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Approximate Dynamic Programming for Dynamic Stochastic Resource Allocation

Dynamic allocation of multiple renewable resources to different types of jobs arriving randomly over time is a class of scheduling problems that arise in many fields such as logistics, transportation, and healthcare. Due to stochasticity inherent in these problems, they are generally termed as Dynamic Stochastic Resource Allocation Problems (DSRAPs). In DSRAPs, the challenge faced by the decision-maker in each time-period is how to schedule jobs waiting in queue or which jobs to service for the current period so as to optimize a certain performance metric over a finite/infinite horizon, given resource constraints. These problems are naturally modeled as a Markov Decision Process (MDP), a mathematical framework used to model systems that evolve stochastically over time.

While different classes of DSRAPs have been studied over decades, there is no mathematical technique to solve realistic instances of these problems mainly due to their combinatorial nature. As such, researchers resort to approximation techniques such as Approximate Dynamic Programming (ADP) to tackle these problems, yet they typically ignore certain aspects of dynamic resource allocation because of imposing assumptions such as single resource and identical resource consumption values per job.

In this research, we employ a mathematical-programming-based ADP technique called Lagrangian-relaxation for dealing with a large class of the DSRAPs. Specifically, we develop abstract problem description, MDP models of these problems, and approximately solve them using the Lagrangian approach. The results of our extensive computational experiments reveal that the Lagrangian approach significantly outperforms easy-to-use heuristic decision rules.