Delivery Route Optimization at E-Bebek Company

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ABSTRACT

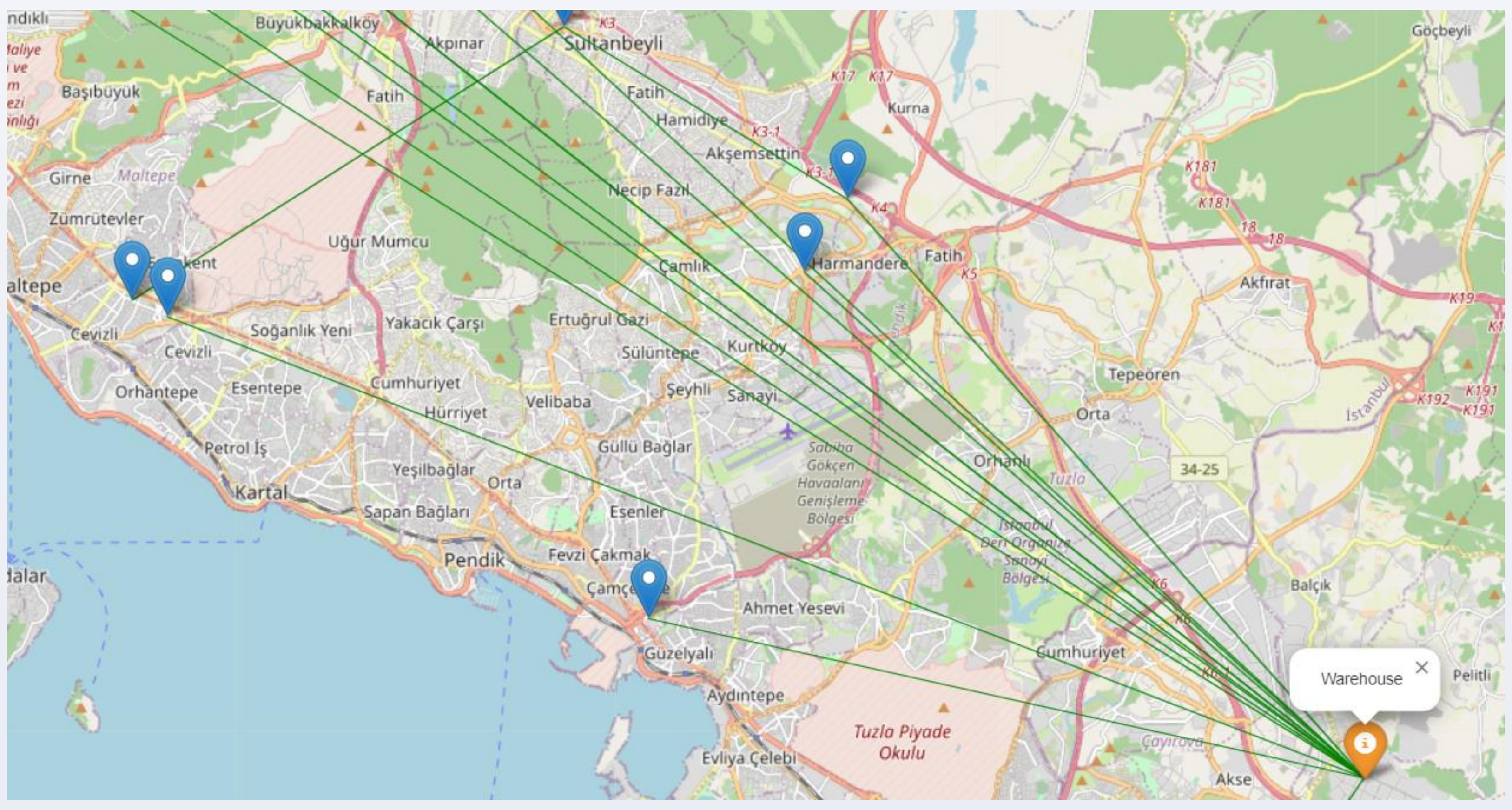


Fig.1. *Visualization output of Decision Support System*

In this project, project team has addressed a particular VRP variant faced by the E-Bebek company. The company aims at matching orders with the delivery vehicles in their fleet and determining the vehicle routes by respecting the delivery time requirements such that total operational costs are minimized. The project team have prepared a model for the problem using Linear Programming and solved it using a solver based on the data provided by the company. The team have also designed a heuristic method, coded it using Python programming language. The whole system is integrated within a decision support system (DSS) which manages the database, visualizes the route plans, and allows what-if analyses except heuristic algorithm which is not fully completed. The Gurobi Optimizer is utilized to formulate and solve the problem, considering factors such as time windows and vehicle constraints. Additionally, the Genetic Algorithm provides a heuristic approach to efficiently explore and search for near-optimal solutions. By incorporating both optimization techniques, we aim to minimize the total distance traveled, optimize resource allocation, and adhere to time windows for deliveries. This project has developed and implemented a DSS which is using OVRPTW with a Mixed Fleet route optimization model for E-Bebek company. This DSS is reducing related delivery costs, improving delivery efficiency and meeting customer demands within their expectations. Additionally, it is visualizing the optimal routes in a map and reporting the solutions with analysis. In conclusion, by utilizing the Gurobi optimizer as a mixed-integer linear programming (MILP) model, we achieved substantial enhancements in route planning and optimization, as the solver efficiently provided near-optimal solutions within the computational time limits.

OBJECTIVES

The first objective focuses on creating a vehicle routing plan that efficiently plans routes to minimize travel distance, resulting in cost savings and improved operational efficiency. Another crucial objective is to provide the company with a visual representation of the proposed vehicle route, allowing for easy understanding and evaluation. Lastly, we will analyze the proposed vehicle route and compare it with the existing routes currently used by the company, identifying potential improvements and assessing the overall efficiency gains that can be achieved.

PROJECT DETAILS

$$\min \sum_{k \in K} \left(z_k + \left(\sum_{i \in C} v_k * y_{ik} \right) - v_k \right) \quad (1)$$

$$\text{s.t.} \quad \sum_{k \in K} y_{ik} = 1 \qquad i \in C \quad (2)$$

$$y_{o_k k} = 1 \qquad k \in K \quad (3)$$

$$y_{D_k k} = 1 \qquad k \in K \quad (4)$$

$$\sum_{j \in C \cup D_k} x_{o_k j k} = 1 \qquad k \in K \quad (5)$$

$$\sum_{i \in C \cup O_k} x_{i d_k k} = 1 \qquad k \in K \quad (6)$$

$$\sum_{i \in C \cup O_k} x_{ijk} = y_{jk} \qquad j \in C \cup D_k, \quad k \in K \quad (7)$$

$$\sum_{j \in C \cup D_k} x_{ijk} = y_{ik} \qquad i \in C \cup O_k, \quad k \in K \quad (8)$$

$$\sum_{i \in C \cup O_k} x_{ijk} - \sum_{i \in C \cup D_k} x_{jik} = 0 \qquad j \in C, \quad k \in K \quad (9)$$

$$\sum_{i \in C} dem_i * y_{ik} \le cap_k \qquad k \in K \quad (10)$$

$$y_{ik} * c_i \le z_k \qquad i \in C, \quad k \in K \quad (11)$$

$$x_{ijk} \le A_{ij} \qquad (i,j) \in A_k \quad k \in K \quad (12)$$

$$a_i \le h_{ik} \le b_i \qquad i \in C, \quad k \in K \quad (13)$$

$$h_{ik} + t_{ijk} + s_i - h_{jk} \le (1 - x_{ijk}) \cdot M \qquad (i,j) \in A_k, \quad k \in K \quad (14)$$

Fig.2. *Mathematical Representation of Optimization Model*

PROJECT DETAILS

The objective function (1) aims to minimize the total costs associated with routing and visiting customers. The visiting cost is incurred when a truck serves multiple customers, and the objective is to minimize this cost. Constraint (2) ensures that each customer can be visited by only one vehicle. Constraints (3) and (4) guarantee that every vehicle starts its tour from the depot and ends at a dummy destination point. Constraints (5) and (6) serve the same purpose as (3) and (4) but are included to reduce solution time without changing the solution itself. Constraints (7) and (8) state that if a vehicle uses a route segment between nodes i and j, it must visit both i and j. Constraint (9) ensures that the number of vehicles entering and leaving a node is equal. Constraint (10) limits the total demand served by each vehicle to not exceed its capacity. Constraint (11) determines the most expensive visited node for calculating the routing cost in the objective function. Constraint (12) ensures that a vehicle can travel between nodes i and j using only allowed arcs due to clustering. Constraints (13) and (14) represent time window constraints that ensure arrival times at customer nodes fall within specific time windows.

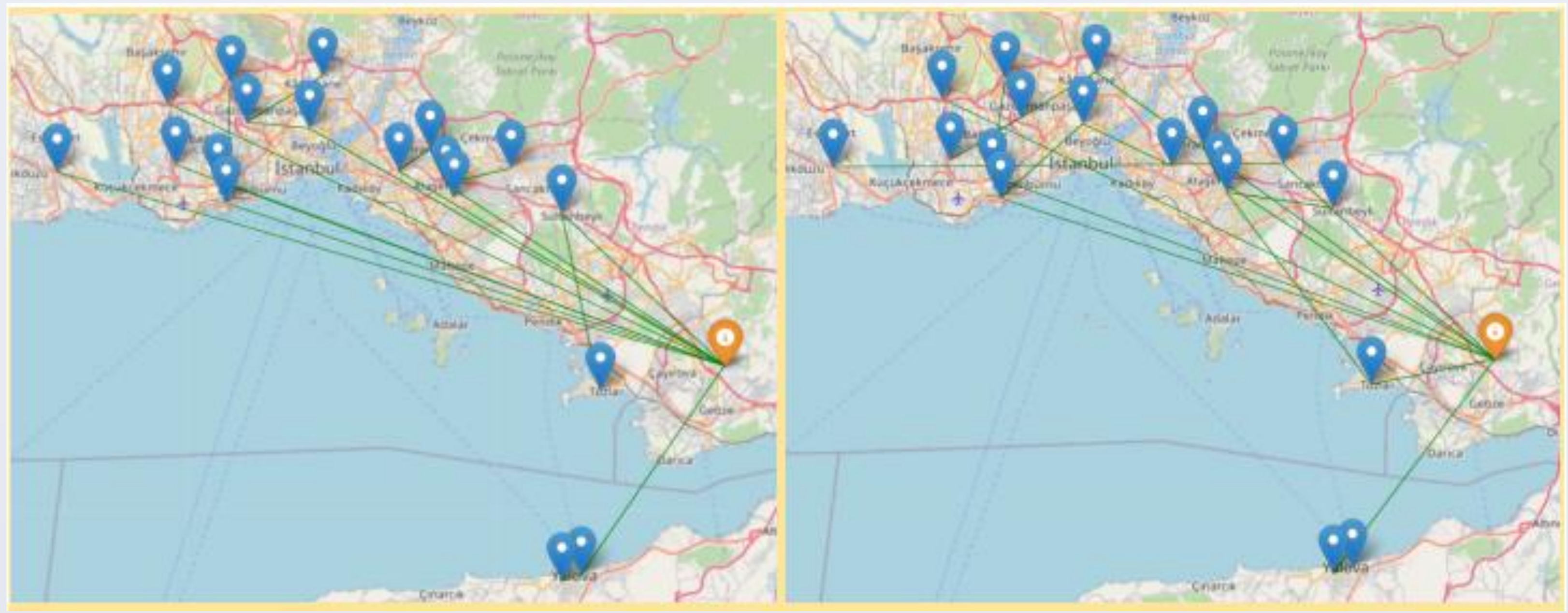
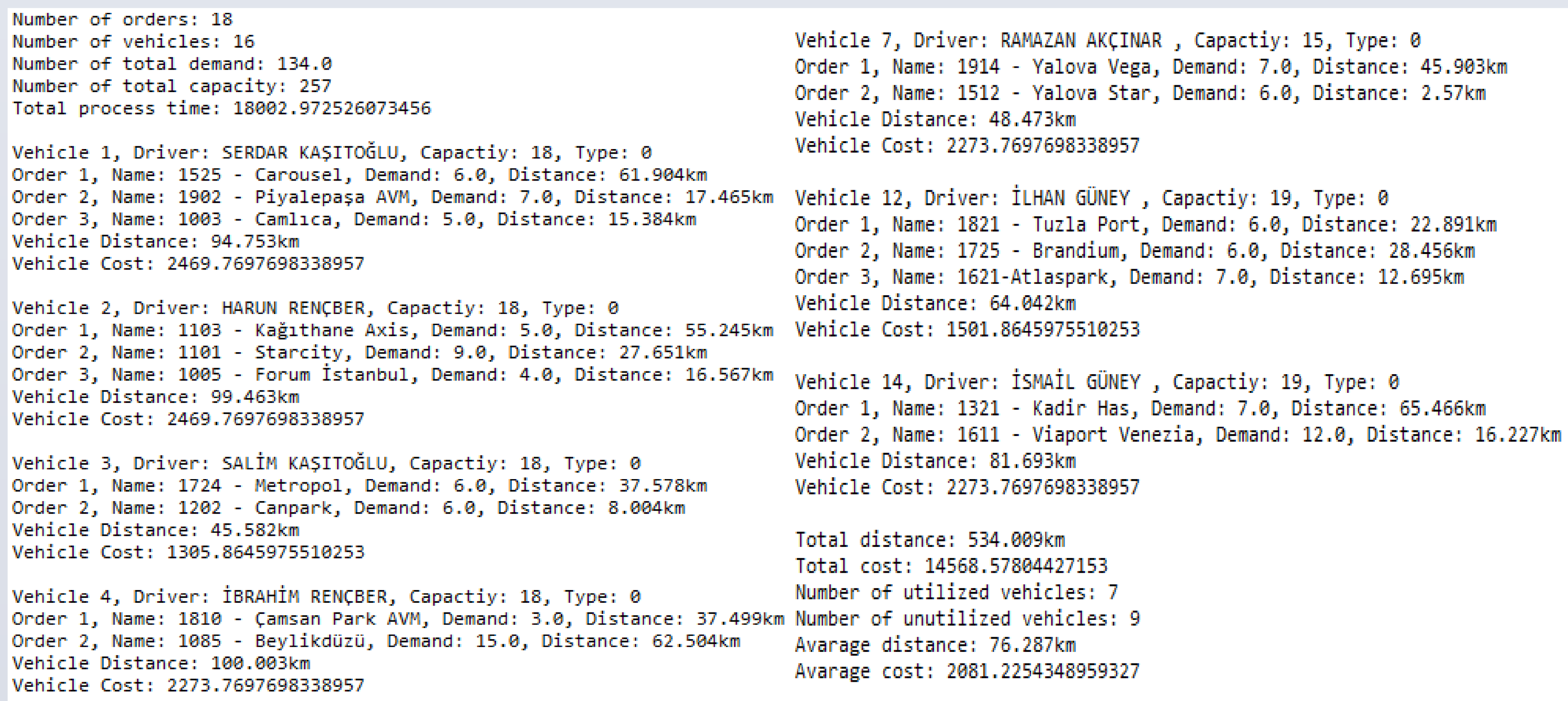


Fig.3. *Comparison of Existing Vehicle Routes wih Proposed Vehicle Routes*

The Gurobi solution obtained for April 6, 2022, shows that the company utilized 10 vehicles to distribute orders, covering a total distance of 683.236 km at a cost of 19,441.98 Turkish liras. Our optimization resulted in a reduction in total traveled distance to 534.009 km, costing 14,568.58 Turkish lira, reflecting a 21.84% decrease in distance and a 25.06% decrease in cost for that day with 7 vehicles.



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Number of orders: 18
Number of vehicles: 16
Number of total demand: 134.0
Number of total capacity: 257
Total process time: 18002.972526073456

Vehicle 1, Driver: SERDAR KAŞITOĞLU, Capactiy: 18, Type: 0
Order 1, Name: 1525 - Carousel, Demand: 6.0, Distance: 61.904km
Order 2, Name: 1902 - Piyalepaşa AVM, Demand: 7.0, Distance: 17.465km
Order 3, Name: 1003 - Camlıca, Demand: 5.0, Distance: 15.384km
Vehicle Distance: 94.753km
Vehicle Cost: 2469.7697698338957

Vehicle 2, Driver: HARUN RENÇBER, Capactiy: 18, Type: 0
Order 1, Name: 1103 - Kağıthane Axis, Demand: 5.0, Distance: 55.245km
Order 2, Name: 1101 - Starcity, Demand: 9.0, Distance: 27.651km
Order 3, Name: 1005 - Forum İstanbul, Demand: 4.0, Distance: 16.567km
Vehicle Distance: 99.463km
Vehicle Cost: 2469.7697698338957

Vehicle 3, Driver: SALİM KAŞITOĞLU, Capactiy: 18, Type: 0
Order 1, Name: 1724 - Metropol, Demand: 6.0, Distance: 37.578km
Order 2, Name: 1202 - Canpark, Demand: 6.0, Distance: 8.004km
Vehicle Distance: 45.582km
Vehicle Cost: 1305.8645975510253

Vehicle 4, Driver: İBRAHİM RENÇBER, Capactiy: 18, Type: 0
Order 1, Name: 1810 - Çamsan Park AVM, Demand: 3.0, Distance: 37.499km
Order 2, Name: 1085 - Beylikdüzü, Demand: 15.0, Distance: 62.504km
Vehicle Distance: 100.003km
Vehicle Cost: 2273.7697698338957

Vehicle 7, Driver: RAMAZAN AKÇINAR , Capactiy: 15, Type: 0
Order 1, Name: 1914 - Yalova Vega, Demand: 7.0, Distance: 45.903km
Order 2, Name: 1512 - Yalova Star, Demand: 6.0, Distance: 2.57km
Vehicle Distance: 48.473km
Vehicle Cost: 2273.7697698338957

Vehicle 12, Driver: İLHAN GÜNEY , Capactiy: 19, Type: 0
Order 1, Name: 1821 - Tuzla Port, Demand: 6.0, Distance: 22.891km
Order 2, Name: 1725 - Brandium, Demand: 6.0, Distance: 28.456km
Order 3, Name: 1621-Atlaspark, Demand: 7.0, Distance: 12.695km
Vehicle Distance: 64.042km
Vehicle Cost: 1501.8645975510253

Vehicle 14, Driver: İSMAİL GÜNEY , Capactiy: 19, Type: 0
Order 1, Name: 1321 - Kadir Has, Demand: 7.0, Distance: 65.466km
Order 2, Name: 1611 - Viaport Venezia, Demand: 12.0, Distance: 16.227km
Vehicle Distance: 81.693km
Vehicle Cost: 2273.7697698338957

Total distance: 534.009km
Total cost: 14568.57804427153
Number of utilized vehicles: 7
Number of unutilized vehicles: 9
Avarage distance: 76.287km
Avarage cost: 2081.2254348959327
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Fig.4. *Analysis Report for Proposed Vehicle Routes*

CONCLUSION

The primary objective of this project was to develop a comprehensive Decision Support System (DSS) capable of identifying optimal routes that fulfill customer demands, adhere to specified time windows, and provide visual representations of these routes. The model was successfully implemented using the Gurobi optimizer, resulting in cost reductions and minimized total distance traveled. However, the heuristic algorithm was not completed, leading to its exclusion from the integrated DSS. Nevertheless, the project achieved its main goal of creating an efficient DSS solution that positively impacted cost efficiency and route optimization. Due to the lack of usable sample data, our test runs were limited by a few shipment dates. As a result of our testing we have reached a improvement of 15% to 25% cost reduction. In addition, we have observed reduction of 11% to 22% in total distance travelled. In an event of E-Bebek switcing to a distance based costing system, we have foreseen both of the parties (E-Bebek and logistics company) reaching a mutual improvement.

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