SCHEDULE OPTIMIZATION ON ROUTES SERVICES OF PUBLIC PASSENGER TRANSPORT

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Urban passenger's public transport, the main component of urban transport, is one of the most important functions of a city because it ensures unity and coherence of all its activities. Although it occupies a prominent place in the human activity, the organization of urban transport, in general, is currently a big issue in most major cities.

Public passenger transport aims to take over passenger flows from the transport network in both directions of traffic. In this context, it is necessary to determine the hourly variation of the flow of passengers for each route and then, depending on the length of the route, capacity and speed of available vehicles, to determine vehicle needs at different times of the day in question to draw appropriate timetable.

The production activity of carriers within the technological process of transportation is focused on achieving at the same time two diametrically opposed goals:

- minimizing travel time of publics;
- minimizing resource consumption in the transport process.

Thus, there is need for objective evaluation of optimal process parameters, characteristic for the transport system and its components.

In public transport, the importance of efficient use of transport capacity is even greater because of the scarcity, fleet structure and characteristics of traffic flow irregularity.

During unloaded periods between rush hours, the efficiency of buses carrying capacity decreases significantly, requiring the need to adopt measures to optimize the system of public transport by linking the number of vehicles on route with real flow of passengers.

The methodology of schedule optimization developed in this paper is based on the queuing theory, arising from the nature of processes characteristic for the operation of a public transport route.

It is considered a random process of accumulation and embarking of passengers at intermediate stations of urban bus routes during unloaded periods between rush hours. For optimization of the routing service it will be use the queuing theory.

Suppose that the accumulation of passengers at intermediate stations of the route takes place according to Poisson law, the arrival of buses is realized as exponential law.

If n is the number of passengers arriving at the station in the intermediate time interval $(0, t_o)$, the probability of arrivals under Poisson law is given by:

$$P_n = \frac{(\lambda t)^n}{n!} e^{-\lambda t_o} \qquad (1)$$

where: λ is the intensity of passengers accumulation (arrival) in the station, passenger, pas·h^{-1};

t_o – the time between arrival of the first passenger and the arrival of the bus in the station, h.

In the case of Poisson distribution, mathematical expectation M (n) is equal to the intensity of arrival passengers in the station, so we have:

$$M(n) = \lambda \qquad (2)$$

On the other hand, according to queuing theory it's necessary to respect the following ratio:

$$\lambda = \frac{N}{T}, \qquad (3)$$

where: N is the number of passengers, accumulated at the station in period T.

In period t_o the accumulated number of passengers the station is as follows:

$$N^* = \frac{N}{T} t_o \qquad (4)$$

Period T is the interval of time in which the number N of passengers accumulates at the station and remains constant, usually this period does not exceed 10-13 min. Beyond that period, passengers choose other available travel options, including other routes or types of transport. Therefore for full takeover of passenger flow of station, it's necessary to comply with the following ratio:

$$t_o < T \qquad (5)$$

Time of arrival of buses to the station complies with the exponential distribution:

$$F(t) = 1 - e^{\mu t} \quad (6)$$

where: μ is the intensity of the arrival of buses in the station, auto·h^{-1}

$$\mu = \frac{60}{I} = \frac{60 \cdot A_R}{T_R} \quad (7)$$

where: I is the interval of circulation on route, in min;

A_R – number of buses on route, units,

T_R – period of a bus turnover, min.

The interval of circulation on route during the day technologically varies from minimum value $I_{\min} = 3 - 5 \text{ min}$, characteristic for rush hours, to the maximum $I_{\min} = 12 - 20 \text{ min}$ for unloaded periods. Real value range of interval of circulation is actually a practical criterion for assessing the quality of services.

The time of arrival of the bus in station t_S is given by:

$$t_S = \frac{1}{\mu} = \frac{T_R}{60 \cdot A_R} \quad (8)$$

To ensure the boarding of all passengers accumulated in station, the following condition must be complied:

$$t_o \leq t_S \quad (9)$$

Substituting in relation (9) relationships (4) and (8), we obtain:

$$\frac{N^* \cdot T}{N} < \frac{T_R}{60 \cdot A_R} \quad (10)$$

If we define the ratio $\eta_F = \frac{N^*}{N}$ as a ratio of revaluation of passenger flow in station, then equation (10) may be transcribed as follows:

$$A_R > \frac{T_R}{60 \cdot \eta_F \cdot T}, auto \quad (11)$$

Equation (11) allows formulating the following optimization principle: minimizing the number of buses to the route may be achieved by increasing the value of the coefficient of revaluation of passenger flow in station and the period of passenger's accumulation in the station to acceptable levels for the passengers.

Traffic flow N * accumulated in period t_o may be taken if there is place in the bus. However, if there is no free place, then the passengers that could not be embarked are waiting for the next bus, which should arrive faster than the time T. If the last condition will not comply, the carrier can't assert passengers flow, which will then degrade or will redirect to other transport solutions.

For maximum revaluation of passenger traffic, accumulated during period t_o in the station, it's necessary to use buses with a larger number of seats or, alternatively, to reduce proportional the period of turnover.

CONCLUSIONS

As a result of developing optimization methodology of the passenger transport on public routes service, the following main conclusions can be drawn:

- applying queuing theory to rationalize transport on public routes service provides real optimal solution, applicable in practice;
- minimum possible waiting time of bus is ensured if the system is planned so as to comply equation (9);
- maximum revaluation of passengers flow at stations is ensured if the route is served by a number of buses, computed in comply with relation (11).

Bibliography

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