DISSERTATION PROPOSAL

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"Theoretical and Computational Methods for Network Design and Routing"

Monday, November 18, 2019
1:30 pm
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In this thesis, we consider three classes of supply chain optimization problems.

In the first chapter, we consider the deterministic inventory routing problem over a discrete finite time horizon. Given clients on a metric with daily demands that must be delivered from a depot, and holding costs over the planning horizon, an optimal solution selects a set of daily tours through a subset of clients to deliver all demands before they are due and minimizes the total holding and tour routing costs over the horizon. In the capacitated case, a limited number of vehicles are available, where each vehicle makes at most one trip per day. Each trip from the depot is allowed to carry a limited amount of supply to deliver. We develop fast heuristics for both cases by solving a family of prize-collecting Steiner tree instances.

In the second chapter, we study a fundamental class of hub network design problems that arise in the design of logistic networks that are configured in two layers. An upper layer is configured by establishing hubs at selected nodes at considerable cost so that the routes between hubs can be operated cheaply. The remaining edges in the network are operated at the regular cost. The resulting problem is to determine the set of nodes to open hubs so that the edges induced between them have cheaper costs and the goal is to find a network of minimum total edge plus hub opening costs. We develop approximation algorithms for several hub network design problems such as spanning trees, Steiner trees, generalized Steiner forests and further one-connected generalizations modeled as proper function cut covers.

In the third chapter, we study future logistics networks involving the collaboration between traditional trucks and modern drones. The drone can pick up packages from the truck and deliver them by air while the truck is serving other customers. The operational challenge combines the allocation of delivery locations to either the truck or the drone, and the coordinated routing of the truck and the drone. In this chapter, we consider the scenario of a single truck and one drone termed as the traveling salesman problem with a drone (TSP-D). The objective is to minimize the completion time (or makespan). We study the computational complexity of a restricted subproblem and then propose a compact constraint programming formulation for the entire problem.

In the fourth chapter, we propose to develop a branch-and-price-and-cut integer programming approach for TSP-D. In addition to standard truck routing variables, our model contains composite variables that represent a set of deliveries that are performed by the truck and the drone in parallel. We show preliminary numerical experiments which suggest the strength of the LP relaxation and propose future work for implementing an exact algorithm for TSP-D.

Finally, we discuss several ideas to extend TSP-D into the setting of multiple trucks and drones based on the results of the previous two chapters.