End-to-End QoS Provisioning in Hurricane Communication Using Packetized Optical Burst Switching Network

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Abstract Hurricanes are the most damaging natural disasters in the United States. They come with oppressive and unimagined natural conditions, can cost unexpected severely damage to city property and infrastructure, and can even put human beings at risk. Communication is extremely important in the hurricane evacuation and emergency situation to connect the command centers, hospitals, and emergency relief authorities to provide emergency communication and monitoring. Most applications for the hurricane emergency are delay sensitive and require sophisticated latency control.

1. Introduction

Hurricanes not only cause damages to the transportation and communication but also expose the widespread rural regions to the threat of diseases. An efficient telecommunication network would be very critical in handling the emergency situations by providing the infrastructure for communication and monitoring. In order to provide end-to-end delay guarantee to such applications, an optimal resource allocation scheme is required to utilize the limited bandwidth more efficiently. However, there is lack of method to assign the minimum amount of bandwidth to serve the incoming flow while guaranteeing its delay requirement. In OBS the well-known fair queueing scheduler Stratified Round Robin [1] has been designed to provide a bounded delay with a simple hardware implementation. The drawback of SRR is that it does not provide arbitrary end-to-end QoS guarantee when assigning weights. We stress that the end-to-end delay is a significant performance measure in the service delivery system.

2. Methodology and Results

In this paper, we propose a Packetized Optical Burst Switching Network by extending virtual burst assembly to provide bandwidth to individual flows while flows share the optical bursts in the core network. In the scheduler's point of view, in order to serve the incoming traffic flows with some required service guarantees, the amount of resources that is assigned to the flow needs to be predetermined.

Under the network calculus[2] framework, for a system S with input and output functions R and R^*, a service curve $S(t)$ is possible, if $R^*(t) \geq R(t) \otimes S(t)$. The virtual delay in a work conserving fashion scheduler such as GPS, SRR, FIFO schedulers is defined as the time needed to handle the backlog traffic in the. The backlog at time t is defined as $B(t) = R(t) - R^*(t)$, thus, the delay is defined as:

$$B\left(t, d(t)\right) = 0$$

$$d(t) = \inf_{\tau \geq 0} \{R(t) \leq R^*(t+\tau)\} \quad (1)$$

Applying the leaky bucket constraint to the input such as the arrival traffic is regulated by the arrival curve $A(t) = \min\{pt, qt+b\}$, the bandwidth allocation of a certain delay requirement can be predicted by:

$$r_{al} = \begin{cases} \dfrac{pb}{(d_{re} - T_{tol})(p-q)+b}, T_{tol} - \dfrac{b}{p-q} \le d_{re} \le T_{tol} + \dfrac{b}{q} \\ q, d_{re} \ge T_{tol} + \dfrac{b}{q} \end{cases} \quad (2)$$

In Fig. 1, the results show that the delay requirement is the upper bound for the delay of each packet. This means the proposed method can provide an end-to-end delay guarantee. As shown in Fig. 2, a tighter time window requires more bandwidth compare to those with wider time window for a fixed delay.

3. Conclusions

We proposed a novel bandwidth allocation algorithm to provide end-to-end QoS guarantee in Packetized OBS networks. Bandwidth assigned to each flow is based on our derived mathematical model on the end-to-end delay requirement. With this optimization, resource allocation in OBS networks can be performed dynamically. The minimum amount of resource assigned to each flow (application) is based on its delay requirement to provide the end-to-end delay guarantee.

4. Acknowledgment

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5. References

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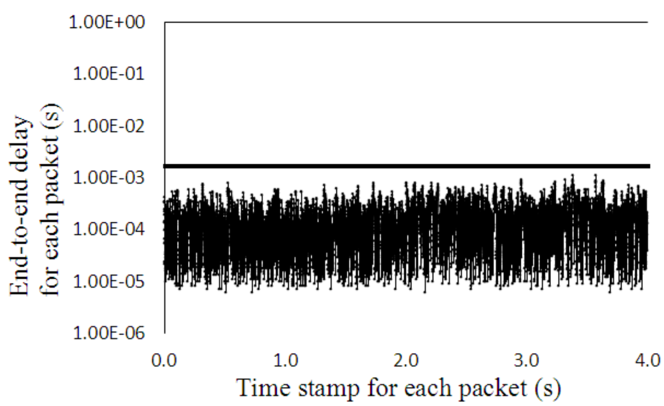

Fig. 1. Delay obtained from simulation compare to the delay requirement

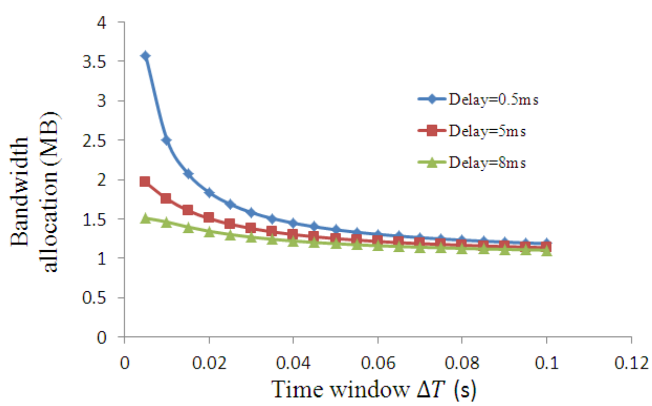

Fig. 2. Delay obtained from simulation with different bandwidth allocation