ABOUT ONE WAY OF SIMULATION OF THE REGIONAL TRANSPORT NETWORK

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Abstract

The method of definition of the maximal stream and its distribution on branches of a network in the set direction is offered. The received distribution is characterized by the best efficiency among other variants of distribution of streams in a network which throughputs of branches change in the casual image.

1 Introduction

The complex structures submitted as graph describe a wide range of systems which have important practical and scientific value. One of the areas using graph structures, define problems of transport network research. To solve a problem of finding the maximal stream in a transport network Ford-Falkerson [1] algorithm is usually used. However, Ford-Falkerson algorithm has a number of restrictions which are not carried out in practice. Taking into consideration what is stated above, researchers are compelled to resort to imitating modeling of transport streams in a network of roads [2]. In the report the method of choosing a rational variant of organizing transport streams in a network in the set direction which removes the restrictions of Ford-Falkerson algorithm is offered. It allows to determine the maximal stream and its distribution on the branches of the network, which possesses the best efficiency among the other variants of distribution of the streams in the network whose throughput abilities of branches change randomly.

2 Formalization of object of modelling

As an object of modeling the system of transport streams on a site of motorways of a certain region is considered. We shall determine a transport network by focused column G of dimension N with the numbered tops (G, N) which doesn't have cyclic arches. As the column represents a transport network, each edge is described by the following characteristics:

- throughput ability of the road between the units of a transport network;
- the length of the road between the units of a transport network;
- the cost of transporting of one transport unit on the road between the units of a transport network;

- the size of a stream on the road between the units of a transport network.

Each direction is characterized by a set of transit streams, i.e. streams from various initial entrances on the one border of a transport network to various final exits on the opposite border. All the streams of a considered site of roads of a regional network are divided into the directions: north - south, west - east, south - north and east - west.

The existence of not transit internal streams in a network is also supposed. These are streams whose vehicles move in a direction from one internal unit of a network (the beginning of an internal stream) to the other internal unit of a network (the termination of the movement of an internal stream). They take away a certain part of resources of a transport network, thus influencing the size of the basic transit streams.

To conduct the research we shall choose one of the directions, for example west - east (ZV). On a considered direction initial units of streams are located on the western border of a transport network of the region, and the final units of the streams are located on the eastern border of the network of the region. We shall set sets: initial units - the entrances of the transit streams $\{Z_1, Z_2, \cdots, Z_m\}$, where$Z_i$, $i = \overline{1,m}$ the numbers of the initial tops of the transit streams which are located on the western border of region; the final units - "exits" of transit streams $\{V_1, V_2, \cdots, V_n\}$, where V_i, $i = \overline{1,n}$ the numbers of the final tops of the transit streams which are located on the eastern border of the region. Various combinations of "entrances" and "exits" determine transit the streams for the chosen direction $\{Z_i V_j\}$, where i=$\overline{1,m}, j = \overline{1,n}$.

The characteristics of the sites of the transport network defined by graph (G, N) are determined by means of the following matrices:

the distributions of the initial stream $X^0 = ||x^0_{ij}||$, containing elements $x^0_{ij}(i, j = 1, \cdots, N)$ which determine the size of the initial transit stream on a branch of a transport network from i-that unit to j-that;

the throughputs $\Sigma(t) = ||c_{ij}(t)||$, containing elements $c_{ij}(t)(t = 1, \ldots, T_m, T_m$ - time of modeling; $i, j = 1, \ldots, N)$ which determine the throughput of the road of a transport network from i-that unit to that, changing in time depending on deterioration of a site of the road and the parameters of the environment. The values of matrix $\Sigma(t) = ||c_{ij}(t)||$ are updated on each step and act from the imitating model of deterioration of the sites of a transport network [4];

the distances $L = ||l_{ij}||$, containing elements l_{ij} $(i, j = 1, \ldots, N)$ which determine the distance in a transport network from i-that unit to that. If $l_{ij} = 0$ in a transport network the unit i is not connected with the unit j;

the costs $Q = ||q_{ij}||$, containing elements $q_{ij}(t)(i, j = 1, \ldots, N)$ which determine the cost of unit of the stream in the transport network from i-that unit to j-that;

the time $T = ||t_{ij}||$, containing elements t_{ij} which are set by the relation $t_{ij} = \frac{l_{ij}}{x^0_{ij}}$ at $(i, j = 1, \ldots, N)$ also determine the time of the movement of transport units of a stream from i-that unit to j-that;

the internal streams $X^{pr} = ||x^{pr}_{ij}|| = ||F_{ij}(\tau)||$, containing elements $x^{pr}_{ij}(i, j = 1, \ldots, N)$ which determine size of an internal stream on a branch of a transport network from i-that unit to j-that.

Because of the influence of the internal streams on the throughputs of branches of a transport network matrix $\widetilde{\Sigma}(t) = \Sigma(t) - X^{pr}(t = 1, \ldots, T_m)$ is paid off. At the subsequent calculations instead of a matrix of throughputs $\Sigma(t)$ the matrix $\widetilde{\Sigma}(t)$ is used.

For each of the streams $Z_iV_j, i = \overline{1,m}; j = \overline{1,n}$ separately the transport problem is solved by means of the modified Ford-Falkerson algorithm [4]. In the result, for each of the streams $Z_iV_j, i = \overline{1,m}; j = \overline{1,n}$ we receive the following target characteristics: the size of the maximal stream φ_{ij}^{max} of the direction $Z_iV_j, i = \overline{1,m}; j = \overline{1,n}$; the size of efficiency Φ_{ij} of the maximal stream of direction $Z_iV_j, i = \overline{1,m}; j = \overline{1,n}$; the distribution of transport streams in a network $X^{ij} == \|x_{kl}^{ij}\|, k, l = 1, \dots, N$ for the direction$Z_iV_j, i = \overline{1,m}; j = \overline{1,n}$.

3 The algorithm of search for an integrated maximal stream of a transport network in the set direction

With the purpose of finding of an integrated maximal stream of a transport network in the set direction for each time interval matrices of sizes of the maximal streams and effectiveness of these streams whose elements are values of the maximal streams and effectiveness of streams on each combination of an entrance and an exit are made. A matrix of the efficiency of streams we shall designate $\varphi = \|\varphi_{ij}^{max}\|, i = \overline{1,m}; j = \overline{1,n}$. A effectiveness matrix streams we shall designate $\Phi = \|\Phi_{ij}\|, i = \overline{1,m}; j = \overline{1,n}$. The received matrices are normalized according to the maximal element:

$$\varphi^* = \|\varphi_{ij}^*\| = \left\| \frac{\varphi}{\max\limits_{ij} \varphi} \right\|, i = \overline{1,m}; j = \overline{1,n}; \Phi^* = \|\Phi_{ij}^*\| = \left\| \frac{\Phi}{\max\limits_{ij} \Phi} \right\|, i = \overline{1,m}; j = \overline{1,n}$$

In the result, all the elements of the matrices φ^*, Φ^* satisfy the inequalities $0 \le \varphi_{ij}^* \le 1; 0 \le \Phi_{ij}^* \le 1$. In a rectangular system of coordinates $\varphi^* 0 \Phi^*$ we mark points $(\varphi_{ij}^*; \Phi_{ij}^*)$. And, by virtue of that elements of matrices are normalized on the maximal element, all points will be within the limits of an individual square, whose left bottom corner is combined with the beginning of coordinates.

The list of streams in which all elements are ranged from "the worst" of efficiency to "the best" according to the data of an individual square is made. The matrix of approachability $D = \|d_{ij}\|, i = \overline{1,m}, j = \overline{1,n}$, where $d_{ij} = 1$ if there is a stream from i-that entrance in j output and $d_{ij} = 0$ if from i-that entrance in j the exit is not present a stream is simultaneously made.

The list is looked through from below to upwards, beginning from a stream, the worst in efficiency. The current stream is excluded from the list if its exclusion does not leave any initial top without a proceeding stream and does not leave any final top without an entering stream. After excluding the list of a stream which goes from i-that entrance in j-that an exit the matrix of approachability D in which on crossing of i-that line and j-that column unit is replaced with zero is modified. Thus we receive, that the current stream from i-that entrance in j-that an output exit is excluded from the list in the event that after its exception and updating of a matrix of approachability

D, i-that line there will be even one unit and in j-that column as there will be even one unit. If the exception of a stream conducts to that in a matrix of approachibility i-that a column or j-thaw a line will consist of zero the stream is not excluded from the list of streams, and we pass to the following stream in the list. As a result of rejection of the streams, we receive a set of the most effective streams $ZV^e = \{Z_iV_j\}$.

The principle of superposition is applied to a set of these streams ZV^e. And the problem of superposition of the streams is solved so that in a network there could be simultaneously all staying streams from set ZV^e.

For each stream$Z_{i'}V_{j'}$ from set ZV^e we determine set of the sated arches which have appeared in a network as a result of the modeling based on a combination of Monte Carlo procedure and Ford-Falkerson algorithm.

Further the general set of the sated arches a $DN = \{(d_{ij}, n)\}$ as follows is made:

- an element of set is the pair: the sated arch and the number (d_{ij}, n), here d_{ij} an arch from i-that unit in j-that, and n — quantity of times, how many this arch meets as sated in all considered staying streams;

- the elements of a set are sorted on n in decreasing order.

The list of DN of the sated arches is looked through, beginning from the first element. The first element of the list $(d_{ij}, n1)$ describes the sated arch which has met in the staying transit streams a great number of times. Therefore in each of the streams of the set the DN is necessary to reduce a stream in $n1$ time. After the performance of the superposition of the staying streams the arch d_{ij} appears sated again. The reduction is made for each stream$Z_{i'}V_{j'}$ on all ways which sated a considered arch; it is proportional to their contribution to saturation of an arch.

Similar actions are carried out for each element of the set a DN. After reduction of all the streams on all sated arches the superposition of the streams is carried out. If as a result of superposition on some arches the size of the stream exceeds throughput on these arches then reduction of a stream is made according to the algorithm described.

References

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