CWT: An Efficient Queue Urgency Metric with Application to High-Speed Packet Switching

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***Abstract*— Determining queue urgency (or weight) is a fundamental challenge, particularly in the context of high-speed packet switching. Weighting schemes have significant impact on the decisions made by arbitration and/or scheduling mechanism, thus directly shaping the overall performance of the system. Various weight functions, including iterative longest-queue-first (iLQF) and iterative oldest-cell-first (iOCF) have been presented in the literature. However, existing schemes suffer from limited performance in the presence of non-ideal traffic patterns. In this paper, we introduce the cumulative waiting-time (CWT) queue-weighting scheme, which is a pragmatic mechanism for dynamically determining the queue weight based on its aggregated cells waiting time.**

Keywords-Packet Switching, Queueing Analysis, High-Speed Switching.

I. Introduction

HIGHLY scalable and efficient packet scheduling algorithms have been the focus of many recent studies both in academia and industry. A predominant component comprising such algorithms is the manner by which queue urgencies are reflected on by the arbitration mechanisms that govern the flow of packets through a switch or router. The majority of the switch fabric architectures targeting high-capacity platforms employ virtual output queueing (VOQ), which is a mechanism whereby packets are queued at the input ports. The queue weight (or urgency) in a given multi-queue configuration has a primary goal of ensuring fairness between the queues in accordance with predefined criteria.

II. Queue Priority Mechanism

There are several factors according to which queue weights can be established. One obvious parameter is queue occupancy, whereby a queue with larger occupancy of packets would be represented by a larger weight. This rationale lies behind scheduling algorithms such as iLQF. However, despite the stability attributed to LQF-base schemes, algorithms that merely consider queue size have been shown to cause queue "starvation", which occurs when packets in queues with low traffic loads are unduly delayed. An alternative to LQF is OCF, whereby the age of the head-on-line (HoL) cell is considered. Although such an approach avoids starvation, it may yield great disparity between queues as it only observes the HoL cell.

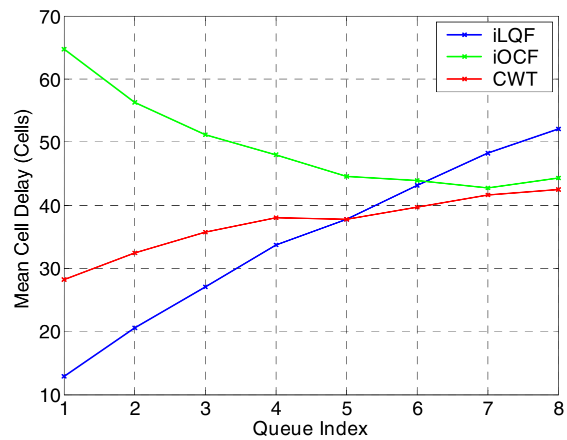

Fig. 1: Performance of CWT compared to iLQF and iOCF.

Since the latency through a queueing system is a fundamental and common performance metric, we propose to adopt the cumulative waiting (CWT) time as a cost function according to which queue weights are to be generated. We define the CWT at time n as

$$CWT_i(n) = \sum_{j=1}^{q_i(n)} \tau_i^j(n),$$

where i is the queue index; $q_i(n)$ and $\tau_i^j(n)$ denote the queue occupancy and amount of time that packet j has been waiting in queue i (at time n), respectively. Observably, the queue occupancy changes with time thus influencing the cumulative waiting time. It becomes apparent that CWT reduces the mean latency as it inherently integrates information regarding the current delay in the system experienced by all cells.

III. Simulation Results

Figure 1 illustrates the mean latency experienced by cells when CWT is employed compared to iLQF and iOCF. An 8-port switch is assumed whereby switching interval lengths are 5 cells. Multiple packet switching is considered a pragmatic approach for next-generation networks. The traffic is Bernoulli i.i.d. with non-uniform destination distribution which obeys the Zipf distribution. It is clear that the CWT offers more balanced performance across the queues.