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Rapid transit network design considering risk aversion

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Abstract

Rapid transit network design is highly dependent on the future system usage. These spatially distributed systems are vulnerable to disruptions: during daily operations different incidents may occur. Despite the unpredictable nature of them, effective mitigation methods from an engineering perspective should be designed. In this paper, we present two new approaches to the rapid transit network design problem. The first one aims at minimizing the impacts of the worst scenario in the network operation. The second one takes into account different risk profiles and also minimizes the impacts of the worst scenario across all the risk profiles.

Keywords: network design, risk aversion, recoverable robustness, rapid transit.

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1 Introduction

Rapid Transit Network (RTN) design is highly dependent on the future system usage. Such networks are urban mass public transportation systems and operate in metropolitan areas and feature frequent train services and heavy passenger loads. When designing a new network, the infrastructure designer must account for the fact that passengers will use the new network if the trip generalized cost is lower than within the current options: when facing a new Rapid Transit Network Design (RTND) there is usually another transportation system already operating in the area where the RTN is to be built or extended. The RTND problem aims at maximizing the demand coverage by the new network subject to design and budget constraints, all while considering demand decisions when evaluating different alternatives.

Spatially distributed systems are vulnerable to disruptions: during daily operations different incidents may occur. Despite the unpredictable nature of them in terms of location, time, and magnitude, effective mitigation methods from an engineering perspective should be designed. Dealing with these uncertainties is a key ingredient for providing a resilient network for daily operations. The more the network is able to absorb these disruptive negative effects, the more resilient the network is. In order to find resilient network designs, different research techniques such as stochastic programming (two-stage) and robust optimization may be applied ([6]). However, these approaches have major drawbacks: first, stochastic programming requires extensive knowledge of the probability distribution of disturbances; and second, robust optimization requires an initial solution which has to be feasible for a large set of possible modifications of the original input (i.e., it might be far too conservative). Solutions may be recovered after data perturbation and the recovery of the system may not be as expensive as the introduction of robustness concepts. This concept is the recoverable robustness: it studies the robustness of the system accounting for limited recovery actions and number of disrupted scenarios. The solution of the problem does not need to be feasible for a whole set of admissible disturbances anymore, but it must be able to be recovered (with a limited cost) from a set of disrupted scenarios. This concept fits very well for RTND problems: in practice, the probability distribution of disruptions is not known, so stochastic programming cannot be applied. Recoverable robustness

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