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On dynamic pickup and delivery vehicle routing with several time windows and waiting times

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Abstract

In 2001, Caramia and his coauthors introduced a very fast and efficient heuristic for rooting a fleet of vehicles for dynamic combined pickup and delivery services [Caramia, M., Italiano, G.F., Oriolo, G., Pacifici, A., Perugia, A., 2001. Routing a fleet of vehicles for dynamic combined pickup and delivery services. In: Proceedings of the Symposium on Operation Research 2001, Springer-Verlag, Berlin/Heidelberg, pp. 3–8.]. The authors assume that every client names a stretch-factor that denotes the maximal relative deviation from the shortest path between pickup and delivery point. Waiting times are not allowed. As these assumptions are not very realistic, this paper now presents the results of adapting this algorithm to the dynamic pickup and delivery vehicle routing problem with several time windows. Waiting times of vehicles are admitted. Moreover, the computational results are considerably improved by local search techniques making use of free computational capacity.

Keywords: Pickup and delivery; Vehicle routing; Dynamic; Vehicle scheduling; Time windows; Dial-a-ride

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1. Introduction

In this paper, the dynamic pickup and delivery vehicle routing problem with time windows is considered. Caramia and his coauthors developed their algorithm during a study concerning a local multi-cab metropolitan transportation system (Caramia et al., 2001). In that system each cab is allowed to transport up to six customers at a time, each of them having his special pickup and delivery places, a time window for pickup and a stretch-factor that denotes the maximal deviation from the shortest possible travel time the customer accepts. The shortest possible travel time denotes the length of the shortest path from the customer's pickup to his delivery place. The deviation from the shortest travel time originates in the cab's detouring in order to pick up or deliver other customers. Giving his stretch factor, the customer impacts directly the time spent in the cab (and indirectly his delivery time). Customers call during the day to apply for service at the same day. Their request must be answered online on the phone: the cab enterprise has to decide at once whether the customer can be accepted or must be rejected. The enterprise is willing to accept as many customers as possible.

Replacing the stretch-factor by a delivery time window the customers' needs are met even better than before: First, the customer may influence directly his delivery time. So he can make sure that he will arrive in time, assuming he is on his way to any kind of appointment. Second, the customer does not have to estimate a stretch-factor. Many customers may have difficulty in naming such a factor, especially as it is based on the shortest possible travel time which might be unknown or has to be named by the cab enterprise. Further, the vehicles shall now be allowed to wait. These modifications ensure that the algorithm can also be applied to transportation problems concerning goods instead of people. Taking into account that lead times in transportation sector are decreasing, this problem may be of special interest in large scale transportation settings. On the other hand it can be established in transportation networks of large operating sites.

The literature on the dynamic pickup and delivery vehicle routing problem deals in most instances with the dial-a-ride problem which was first examined by Wilson et al. (1971). In the following, mainly the dynamic single-vehicle routing problem with pickup and delivery and time windows and the static multi-vehicle routing problem with pickup and delivery and time windows have been treated. A good overview of time window constrained vehicle routing problems including the dial-a-ride problem can be found in Solomon and Desrosiers (1988). Psaraftis (1995) summarizes all dynamic vehicle routing problems and classifies them. New developments on dial-a-ride problems are presented by Cordeau and Laporte (2002) in their paper. An exact algorithm based on column generation has been developed by Dumas et al. (1991). Ruland and Rodin (1997) present exact branch-and-cut procedures to solve small problem instances. The heuristic approaches have mainly been insertion heuristics and local search techniques. Local search techniques have been presented by Healy and Moll (1995) and Van der Bruggen et al. (1993). Cordeau and Laporte (2003) published a tabu search heuristic for the static dial-a-ride problem. Jaw et al. (1986) presented an insertion algorithm which Madsen et al. (1995) used to develop their algorithm REBUS. Caramia et al. (2001) proposed an insertion algorithm including an optimal vehicle routing procedure which has now been adapted to the dynamic vehicle routing problem with two time windows and which has been combined with a tabu search procedure to improve the heuristic assignment.