Optimization problem of the delivery of goods

E. Y. Rassadnilova[*], A. F. Valeeva[†], N. I. Yusupova[‡]

[*]Ufa State Aviation Technical University ,catiche89@mail.ru
[†]Ufa State Aviation Technical University , Aidavaleyeva@yandex.ru
[‡]Ufa State Aviation Technical University , Yusupova@ugatu.ac.ru

1 Introduction

Currently, companies produce the automated industrial management system, resources management system, transport management system, and these systems make it possible to reduce costs and improve the quality of work. As referred to in [4], optimization of transportation costs, computer technology use for solving the routing problems will save 5-20 % of transport costs.

2 Problem statement

We consider the problem of delivery of petrochemical product (reagent) to several Russian cities. The company buys disposable containers of parallelepiped shape or drums for the transportation of finish goods. Also, the company rents trucks of the same capacity to deliver the reagent to the destination company. Primary cargo units are to be formed and to be placed on pallets with deck and configuration for securing cargo. The company is interested in delivery of finish goods by the shortest route and in reduction of vehicle costs. Thus, the problem of delivery to consumers has the following optimality criteria:

Criterion 1: Choice of way and means of transportation

The optimal way of transportation may be by railway, highway, sea or river. Here, the more suitable means of transportation will be highway transportation, and in this case the available types of vehicles will be semitrailer tanks, high sided trucks, stream lined semitrailers. The type of the vehicle will be chosen according to the overall dimensions, technical characteristics of transportation, customers evaluation, and availability of vehicles in transport parks, renting or purchasing costs of trucks. The criteria for the optimal choice will be the minimal overall cost.

Criterion 2: Optimal route

It is required to find the minimum cost route to each of the cities-consumers of the reagent by taking into account the following restrictions: technological restrictions (cross-country ability, time waiting), economic restrictions (toll roads, the cost of gasoline in the region, the cost of food, housing in the region), social restrictions (crime rate, availability of hotels and cafete-rias).

Criterion 3: Choice of container type

It is required to select types of containers. We should take into account the specific technical requirements and state standard specifications for the carriage of flammable substances; available assortments according to consumer evaluations (see figure 1). This consumer evaluation includes such options as size, integrity, strength, quality of paint application layer, occurrence of rust, material quality, weight, color. Also we should choose the minimum cost containers and the maximum occupancy of the reagent when it is delivered to consumers.

Criterion 4: Exploitation of the loading space

It is required to find such an accommodation of the re-agent containers in the cargo bay vehicle so that it will minimize the free space in them.

3 Formal problem statement

Criterion 1: Choice of way and means of transportation. We have the cost of rental vehicle, cost of fuel per 1 liter, service payment for the driver, total cost of loading vehi-cles, cost of purchasing and shipping containers to the producer, the distance between cities (shown on maps of roads). It is necessary to select the type of trucks with which the cost of delivery is $Cost \to min$.

Criterion 2: Optimal route. It is assumed that highway transportation is used to deliver finish goods. To find the shortest route on the map of roads it is necessary to note all sorts of routes taking into account: impassible road, road (paths) with traffic jam, paid road in regions, the least gasoline coast in regions, high level of criminality on the road in regions, counties bordering on other regions. Currently, interactive maps of roads, online servers are used for finding the minimum cost routes. In this paper, the desired route of delivery was found by using search and mapping service information "Yandex", developed by Yandex Company. Since the interactive scheme of road junctions, indicating the routes exists only within Moscow and Moscow region, we should also highlight the desired area containing all the possible routes of delivery of the reagent to consumers, and these roads should be represented as a weighted graph routes $G' = (V', E')$, where V' - a set of all tops of the graph-cities, including et of tops cities through which the given route can pass, set of tops cities, where the reagent is produced , set of tops cities, where the required reagent is to be delivered (city-customer) , and E' - set of edges if a graph-parts of truck roads. Also preferred conditions known $(Y_1, ..., Y_5)$ - impassable road, road (paths) with traffic jam, paid road in regions, the least gasoline coast in regions, high level of criminality on the road in regions, counties bordering on other regions. It is necessary to transform the graph $G' = (V', E')$ into the graph $G'' = (V'', E'')$, taking into account these requirements, and then to find the route.

Criterion 3: Choice of containers type. Selecting the types of containers we should take into ac-count their consumers evaluation. It includes the follow-ing parameters: type of container (barrel, containers of parallelepipedic shapes), hermetic properties, quality of paint layer, rust, type of material, weight, color. Thus, we know N_{vol} - total quantity of different capacities types for the reagent transportation; N_{cust}- the quantity of the customers,$V = V_{par \cup V_{cyl}}$ - a set of capacities, where in consist into 2 subsets V , V_{par} - a set of parallelepipedicshape capacities, V_{cyl} - a set of cylindrical shape capacities and $CE_i\,(X_1, ..., X_7)$ - customers evaluation of i capacities ,$i = 1, ..., N_{vol}$. Lets introduce a number of definitions to indicate the customers evaluation $(X_1, ..., X_7)$ indicators of ca-pacity tightness, indicators of capacity the material qual-ity, indicators of capacity color, indicators of the rust availability, and indicators for assessment painted layer quality, capacity volume, and capacities weights. It is required to choose vessels with high customers evolution $CE_i\,(X_1, ..., X_7) \to max$. Moreover, it is necessary to select capacities with mini-mum price and maximum occupancy of the reagent (with the highest consumer evaluation). For this purpose, the following problem is proposed to solve: h_i- coast of i capacity,$i = 1, ..., N_{vol}$; w_i- weight of i capacities ; W_j- the required reagent quantity being loaded into vehicle for j customer,$j \in V_c$;$0 \le w_1 \le w_2 \le ... \le w_n \le W_j$. Lets find $\mu(x) = \sum_{i=1}^{N_{vol}} h_i * x_i \to min$ from the set of vectors $x = (x_1, ..., x_{N_{vol}})$, where x_i - quantity of capacities to be loaded into vehicles, satisfying the conditions:

1. $x_i \ge 0$, integral, $x = (x_1, ..., x_{N_{vol}}$, ;
2. $\sum_{i=1}^{N_{vol}} w_i * x_i \le W_j, j \in V_c$

4 Methods of solution

The algorithm Opt_Route is proposed for finding the preferred route. The algorithm is based on the following idea: firstly we construct a graph of routes , which excludes the edges with impassable road sections, further the transformed graph is constructed, then the method Keeney-Raffia is used [1], which allows to select the edges satisfying conditions on preferences $(Y_1, ..., Y_5)$. And the shortest route is searched in the transformed

graph using Dijkstra algorithm [3]. The Algorithm Ch_Cap is proposed for selecting the types of containers to transport the finish goods. This algorithm is based on the following algorithms: first, we search capacities satisfying the required criteria $(X_1, ..., X_7)$, compile the ranking system, and choose capacities with the highest consumer evaluation. Then, we select capacities with minimum price and maximum occupancy of the reagent by using the method of dynamic programming. The selected containers should be placed in the minimum number of trucks. Evolutionary algorithms and swarms hiperheuristic are used for this purpose [2, 4].

References

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