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Decision support system for real-time urban freight management

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Abstract

The urban network is a highly dynamic system. Thus, a modern and efficient fleet management in urban areas should account for dynamics of traffic conditions and variability in travel times, since they significantly affect the distribution of goods and the provision of services. For the proficient dynamic fleet management decisions it is proper instead of relying exclusively on the experience of a dispatcher, to base the freight management decisions on information provided by a professional *Decision Support System* (DSS), which facilitates the consideration of all the factors conditioning the addressed problem. This paper provides a proposal of such DSS for real-time freight management. Its design is based on integration of selected pickup and delivery vehicle routing model and dynamic traffic simulation models, which objective is to carefully emulate the evolving traffic conditions. The optimal dynamic routing and scheduling of a vehicle fleet is obtained due to dynamic modifications of the current routing and scheduling plan on the basis of the newly revealed information conditioning the addressed problem.

Keywords: Decission support system; real–time freight management; dynamic traffic simulation models; pickup and delivery vehicle routing problem with time windows; parallel tabu search

1. Introduction

The proficient dynamic fleet management decisions need to take into consideration all the factors conditioning the addressed problem. Hence, the customers' requests and service conditions (demands, time windows, etc.), operational conditions of employed fleet (vehicles' availability, status, positions,

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current occupancy of the carriage space, etc.) and the traffic conditions need to be reckoned with. This information can be provided in the real-time fashion and at affordable price by the ICT applications and tools such as: ATIS, GPS, GPRS or other.

The recent developments in ICT have accelerated the research regarding the dynamic routing and scheduling problems. However, although the static version of *the Pickup and Delivery Vehicle Routing Problem with Time Windows* (PDVRPTW) has been widely studied in the literature, little attention was paid to its dynamic case. In addition, in each publication there is taken into account different set of constraints and initial assumptions regarding definition of the dynamic problem.

For example, Yang et al. [1] assume that the vehicles move at constant speed and the distances between the clients are consistent with Euclidean metric. Thus, the only considered dynamic feature regards continuously arriving customers' requests. Mitrovic-Minic et al. [2] address the PDPTW emulating operations of a real life courier company in city area, where the information about the customers' requests is not known to the dispatcher in advance. Still, the freight cars move at constant speed while the arcs of the underlying road network are associated with values defining both the distance and the travel time. Fabri and Recht [3] undertook the task of modification of the model proposed by Caramia et al. [4] taking into account the M2M dynamic request dial-a-ride problem regarding transport of passengers by taxis and adapt it to goods transportation by freight vehicles. Equally as in the previous cases the dispatcher has no access to the information on the future requests calls. The underlying road network is represented as a graph of Euclidean distances in which some of the nodes correspond to the clients' locations. Consequently, the elementary problem consists in finding the shortest path between the nodes representing customers and the A* algorithm originally introduced by Hart et al. [5] was employed to do so. In contrast to the previous, Fleischmann et al. [6] consider travel times, which vary with the time of the day and according to a cyclically provided forecast, which is updated when random incidents occur. The travel times stand for the shortest paths, which are obtained in a calculation process integrated into the routes planning procedure. The algorithm employed for this purpose was originally proposed by Dijkstra. To model the time-dependent travel times there was used a piecewise constant representation in combination with a smoothing function, which objective is to avoid discontinuities. What is more, only part of the customers' requests is considered to be known in advance. Similarly, Gendreau et al. [7] take into consideration two dynamic factors: client's requests arrivals and travel times. Although, it is assumed that the trucks move at constant speed, the regarded time horizon is divided into five intervals, which correspond to the time of the day and are characterised by different traffic intensity. The dispatcher has no access to forecasts of the future.

As was shown by Barceló and Orozco [8] the sole consideration of average values of travel times may lead to significant deviations in city logistics problems since the temporality is an important factor. Thus, the approach proposed in this paper is based on assumption that the real-time information is available. Thereat, a dynamic traffic simulation model was used for both testing and data prevision purposes. It emulates the operation of an ATIS giving the current travel times estimates resulting from the influencing traffic conditions. At the same time it serves as vehicle tracking system providing current operational conditions of vehicles in the fleet. This function in the real life could be performed by ICT systems (e.g.: AVL and GPRS). As far as we are concerned, the combination of dynamic traffic simulation tools and a model for the PDVRPTW has not been addressed in the literature.

Inspired by Regan et al. [9,10] we provide a conceptual framework for the evaluation of real-time fleet management systems. Its scheme is presented on Fig. 1.

The list of essential input requirements of the proposed DSS includes the description of the underlying urban roads network in form of a graph. The costs of the arcs comprise the sum of the time-dependent time necessary to travel the street and the time required to execute the corresponding turning movement on the junction.