OPTIMIZATION OF PUBLIC TRANSPORT ROUTING

ОПТИМИЗАЦИЯ СОСТАВЛЕНИЯ МАРШРУТОВ ОБЩЕСТВЕННОГО ТРАНСПОРТА

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Abstract:*The paper describes the urban passenger transport system which is a set of interdependent subsystems: «city», «transport», «passengers». The urban passenger transport performance indicators have been determined for all system participants. The objective functions of an optimization problem of urban passenger transport are given in general terms. The optimization criterion for traffic routing of urban passenger transport has been determined, which takes account of mutual influence of the interests of all system participants has been determined. The passenger traffic flow density on the studying road section, has been suggested as such optimization criterion. The formulation of an optimization problem of urban passenger transport have been defined as well.*

KEYWORDS: PASSENGER TRANSPORT; ROUTING; EFFECTIVENESS; OPTIMIZATION, TRANSPORT SYSTEM.

1. Introduction

Passenger transport is among the most important sectors of sustainable livelihood in cities, the functioning of which affects the quality of life of people, efficiency in the economic sectors of cities and the possibility of using their city-planning and the social and economic potential.

This results from the process of dynamic social and economic development of cities, which has resulted in creating new facilities and the attraction zones for passenger flows, such as business, trade, entertaining and sports centers, changes in the structure of resettlement of residents in connection with the emergence of new zones of the active housing construction.

Concomitant with the increase of the level of automobilization of the population, road load in transport has also increased, one of essential parts of which is passenger transport.

All this predetermines the need for optimizing the spontaneously developed system of urban passenger transport (UPT) which does not compatible with present-day needs.

2. Preconditions and means for resolving the problem

Effective solution to this problem is the use of the decision support systems in the field of vehicle routing [1]. However, automation of tasks related to this sector calls for research input for the purpose of obtaining effective algorithms suitable for use in practice.

According to [2,3], in its simplified form the UPT system is presented in the form of three mutually influencing subsystems: "city", "transport", "passengers" (Fig. 1).

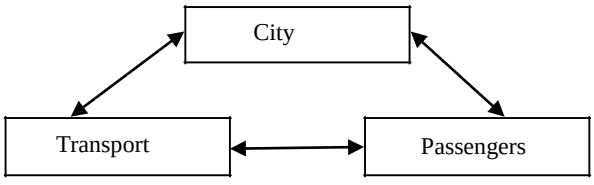

Fig. 1.

The subsystem "city" includes such elements as "industry", "housing construction", "street-road network", as well as service and management of these elements. The basic requirement to be met by the “City” subsystem "City" for the operation of UPT.

systemis ensuring uninterrupted transportation of passengers. The "Transport" subsystem includes the organizations providing passenger traffic. For the "Passengers" subsystem, the effectiveness of the functioning of the transport system is determined by quality of satisfaction of demand for transportations.

Thus, it is evident that the interests of the participants of the UPT system considerably differ from each other. Recently, private carriers have come onto the UPT market. Therefore, the problem of UPT optimization has become more complex in a competitive environment.

Functioning of the UPT system is directly associated with its effectiveness. The effectiveness for the UPT is completely determined by the needs of its participants, which have to be taken into account at the analysis stage

From the point of view of the city administration, the effectiveness indicators could be as follows:

- meeting demands of the public for transportations;
- economic efficiency of the municipal transport organizations (the maximization of their profit);
- the effectiveness of road traffic organization;
- the absence of the conflicts of interest of the municipal and private transport operators developing into the conflicts.

Fromthepointofviewofthetransport organizations, the basic indicator of the effectiveness is the maximization of profit from transportation activities.

From the point of view of the passengers, as the final consumer soft transport services, the effectiveness indicators could be as follows:

- the minimization of travel time;
- theminimizationoftravel cost (including possible stopovers);
- improvingthetravelcomfortableness (through the type of vehicle and the level of its filling.

Determination of a single criterion of the effectiveness for passengers is significantly complicated by various motivation when making decision on movement and its mode, that is the concept of optimality of specific passenger considerably differs from criterion of optimality of the population in general.

As the integrating efficiency indicators of the UPT system for the population, the following criteria can be determined:

- the minimum cumulative waiting time of all passengers, who, with certain probability, go from starting points of departure to the destination;
- the minimum travel time from any starting point of departure to any destination;
- the minimum number of stopovers when moving from any starting point of departure to the required destination, and so on.

It is obvious that the efficiency indicators, from the points of view of the UPT system participants, are contradictory. So, for example, reduction of waiting time of passengers has clear links with the increase in a number of the motive power on the route, and, consequently, with the decline of its loading and the economic benefit. On the other hand, the commitment to increased profitability of the transport organizations may lead tothe abandonment by the population of transportations and to the emergence of the competing organizations. Thus, the assessment of the efficiency indicatorsshould be carried out taking into account the needs of all participants of the UPT system[4].

Turning to formal description of the UPT system optimization problem, it is possible to highlight several basic criteria of the effectiveness, in a general view presented in the form of purposive functions:

$$(1) \qquad T_p = T_1 + T_2 + T_3 + T_4 \rightarrow min$$

$$(2) \qquad C_p = \sum_{Q_p}^{n} Q_d \cdot T \rightarrow max$$

$$(3) \qquad P_{to} = Q_p \cdot T - E \rightarrow max$$

whereT_p – timespentbypassengersformovement; T_1 – timespentforapproachingtothestoppingpoint; T_2– vehiclewaitingtime; T_3 – travel time; T_4 – timespentfor movement to destination; Q_P – number of passengers; C – travel cost, including the possible stopovers; Q_d – number of travels/stopovers per day; T – passenger transport tariff; S – profit of the transport organizations; E – operating costs of the transport organizations.

Formal description of the UPT system is applied in the decision support systems making in the field of transport routing: design of route network of the locality, determining the type and the number of the motive power on routes, optimization of the existing route schemes, and so on. At the same time, the issues of optimization should be considered from the positions of all participants of the system of passenger traffic. Their interests are often contradictory, but optimization of the UPT system has also to consider and balance the needs of all participants of UPT.

The classic version of a vehicle routing problem not always covers all features of practical problems routing, specifics and the formulation of which are given in Tab. 1.

Currently, there are known many methods for the vehicle routing problem. As stated earlier, the vehicle routing problem is a generalization of the well-known travelling salesman problem, in which it is necessary to arrange at once several loop routes passing through a certain common top (depot). These problems belong to class of the problems of combinatorial optimization, and are complex ones.

3. Conclusion

There is considered the classic problem of vehicle routing, its varieties and solution methods. On the basis of the analysis of vehicle routing problems, there have been determined additional restrictions, which must be taken into account in optimization of route schemes for UPT. As an optimization criterion for the UPT system. it is offered to use passenger traffic density on the particular section of the road.

Varieties of vehicle routing problems

Table 1.

Problem	Formulation
Vehicle routing problem with account for vehicle carrying capacity	There is set the value $q>0$ – carrying capacity of each vehicle, and a set $Q=\{q_1,q_2,\ldots,q_n\}$,where q_i defines the volume of cargo in each top of v_i
Vehicle routing problem with the limitation of the number of knots on the routes	There is set the value $d>0$ – the maximum number of tops required for visiting on each route.
Vehicle routing problem for several depots $P_{to} =$	The rout may start in any possible depot, but it must be ended where it starts. There is determined a set $D=\{d_1,d_2,\ldots,d_k\}$of the tops of depot.
Vehicle routing problem with graded delivery	It is permitted to visit the route knots not by one, but by several vehicles
Stochastic vehicle routing problem	Some parameters of problem (the number and the requests of customers, and so on) may appear to be random, set by stochastic observations.

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