15.094 PROJECT: ROBUST AMBULANCE DEPLOYMENT

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Introduction

Emergency services, such as emergency medical service (EMS) and fire rescue, are a major concern of most regional and urban planners, who must make strategic decisions on the location of emergency services, and the number of vehicles to deploy at each location. Significant research attention has been directed towards these problems, and some models have been deployed in practice.

A few recent developments have made it fruitful to review existing models.

Motivation

In urban cities that are experiencing an aging population (such as Singapore and Japan), there is an increasing demand for swift pre-hospital ambulatory care in medical emergencies.

With improvements in geographic information systems that allows for precise tracking of emergency calls and ambulance locations, and changes in operational procedures that records each emergency call, there have been recent efforts to move towards data-driven approaches for the planning of facilities and resources.

Approach

In ambulance deployment, the bias towards anticipative rather than adaptive models derives from the nature of the problem: here and now we want to design a reliable EMS without knowing any realization of the emergency calls.

Therefore, we tackle the strategic problem of deciding how many ambulances to position at a given set of predetermined locations in a two-stage setting. Although the problem shares many common traits with inventory management, and electricity production, the nature of the demand is different, as it deals with individually rare events that are cumulatively significant.

Challenge

The discrete nature of both the demand (emergency calls), and the response (number of ambulances) requires the application of techniques from integer programming, to a framework (two-stage problems) that has been practically tractable only recently for models that are continuous in the demand (e.g. polyhedral uncertainty sets) and the response (e.g. linear decision rules).

Nonetheless, the introduction of cutting plane methods in RO, and the recent development of column-and-constraint generation methods, has inspired me to explore a robust integer formulation that can provide high quality solutions within tight time constraints, which I'll explore in greater detail through this project.