

Solving an integrated order picking-vehicle routing problem with record-to-record travel

Stef Moons, Kris Braekers, Katrien Ramaekers, An Caris

UHasselt - Hasselt University, Research group Logistics

e-mail: stef.moons@uhasselt.be

Yasemin Arda

QuantOM, HEC Liège - Management School of the University of Liège

Presented at the 32nd annual conference of the Belgian Operational Research Society (ORBEL) at HEC Liège, 1-2 February, 2018.

In the last decade, European business-to-consumer (B2C) e-commerce sales have been increasing with an annual growth rate of approximately 17%. The growing popularity of e-commerce has a positive impact on the number of parcels that needs to be delivered with approximately 4.2 billion parcels in Europe in 2016 [1]. When customers purchase goods online, they expect a fast and accurate delivery at low cost. The combination of the increasing number of orders and the high expectations puts a pressure on the logistic activities of B2C e-commerce companies. In order to efficiently satisfy the customer expectations, companies have to optimize their picking and distribution operations. Implementing an integrated approach to obtain simultaneously order picking schedules and vehicle routes can lead to better results [2].

Goods purchased online at webshops need to be picked in a distribution centre (DC) before they can be delivered to the customer. As such, the order picking and delivery operations are related. Consequently, to determine better picking lists and vehicle routes, ideally, these two problems should be integrated into a single optimization problem. In an integrated order picking-vehicle routing problem (I-OP-VRP), the two problems are solved simultaneously by taking into account the requirements and constraints of both problems.

In the I-OP-VRP, order pickers work in parallel in a single zone in a DC. Additional temporary order pickers can be hired from a fixed pool of workers in case of high customer demand. The labour cost of the temporary pickers is slightly higher than this of regular pickers. Each order is picked in an individual tour throughout the DC without batching. The picking routes are considered to be known in advance. A homogeneous fleet of vehicles is used for the deliveries to the customers. During the purchasing process, each customer has selected a delivery time window. A cost is incurred for each kilometre travelled and for the working time of the driver. The objective of the I-OP-VRP is to minimize total cost, i.e., both order picking and distribution costs.

Since both an order picking problem and a vehicle routing problem are hard to solve themselves, a heuristic solution algorithm is needed to solve the I-OP-

VRP. A record-to-record travel (RRT) algorithm with local search operators is developed to solve the integrated problem in a small amount of computational time. RRT is a deterministic variant of simulated annealing and is first developed by [3]. Each new solution is accepted when its objective value is not worse than the record, i.e., best solution found, plus a deviation value, which is a certain percentage of the record.

An initial solution is generated by using a constructive heuristic which consists of two parts; one for each subproblem. The RRT solution algorithm is used to improve the quality of the initial solution and is applied for a maximum number of iterations. Within each iteration, five local search operators are executed. Three operators are related to the vehicle routing part of the problem: exchange, relocate, and, 2-Opt. Two operators work on the order picking schedules: exchange and relocate. The algorithm restarts with the best solution found so far when the RRT could not improve the solution for a number of consecutive iterations.

The algorithm is tested on randomly generated instances with 10 and 15 customer orders. The performance of the proposed heuristic is evaluated by comparing its results with the optimal solutions obtained by CPLEX. The heuristic is capable of obtaining high-quality solutions in small computational time. Solving an instance with 10 customer orders to optimality using CPLEX takes 15 minutes on average, while the RRT heuristic finds a solution within less than a second. Obtaining the optimal solution of an instance with 15 customer orders with CPLEX takes 57 hours on average, whereas the proposed heuristic is capable of finding a solution within 3 seconds.

References

- [1] Ecommerce Europe (2016). *European B2C E-commerce Report 2016*.
- [2] Moons, S., Ramaekers, K., Caris, A., & Arda, Y. (in press), Integration of order picking and vehicle routing in a B2C e-commerce context, *Flexible Services and Manufacturing Journal*, doi: 10.1007/s10696-017-9287-5.
- [3] Dueck, G. (1993). New optimization heuristics: The great deluge algorithm and the record-to-record travel. *Journal of Computational physics*, 104(1), 86-92, doi: 10.1006/jcph.1993.1010.