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INTELLIGENT SYSTEM FOR SCHEDULING TRANSPORTATION WITHIN GAS STATIONS NETWORK

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ABSTRACT

The poster describes deployment experience of a decision support system for planning fuel supplies within a network of gas stations, which is based on simulation, multi-agent and expert modeling. Authors focus on various methods used in decision support system BPsim.DSS. Mainly the system is used by logistical management and planning departments. The system implement such features as forecasting next day fuel sales, searching for effective fuel supply plan, planning trips for each fuel tanker. Simulation model estimates fuel sales. Planning is implemented in BPsim.MSN on the basis of logical output visual machine, based on UML diagrams and T-SQL language scripts. Testing results prove effectiveness of decisions: sales volume can be increased by optimizing usage of fuel tankers.

1 INTRODUCTION

Transportation planning is based on scheduling theory and transportation graphs, built upon systematization of contracts, available orders, and study of cargo flows. Schedules and graphs must provide 1. satisfaction of requirements of the maximum number of transportation customers; 2. minimization of time costs for transportation; 3. regularity of transportation; 4. maximization of gas sales within gas stations network; 5. effective use of fuel tankers; 6. interconnection with graphs and schedules of different transport types (e.g., railroad); 7. minimization of empty vehicle runs.

2 REQUIREMENTS FOR INTELLIGENT PLANNING SYSTEM

General problem of fuel distribution within a network of gas stations consists of defining a set of structures $S_i = \langle R_i, F_i, T_i \rangle$ before the beginning of working shift. Here R_i is a route for *i*-th transportation, F_i – fuel tanker on *i*-th transportation, T_i – terms of start and end of *i*-th transportation, effective on the total costs criteria on the *i*-th transportation $C_i = \sum C_{ij}$, where C_{i1} – cost of fuel transportation on the route R_i; C_{i2} – volume of missed profit during filling of station tank; C_{i3} – fuel costs for the fuel tanker F_i and other costs of *i*-th transportation. Rational design of transportation system is based on elements of linear programming, scheduling theory, simulation, multi-agent, and expert modeling. In order to compile an effective transportation plan authors offer the method of sequential improvement of initial transportation scheme, based on linear programming theory and simulation model of fuel tankers operation. The method consists of the following stages: 1. Generation of information structures, corresponding to orders from gas stations, which is in turn based on the current fill ratio of station fuel tanks; 2. Defining supplier and delivery route for each order; 3. Assignment of a fuel tanker to each order, determination of terms for delivery; 4. Manual correction of the plan by an expert; 5. Checking and correction of the plan on the simulation model. The proposed method of combined order distributing between suppliers and fuel tankers allows a complete solution for designing transportation plan. The method also provides capability to select the most applicable option of fuel tankers assignment, and redesign the scheme in case of emergencies.

3 SOFTWARE IMPLEMENTATION AND APPLICATION OF PLANNING SYSTEM

Decision support system is implemented on the basis of BPsim.DSS software suite (Aksyonov, Sholina and Sufrygina 2009; Aksyonov 2011). BPsim.DSS targets modeling complex business systems. Architecture of BPsim.DSS relies on the principles of three-tier hierarchical architecture InteRRaP (Muller and Pischel 1993). Interaction of intelligent system modules is presented on Figure 1.

At present the intelligent planning system is under development. It is going to be deployed at logistical department of gas supplying company, located in Ekaterinburg, Russia, a major city in authors' area. The gas stations network of the supplier consists of 24 gas stations.

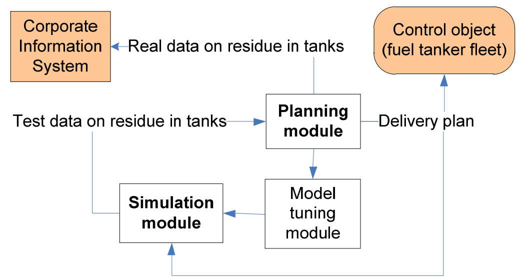

Fig. 1. Interaction of planning system modules

In order to improve speed of simulation models, including intelligent agents, the production knowledge base rules were separated into 2 types: 1. *Global condition* rules, and 2. General rules. If an intelligent agent contains both rule types, then the global conditions are checked in the first place, and in case a condition is fulfilled, the full knowledge base scan is started (including general rules). If global rules are not contained within an agent, then the search is carried out on the whole knowledge base. Such separation of rules into two times allowed great improvement in speed (approximately 5 times faster). Initially a logistics specialist sets initial values. They include date of the plan, fuel tankers shift start time, distribution strategy for various fuel types. Initial data also includes residues at gas stations and technical condition of tanker fleet. After finish of algorithm operation, users have an opportunity to modify the plan. Next the plan is exported into simulation module and is corrected depending on simulation results. Simulation model also monitors residues on each gas station and fuel usage dynamics.

4 CONCLUSION

The problem of deliveries to a network of gas stations and its software implementation is solved with aid of hybrid approach, with application of linear programming method (modified transport algorithm), heuristic planning algorithm and multi-agent simulation modeling.

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