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CARGO TRANSPORTATION ROUTING UNDER FUZZY CONDITIONS

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Abstract- In the present paper the problem of cargo transportation routing under fuzzy conditions is solved. In general, the solution of this problem is related with great difficulties resulted from necessity of taking into account a lot of uncertain factors. Uncertainty, in turn, is conditioned by impossibility of obtaining credible information and impossibility of formalizing a series of factors.

Keywords: Route, Transportation Routing, Fuzzy Set, Fuzzy Rules.

I. INTRODUCTION

The operation of cargo motor transport is carried out under the paths specified in advance. Therefore the rational paths should be planned carefully to achieve maximal size of transportations. The routing of transportations is such composition of transportation paths among corresponding enterprises - suppliers and customers. In general, the routing problem is formulated as follows. Given the location of suppliers, customers, transportation enterprises, characteristics of the transportation network and driving conditions, it must be determined the value of some function satisfying certain criteria [2].

The planning of transportations is mainly based on the experience of a dispatcher group, which presently is not able to solve this problem as required because of increasing number of quantities and complicating the conditions of transportation. An increase in the efficiency of the use of auto-transportation units is reached improving the organization of transportations by using mathematical methods.

Various criteria are used for routing freight traffic. Main criterion of efficiency of routing is the economic criterion. Eventually, the quality of routing consists in obtaining a maximal efficiency. With other things being equal the outcome depends on quality of the routine schedule and technology of the paths, as well as on exactness of its accomplishment. Thus the most universal quality index of routing is its efficiency, which is expressed by saving money resources or reducing the usage time [4].

It follows from the carried out analysis of the routing technology that for an increase in efficiency, it is necessary to provide automation of loading and unloading. These measures are essential to efficiency of the paths.

The factors increasing the efficiency of the transportation process are [5]:

- correct choice of transport means, taking into account features of a transported cargo and providing high dynamic qualities;
- rational allocation of transport means on the paths;
- minimization of the latency in both loading and unloading;
- knowledge of productivity of transport means.

Here it is necessary to take into consideration not a multiplicity of operating time on the path, i.e. the amount of driving time is rounded off up to an integer. Then the value of the overtime or under-fulfillment in relation to a given operating time on the path is calculated.

The execution of this task in general form is very difficult, as it is necessary to take into consideration set of the factors having a random variable, which are to some extent uncertainty due to an impossibility to obtain the information with a necessary degree of reliability, impossibility of formalization of many factors: essential role of the drivers in execution of the transportation process etc.

The formalization of the uncertainties will serve as a resource for an increase of adequacy of calculations of operation of transport means.

II. PROBLEM STATEMENT

The persons making decision on motor transport frequently come across the task of allocation of vehicles of different weight-lifting ability on the paths of various expansions. In the beginning it is necessary to choose alternative transport means which best fit the characteristics of a transported cargo and conditions of transportations, which would enable to develop the optimal strategy of transportations. The transportations with minimum material and labor expenditures require also keeping appropriate quality metrics, which should be thoroughly inspected.

Solution of the task can be two variants of allocation, A and B:

- At variant A, transport means with the greater weight-lifting ability is routed on the path with greater length of a turnover, and transport means with smaller weight-lifting ability on the path with smaller length of a turnover;

- At variant B, transport means with the greater weight-lifting ability is routed on the path with smaller length of a turnover, and transport means with smaller weight-lifting ability on the path with greater length of a turnover.

Therefore, the framing transport means for T of clocks on size of a transported cargo under the paths can be presented by the equations (1) and (2), and on executable transport operation by the equations (3) and (4).

$$\frac{T_M q_{H_1}\gamma_{c_1}}{\frac{l_{o_1}}{v_{t_1}}+t_{n-p_1}}+\frac{T_M q_{H_2}\gamma_{c_2}}{\frac{l_{o_2}}{v_{t_2}}+t_{n-p_2}}=A_Q \quad (1)$$

$$\frac{T_M q_{H_1}\gamma_{c_1}}{\frac{l_{o_2}}{v_{t_1}}+t_{n-p_1}}+\frac{T_M q_{H_2}\gamma_{c_2}}{\frac{l_{o_1}}{v_{t_2}}+t_{n-p_2}}=B_Q \quad (2)$$

$$\frac{T_M q_{H_1}\gamma_{c_1}l_{o_1}}{\frac{l_{o_1}}{v_{t_1}}+t_{n-p_1}}+\frac{T_M q_{H_2}\gamma_{c_2}l_{o_2}}{\frac{l_{o_2}}{v_{t_2}}+t_{n-p_2}}=A_P \quad (3)$$

$$\frac{T_M q_{H_1}\gamma_{c_1}l_{o_2}}{\frac{l_{o_2}}{v_{t_1}}+t_{n-p_1}}+\frac{T_M q_{H_2}\gamma_{c_2}l_{o_1}}{\frac{l_{o_1}}{v_{t_2}}+t_{n-p_2}}=B_P \quad (4)$$

It is necessary to mark, that unambiguously it is not possible to spot preferable variant. It is necessary to compare relations (1) and (2) to usage of various criteria. Matching of variants we shall carry out by criteria of framing transport means: on size of transportations (1) and (2) and fulfilled transport operations (3) and (4).

After simple algebraic conversions of expression of compared variants it is possible to present as follows.
On size of transportations:

$$\frac{q_{H_1}v_{t_1}}{q_{H_2}v_{t_1}} * \frac{(l_{o_1}+v_{t_1}t_{n-p_1})(l_{o_2}+v_{t_1}t_{n-p_1})}{(l_{o_1}+v_{t_2}t_{n-p_2})(l_{o_2}+v_{t_2}t_{n-p_2})} \quad (5)$$

On the fulfilled transport operation:

$$\frac{q_{H_1}t_{n-p_1}v_{t_1}^2}{q_{H_2}t_{n-p_2}v_{t_2}^2} * \frac{(l_{o_1}+v_{t_1}t_{n-p_1})(l_{o_2}+v_{t_1}t_{n-p_1})}{(l_{o_1}+v_{t_2}t_{n-p_2})(l_{o_2}+v_{t_2}t_{n-p_2})} \quad (6)$$

Under condition of:
$q_{H_1}v_{t_1}=K_1$, $q_{H_2}v_{t_2}=K_2$, $v_{t_1}t_{n-p_1}=K_3$, $v_{t_2}t_{n-p_2}=K_4$

$$\frac{K_1}{K_2} * \frac{(l_{o_1}+K_3)(l_{o_2}+K_3)}{(l_{o_1}+K_4)(l_{o_2}+K_4)} \quad (7)$$

$$\frac{K_1K_3}{K_2K_4} * \frac{(l_{o_1}+K_3)(l_{o_2}+K_3)}{(l_{o_1}+K_4)(l_{o_2}+K_4)} \quad (8)$$

where the sign * depending on outcomes of matching can accept value >, =, <. From expressions (5) and (6), it is impossible to place, what sign bridges its left and right parts. Let's reduce expressions (5) and (6) in sort (7) and (8).

From the analysis of expressions (7) and (8) follows, that if the left part is more right, the preference should be returned to variant A, otherwise preference should be returned to variant B.

At matching variants the professor S.R. Laydermann [3] has tried to prove validity of a principle of allocation transport means of major weight-lifting ability on far paths, and on the short paths transport means of small weight-lifting ability. However this principle has appeared not proved.

The solution of the following practical task, Carried out by the author, allocation transport means of two types with load-carrying capacities q_{H_1} and q_{H_2}, under two paths with length of a turnover l_{o_1} and l_{o_2}, at a given operating time on the path T_M, technical speeds v_{t_1} and v_{t_2}, execution time of loading and unloading operations t_{n-p_1} and t_{n-p_2}, and also keeping of conditions between metrics transport means by framing in sizes of transportations of cargoes and execution of transport operations has allowed to test the statement of the professor S.R. Laydermann.

At transportations of a concrete cargo on the given path selected transport means as indistinct parameters exhibits itself: technical traveling speed, time of shipment - unloading, cooperative latency of shipment - unloading and idle times on the path for technical reasons. Remaining metrics which are included in criterion of choice of optimal variant of allocation transport means on the paths with the purpose of reaching of maximal size of transportations: rated weight-lifting ability, a capacity factor of rated weight-lifting ability, capacity factor of run, zero run, and duration of operation for day will have fixed value.

Let's consider the following task of routing. Let there are two types transport means and two paths. The weight-lifting ability transport means first is less than weight-lifting ability second transport means. The expansion of a turnover on the first path is less than length of a turnover, i.e. it is required so to arrange transport means under the paths, that the cooperative framing transport means on the paths for fixed time would be maximal.

The existing principle of routing, at which allocation transport means with major weight-lifting ability on the paths with the greater expansion, and on the paths with a small expansion transport means with smaller weight-lifting ability is fair partly. There is a set of situations, when it is impossible to be guided by this principle.

At transportations of a concrete cargo, on the given path selected transport means as indistinct parameters exhibits itself: technical traveling speed, time of shipment - unloading and idle times on the path for technical reasons. The carried out researches on detection of quantitative influence of the various factors on a level of traveling speed have shown, that any of known computational methods of average speed on the path cannot be recommended for practical usage.

Therefore, the definition of framing transport means is to some extent bound to uncertainty stipulated: by impossibility of obtaining of the information of a necessary degree of reliability, impossibility of formalizing of a number of the factors. Thus, the substantial intervals of change of technical speed and execution time of cargo handling operations transport means substantially are indistinct, that makes the impossible determined mathematical interpretation of metrics.

Subjectivity of thinking and degree of approximation of character of conclusions owing to illegibility of the description of separate units of the process essentially influence quality of accepted solutions. On the other hand usage traditional, even of the detailed models and algorithms at solution of this problem do not give of considerable positive takes. And the heuristic rules used by managers, despite of adequacy to substantial conditions of transportations, cannot guarantee a mathematical optimality.

By virtue of it the set task is solved with application of a method basing the concept of indistinct sets *L*. Back and permitting to take into account such difficultly is formalizable factors, as experience and intuition, i.e. knowledge of the manager.

III. METHOD OF SOLUTION

The development and practical usage of a method oriented on reaching of high finite outcomes with wide application of the computer, is one of the most actual tasks of development and rise of efficiency of motor transport.

Main problem at definition and analysis of routing, under effect of the various factors is the reconstruction with the help of the computer of reasonable reasoning summing decision making by the man at the inexact and a critical environment. For solution of a considered problem the model is constructed, on the basis of the indistinct system mapping dependence between variables.

By metrics and framing transport means. The idea of simulation consists, in replacement of mathematical dependence between framing of the automobile and parameters defining *e*, quality ratios expressed in the terms of linguistic rules. The linguistic odd model of framing transport means has 6 inlets and two outputs.

On the basis of learning the transportation process, for is concrete of a given cargo, install among alternate variants transport mean rational. For considered linguistic variables the appropriate indistinct sets *M* with the carrier, particular are created on the basis of learning expert estimations. Thus, under carriers of odd set understand, set X^*, such, that $X^* = \{x/mm(x) > 0, x € X^*\}$. The results of the given stage of simulation are represented in Table 1.

At the following stage [1], the set of rules circumscribing dependence of framing of the automobile from the various factors is created. Rule look like: If A=N, B=M with the help of the constructed model and generated set of rules. The considered problem of routing was solved. For formalizing and processing of the similar information fuzzy set theory will be utilized which allows refusing excessive accuracy intrinsic traditional approaches, to build-up of models at saving reasonable strictness.

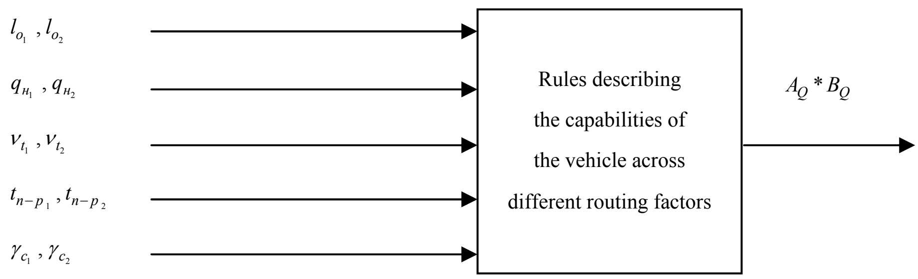

Figure 1. Vehicle capabilities across different routing factors

Table 1. Simulation results

No	Name of linguistic variable	Fuzzy terms and their supports		
1	Nominal cargo-lifting ability	Small (S)	Average (A)	Big (B)
		5-10	10-20	20-40
2	Static coefficient of usage of cargo-lifting ability	Small (S)	Average (A)	Big (B)
		0.4-0.6	0.6-0.8	0.8-1.0
3	Distance of transportation	Small (S)	Average (A)	Big (B)
		1-10	10-30	30-50
4	Technical speed	Low (L)	Average (A)	High (H)
		10-20	20-30	30-50
5	Time of loading/unloading	Below norm	Norm	Above norm
		0.2-0.4	0.4-0.8	0.8-1.2
6	Transportation volume in tons	Small (S)	Average (A)	Big (B)
		45-100	100-150	150-230

IV. RESULTS

The computer simulation, carried out by us, has confirmed not a competence of the statement about expediency of application transport means of major weight-lifting ability on the paths major, and small weight-lifting ability on the paths of a small expansion in all cases (Figures 2 and 3). From the obtained outcomes follows, that this statement corresponds (meets) to a reality only at 23% variants. At 17% the equality of compared variants is observed, and at 41% transport means the major weight-lifting ability should route on the paths with a small expansion.

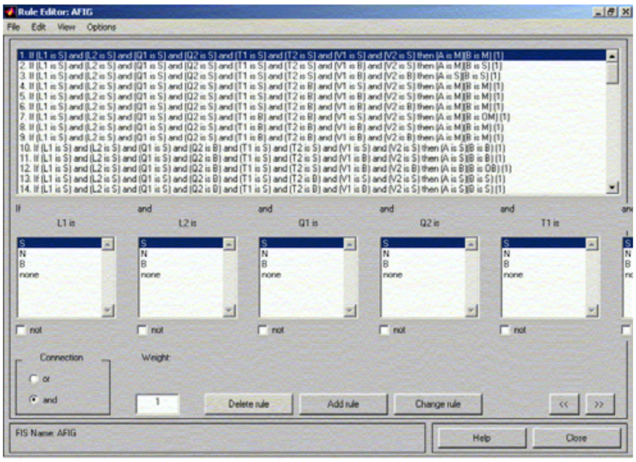

Figure 2. Fuzzy "if-then" rules

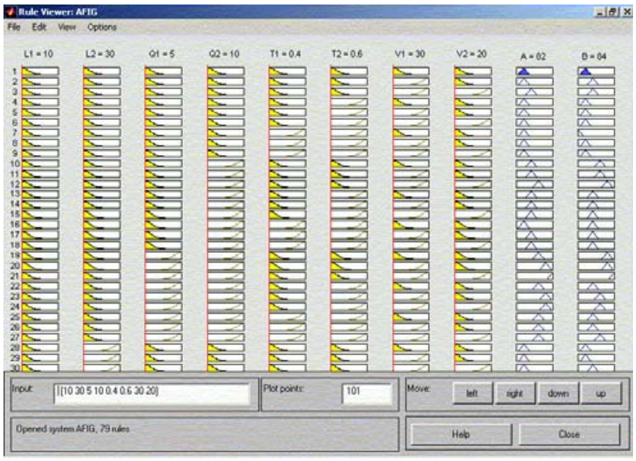

Figure 3. Computations with the fuzzy rule base

V. CONCLUSIONS

Efficient solving of transportation routing problem on the base of a traffic team experience is impossible due to increasing amount of transportation, its complicated conditions and uncertainties.

Increasing of efficiency of vehicles use can be achieved by improvement of transportation organization through application of mathematical methods for problem solving. The main problem in determination and analysis of routing taking into account various factors is computer-based reconstruction of reasonable judgments which aggregate human decision making in imprecise and uncertain environment.

The developed and practically realized method of formalization of uncertainties is oriented on achievement high final results. The method serves for increasing adequacy of computations of operation to real conditions of functioning of vehicles which is one of the most actual problems of development of efficiency of motor transport.

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BIOGRAPHY

Afiq (Allahverdi oglu) Allahverdiyev was born in Azerbaijan, 1937. He received the M.Sc. degree in the field of Operation Road Transport as Mechanical Engineer from Azerbaijan Polytechnic Institute (Baku, Azerbaijan) in 1960. He graduated to Ph.D. degree in automation of experimental research from Faculty Specials Retraining for New, Promising Areas of Science and Technology at the Moscow Automobile and Road Institute, Russian Academy of Sciences (Moscow, Russia) in 1985. Currently, he is the Associate Professor in the field of organization of road transport and road safety in Azerbaijan Technical University (Baku, Azerbaijan). He has authored 150 scientific papers. His research interests are in road transport of articles large-panel management, developing methods and models optimization in road transport logistics, and automation and process control and production.