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Cooperative Traffic Control Management for City Logistic Routing

Felix Köster [a,*], Marlin W. Ulmer [a], Dirk C. Mattfeld [a]

[a] *Technische Universität Braunschweig, Mühlenpfordtstrasse 23 38106 Braunschweig, Germany*

Abstract

In city logistics, courier express and parcel services (CEP) deal with last mile deliveries in an urban environment. CEP route vehicles to deliver parcels to costumers distributed in the cities area. Customers expect fast and reliable services to reasonable prices. As a result, CEP have to plan and execute their routing efficiently. In a city logistic environment, CEP faces several challenges. Especially, travel times between customers are not deterministic but uncertain and differ during the day regarding traffic volumes and stochastic events like congestion. Further, city traffic flows are controlled by traffic control management (TM). TM decisions additionally impact travel times for CEP. This paper shows the impact of TM decisions to travel times and emphasizes the benefit of cooperational planning between CEP and TM.

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Keywords: City Logistic, Traffic Management, Vehicle Routing, Dynamic Vehicle Routing, Stochastic Travel Times, Time Dependent Travel Times

1. Introduction

Urbanization leads to an increased individual and freight traffic volume [3, 24]. Globalization results in a worldwide transportation of goods and is another factor for the increasing number of transports in cities [30]. This development is further reinforced by the continuous growth of e-commerce [25]. The online purchase of goods make the delivery process more complex as each customer gets a delivery to his home. As a results of these depicted trends, demand of transports in cities is constantly growing. These transports are generally known as last mile deliveries [13]. To fulfill these transports, courier, express and parcel services schedule vehicles in an urban environment. This is defined as city logistic [34]. CEP distribute products from manufactures to consumers, who expect fast and reliable service [6]. An efficient transportation planning in cities is challenging. CEP have to plan considering city logistic uncertainties. In particular, travel times are varying regarding traffic volume, following daytime pattern. At the same time travel times are changed by uncertain events like sudden congestion or accidents [7]. CEP must consider varying travel times in tour planning and, if necessary, adjust scheduled tours accordingly [26, 40].

City administrators have a major impact on travel times. Objective of city traffic control managements (TM) is to maintain efficient city traffic by controlling traffic flows in city areas [27, 39]. Therefore, TM uses a number of

* Corresponding author. Tel.: +49-531-391-3214 ; fax: +49-531-391-8144.
E-mail address: f.koester@tu-braunschweig.de

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possible actions. This can be changes traffic control light programs, lane control and speed limits. Usually, TM combines sets of actions to so called *traffic strategies* [27]. Each traffic strategy is suitable for a specific traffic flow pattern. As a result, travel times between city locations situate not only by the occurring traffic volume but also by the traffic strategy applied by TM. Even though the strategy applied by the TM significantly impacts travel times, the strategies are generally not communicated. This research looks into the possibility of improving CEP routing efficiency, if information can be acquired from a cooperative traffic management and included in the tour planning by the CEP. We consider a routing problem, where a vehicle has to serve a set of customers. Travel times are time-dependent, stochastic and depend on the applied traffic strategy. Objective is to minimize the overall travel times. We apply approaches differing in the degree of information provided by TM. Results show, that considering TM-decisions in routing allow an increase in solution quality.

This article is structured as follows: In Section 2, a literature overview about vehicle routing problems in city logistics is given, especially considering uncertain and varying travel times. In Section 3, an overview of traffic management operations is given motivating the introduction of stochastic time-dependent travel times with TM information in Section 4. In Section 5, we define a vehicle routing problem. The results of a computational evaluation are shown in Section 6. This article closes with a conclusion and an outlook of future work in Section 7.

2. Literature Review

The problem can be described as a stochastic dynamic time-dependent vehicle routing problem in a city logistic environment. It is stochastic, because travel times are uncertain and not entirely known at the point of decision [16]. It is dynamic, because rerouting based on new information is allowed. As the research on dynamic vehicle routing problems is vast, the interested reader is referred to the review of Pillac et al. [28]. In sequence, we focus first embed routing in city logistic environment and then we explicitly consider vehicle routing problem with varying travel times.

2.1. City Logistics

Taniguchi et al. [34] describes city logistics as ”the process of totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy”. City logistics is steadily growing, because of urbanization and e-commerce leads to an increased number of business-to-customers shipments inside cities. The CEP services have to react to a growing parcel market, while competition and therefore price pressure is increasing [25]. According to Dublanc et al. [4], about one fourth of city traffic is related to freight transportation. When compared to rural deliveries, the delivery process of goods in cities is influenced by a significantly higher number of parameters. Challenges arise though traffic regulation and congestion, road condition, road works, limited parking space for stopping for a delivery and varying traffic volume. Especially the impact of rush hours on travel times is high [9]. Kim et al. [18] therefore concludes that the research on vehicle routing problems differs for the city areas and classifies them as ”City Vehicle Routing Problem”. The difference to rural deliveries is the number of involved stakeholder [33]. These stakeholders in city logistics are classified by Taniguchi et al. [34] into residents, shippers, freight carriers and administrators. The stakeholders have different, sometimes opposing, interests and goals. As seen in Figure 1, decisions made by each stakeholder also influences other stakeholders as they share the city environment [18].

Residents interests are not only decreased traffic congestion, air and noise pollution, but also a high level of work and leisure opportunities. Shippers are the manufacturers or retailers of goods and send them to other business or the customers. They are especially interested in a fast delivery, a high service level and high reliability. According to Taniguchi et al., the shippers interest is an undelayed delivery process arriving at the designated arrival time while not damaging the goods [34]. CEP services, representing the freight carriers, handle most of the business to customer deliveries in city logistics. They pick up shipments at a distributing center or directly at the shipper. For delivery, CEP provider use vehicles, which are routed to the customers. In the delivery tour, they are constantly challenged with a high number of customer stops and face many problems of city traffic, e.g. uncertain traffic settings and limited parking spaces. According to Taniguchi et al. city administrators work on the overall development of the city. Their objective is to enhance the city environment for the other stakeholders [33]. Traffic congestion is a major problem for all stakeholders nowadays. According to the European Commission, 9 out of 10 Europeans believe that the traffic