ADDRESSING DEMAND UNCERTAINTY IN TWO-TIER CITY LOGISTICS SYSTEMS

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Extended abstract

Objectives and motivation

We introduced the tactical planning problem for City Logistics systems when demand uncertainty is explicitly considered, focusing on the general, and more complex, two-tier City Logistics setting. At the best of our knowledge, no previous contribution in the literature addresses uncertainty issues in tactical planning for City Logistics.

General description

Several concepts have been introduced and projects have been undertaken in recent years to reduce the negative impact of freight-vehicle movements on city-living conditions, particularly in terms of congestion/mobility and environmental impacts, while continuing to support its social and economic activities. The fundamental idea that underlies most initiatives is to consider shipments, firms, and vehicles (as well as the other stakeholders in a city’s transportation system) not individually but rather as components of an integrated logistics system. Such a view emphasizes the need for an optimized consolidation of loads of different shippers and carriers within the same vehicles and for the coordination of the resulting freight transportation activities within the city.

Similarly to any complex consolidation-based transportation system, City Logistics systems require planning at strategic, tactic, and operational levels [1, 4]. We focus on tactical planning because of its central role in the overall planning process and management of consolidation-based transportation systems to which a 2T-CL system belongs.

Tactical planning selects the services and schedules to run, assigns resources, and defines broad policies on how to route the freight and manage resources. The goal is to provide the means to satisfy demand and operate efficiently with respect to the economic and service-quality objectives of the system, given its overall constraints (layout, resources, operating policies, etc.). Tactical plans thus guide operations and provide the means to efficiently satisfy demand and attain the economic, service-quality, and city-impact objectives of the system.

They are also required to evaluate strategic scenarios and plans (e.g., resource acquisition, modifications to infrastructure, service expansion or contraction, and so on). Planning means a certain level of look-ahead capability and the inclusion of forecast events into today’s decision process. Various sources and types of uncertainty may be defined, from the variability in demand and travel and service times, to accidents and temporary modifications to infrastructure access.

In this work, [2] we focus on the uncertainty related to the variation in demand over the horizon of the tactical plan, from a season to a year, variation that is observed and has to be dealt with when the plan is applied day after day during actual operations. The challenge in introducing the explicit consideration of uncertainty into tactical planning for City Logistics therefore is not only building an appropriate mathematical formulation of the problem, but also understanding the impact on the management and performance. This paper is a first answer to this double challenge.

We thus gave a first formal description of the problem describing several possible strategies to adapt the plan to the observed demand, and experimentally evaluated and compared these strategies not only in terms of "costs", but also in terms of impact of transported freight in the city (e.g., number of vehicles and their utilization in terms of loading factors and empty movements) and insights into the management process.

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We proposed a two-stage stochastic-programming model, where the first stage selects the first-tier service network design and the
general workloads of the inter-tier transfer facilities, while the second stage determines the actual vehicle routing on the second tier as
well as some limited adjustments of the first-stage service design decisions.
Four different recourse strategies and formulations were proposed to adapt the plan to the observed demand.

Results and conclusions
These strategies were experimentally compared through an evaluation procedure that, based on Monte Carlo principles, aimed to
mimic the decision process of a priori planning, followed by the repetitive application of the adjusted plan for the periods of the planning
horizon.
The performances of the 2T-CL system under the adjustment strategies were contrasted through performance measures relative to
the costs of operating the system, including those of the additional vehicle capacity and movements required when the plan was not
providing sufficient transportation means, the utilization of the various types of vehicles, including the expected loading factors, the
intensity of the vehicle presence within the city, including the amount of empty movements, as well as the utilization of the inter-tier
satellite facilities.
The comparisons were discussed both based on the numerical figures obtained through simulation and from the point of view of
managerial insights into the implication for managing CL physical and human resources.
Given the instances used for the evaluation, the analysis emphasized the interest of flexibility in managing resources and operations
for the overall performance of the system, and discussed the associated trade-offs that must be reached for each particular application.

The results underlined the benefits of consolidation in terms of vehicle utilization (high) and presence in the city (low), as well as the
need to carefully design the layout of the system in terms of inter-fleet synchronization capabilities, which may affect quite directly the
sizes of the fleets required to service a given amount of demand.
Not surprisingly, the results also showed that optimizing the service for each period once the demand is known, applying, e.g., the
day-before planning model of [3], yields the lowest-cost operation with no additional vehicles required to perform direct customer
servicing.
This option is only feasible, however, when material and human resources can be mustered without advance notice and their
deployment can be modified every period at no additional cost.
This is rarely possible, however, particularly given the work rules of the personnel. Performing tactical planning then offers the
means to find the best trade-off between the many objectives and constraints of City Logistics efficient operations and the concerns
of management.
In fact, the experimental comparisons we performed showed that, even when demand variability and management constraints on
limited recourse flexibility are explicitly taken into account, our approach is still able to build good operating plans.

Keywords: city logistic; urban freight transportation; demand uncertainty; two stage stochastic programming

References
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