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DEVELOPMENT OF SPECIALIZED MODELS OF URBAN PASSENGER TRANSPORTATION

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Abstract. Peculiarities of transport services for the transportation of passengers, which must be taken into account when creating logistics models for organizing and managing passenger flows, are considered. Need of cost reduction of time of passengers for transport service is proved. The conclusion is drawn on need of the effective transport system creation, for the purpose of observance of intervals of the movement of buses on routes. The possibility of use of architectural approximations classes for the solution of transport logistics problems is analysed. The methods used for solving transport problems where the most widespread is modeling and algorithmization of the determined task formulation strategy with use of a classical algorithm of mathematical programming are considered. The prospects of a meta-heuristic method use is a genetic algorithm for the solution of tasks of the control of city passenger transport adapted to objective conditions are proved. The main features of genetic algorithms consisting in an opportunity by optimization to use criterion function and to consider the necessary number of restrictions are defined. The structure of a chromosome which represents the coded option of the movement of the bus in real time depending on a road situation is received.

Statement of problem. In strategic programs of the transport systems development of any city, special attention is paid to management of traffic flows, increase in capacity of a street road network and safety of the movement. At the same time the urban passenger transport (CPT) is always one of the main components of transport infrastructure and has significant effect on social stability [1]. It is known that a main type of GPT is bus transport which is capable to provide most necessary mobility of citizens and therefore improvement of the organization of its work has priority value.

Basic provisions on control of passenger transport and improvement of its functioning with use of logistic technologies were considered by many authors [3, 4, 5, 7].

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The theoretical bases of organizational economic activity of the passenger motor transportation enterprises (ATP) concerning ensuring the uninterrupted and safe movement of buses along all routes are investigated in works of domestic and foreign experts [1, 4, 6].

It is known that transport transportation services of passengers have a number of features, at the same time they are influenced by a set of various and often uncontrollable factors which need to be considered at creation of logistic models of the organization and management of passenger flows [8]. At the same time it is necessary to unite separate elements of transportation process in the uniform system capable to provide high-quality services to the population at the minimum expenses. A basis of logistic approach in relation to passenger transport is identification of the shortest communications between the main passenger created points, accounting of volumes of passenger traffics and requirements of comfortable journey when choosing type and calculating required number of vehicles [5].

Analysis of the main achievements and publications. The extensive analysis of publications [1, 4, 5, 8, 9] and the accumulated experience of the advanced passenger motor transportation enterprises suggests what remains so far insufficiently studied a problem of public passenger transport logistic service improvement taking into account specifics of technical and operational and economic indicators of ATP of all forms of ownership. It is necessary to emphasize that special attention at the solution of tasks of management of urban passenger traffic has to be paid to issues of cost reduction of time of passengers for transport service and consequently, observance of the schedule of buses on routes.

Allocation of unresolved parts of common problem. Despite the increasing number of studies on this subject, problems of control and management of urban passenger transport, especially in megalopolises, are insufficiently covered in scientific literature; besides, questions of formation of flows of passengers on stops and ways of impact of the passenger enterprises on losses from the services which are not provided in time are practically not considered in it [4, 9].

The purpose of this research is creation of passenger transport and the urban infrastructure work logistic model allowing to establish functional connection between the main passazhiroobrazuyushchy points. A necessary operating condition of model is the equipment of these points the corresponding constructions for accounting of volumes of passenger traffics and requirements of comfortable journey when calculating necessary quantity and choosing the rolling stock.

Statement of the main material of probe.

On the basis of Rostov-on-Don Trasservice trucking company-3 rolling stock functioning studying problems the main stages of creation of transportations management model in the conditions of unstable passenger traffics are allocated:

– selection of criteria for evaluating the performance of the trucking company;
– creation of logistic model of urban passenger traffic;
– the choice of mathematical methods for the solution of objectives;
– formation of basic data of an optimizing task;
– designing of control algorithms;
– calculation of model;
– realization of model and analysis of results;
– adjustment of the entering parameters and the choice of option of optimum performance of a system.

On the basis of the performed analysis the conclusion is drawn that on trucking company an effective functional system should be created which demands a certain material, technological, financial and information support [7]. At the same time, indicators of passenger traffic system efficiency of each participant have to be considered, while they often are contradictory. For example, reduction of waiting time of passengers is evidently connected with increase in number of the rolling stock on a route and consequently, with decrease in its load and an economic benefit from use [11]. But the aspiration to increase profit the transport organizations can lead to refusal of the population of services of carrier and emergence of the competing organizations.

The development of specialized models of urban passenger traffic even on individual routes is a complex process, and therefore they are used in practice, which allows us to answer the question of what will be the characteristics of the simulated system if the initial parameters acquire the planned values.

In the existing models such descriptions are carried out at the production and technological level in the integrated indicators [7, 11]. Need of development of more high-class models which not only describe process of transportation and separate stages of its organization is explained by it, but also reflect relationship of cause and effect between characteristics of process and output parameters.

The choice of a numerical method of the solution of management assumes realization optimization problem of the following stages:
– choice of the solution method of the differential equations, and/or functions integration;
– justification of a method of the solution of optimization the nonlinear algebraic equations and problem systems;
– drawing up simulation or mathematical model.

Application of the differential equations demands for all numerical methods of optimum control. In indirect approach numerical solutions of the differential equations are combined with methods of the nonlinear equations, and in direct – with methods of the solution of nonlinear problems of optimization.

The algorithms offered [3, 5, 6] for the solution of resources on transport dynamic distribution are reformulation major problems of the dynamic equations of programming in terms of "a condition of the after solution". They assume statement of approximations and algorithms of execution which correspond to architecture of approach to criterion function – minimization of costs for transportation.

Two classes of architecture of approximations were successfully used for the solution of various problems of transport logistics:

– linear architecture:

$$\bar{V}^x\ R_t, v_t\ = \Sigma_{a \in A} v_{ta};$$

– concave (nonlinear) architecture:

$$\bar{V}^x\ R_t, v_t\ = \Sigma_{a \in A}\ \Sigma_{i=1}^{|R_{ta}|} v_{tai} + R_{ta} - |R_{ta}| v_{taR_{ta}}\ .$$

Proceeding from it, linear approximations provide advantages in relation to algorithms of the corresponding parameters calculation. Linear approximations, as a rule, should be used at the initial stage of implementation of difficult strategy, but sometimes they can badly work. In such cases it is necessary to pass to more difficult architecture and approximation algorithms [6].

For a solution of transport and logistics problems the most widespread is modeling and algorithmization of strategy of formulation of the determined task with the subsequent use of a classical algorithm of mathematical programming. The determined tasks differ in big expenses of time for development of linear integer models which can be effectively solved. Besides, they completely ignore uncertainty and difficult dynamics which arise in actual practice.

The most widespread approach to a solution of the problem of modeling of distribution of resources in practice is setting of the determined task and application of the mathematical algorithms of programming developed for the selected parameter.

Dynamic problems of distribution of resources, as a rule, result in high dimension of a stochastic dynamic programming. There are approximation algorithms which were successfully applied in applications to transport and logistics [6]. They are constructed on several key ideas which solve dimension problems. Among these ideas: reformulation of classical problems of a dynamic programming around a variable recursion, in a status of acceptance of "after solution"; modeling on the basis of methods of stochastic approximation and continuous approximations of architecture of functional forms which facilitate software solutions for optimization of a solution of subtasks [6].

The analysis of methods of a solution of tasks of control of urban passenger transport showed that the most perspective are metaheuristic methods, to be exact genetic algorithms [5, 6]. The main feature which an opportunity is by optimization, first, to use target function, but not its estimates or approximations, and secondly, to consider the necessary number of restrictions and an unlimited number of parameters of a system.

Application of the genetic algorithm (GA) allows to receive a set of the solutions satisfying possible variations to target function and restrictions of model.
Process optimization of dynamically changing passenger traffics assumes use mastering of this method adapted to objective conditions. At the same time consideration of concepts of a chromosome, gene, population and operators of random changes assumes designing of an algorithm [6].

The coded way of solving the task represents a chromosome and consists of solution elements – genes. The set of such candidate solutions makes population. For designing of chromosomes there are different approaches, however the most effective is the following [3, 5, 6].

The first – is used when the solution has an appearance of set of the elements accepting values in continuous area. In that case to each element the gene presenting it in the binary form is put in compliance. For the purpose of reduction of length of a gene the solution can be coded.

It is reasonable to apply the second approach in case of a discrete solution for which the state space can be described in a binary look [6]. Then length of a chromosome corresponds to dimension of the state space of a system in a binary look.

It is revealed that for a solution of the considered task it is reasonable to use the second approach and consequently it is necessary to execute designing of genes for everyone, entered into model Boolean variable (x_{ij}, y_j, z_j, ...). These genes, according to the accepted approach, should have dimension of the corresponding variables. In this case use of such approach will lead to obtaining a large number of the discarded solutions received as a result of execution of operators of random changes as there are restrictions for the number of "units" in one gene. So, according to these restrictions the gene of □i, j may contain one unit in any j-y of position (0001000).

The chromosome A consists of (m+2) of a gene:

$$A = \alpha_1, \alpha_2, \ldots, \alpha_j, \ldots, \alpha_m, \beta, \gamma \ ,$$

where genes of α_i represent the vectors defining time intervals between stopping points, $\alpha_i = bin\ j^i$, here j^i – conditional number of time intervals of passing of a route, $x_{ij} = 1$. The *bin* function carries out conversion of an argument to binary form. Thus, the gene of α_i has an appearance $\alpha_i = \alpha_{i1}, \alpha_{i2}, \dots, \alpha_{it}, \dots, \alpha_{iq}$, $i = \overline{1,k}$, where q – the number of bits necessary for binary representation of number n time intervals: $q = \log_2 n$ rounding of a fractional part is made to the next bigger whole.

The gene of β defines $\beta = z_1, z_2, \dots, z_j, \dots, z_n$; gene $\alpha = \alpha^1, \alpha^2$ bears information on the number of runs; the gene bears information on a bus *v*-go start of motion in minutes for *N*-y run $v = \overline{1,z}$, where z – the number of the rolling stock on the line in time in a dress; in a gene $\delta^v = \delta_1^{v,N}, \delta_u^{v,N}, \dots, \delta_h^{v,N}$ start time of the movement *v*-go of the bus in minutes for *N*-y run is coded $v = \overline{1,z}$.

Genes

$$\gamma_{1,2}^{v,N} = {}^{l}\gamma_{1,2,1}^{v,N}, {}^{l}\gamma_{1,2,2}^{v,N}, {}^{l}\gamma_{1,2,3}^{v,N}, \dots,$$

$$\gamma_{j,i+1}^{v,N} = {}^{l}\gamma_{j,i+1,1}^{v,N}, {}^{l}\gamma_{j,i+1,2}^{v,N}, {}^{l}\gamma_{j,i+1,3}^{v,N}, \dots,$$

$$\gamma_{k-1,k}^{v,N} = {}^{l}\gamma_{k-1,k,1}^{v,N}, {}^{l}\gamma_{k-1,k,2}^{v,N}, {}^{l}\gamma_{k-1,k,3}^{v,N}$$

act as vectors of separate stages passing time intervals on a v-m route as the run *N*-go bus where $i = \overline{1,k}$.

The gene $\mu^v = \mu_1^{v,N}, \mu_2^{v,N}, \dots, \mu_i^{v,N}, \dots, \mu_k^{v,N}$ sets the place of the bus *v*-go motion start, $v = \overline{1,z}$.

Comparison of chromosomes is carried out as follows: from the analyzed population of $P = A_1, \dots, A_t, \dots, A_z$ the best A_i chromosome with the smallest value of violation of restrictions $\Delta(A_i)$, is considered, and among chromosomes with equal violation of restrictions the chromosome with the greatest value of target function $F(A_i)$.is selected.

For determination of value of violation of restrictions of$\Delta(A_i)$ the following variables are entered:

$$d_1 = \left(\max\left(0, \left(z_j y_j \sum_{i=1}^{m} \sum_{k=1}^{m} x_{ij} \lambda_{ik} - P^{hub,j} \right) \right) \right)^2 ;$$

$$d_2 = \sum_{i=1}^{m}\left(\max\left(0,\left(\bar{y}_j z_j \sum_{k=1}^{m} x_{ij}\lambda_{ik} - P^{sw}\right)\right)\right)^2;$$

$$d_3 = \sum_{i=1}^{m}\left(\max\left(0,\bar{y}_j z_j\left(\sum_{i=1}^{m}\sum_{k=1}^{m} x_{ij}\lambda_{ik} - \sum_{i=1}^{m}\sum_{k=1}^{m} x_{ij}\lambda_{ik}\right) - P^{sw}_{маг}\right)\right)^2;$$

$$d_4 = \eta\sum_{i=1}^{m}\left(0, z_j \max_j\left(y_j \sum_{i=1}^{m}\sum_{k=1}^{m} x_{ij}\lambda_{ik} + \bar{y}_j\left(\sum_{i=1}^{m}\sum_{k=1}^{m} x_{ij}\lambda_{ik} - \sum_{i=1}^{m}\sum_{k=1}^{m} x_{ij}\lambda_{ik}\right)\right) - P^{sw}_{маг}\right)^2;$$

$$d_5 = \sum_{i=1}^{m}\sum_{j=1}^{n}\left(\max\left(0, l_{ij} z_j - L^{\max}\right)\right)^2;$$

$$d_6 = \sum_{j=1}^{m}\left(\max\left(0, b_{\mu j} z_j - L^{\max}\right)\right)^2;$$

$$d_7 = \left(\max\left(0, \sum_{j=1}^{n}\left(\gamma_j - n\right)\right)\right)^2; \quad d_8 = \left(\max\left(0, \mu - n\right)\right)^2,$$

where all genes belong to Ai chromosome A_i.

The value of violation of restrictions is equal to the sum of the entered variables:

$$\Delta\ A_i = d_1 + d_2 + d_3 + d_4 + d_5 + d_6 + d_7 + d_8.$$

Thus, the structure of a chromosome which represents the coded option of the movement of the bus in real time depending on a road situation can be received. The structure of the created chromosome allows to work without loss of accuracy with the reduced state space in comparison with initial model of optimization and also simplifies a type of some restrictions.

Implementation of this algorithm allows:

– define the optimum number of the rolling stock on the line for route operating time;
– set the necessary number of the rolling stock on the line in "rush hours";
– make the optimum schedule for each bus in time in a dress;
– assess a road situation at present of time;
– adjust the schedule of the rolling stock depending on a road situation;
– set motion speed on route stages;
– make effective decisions under force majeur circumstances;
– define the reasons of failure of the schedule.

Conclusion.The offered methods of passenger traffic management logistic models creation are approved at improvement of work of Rostov-on-Don JSC trucking company-3 Transservice rolling stock . The cost efficiency during introduction of a system was 10.83% that allows to draw a conclusion on expediency of practical application of the developed algorithm.

In development of the offered technique of creation of management logistic models of passenger traffic use of the rank analysis (cenological approach) which essence and the principles act as the new direction promising high practical results seems perspective.

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