Decision-Making Support System for Light Petroleum Products Traffic and Transport Management

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Abstract - In this paper the decision-making support system for large scale transport management is presented.

Keywords - logistics, vehicle routing problem, combinatorial optimization, GIS system.

I. INTRODUCTION

The problem to manage distribution process for light petroleum products for large gas station network is considered in the paper. The network is seemed to be the largest one in the South-East Ukraine. The network consists of an oil refinery, 15 petroleum depots, and more than 300 gas stations, and a certain amount of gas tank trucks of different kinds and storage capacities. The bottleneck to organize the process is to deliver petroleum products to the gas stations from the depots in order to ensure the regular functioning of the gas stations.

II. MATHEMATICAL MODEL AND SYSTEM DESCRIPTION

The network expansion leads to inevitable mistakes if the decisions are based on dispatchers experience only. There are three possible kind of dispatchers’ mistake. The first one causes gas station suspension of work due to lack of fuel. The second one leads to the tank truck stands idle at the gas station because of lack of free volume to drain whole tank truck. The last one lays in non-optimal trucks routes with respect to routes lengths and transport charges.

The designed decision-making support system consists of two main parts. The first part deals with fuels sales forecasting for each gas station in order to obtain reliable estimation of gas station suspension time. The second part charged with tank trucks optimal scheduling and routing.

Prediction algorithms used in the first part are based on the information about fuel remains collected from gas stations every two hours. The system was connected to Automatic Data Acquisition system installed in the network. It allows gathering fuel sale time series for each gas station and for each kind of fuel. Time series characteristics occur to be essentially different that depends on the gas stations locations and their social environment. The data inhomogeneity demands general algorithm to predict time series of different nature. The modified ARIMA model possesses sufficient generality to provide prediction quality good enough to make operational decision for overwhelming majority of the cases. The estimated suspension times for all gas stations result from used prediction model.

Information used in the second part includes route graph, gas stations and petroleum depots geographical coordinates, tank trucks and gas stations capacities. The system provides with on-the-fly information for each gas station of the network.

The gas stations and petroleum depots geographical coordinates were obtained using GPS tracker installed on tank trucks of the network. The other vertices of the route graph were obtained from Open Street Map database. The edges meet demands of the Ukrainian traffic police regulation rules for dangerous cargo transportation. The graph has clear cluster structure and therefore we proposed to modify Floyd-Warshall algorithm to take into account the graph topology. It results in fast calculation of the distance matrix between all pairs of the gas stations (petroleum depots) to analyze. The distance matrix is asymmetric due to the roads with one-way movement.

From the mathematical standpoint the process of decision-making to establish priorities of the gas station deliveries is the multiobjective optimization problem. The first criterion is to put off the minimal suspension time as far as possible. The second one lies in total transportation costs minimization. The problem has many constraints, among which are the number of available tank trucks and number of trips for each truck per day, maximal route length, maximal number of gas stations per one route. Also the tank truck movement between gas stations in its route could be carried out only in accordance with a set of predefined patterns of empty and filled tanks determined by vehicle technical features. To improve the decision quality the system considers route times of the tank trucks.

The Pareto set is constructed for the above-mentioned criteria. To select appropriate decisions from the Pareto set the system takes advantage of the expert rules that generalize the dispatcher group experience. Then the first criterion was considered to be the main one, while the second one was transformed into the additional constraint. One should stress that even for the single-objective optimization problem the greedy solution sometimes leads to constraint violation (certain gas station suspension).

The system also allows solving some inverse problems. For example an estimation of the time period one should wait for the tank truck is able to be drained in the predefined gas station.

III. CONCLUSION

The designed system has been implemented in order to improve the decision-making of the network dispatcher group. The system demonstrates stable operation and decrease the total gas station suspension time period to zero. The system demonstrates good scalability characteristics potentially up to whole country. The elaborated principles could be used as a design pattern for other logistic systems.