Chapter 6

VRPSPD MODEL TO RE-ROUTE THE SEA BUSES IN ISTANBUL: THE CASE OF BOSPHORUS

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INTRODUCTION

In today's transportation environment, the vehicles' routes, route strategies, temporal strategies, managerial targets, and customer demand must be seen as an integrated process that should be analyzed and structured well. The main purpose of the route strategies in an efficient transportation system is to meet customer demand in time and right place.

The transportation problems are being considered in line with the system approach because of their structural aspects. These systems are multi-disciplinary and may consist of multi models, multi-sectoral or multi-problems. To set a problem in line with targets and to estimate potential changes in different conditions, the relation between systems and their variables that generates the system environment should be investigated in detail. On the other hand, how this relationship affects the system outputs should be analyzed.

A vehicle routing problem may have a different type of variables. Vehicle types or fleet size may be homogeneous or heterogeneous. Cost may be fixed or variable for vehicles based on vehicle usage. On the other hand, time-related conditions may differ. When the horizon is single or multiple, time windows can be hard or soft. In terms of demand nature, operation characteristics may differ. Vehicle routing problems can generally be divided into three groups; vehicle routing problems (VRP), vehicle routing problems with time windows (VRPTW), and vehicle routing problem with simultaneous pick-ups and deliveries (VRPSPD).

VRP involves the design of a set of minimum-cost vehicle routes, originating and terminating at a central depot, for a fleet of vehicles that services a set of customers with known demand. Each customer is serviced exactly once. Furthermore, all customers must be assigned to vehicles without exceeding vehicle capacities (Solomon, 1987). The objective of VRPTW is to optimize route groups

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CONCLUSION

Although there are many residential places in the Marmara region and around the seaside, the city cannot benefit enough from sea transportation in Istanbul. The high cost of fast sea transportation mode in Bosphorus makes it also difficult to pull the road transportation demand to the sea.

Based on a mathematical model consisting of 65326 variables and 65847constraints, results show that it is possible to maintain 260 missions at Bosphorus by using 16 sea buses instead of 17. Additionally, the total transportation cost was reduced by 17.2 %, and the sea buses usage ratio improved by 18.1 %. In addition to one less sea bus usage, there will be a significant reduction in operational cost, insurance, tax, maintenance cost, and personal expenses. These results are expected to reflect directly on corporate profitability or ticket prices may be reduced due to the reduction in travel costs.

In this study, passenger capacities and types of sea buses were not considered. Sea buses are assigned the specific routes by considering the passenger demand for a mission after determining the routes. As the real-world process is stochastic based, the simulation models and scenarios may be developed by considering opportunity costs, customer demand deviation, and sea bus variety.

REFERENCES

Avci, M., & Topaloglu, S. (2015). An adaptive local search algorithm for vehicle routing problem with simultaneous and mixed pickups and deliveries. *Computers & Industrial Engineering,* 83, 15-29.

Belgin, O., Karaoglan, I., & Altiparmak, F. (2018). Two-echelon vehicle routing problem with simultaneous pickup and delivery: Mathematical model and heuristic approach. *Computers & Industrial Engineering*, 115, 1-16.

Bodin, L., Golden, B., Assad, A and Ball, M., (1983). "Routing and Scheduling of Vehicles and Crews: The State of the Art". *Computers and Operations Research* 10, 63-211.

Braekers, K., Ramaekers, K., & Van Nieuwenhuyse, I. (2016). The vehicle routing problem: State of the art classification and review. *Computers & Industrial Engineering*, 99, 300-313.

Bronmo, G., Christiansen, M., Fagerholt, K., & Nygreen, B. (2007). A multi-start local search heuristic for ship scheduling—a computational study. *Computers & Operations Research*, 34(3), 900-917.

Bronmo, G., Nygreen, B., & Lysgaard, J. (2010). Column generation approaches to ship scheduling with flexible cargo sizes. *European Journal of Operational Research,* 200 (1), 139-150.

Christiansen, M., Fagerholt, K., Nygreen, B., & Ronen, D. (2013). Ship routing and scheduling in the new millennium. *European Journal of Operational Research*, 228(3), 467-483.

Cho, S. C., & Perakis, A. N. (1996). Optimal liner fleet routeing strategies. *Maritime policy and management*, 23(3), 249-259.

Dantzig G.B., Ramser J.H., (1959), "The truck Dispatching Problem", *Management Science,* 6, 80-91.

Darzentas, J., & Spyrou, T. (1996). Ferry traffic in the Aegean Islands: a simulation study. *Journal of the Operational Research Society*, 47(2), 203-216.

Dethloff, J., (2001), " Vehicle Routing and Reverse Logistics: The Vehicle Routing Problem With Simultaneous Delivery and Pick-Up", *OR Spectrum,* 23, 79-96.

Drexl, M. (2013). Applications of the vehicle routing problem with trailers and transshipments. *European Journal of Operational Research*, 227(2), 275-283.

Fagerholt, K. (2001). Ship scheduling with soft time windows: An optimization-based approach. *European Journal of Operational Research*, 131(3), 559-571.

Fagerholt, K., & Ronen, D. (2013). Bulk ship routing and scheduling: solving practical problems may provide better results. *Maritime Policy & Management*, 40(1), 48-64.

Fan, X. C., Li, N. L., Zhang, B. Y., & Liu, Z. H. (2011). Research on vehicle routing problem with soft time windows based on tabu search algorithm. *18th International Conference on Industrial Engineering and Engineering Management,* Singapore, (pp. 420-423).

Fazi, S., Fransoo, J. C., Van Woensel, T., & Dong, J. X. (2020). A variant of the split vehicle routing problem with simultaneous deliveries and pickups for inland container shipping in dry-port based systems. *Logistics and Transportation Review,* 142, 102057.

Gajpal, Y., Abad, P., (2009), "An Ant Colony System (ACS) For Vehicle Routing Problem With Simultaneous Delivery and Pick-up*", Computer & Operations Research*, 36, 215-223.

Gansterer, M., & Hartl, R. F. (2018). Collaborative vehicle routing: a survey. *European Journal of Operational Research,* 268(1), 1-12.

ISB (Istanbul Sea Buses) A.Ş. (2020). Official Web Page. (Access date and address: www.ido.com.tr, 15/09/2020)

Jozefowiez, N., Semet F., Talbi E., (2008), "Multi-objective Vehicle Routing Problems" *European Journal of Operational Research*, 189, 293-309.

Jun, Y., & Kim, B. I. (2012). New best solutions to VRPSPD benchmark problems by a perturbation based algorithm. *Expert Systems with Applications*, 39(5), 5641-5648.

Kassem, S., & Chen, M. (2013). Solving reverse logistics vehicle routing problems with time windows. *The International Journal of Advanced Manufacturing Technology*, 68(1-4), 57-68.

Koç, Ç., & Laporte, G. (2018). Vehicle routing with backhauls: Review and research perspectives. *Computers & Operations Research*, 91, 79-91.

Koç, Ç., Laporte, G., & Tükenmez, İ. (2020). A Review on Vehicle Routing with Simultaneous Pickup and Delivery. *Computers & Operations Research,* 104987.

Min, H., (1989), "The multiple Vehicle Routing Probem with Simultaneous Delivery and Pick-up Points" *Transportation Research*, 23A, 377-386.

Mingyong, L., & Erbao, C. (2010). An improved differential evolution algorithm for vehicle routing problem with simultaneous pickups and deliveries and time windows. *Engineering Applications of Artificial Intelligence,* 23(2), 188-195.

Mu, D., Wang, C., Zhao, F., & Sutherland, J. W. (2016). Solving vehicle routing problem with simultaneous pickup and delivery using parallel simulated annealing algorithm. *International Journal of Shipping and Transport Logistics*, 8(1), 81-106.

Quirion-Blais, O., & Chen, L. (2020). A case-based reasoning approach to solve the vehicle routing problem with time windows and drivers' experience. *Omega,* (In press) 102340.

Rodrigues, V. P., Morabito, R., Yamashita, D., Da Silva, B. J., & Ribas, P. C. (2016). Ship routing with pickup and delivery for a maritime oil transportation system: MIP model and heuristics. *Systems*, 4(3), 31.

Ronen, D., (1993), "Ship Scheduling: The Last Decade", *European Journal of Operational Research*, 71, 325–333.

Santos, P. T. G., Kretschmann, E., Borenstein, D., & Guedes, P. C. (2020). Cargo routing and scheduling problem in deep-sea transportation: Case study from a fertilizer company. *Computers & Operations Research*, (In press) 104934.

Solomon, M.M., (1987), "Algorithms for the Vehicle Routing and Scheduling Problems with Time Window Constraints" *Operations Research*, 35(2), 254-265.

Subramanian, A., Drummond, L. M. D. A., Bentes, C., Ochi, L. S., & Farias, R. (2010). A parallel heuristic for the vehicle routing problem with simultaneous pickup and delivery. *Computers &*

Operations Research, 37(11), 1899-1911.

Subramanian, A., Uchoa, E., & Ochi, L. S. (2013). A hybrid algorithm for a class of vehicle routing problems. *Computers & Operations Research,* 40(10), 2519-2531.

Trottier, L. P., & Cordeau, J. F. (2019). Solving the vessel routing and scheduling problem at a Canadian maritime transportation company. *Information Systems and Operational Research,* 57(2), 260-285.

Vidal, T., Laporte, G., & Matl, P. (2019). A concise guide to existing and emerging vehicle routing problem variants. *European Journal of Operational Research*. 286(2), 401-416.

Wang, H. F., & Chen, Y. Y. (2012). A genetic algorithm for the simultaneous delivery and pickup problems with time window. *Computers & Industrial Engineering,* 62(1), 84-95.

Wang, X., Choi, T. M., Liu, H., & Yue, X. (2016). Novel ant colony optimization methods for simplifying solution construction in vehicle routing problems. *IEEE Transactions on Intelligent Transportation Systems,* 17(11), 3132-3141.

Yin, C., Bu, L., & Gong, H. (2013). Mathematical model and algorithm of split load vehicle routing problem with simultaneous delivery and pickup. *International journal of innovative computing, information and control,* 9(11), 4497-4508.

Zachariadis, E. E., & Kiranoudis, C. T. (2011). A local search metaheuristic algorithm for the vehicle routing problem with simultaneous pick-ups and deliveries. *Expert Systems with Applications,* 38(3), 2717-2726.

Zhang, Z., Cheang, B., Li, C., & Lim, A. (2019). Multi-commodity demand fulfillment via simultaneous pickup and delivery for a fast fashion retailer. *Computers & Operations Research,* 103, 81-96.