A web-based support tool to coordinate logistic activities in dense populated areas using auctions

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Abstract

In the context of research project MOSCA (MOSCA: Decision Support System for Integrated Door-To-Door Delivery: Planning and Control in Logistic Chains, IST 2000-29557), promoted by the European Union, a prototype of a web-based support tool (web-portal) was developed. Its purpose was to improve communication and coordination between participants of the traffic system. These participants were divided into two segments: the supply-side and the demand-side. The supply-side consists of cities and municipalities which “supply” the traffic infrastructure. On the other hand, the senders and receivers of goods (companies, stores) use (“demand”) this traffic infrastructure. The starting point is the rising extent of utilization of the traffic system in urban areas, which today has already reached its capacity limits. In order to work against this, the city of Lugano in Switzerland examined whether it is meaningful to limit the entry of trucks into the city. Only vehicles that can show proof of an existing parking bay will be granted admission to the city center. Thereby the possibility of dynamic pricing of parking areas and the assignment of parking bays by means of auctions were investigated. The suggested web-portal represents a technical possibility to implement such an access restriction. By publishing information of open capacities, all participants are able to realize more efficient plans of city-logistic activities in dense populated areas, since this information can be used in logistic planning algorithms.

1 Introduction

A better calibration between the individual participants of a logistic system as a mean of improvement of efficiency has already been recognized for quite a while
now [1, 2]. This includes the economic side as well as the utilization of the traffic system. The overall capacity of the traffic system is considered as sufficient, though close to its maximum and still increasing [3]. Yet, temporary overloads of the system lead to unbearable traffic situations at peak hours. In the context of the European project MOSCA a web-based support tool was prototypically developed as an instrument for the coordination between the participants involved in the traffic system. Beside the classical participants of a logistics chain (senders, carriers and receivers), the public hand as supplier of the traffic infrastructure plays an important role. By combining the new technology of the web services and use of auctions as means of coordination, new technical possibilities of cooperation arise between senders and receivers of goods and suppliers of traffic infrastructure. These cooperations allow a more cost effective organization of logistic relations, as well as a more efficient use of the limited resource “traffic system” [4].

2 Situation

Planners in today’s supply chains face risen requirements. Besides the growing importance of delivery accuracy (regarding time and quantity) and the constant reduction of delivery volumes, there are a growing number of other restrictions. In particular, population centers have to be considered [5]. Examples of such restrictions are opening times gates for incoming goods, a limited number of ramps for incoming goods or road access restrictions for certain types of vehicles. It must be pointed out that for deliveries within city centers no classical incoming goods ramps with the appropriate waiting spaces for arriving trucks are usually present, but rather the existing public parking infrastructure is being used. Commercial traffic increases the extent of utilization of the existing park areas to the disadvantage of private vehicles, or leads to an overloading of the limited capacity “parking space”. Chronically overloaded parking areas again induce parking search traffic, a useless burden on the traffic system. This is an unnecessary load to the traffic infrastructure and the environment with noise and exhaust gases. Classical symptom of overloaded parking capacities are circling vehicles or vehicles parking in “second lane”. From the receiver’s point of view this leads to unreliable delivery dates, since it cannot be assured the shipper finds proper parking possibilities and more time will be consumed in finding appropriate parking areas. Senders/shippers on the other hand are not capable of planning exact and realizable routes, since the necessary variables like traveling times, length of time windows, unloading duration become highly stochastic. In order to work against the rising traffic utilization in city centers, the city of Lugano in Switzerland has investigated if it is sensible to restrict the access to the city center for trucks. Only those trucks are granted access, who already posses proof of a reserved parking space. By doing so, the number of entering vehicles can be limited, search traffic reduced and transit traffic eliminated. This approach presents a new challenge to the planning and coordination of city logistic activities, since now a further restriction has to be considered in distribution planning and vehicle routing. On the other hand, senders now have the possibility to plan realizable arrival-times and cost optimal routes.
3 Web-based support tool

In order to coordinate the allocation of parking bays in the city of Lugano, a web-portal has been developed, through which the suppliers of parking infrastructure can publicize open parking capacities, as well as receivers, who can supply information about private parking spots or incoming goods ramps. Within the time of the project, all public parking areas of Lugano were implemented (Figure 1). To each parking area certain opening times correspond. These opening times were sliced in time windows of 15 minutes length each. Additional information, such as vehicle restrictions, dangerous goods restriction, temporary road closures, etc., can also be supplied.

A logistics service provider now has the possibility to reserve necessary time windows at certain parking spots, which are needed for loading and/or unloading of goods (Figure 2).

The access to public parking areas is, of course, not limited to commercial traffic. Private users, who want to omit the tedious search for open parking lots in the city center, can (after a registration) book temporary parking space as well. For commercial transports additional information about dangerous goods can be supplied. That way, this information can be matched with restrictions given by the authorities and it can be assured, that only parking spots will be selected which have clearance for that particular good. Examples would be parking areas next to schools or other public buildings.
With the reservation of one or more time windows, a certain financial transaction for the payment of parking fees corresponds. After the selection, the user of the web-portal will be informed about the costs due for this selection. The existing prototype has no actual payment processes implemented, but the access on existing eCash-Systems is possible. The payment of the booked time windows is dependent on the actual users of the web-portal and their degree of cooperation. It is thinkable, that a private user pays the usual fees for public parking to the municipality, while a commercial truck gets the payment refunded by the receiver of the goods. Virtual credit systems have also been investigated. In these credit systems the senders get a virtual account balance according to their amount of loaded goods, which they can use, to book parking space. Via mobile communication interfaces (UMTS, GPRS, WLAN), the driver of a transport would have the possibility to get informed about the situation in the city center and book parking bays according to his actual time of arrival.

4 Dynamic pricing and auctions

In general, parking lots underly a static pricing, meaning the price for a reservation is constant over time and independent of the time of day or the demand. The only change of price occurs, when the usage becomes free of charge, e.g. after 8:00 p.m. or special rights for residents. The only way for the authorities to steer parking behavior, is to increase the fees. Within the scope of the undertaken research
The project, the possibilities of dynamic pricing for the resources with means of auctions were investigated and implemented in the prototype. Dynamic pricing means a time and/or demand depended pricing. By an individual pricing strategy, the supplier of parking infrastructure has the capability to influence the booking behavior, through which a better, distributed usage of the parking capacities can be achieved.

In the case of logistic distribution relations the situation is more complex than in the private sector. With regard to a commercially used parking area for the loading and unloading of goods, the pricing strategy (in the following only the term “pricing” will be used, even when virtual currencies can still be used) must be coordinated between three parties: receivers, senders and suppliers of parking infrastructure.

One mean to coordinate these parties is the allocation of time windows using auctions. Through different auction mechanisms (investigated have been the combinatorial auction [6] and the reverse auction [7], also called dutch auction) the allocation problem can be solved efficiently [8], [9]. In a combinatorial auction, the bidders, in this case the senders of goods, select the time windows they need to complete the delivery tour. They only receive the package of time windows if all time windows are available, otherwise they loose the auction, and have to select a different package of time windows. In case of the reverse auction either the supplier or receiver (possibly a combination of both) define starting prices for the existing time windows. These vary, according to defined price/time-function, generally a linear depreciation to the value zero. A zero value must be reached at one point in time, at the latest when the time window begins, because from that time on, no reservation is possible any more. Yet, any price development is possible, e.g. to encourage early booking (Figure 3). The sender can, according to his vehicle routing plan, book the time windows he needs. The quantitative influence of different auction mechanisms and pricing strategies on the booking behavior is the present object of research at the Institute of conveying technology and logistics systems.

5 Logistic effect

With the developed web-based support tool it is possible to provide information about open parking capacities and their corresponding prices. By using these information and the web-portal’s booking capability, the logistic process of distributing
goods in dense populated areas could be tremendously improved. Together with proper applications for vehicle routing, that are capable of processing information about alternative time windows and prices corresponding to these time windows, open parking bays could already be taken into account in the initial vehicle routing, hence calculating cost optimal routes at minimum traveling time. More than that, the distributor is able to comply with the covenant time windows, because the agreed delivery dates do not result from a local optimization of processes at the receiver any more, but from the coordinating process of auctioning. On the other hand, the receiver of goods is able to make his incoming goods processes more steady, resulting in steadier processes over the complete logistic chain. Examples would be production processes or personnel planning. From the point of view of the supplier of public traffic infrastructure other advantages arise. Through the assignment of parking bays to vehicles before they enter the city, a direct travel to these parking bays occur. This relives the traffic system in general, since the “search traffic” is eliminated and “second lane”-parking reduced. Figure 4 shows the concept of implementation for the suggested web-based support tool.

6 Outlook

Within the introduced research project MOSCA, the web-based support tool has been developed and prototypically implemented. For a more accurate quantification of the expected cost advantages a further field test with more participants is necessary. So far the resonance is promising and the further development of the auction platform as a mean of coordinating decentralized planning processes in city logistics is currently the object of research at the institute for conveying technology and logistic systems. Under investigation will be the influence of different auction mechanisms and pricing strategies on the bidders’ behavior. Furthermore a
financial penalty system for participants not complying with the agreed time windows has to be developed. Additionally under investigation is the transfer of the previous results on distribution centers and larger production sites. In this context the connection of the suggested web-portal to existing ERP-systems will be of high importance.

References