An integrated approach for order picking and vehicle routing in a B2C e-commerce context

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Every year, business-to-consumer (B2C) e-commerce sales increase. In the last decade, the B2C e-commerce sales has been growing annually with 12% on average in Europe. More specific, in 2015, the European B2C e-commerce sales grew with approximately 13.5% [1]. New challenges and opportunities for the logistic system are created by the rise of e-commerce [3]. New distribution channels and structures arise, which lead to more complex distribution networks. Moreover, customers order more frequently in smaller quantities in an e-commerce context. As a consequence, the number of consignments increases, which makes the consolidation for delivery more complicated. Customers still expect a fast and accurate delivery. In order to fulfill these high customers' expectations all supply chain functions have to be optimized simultaneously.

However, nowadays, in most e-commerce DCs a fixed cut-off time is implied before which all orders need to be picked. This cut-off time separates the warehouse operations and delivery operations. By integrating both problems, the cut-off time can be eliminated and late orders can be handled with more flexibility. Instead of solving an order picking (OP) problem and a vehicle routing problem (VRP) separately and sequentially, these two problems can be integrated into a single optimization problem. Both an order picking schedule and vehicle routes need to be determined. According to the authors, it is the first time order picking and vehicle routing decisions are integrated. In literature, papers on coordinating supply chain functions generally integrate a production environment with a VRP [2]. A mathematical formulation for an integrated order picking-vehicle routing problem (OP-VRP) in a B2C e-commerce context is presented. The performance of the proposed integrated OP-VRP is compared to an uncoordinated approach in which first an order picking problem is solved and afterwards a VRP. The total costs obtained by using an uncoordinated approach are compared to the these obtained by using the integrated approach.

In the DC, manual order pickers travel along the different picking locations in a single picking zone, i.e., a picker-to-product system [4]. The DC employs a fixed number of regular order pickers. Additional order pickers from a fixed pool of flexible workers can be hired in case of high customer demand. However, a maximum number of order pickers is allowed to work in parallel to avoid congestion in the picking aisles. Per time unit an order picker works a wage is incurred. The wage of an additional hired picker is higher. Each order, which can consist of one or more order lines, is picked individually without interruption in a single tour through the warehouse, i.e., single order picking policy. Thus, batching of orders is not allowed. The delivery operations are executed by a limited number of vehicles. Both a variable cost incurred per time unit of the tour length, which includes the driver's wage and the fuel cost, and a fixed cost for using a vehicle are incurred. Service times at the warehouse and the customers are taken into account.

Experiments with small-size instances with up to 20 customer orders are executed. The integrated approach always results in a better solution compared to the uncoordinated approach. Integration of both problems leads to cost savings of 12% on average, with even up to approximately 30%. Integration lowers the need to hire additional order pickers. Due to the higher flexibility of the arrival times of the vehicles at the DC, vehicles do not have to wait before their delivery route can start, which results in lower driver wages. Furthermore, when order picking and vehicle routing decisions are integrated into a single problem, B2C e-commerce companies can offer a higher service level to their customers. Companies can allow their customers to place their orders later and still offer the same delivery time windows as with an earlier placed order. In the uncoordinated approach, it is not possible to offer this service, because all orders need to be picked before the cut-off time, and when orders are placed late, not enough time is left to pick all these orders on time. The integrated problem can be solved within one minute on average for instance classes with 10 and 15 customer orders. Solving the instances with 20 customer orders can take up to 17 hours. As a real-world distribution center has to handle a large number of orders a day, a heuristic needs to be developed to solve the integrated order picking-vehicle routing problem in a small amount of time.

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References

[1] Ecommerce Europe (2016). *European B2C E-commerce Report 2016.*

[2] Moons, S., Ramaekers, K., Caris, A., & Arda, Y. (forthcoming), Integrating production scheduling and vehicle routing decisions at the operational decision level: a review and discussion, *Computers & Industrial Engineering.*

[3] Richards, G. (2014). *Warehouse Management: A complete guide to improving efficiency and minimizing costs in the modern warehouse* (2nd ed.). London: Kogan Page Limited.

[4] van den Berg, J.P. (1999). A literature survey on planning and control of warehousing systems. *IIE Transactions*, *31*(8), 751-762.