Threshold-Based Differentiated Intermediate-Node Initiated (TDINI) Signaling for Optical Burst-Switched Networks

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Abstract: We introduce a new technique for providing service differentiation based on burst lengths using intermediate-node initiated signaling in OBS. This technique provides packet-loss probability close to TAW and average end-to-end delay close to JET.

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1 Introduction

Recent increase in the bursty broadband traffic on the internet has paved way for the fast evolving Optical Burst Switching (OBS). In OBS, bursts of data, composed of several packets, are switched through the bufferless all-optical WDM networks [1]. Packets arriving at the edge nodes are first accumulated into bursts, which are then transported through the network based on several channel reservation schemes. Two well-known channel reservation schemes are Tell-and-Wait (TAW) and Just-Enough-Time (JET).

TAW is a two-way reservation scheme, in which a burst header packet (BHP) is sent ahead of the burst, to gather information on channel availability at every node along the path. This information is then used by a channel assignment algorithm at the destination node to reserve the earliest available channel spanning all the intermediate nodes along the path. A *reply* packet is sent by the destination node in the reverse direction, which reserves the channel at each intermediate node, for appropriate time interval (see Fig. 1(a)). If at some node, the required channel is not available, then a *fail* packet is sent back to the destination asking it to release the previously reserved resources. A successful arrival of the reply packet at the source node triggers the transmission of the burst at the scheduled time.

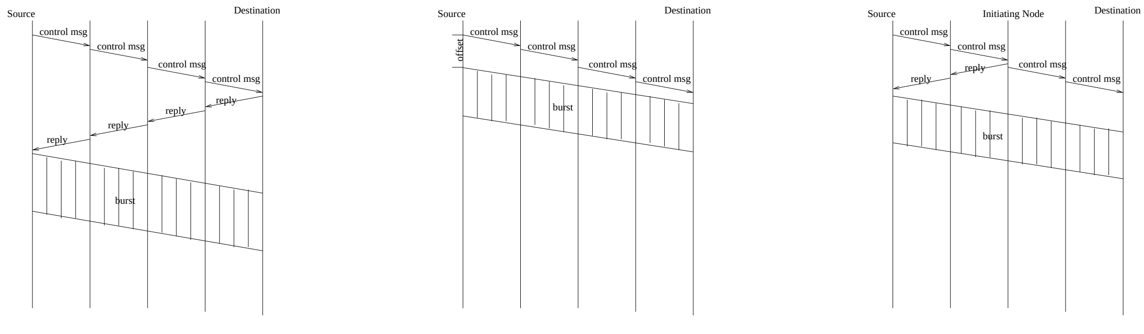

Fig. 1. (a) Tell-And-Wait (TAW) (b) Just-Enough-Time (JET) (c) Intermediate-Node-Initiated (INI).

Unlike TAW, JET is a one-way reservation scheme, in which the burst is sent shortly after the BHP is transmitted into the core. After transmitting the BHP, the source waits for a small offset time, T, before sending the burst. The BHP is processed at each intermediate node, and the desired channel, if available, is reserved (see Fig. 1(b)). A successful reservation at every intermediate node results in a successful transmission of the burst. A failure in reservation at any intermediate node will result in the burst being dropped.

The two-way based TAW reservation scheme guarantees relatively lesser burst-loss probability when compared to the one-way based JET reservation scheme, since the average end-to-end delay experienced by each burst is high due to the round-trip setup time. The low end-to-end delay makes JET more suitable for loss-sensitive traffic while low burst-loss probability makes TAW more suitable for delay-sensitive traffic. A hybrid reservation scheme, known as intermediate-node initiated (INI) signaling, which combines the best of

JET and TAW was recently introduced by Karanam et al. [2]. In INI signaling, an intermediate node (IN) along the path from source to destination initiates the reservation scheme. The channel reservation from source node to the IN is reserved based on TAW, while the channel reservation from IN to the destination node is reserved based on JET (see Fig. 1(c)). The burst-loss probability and the average end-to-end delay of INI lies in between JET and TAW.

2 Threshold-Based Differentiated Intermediate-Node Initiated Signaling

We introduce a threshold-based differentiated intermediate-node initiated (TDINI) signaling, a variant of the INI signaling, in which the IN is determined based on the burst length. In TDINI scheme, for every burst that is to be transmitted between a given source and a destination pair, we choose one of the nodes on the path, from source to destination, to be the IN based on the following function:

$$f = \lfloor (l/l_{\max})(h+1) + 0.5 \rfloor$$

where l is the length of the burst to be transmitted, $l_{\max}$ is the maximum burst length and h is the number of hops from the source to the destination. The f^{th} node from the source is chosen to be the IN.

In the TDINI scheme, the BHP that is sent from the source collects the channel availability information at every node along its path until it reaches IN. At IN, a channel assignment algorithm is used to determine the time intervals for which each channel between the source and the IN needs to be reserved. IN sends a *reply* packet to source, which reserves the channels along the path from IN to source for appropriate time intervals. If, in the case a channel is busy, a *fail* packet is sent to the IN asking it to release the already reserved resources. If the *reply* packet reaches the source successfully, then the source transmits the burst at the scheduled time. In the mean time, the BHP traveling from IN to the destination reserves the channel along the path from IN to destination similar to JET scheme.

While the INI scheme in [2] measures burst-loss probability, our scheme measures packet-loss probability. The primary reason behind measuring packet-loss instead of burst-loss is that the burst-loss does not reflect the accurate performance of the scheme. For example, if 10% of the bursts constitute 90% of the total packets being transmitted, it is important that these 10% of the bursts (relatively larger bursts) arrive at their destinations safely. That is, we would be well off losing the remaining 90% of bursts (relatively shorter bursts), which constitute only 10% of the total packets than losing relatively larger bursts. It is important to understand that low burst-loss probability does not necessarily translate into low packet-loss probability. While a network can have low burst-loss probability, at the same time it could have a high-packet loss probability if a small number of relatively larger bursts were lost.

Ideally, we want larger bursts to reach the destination safely to reduce the packet-loss probability. Our idea of using burst-lengths to determine the IN that reduces the probability of dropping a lengthy burst, which in turn guarantees lower packet-loss probability. For longer bursts, the IN will be closer to the destination node, which means that a greater part of the path will be acknowledged, thereby guaranteeing a higher success rate. For smaller bursts, the IN will be closer to the source node, which means that greater part of the path will be un-acknowledged, thereby having a high burst-loss probability. But since smaller bursts constitute less number of packets compare to the total number of packets, there should not be any paramount concern about losing smaller bursts.

3 Simulation Results

We simulated the performance of the TDINI scheme on the 14-node NSFNET (Fig. 2). Burst arrivals are implemented using Poisson distribution and the length of the bursts are exponentially distributed with mean burst length of 100 ms. Packet length was set to 1250 bytes and the transmission rate was to set to 10 Gb/s. Switching re-configuration time is 10μs. Nodes do not support wavelength conversion or buffering. Retransmission of lost bursts is not considered.

Fig. 3(a) and (b) depict load versus packet-loss probability and average end-to-end delay, respectively. We compared the performance of TDINI with that of JET and TAW. We observe that the packet-loss probability of TDINI is less that of JET. The packet-loss probability is closer to that of TAW than that of JET. We also noticed that TDINI experiences lesser average end-to-end delay when compared to TAW. The average

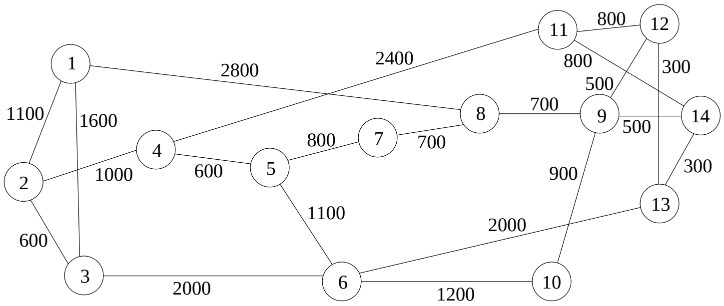

Fig. 2. 14-Node NSFNET.

end-to-end delay for TDINI is closer to JET, which makes TDINI close to best in both packet-loss probability and average end-to-end delay. In other words, TDINI provides close to TAW's packet-loss probability and JET's average end-to-end delay.

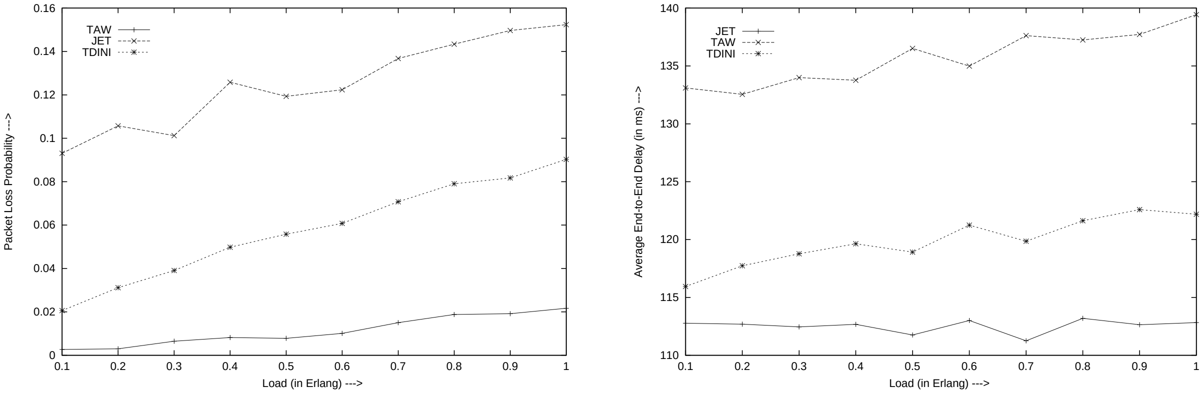

Fig. 3. (a) Packet loss probability versus load and (b) Average end-to-end delay versus load.

4 Conclusion

In INI, dropping 10 shorter bursts is the same as that of dropping 10 longer bursts when it comes to computation of burst-loss probability. But, when it comes to packet-loss probability, it is desirable that shorter bursts are dropped rather than dropping longer bursts, as longer bursts comprises more packets. Our technique of determining IN, based on burst-lengths, results in more successful transmission of relatively longer bursts.

We introduced an alternate intermediate-node initiated reservation scheme, known as the threshold-based differentiated intermediate-node initiated scheme. Our scheme provides close to TAW's packet-loss probability and close to JET's average end-to-end delay, thereby capturing the advantages of both TAW and JET.

References

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