Adaptive Classified Cloning and Aggregation Technique for Delay and Loss sensitive Applications in OBS Networks

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Abstract: An adaptive classified cloning and aggregation technique is introduced for deployment with Optical Burst Switching. Simulations show up to 74% reduction in loss rate over conventional cloning for applications with specific delay and loss requirements.

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1. Introduction

Contemporary Internet traffic tends to be bursty because of the increased prevalence of triple-play services (i.e., data, voice, and video) and web-based multimedia applications. OBS is ideally suited to such traffic and represents an easy evolution from optical circuit switching while providing much of the improved granularity associated with optical packet switching. However, contention is a major problem which prevents the deployment of OBS networks [1]. Burst assembly plays a major role in this as it determines the characteristics of OBS traffic, thus affecting burst loss probability and burst transmission delay [2]. For this reason this paper proposes an adaptive classified cloning scheme, which leverages the advantages of classified cloning while deploying adaptive aggregation, in order to provide superior loss rate and ETE delay for applications which require it.

2. Basic Cloning Scheme (BCS)

In BCS, one or more cloned bursts can be made from each original burst and sent simultaneously; if one or more of them reaches the destination, the original burst is considered to be successful. If more copies are made of a particular burst then it is less likely to be lost. However if more copies are made overall, more cloned traffic is added to the network, which then actually increases the overall probability of cloned bursts being lost because of the class isolation characteristic of BCS. Furthermore, optical links will on average be carrying twice the original load. A comparison between retransmission recovery and cloning showed that cloning avoids both the need for large buffers and the increased delay associated with the existing retransmission mechanism [3].

3. Adaptive Classified Cloning and Aggregation Scheme (ACCS)

The Adaptive Classified Cloning scheme introduced in this paper coexists with an adaptive aggregation technique, resulting in superior performance over classical cloning in terms of both delay and loss rate, thus enhancing overall network performance. The ACCS Ingress node in Figure 1 consists of two buffers; the primary buffer aggregates both best effort (BE) and high priority (HP) packets, while the secondary buffer accepts high priority IP packets only [1]. The aggregation parameters adopted by each ingress node depend on the loss rate incurred at the core nodes; a notification is sent to all edge nodes if the loss rate increases or decreases by a certain value Δ. When there is a high loss rate, shorter bursts are preferred while longer bursts are generated with low loss rates. As expected it can be shown that there is a low loss rate when the network is lightly loaded, so that longer bursts can be generated and still yield acceptable performance. However, generating longer bursts will increase the delay indefinitely thus the delay is limited by a hybrid aggregation technique with a maximum aggregation delay of 40 ms. The ingress node applies admission control by dropping best effort packets if the incoming load exceeds the ingress node's allocated bandwidth when the offered load is high. For the purpose of demonstrating the ACCS concept, the bandwidth available for each ingress node is calculated using the following simple load balancing equation:

$$BE_i = \sum_{j=1}^{n} \mathrm{Utilize}(\mathrm{E_i}, \mathrm{E_j}, \mathrm{L}) / \sum_{j=1}^{n} \sum_{k=1}^{n} \mathrm{Utilize}(\mathrm{E_j}, \mathrm{E_k}, \mathrm{L})$$

In this equation, n = total number of edge nodes, E_i = ingress node number i, utilize(E_i, E_j, L) = 1 if the path from E_i to E_j traverses link L, otherwise it is 0, BE_i = bandwidth available to ingress node i over link L.

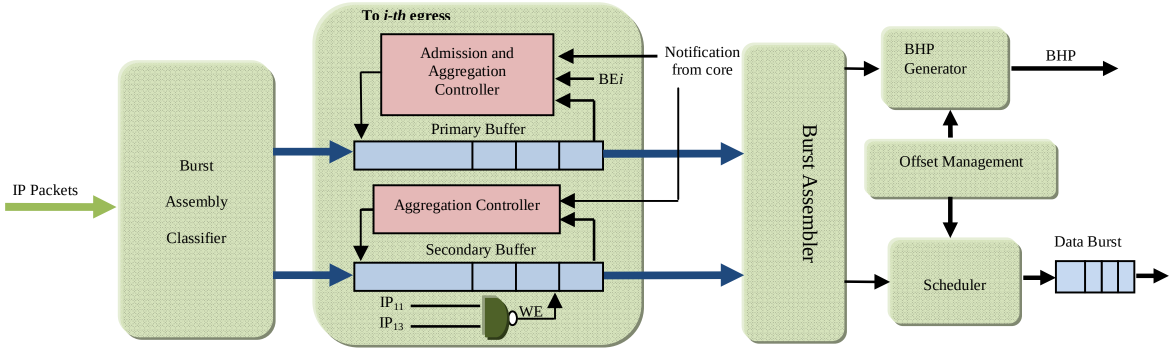

Figure 1. ACCS ingress node

Dijkstra’s shortest-path algorithm is used to determine the shortest path for sending bursts to their destination. Once the BE_i values have been calculated for all the links forming the path, the lowest value is taken as the load that can be transmitted. Only packets for delay and/or loss sensitive applications will be placed in the secondary buffer. Core nodes send notifications to all edge nodes if their link loss rate exceeds the upper loss threshold value (LTU) or is lower than the lower loss threshold value (LTL), as shown in Figure 2.

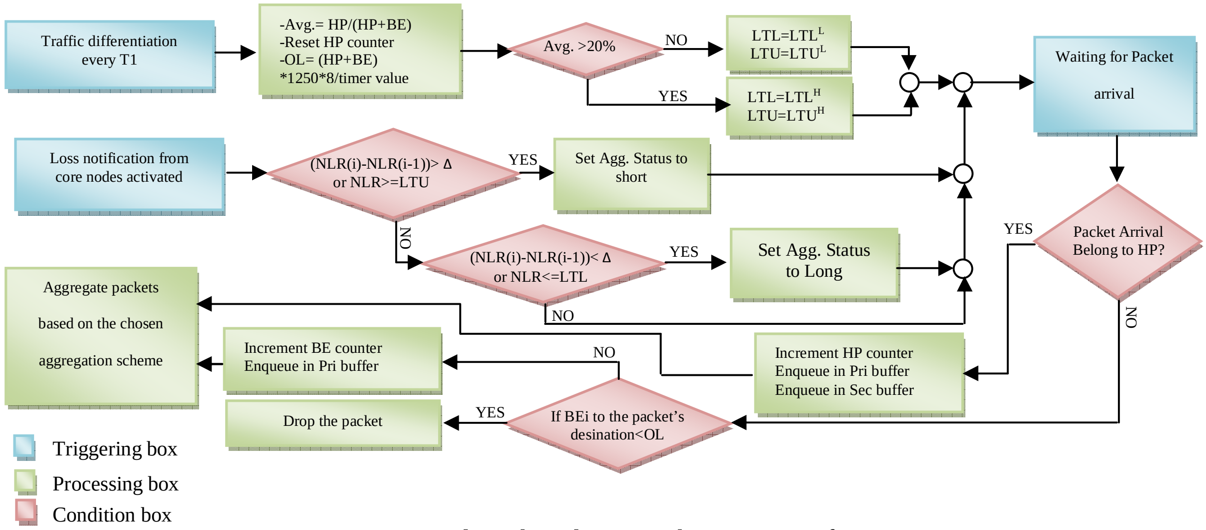

Figure 2. Flow chart depicting the operation of ACCS

The length of the generated bursts will depend on the NLR (Network Loss Rate) value, motivated by the reasonable observation that with a higher percentage of higher priority (HP) traffic, the loss rate will be higher even when applying ACCS. Thus the upper and lower loss threshold values will be decided based on the percentage of higher priority traffic; the upper/lower loss threshold value will be LTU^L/LTL^L if the percentage of higher priority traffic is less than 20%, while it is LTU^H/LTL^H otherwise.

4. Results and Analysis

This section compares the performance of ACCS, BCS and STD (standard OBS) using ns2 simulations. In the interests of brevity, the best loss rates for BCS and STD are compared with our proposed ACCS scheme. To illustrate our concept we have chosen $LTL^L = 0.02$, $LTU^L = 0.025$, $LTL^H = 0.03$, $LTU^H = 0.035$, T1 = 0.5 s and $\Delta = 0.01$. The loss rate values take into account bursts that are dropped by the ingress node because of the admission control strategy. Simulations took place on an 19-node NSF network with 10 Gbps link bandwidth [1], an OBS control plane supporting JET (Just Enough Time), while burst generation is described by a Poisson distribution. Both HP and BE traffic is distributed over the network equally; for instance if HP percentage is 30% then all the ingress nodes will receive 30% of HP and 70% of BE traffic. Figure 3 shows packets’ average ETE delay, comparing three BCS scenarios (1 ms, 20 ms, and 40 ms time- based aggregation) and ACCS. Our proposed scheme outperforms even the 1 ms BCS scenario (which has the best ETE delay performance of BCS scenarios) when the utilization exceeds 29%; the ETE delay is slightly greater (although easily low enough for practical deployment) when the utilization is under 29% because ACCS generates longer bursts under light loads. The ETE Delay with BCS increases not only with increasing aggregation time, but also because of the extra offset time required to provide the necessary isolation between HP and BE traffic. To provide class isolation in BCS, the offset time is set to five times the average generated burst length. As this increases, the offset time increases also, which increases the ETE delay. However, our scheme outperforms BCS in terms of loss rate. It is also important to show how much additional traffic will be incurred due to the utilization of BCS and ACCS for different HP percentage values (when HP is 10% and 30%). Figure 4 compares the additional traffic added for the different schemes compared to the standard OBS network utilization in order to observe the exact increase in the network traffic. Our scheme adds less traffic to the network than BCS; 90% and 70% less when the HP percentage is 10% and 30% respectively, BCS double the whole traffic with no considerable loss reduction as shown in Figure 5. However, the network utilization shown in Figures 3,4, and 5 represent the original traffic utilization without cloning in order to provide a fair comparison. For instance, in Figure 5 when the network utilization is 40% then this means that the loss rate of ACCS is 3.8% when HP is 10%, thus the overall network load is approximately 44%.

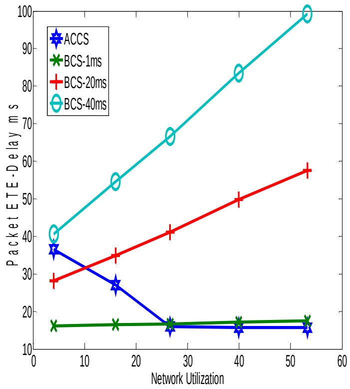

Figure 3. Packet ETE delay comparison

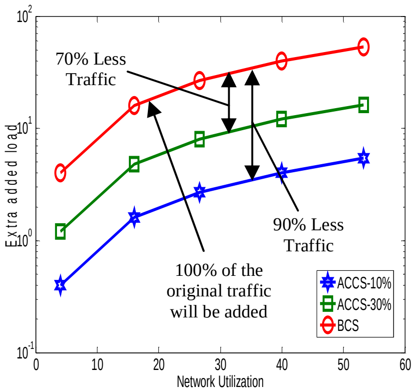

Figure 4. Extra incurred Load

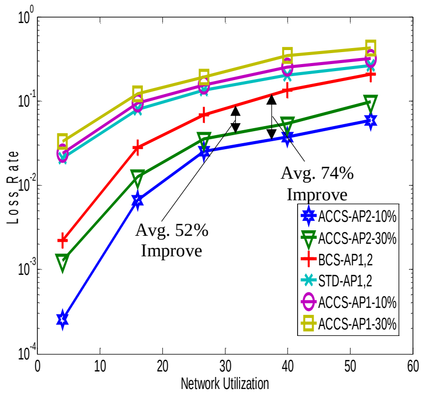

Figure 5. Loss rate comparison of different schemes

Figure 5 shows the loss rate for AP2 (higher priority packets) and AP1 (best effort packets) when applying STD (standard OBS), BCS and ACCS. Because it is expected that applications with special requirements will be used increasingly in the future, we have assumed that HP packets constitute 30% of the total traffic, in addition to the 10% scenario. Figure 5 shows that ACCS outperforms BCS, especially at high network utilizations, for both 10% and 30% HP traffic. However ACCS with an HP ratio of 10% performs better than with 30%, as the contention probability of HP packets increases. Figure 5 shows that BCS improves upon the loss rate of STD, but converges with STD as network utilization increases, while ACCS minimizes the loss rate, even at higher utilizations. The only disadvantage of ACCS is the increased loss of BE packets, although BE applications don't have loss rate constraints.

5. Conclusion

This paper presented an adaptive classified cloning scheme which supports real time applications that have delay and loss requirements. ACCS benefits from an adaptive aggregation technique that changes its parameters depending on the network loss rate, in addition to admission control which is implemented within each ingress node. Simulation results show the superiority of our proposed scheme over BCS and STD in term of packet ETE delay and loss rate; an average of 74.5% and 52% loss reduction is obtained when compared with BCS, when there is 10% and 30% HP traffic respectively, while minimizing packet ETE delay.

6. References

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