Optimization of Postal Collection Networks

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Abstract. The talk presents two optimization problems within the part of a postal logistics network where collection takes place. First, the optimization of collection tours and, second, the allocation of pickup locations to sorting terminals. Both problems consider not only service time windows at customer locations and at terminals but also complex sorting capacities at the sorting terminals.

Keywords. Postal Logistics, mail collection, allocation, MDVRPTW, inter-tour resources, time-varying processing capacities

1 Introduction

Some providers of postal or parcel services promise high levels of service to their customers, e.g., next day delivery, resulting in tight lead times. To meet these high service levels, complex logistics networks need to be planned and operated. Such networks are typically divided into transportation of letters or parcels from customer locations to a local sorting terminal (collection), inter-terminal transportation, and transportation from a terminal to customer locations (delivery). Within postal logistics networks the interaction of processing at and transportation between different kinds of facilities plays a vital role. Normally, collection and initial sorting, as well as inter-terminal transportation and final sorting need to be finished before certain cut-off times. Thus, guaranteeing the subsequent transportation to start on time.

2 Time-varying processing capacities

Sorting capacities in mail sorting terminals are in general not constant throughout the sorting time window. Customers prefer to send out their mail as late as possible. Also, transportation costs may be significantly decreased if more time is allowed for consolidation in mail collection. At the same time, an early final sorting time (cut-off time) allows for a longer time window for long-haul transportation. Thus, sorting time is restricted and capacity needs to be increased during the sorting time window to be able to sort all mail before the end of sorting. Capacity increasing over time may be guaranteed by appropriately planning the personnel operating sorting machines.

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3 Optimization of mail collection tours

The optimization of mail collection tours can be modeled as a Vehicle-Routing Problem (VRP). We consider multiple depots to implicitly allocate pickup points to mail sorting terminals. Also, collection tours must not arrive at pickup points outside defined service time windows. These aspects can be modeled as a multi-depot VRP with time windows (MDVRPTW) [1].

In literature the optimization of mail collection tours is discussed for the example of mailboxes by [2], [3] and [4]. None of them consider restricted vehicle capacities as mail volume on a tour is small in general. However, the latest arrival time at a depot or the maximal duration of tours prevent the introduced models from visiting all mailboxes with a single tour.

Different to other known approaches in our model time-varying sorting capacities at mail sorting centers are restricted. As collection tours may arrive until a defined final sorting time (cut-off time), restricted capacities cannot be modeled as a single capacity resource. Much more, a certain arrival rate of mail at the sorting center must be met to guarantee completion of sorting before cut off. This required arrival rate is discretized into a set of points in time with corresponding arrival capacities within the sorting time window of each depot. We introduce a new class of inter-tour resource constraints to the MDVRPTW where inter-tour resources are restricted globally for all tours at the same time. The new class of resource constraints ensures that mail volume arriving at the depot with tours later than a certain time does not exceed a given capacity. The model is solved using efficient local search methods [5].

4 Allocation of pickup points

Problem instances in collection tour optimization (see section 3) may contain several thousand pickup points. To decompose the problem into single-depot VRPTWs we propose a generalization of the Generalized Assignment Problem (GAP) [6]. The proposed model introduces a new class of constraints to the GAP restricting the mail volume brought into each sorting terminal later than certain points in time. This model is solved by ILOG CPLEX within several seconds for instances with more than 20 thousand pickup points and about 10 mail sorting terminals.

5 Conclusions

When optimizing mail collection tours or the allocation of pickup points to mail sorting terminals time-varying sorting capacities need to be considered. We propose approaches to model such sorting capacities within a multi-depot Vehicle-Routing Problem with time windows (MDVRPTW) and inter-tour resource constraints and within a Generalized Assignment Problem (GAP) respectively.

The MDVWPTW provides us with an optimal tour plan and thus with realistic arrival times of mail at sorting terminals. It also implicitly determines the

allocation of pickup points by assigning them to tours with pre-defined origin and destination depots. Yet, the problem is complex and even heuristic solutions methods may not be able to find good solutions for real-life problem instances. The GAP allows for the efficient solution of real-world problems with more than 20 thousand pickup points with ILOG CPLEX. It assumes direct trips from pickup points to sorting facilities and thus underestimates the arrival time of mail at sorting terminals. Still, the GAP helps partitioning the set of pickup points to decompose the MDVRPTW into several single-depot VRPTWs.

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