

DISSERTATION DEFENSE

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Deterministic and Stochastic Models for Practical Scheduling Problems

This dissertation analyzes three scheduling problems motivated by real life situations. In many manufacturing and service industries, scheduling is an important decision-making process since scheduling problems are often computationally challenging to solve, and even modeling a scheduling problem can be difficult.

Chapter 2 considers single-facility non-preemptive scheduling problems with long time horizon having jobs with time windows (i.e., release times and due dates). I combine constraint programming (CP) and mixed integer linear programming (MILP) using a hybrid method: logic-based Benders decomposition. I first divide the long time horizon into segments to make the problem tractable. I consider two versions of the single-facility scheduling problem: *segmented* and *unsegmented*. In the *segmented* problem, each job must be completed within one time segment. In the *unsegmented* problem, jobs can overlap two or more segments. I analyze different objective functions, and introduce relevant Benders cuts. I find that for the segmented problem, logic-based Benders decomposition is always superior and should be used from the start. For the unsegmented problem, I further find that logic-based Benders decomposition is not necessarily the fastest method, but clearly the most robust. Hence, I suggest a strategy of applying CP first, and if it fails to solve the problem within a few seconds, switching to logic-based Benders decomposition.

Chapter 3 addresses the problem of staffing of a service center with cross-trained agents, heterogeneous customers, and quality guarantees, inspired by a large IT SDO. Agents are either high or low skilled that serve customer requests that are also heterogeneous - with respect to both the complexity and their priority: (i) Higher priority customer requests preempt lower priority customer requests in the queue; and (ii) Less skilled agents can only service low complexity requests, while highly skilled agents can service all types of requests. I capture this service center's operations using a multi-server queue under a preemptive-resume priority service discipline, and model it as a Markov chain. I apply approximation and bounding techniques to evaluate different control policies. I consider the class of threshold-based priority policies that prioritize the requests according to the number of each class of requests in the system. I show that four different types of customer requests and up to six different skilled agents can be

successfully analyzed by our method: our method is accurate and fast when compared to simulation. I also provide managerial insights about the capacity provisioning problem at the service center, such as, how to set thresholds, how to negotiate costs with customers, what mix of agents to hire. I demonstrate a simple but effective request-assignment policy, and find that the threshold-based policy might decrease the total cost without any changes in the service center.

In Chapter 4, I analyze a project scheduling problem with disruptions, cross-trained agents, heterogeneous projects and quality guarantees where the durations of a project's tasks and the arrivals of the projects are uncertain. This problem is inspired by a real problem at a large, global SDO's service center. Analysis of real data shows that considering delays in the release times and processing times are sufficient to capture the uncertainty. The goal is to find a robust and effective assignment and schedule of the tasks for each agent. I develop a robust scheduling model based on logic-based Benders decomposition, in which uncertainty is illustrated by an uncertainty set which might not include the least likely outcomes. I prove that the objective function is convex in terms of these delays when the uncertainty set is a polyhedron. Interestingly, the decomposition is simplified by using the convexity analysis.