D I S S E R T A T I O N   P R O P O S A L

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Tuesday, December 13, 2016
2:00 pm
384 Posner Hall

Algorithms for Ranking, Routing, and Packing

In this thesis, we develop new algorithms for three categories of problems — ranking, routing, and packing. In the first category, we classify the complexity of new problems for mutually ranking participants and tasks when a ranking of the participants "nearby" the optimal is given. In the second category, we give approximation algorithms for inventory routing on line metrics and introduce two variants that we plan to study. In the third category, we propose to improve the best-known approximation for a classical packing problem, Multicommodity Flow on Trees.

For the first category, we introduce and resolve the computational complexity of a set of new problems that require ranking participants and tasks by their strengths and difficulties, given the set of tasks that each participant completed successfully. The ideal ranking ensures that stronger participants succeed at all tasks that weaker participants performed successfully and easier tasks are performed successfully by all the participants who succeeded at harder tasks. The new variants we introduce and study account for recurring participants, by constraining the outcome of the current ranking to be close to an initial given ranking of the participants arrived from past contests. We provide a comprehensive study of the complexity of all the variants.

The second category involves three sets of routing problems. The first among them is the Inventory Routing Problem (IRP). Given clients on a metric, each with daily demands that must be delivered from a depot, and holding costs over the planning horizon, a solution selects a set of daily tours from the depot through a subset of clients to deliver all demands before they are due. For Inventory Routing on line metrics, we give a 26-approximation algorithm that, in practice, performs much faster than the existing exact algorithm while obtaining near-optimal costs. The second set of routing problems we propose to study are variants of Inventory Routing with Facility Location, which allows multiple depot locations to be opened for service at an extra cost. We will investigate the approximability of Inventory Routing with Facility Location and its variants on lines, trees, and general metrics. We introduce a third variant of inventory routing problems that we call Deadline IRP. In this version, every client has a deadline within which it will run out if it starts at full capacity, and each visit to every client fills the client location to capacity. The goal is to determine an IRP solution so that no client ever runs out. We propose to improve a simple logarithmic approximation that is already known and examine the hardness of approximation. We will also consider generalizations when the deadlines depend on the time of visit to the clients.

In the third category, we propose to improve the current 4-approximation for Multicommodity Flow in Trees. The problem has as input a tree with integer capacities and unit demands (nontree edges between vertices of the tree) with profits. If a demand is picked, it loads each tree edge in the unique path of the tree connecting the endpoints the demand by one unit of flow. The objective is to find the maximum weight set of demands such that the total load on each tree edge does not exceed its capacity. While a 3-approximation is known in the special case when all capacities are at least two, for the case that all capacities are at most two, we provide a simple 3-approximation by gluing convex decompositions of star instances. We propose to obtain a 3-approximation overall by combining these ideas.