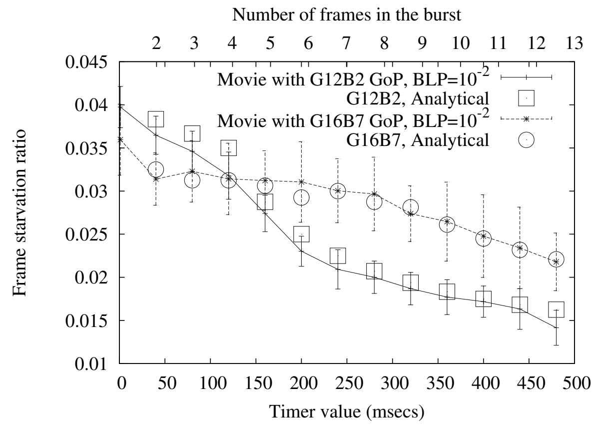

Fig. 7: Frame Starvation Ratio (FSR) versus number of frames in a burst

rate and thus enhance video reception quality. Although this reduction is not always enough to compensate the increased burst drop rate due to the large number of sources. In a scenario with high input load the effect is noticeable enough to get better video quality (lower FSR) with the separated video approach. Nevertheless, this reduction occurs for a high utilization situation where frame loss probability is over 10% thus making difficult to benefit from the reduction effect.

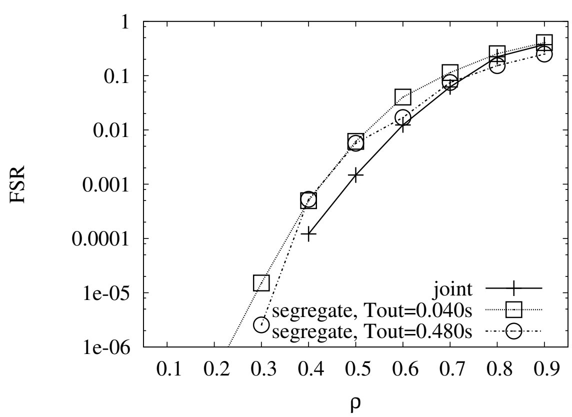

Fig. 8: Comparison of FSR in joint and segregate video scenarios

This result shows that the effect of aggregating traffic to reduce the number of burstifiers is very important to dimension scenarios of video over OBS transport networks. Separating video to reduce FSR by increasing burstifier timeout values is not enough to compensate the increased losses due to not keeping low the number of burstifiers. This also opens interesting questions on the effect of other quality of service mechanisms like priority schemes that require the separation of video traffic and thus increasing the number of burstifiers.

IV. CONCLUSIONS

The use of separate burstifiers for video and data traffic in the OBS transport network of a video on demand provider has been analyzed and evaluated by simulation. Results show that, in reasonable scenarios of traffic composition, the benefits of treating video separated from data may not compensate the increase in loss probability due to larger number of independent burst traffic sources. Thus, even if video reception quality may be controlled by appropriate choosing of burstifier timeout values and video coding parameters, the number of burstifiers is a critical parameter.

REFERENCES

[1] L. Xu, H. G. Perros, and G. N. Rouskas, "Performance analysis of an edge optical burst switching node with a large number of wavelengths," in *In 18th International Teletraffic Congress (ITC)*, 2003.

[2] A. Zalesky, E. Wong, M. Zukerman, H. L. Vu, and R. Tucker, "Performance analysis of an OBS edge router," *Photonics Technology Letters, IEEE*, vol. 16, pp. 695–697, Feb 2004.

[3] H. Li and I. L.-J. Thng, "Edge node buffer usage in optical burst switching networks," *Photonic Networks Communications*, no. 13, pp. 31–51, 2007.

[4] T. Vargas, J. Guerri, and S. Sales, "Effect and optimization of burst assembly algorithms for video traffic transmissions over OBS networks," in *Proceedings of BROADNETS08*, (London, 2008).

[5] F. Espina, D. Morato, M. Izal, and E. Magaña, "The effect of burst formation timers on video streaming over optical burst switched networks," in *Proceedings of BROADNETS08*, (London, 2008).

[6] F. Espina, M. Izal, D. Morató, and E. Magaña, "Performance analysis of OBS edge nodes for video streaming," in *Proceedings of the IEEE ICCCN'09*, (San Francisco), August 2009.

[7] F. Espina, M. Izal, D. Morató, and E. Magaña, "The effect of multiplexing video flows in the performance of obs edge node buffers," in *Proceedings of NOC/OC&I 2009* (I. de Miguel, R. Lorenzo, D. Faulkner, and R. Neat, eds.), (Valladolid), pp. 461–468, June 2009.

[8] A. Varga and R. Hornig, "An overview of the OMNeT++ simulation environment," in *Simutools '08: Proceedings of the 1st international conference on Simulation tools and techniques for communications, networks and systems & workshops*, (ICST, Brussels, Belgium, Belgium), pp. 1–10, ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering), 2008.

[9] G. V. der Auwera, P. T. David, and M. Reisslein, "Traffic Characteristis of H.264/AVC Variable Bit Rate Video," tech. rep., (Arizona State University, March 2007).

[10] M. Izal, J. Aracil, D. Morató, and E. Magaña, "Delay-throughput curves for timer-based obs burstifiers with light load," *IEEE/OSA Journal of Lightwave Technology*, 2005.