QUEUEING DYNAMICS AND MAXIMAL THROUGHPUT SCHEDULING IN SWITCHED PROCESSING SYSTEMS

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Abstract

We study a processing system comprised of parallel queues, whose individual service rates are specified by a global service mode (configuration). The issue is how to switch the system between various possible service modes, so as to maximize its throughput and maintain stability under the most workload-intensive input traffic traces. Stability preserves the job inflow-outflow balance at each queue on the traffic traces.

Two key families of service policies are shown to maximize throughput, under the mild condition that traffic traces have long-term average workload rates. In the first family of *cone policies*, the service mode is chosen based on the system backlog state belonging to a corresponding cone. Two distinct policy classes of that nature are investigated, MaxProduct and FastEmpty. In the second family of *batch policies* (BatchAdapt), jobs are collectively scheduled over adaptively chosen horizons, according to an asymptotically optimal, robust schedule. The issues of *non-preemptive* job processing and non-negligible *switching times* between service modes are considered. The analysis is extended to cover *feed-forward networks* of such processing systems/nodes.

The approach taken unifies and generalizes prior studies, by developing a general *trace-based modeling* framework for addressing the queueing stability problem. It is based on *direct structural* analysis of the system state evolution trajectories and treats the queueing structure as a *deterministic* dynamical system. It does not require any probabilistic super-structure, which is typically used in previous approaches. Probability can be superposed later to address finer performance questions (e.g. delay). The throughput maximization problem is seen to be primarily of structural nature. The developed methodology seems to have broader applicability to other queueing systems.

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