"Queue length asymptotics under heavy-tailed traffic: Why CSMA is more robust than max-weight scheduling"

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We consider a simple queuing network consisting of two conflicting links, served by one server. One of the links receives bursty (heavy-tailed) traffic, and the other receives light-tailed traffic. We first show that under maximum weight scheduling, the light-tailed traffic experiences heavy-tailed delays, for any non-zero arrival rates to the two links. Indeed, we derive an exact asymptotic characterization of the steady state queue occupancy at the link receiving light-tailed traffic, under the class of throughput optimal max-weight-alpha policies. We show that the tail of the light queue distribution is at least as heavy as a power-law curve, whose tail coefficient we obtain explicitly. Motivated by the above negative result regarding the max-weight-alpha policy, we analyze a log-max-weight (LMW) scheduling policy. We show that the LMW policy guarantees light-tailed queue distribution at the light-tailed link, while still being throughput optimal.

Finally, we study a scenario where the two links access the server using an adaptive, Jiang-Walrand type CSMA mechanism, and demonstrate the following threshold phenomenon. When the arrival rate of the light-tailed traffic is less than a particular threshold value, the light-tailed traffic experiences a light-tailed queue backlog at steady state, whereas for arrival rates above the same threshold, the light-tailed traffic experiences a heavy-tailed queue backlog. Comparing these results, we conclude that adaptive CSMA is potentially more robust to bursty traffic, compared to max-weight scheduling.