Real-Time Fleet Management and Rerouting in City Logistics

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ABSTRACT

The urban freight distribution is highly susceptible to unexpected events that often occur during delivery, such as delays at customer locations or due to traffic conditions. Such events may lead to inferior customer service, or higher costs, areas in which intelligent real-time fleet management may prove beneficial. In this paper, the authors present such a system that incorporates methods to estimate the expected travel time of a delivery vehicle, combining AVL-based real-time and historical data, with algorithms for efficient vehicle re-routings. The system continuously monitors the delivery process, detects possible delays in real-time, and adjusts the delivery schedule accordingly by suggesting effective re-routing strategies. The authors report results from testing the system via simulation and in a case study, and illustrate the extent of delivery performance improvements that may be achieved through such an approach.

Keywords: City Logistics, Intelligent Transportation Systems, Real-Time Fleet Management, Travel Time Prediction, Urban Freight Distribution

INTRODUCTION

Distribution is a major activity of supply chain operations and contributes significantly to total logistics costs (Ballou, 2004). Consequently, over the last five decades, both professionals and academics have devoted considerable efforts to improve and streamline key distribution processes. Considerable attention has been focused on city logistics environments, and in particular, on dynamic incident handling through real-time fleet management (Crainic, Gendreau, & Potvin, 2009; Awasthi, Chauhan, Parent, & Proth, 2011). In an urban environment, the use of an initial distribution plan, although necessary, is by no means sufficient to address unexpected events that may have adverse effects on the performance of delivery execution (Zeimpekis, Tatarakis, Giaglis, & Minis, 2007).

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Table 1 presents a typical classification of incidents and their effects on goods delivery.

Various systems have been developed for fleet monitoring and incident detection in urban environments (see Powell, 1990; Savelsbergh & Sol, 1997; Gendreau, Laporte, & Semet, 2001; Slater, 2002; Ichoua, 2003; Kim, Lewis, & White, 2005; Cheung, Choy, Li, Shi, & Tang, 2008). However, most of these systems typically focus on handling customer orders that arrive during the execution of the delivery plan and need to be assigned to vehicles en route (Gendreau & Potvin, 1998; Yan, Jaillet, & Mahmassani, 1999; Fleischmann, Gietz, & Grutzmann, 2004; Cheung et al., 2008).

This paper addresses a case of dynamic fleet management, in which the distribution plan needs to be adjusted in real-time to accommodate disturbances of the delivery environment (such as traffic congestion, adverse weather conditions, occupied unloading area at customer’s site, etc). The proposed system continuously monitors the execution of the initial plan, detects significant deviations per vehicle, solves the related rerouting problem of each vehicle (independently), and transmits the revised plan to the vehicle, all in real time. The mathematical model related to this problem resembles the so called Orienteering Problem (OP) (see Tsiligirides, 1984), a variation of the Traveling Salesman Problem (TSP).

The remainder of the paper is organized as follows. The next section presents research to date in the area of real-time fleet management systems, travel time prediction, and re-rerouting algorithms. The section following presents the requirements of the proposed system and its architecture. It also presents the travel time prediction methods, and the vehicle rerouting algorithm. The next section describes the results obtained by testing the system in a simulated environment, whereas the section after that presents the results obtained by a case study in a Greek 3PL company. Conclusions, future research directions, as well as limitations of the proposed system are discussed in the last section.

**BACKGROUND**

In this Section we first overview significant work in real-time fleet management systems. Subsequently, we survey work that is relevant to a) prediction methods for the time of arrival of a vehicle at a certain site, and b) vehicle rerouting techniques.

**Real-Time Fleet Management Systems**

The operation of an intelligent real-time fleet management system is shown in Figure 1. Complementary to the fleet monitoring process, an event management mechanism detects events that may affect significantly the execution of a vehicle’s plan, such as delays, deviations from the original route, or new orders that arrive dynamically. Once such a significant event is detected, the system may suggest alterations to the original plan. In this case, the updated delivery schedule is transmitted to the driver. This process continues till the return of the vehicle to the depot.
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