Flow-level performance of channel-aware scheduling algorithms in wireless data networks

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Abstract

Channel-aware scheduling strategies, such as the Proportional Fair algorithm for the CDMA 1xEV-DO system, provide an effective mechanism for improving throughput performance in wireless data networks by exploiting channel fluctuations. The performance of channel-aware scheduling algorithms has mostly been explored at the packet level for a static user population, sometimes including packet-scale dynamics, but often assuming infinite backlogs.

The assumption of a static user population is a reasonable modeling convention because scheduling algorithms tend to operate on a much finer time scale than the flow-level dynamics. However, when examining throughput performance, and comparing the throughput allocation among elastic traffic streams under various strategies, it is not satisfactory to assume that the user population is independent of the throughput characteristics and the parameter settings of the scheduling algorithm. In order to capture the interdependence between the scheduling algorithm and the user population, we move away from a static scenario with a fixed ensemble of persistent users, and consider a dynamic setting where elastic traffic flows come and go over time as governed by the arrival and completion of random service demands.

We show that in certain cases the flow-level performance may be evaluated by means of a multi-class Processor-Sharing model where

the total service rate varies with the total number of flows. The latter model provides explicit formulas for the distribution of the number of active flows of the various classes, the mean response times, the blocking probabilities, and the flow throughput.

In the presence of varying channel conditions, it further turns out that it is not so much maximizing the instantaneous throughput in an absolute sense that determines stability, but rather taking maximum advantage of the relative channel variations. In particular, we show that greedy, myopic strategies that maximize throughput in a static scenario, may result in sub-optimal throughput performance for a dynamic user configuration and cause potential instability effects.