modes of technological units. These rules became the basis for the creation of algorithmic support information-analytical system technology security PChI.

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Х.Сиддиқов, Х.А.Бахриева

Neftoximik korxonalarining qurilmalarini texnologik holatlarini monitoring qilishning logik-grafik modeli

Ушбу мақолада нефт-кимёвий ташкилотнинг мантиқий-график моделини (МГМ) автоматлаштирилган ахборотли-аналитик тизими технологик ускунаси ҳолати мониторинги келтирилган. Фавқулодда вазият режимини прогнозлаш ва МГМ ишлаб чиқариш вазиятида қуриш тамойили шакллантирилган. МГМ ишлаб чиқариш вазиятида яратишда ҳисоблаш муносабатида қулайлик яратувчи мантиқ ва нефт-кимё саноатининг технологик ассамблеяларининг хатти-ҳаракати ва фаолиятининг динамикасини намойиш қилиш ҳамда турли хил ишлаб чиқариш шароитларида бошқарув қарорларини қабул қилиш ва фавқулодда вазиятларнинг олдини олиш учун шакл, кўпликдаги ноаниқликлар назарияси таклиф этилган.

Таянч иборалар: нефт-кимё, мантиқий-график модел, динамика, технологик, фавқулодда вазият, бошқарув.

УДК 656.6/8

M.R. Turgunov

IMITATION MODELS OF THE RAILWAY ORGANIZATION FOR RAILWAY TRANSPORT FLOWS

The article is devoted to the questions of solving the problem of optimization of cargo traffic management in the railway transport throughout the logistics chain, organizing the formation and implementation of cargo loading plans that do not allow exceeding the maximum and reduce the minimum levels of availability of a particular cargo on the destination road. And also the article justifies the solution of the problem of finding the maximum flow in the railway network, it is noted that in any transport network the maximum flow is equal to the minimum capacity. If the flow is maximal, then there is a section whose transmission capacity is equal to the cardinality of the flow and this theorem is proved by applying the Ford-Falkerson algorithm.

Keywords: railway network, material and information flow, graph model, formalization, structure, carrying capacity, maximum flow, formation.

Introduction

At present, due to a sharp increase in the number of vehicles in road networks, the requirements for the rational organization of traffic flows have significantly increased. The road network itself can be represented as a graph consisting of nodes and arcs. Each edge of the graph corresponding to a section of the road is characterized by the length, throughput and cost of a vehicle unit along it. The carrying capacity of the graph branch is affected by the speed of movement of the unit of transport, which in turn depends on many factors, among which the most important are the loading of road sections, the condition of the road surface, and the environmental conditions. The load on different sections of the road varies and depends on the availability of internal traffic flows in this area, which can be considered as interference with the movement of the transport unit from the starting point of the network to the final destination. The parameters of the external environment vary with the time of the year, the time of day and are subject to the influence of weather influences.

Main part.

In the transport network, when managing the flows, optimal distribution of the transport stream along the network branches is found, estimate the maximum flow in the network and find the shortest path between the given input and output, identify bottlenecks in the network for the purpose of their timely elimination. Simultaneously with these tasks, the total costs of vehicles are estimated as they move from the starting point to the final one.

In practice, the presence of random factors affecting the state of the transport network does not allow to solve the listed problems using a well-known apparatus based on analytical models, called graph models. Especially great difficulties for researchers are the definition of bottlenecks in the network in the presence of traffic flows related to different directions and probabilistic internal flows in some parts of the network, which can lead to an increase in the number of accidents and the occurrence of "downtime."

Often researchers apply simulation simulations of traffic flows in a road network, taking into account random factors.

The structure of traffic flows in the railway network can be represented in the form of graph Gh, where h is the variant of the organization of traffic flows in the railway network. Transportation in the network is realized in accordance with the following parameters, determined by the matrices:

$$C_k = \|C_{ij}\|;\ L_k = \|I_{ij}\|;\ X^o = \|X^o_{ij}\|;\ Q_k = \|q_{ij}\|, \qquad (1)$$

where c_{ij} is the capacity of the branches of graph G_h connecting node *i* to node *j*; l_{ij} - distances between the nodes *i* and *j*; x^o_{ij} - is the initial flow along branch *ij*; q_{ij} - the cost of a unit of the vehicle's traffic path along branch *ij*. We define the set of inputs to the network $Z = z_i, i = \overline{1,b}$ ¯ and the set of outputs from the network $Y = \{y_i\},\ i = \overline{1,r}$, in one direction. In the network, in addition to the transit flows, there are internal traffic flows on separate road segments to one side and the other, which reduce the carrying capacity of the branches of the graph G_h. The values of the internal transport streams for the *ij*-th sections are determined by the distribution functions $H_{ij}(\nu)$. The throughputs of branches ij of graph G_h, taking into account internal flows, change and are random variables determined using distribution functions $F_{ij}(\tilde{c}) = c_{ij} - H_{ij}(\nu)$.

In the railway network, formation and disbanding of the compounds takes place at each site [1]. The duration of these processes, as a rule, is of a probabilistic nature and is described by distribution functions. The distribution functions for each *i*-th node of the network are given by the matrix H_i, where each element of the matrix is the distribution function of the formation-disbanding time in the *i*-th node for the composition that came from the node k and the next node *j*. The matrix has the form:

$$H_i = \begin{pmatrix} 0 & h_{i12}(\tau_{ij}) & \dots & h_{i1w}(\tau_{ij}) \\ h_{i21}(\tau_{ij}) & 0 & \dots & h_{i2w}(\tau_{ij}) \\ \dots & \dots & \dots & \dots \\ h_{iw1}(\tau_{ij}) & h_{iw2}(\tau_{ij}) & \dots & 0 \end{pmatrix}.$$

where *w*- is the total number of incoming and outgoing arcs for node *i*. Time for formation and disbandment of local formulations is assumed to be zero.

The maximum flow between nodes is distributed along the branches of the network, where *k*-is the iteration number of the Ford-Falkerson algorithm in determining the maximum value of the flow. The indicator of the costs of movement of vehicles along the branch *ij* of the graph G_h can be specified by one of the following functions:

$$f^*_{ij} = \delta_1 * l^*_{ij} + \quad \delta_2\left(\tau_{ij} + \frac{l_{ij}}{x_{ij}}\right)\delta_3 * (q_{ij} * l_{ij}), \qquad (2)$$

where $0 \le \delta_k \le 1$, weighting factors of importance, respectively, distance (δ_1), time (δ_2), value (δ_3)) of traffic along the branches of the network. The value of τ_{ij} is the average time taken by the transit convoys to form-disband in the i-th node. It is determined by the formula:

$$\tau_{ij} = \frac{\sum_{k-1}^{w} x_{ki}\tau_{ij}}{\sum_{i-1}^{w} x_{ki}}, \qquad (3)$$

where τ_{ij} is the value of the formation-dissociation time obtained from the distribution function $h_{ikj}(\tau_{ij})$. Since the movement of vehicles along the G_h network should be aimed at minimizing these costs, the overall cost characteristic is taken as the "benefit" indicator of the maximum flow, which is calculated from the maximum flux distribution matrix over all branches *ij* of the graph G_h:

$$\Phi xy = ijfij*, \qquad (4)$$

It follows that formula (4) determines the amount of costs when moving a vehicle in the network G_h under conditions of maximum flow. On the one hand, the flow must be maximized, and on the other hand, the "benefit" indicator should be minimal.

The presence of internal transport streams in G_h causes probabilistic character of the capacity on many branches of graph G_h. The non-deterministic formation and disbandment time of the formulations affects randomly the transit time of transit convoys from the point of departure to the destination along the path containing this node. These features do not allow the Ford-Falkerson algorithm to be used to search for the maximum flow in the network. Therefore, the use of an imitation model based on a combination of the Monte Carlo procedure and the Ford-Falkerson theorem is relevant [2]. Thus, problems are set for determining, using the simulation model, the maximum flow in a given direction between the set of nodes of inputs to the network and the set of output nodes, as well as the search for bottlenecks in the network G_h when moving transport in a given direction, the elimination of which will allow the optimal organization of flows in network. When searching for the integral maximum flow in a network, the following conditions must be met: for each combination of input and output there is a maximum flow, the integral cost function has a minimum value.

The solution to the problem of finding the maximum flow in a railway network is based on Ford-Falkerson: in any transport network, the maximum flow is equal to the minimum capacity. If the flow is maximal, then there is a section whose transmission capacity is equal to the power of the stream. This theorem is proved by applying the Ford-Falkerson algorithm. According to this algorithm, starting with some initial incomplete flow, it is possible to obtain the total flow by the iterative algorithm if we add the minimum of the numbers $[c(g) - l(g)]$, to the different values of the flows $l(g)$ of the path S_i, which are computed from this ways. After such an operation, the path S_i contains at least one unsaturated arc. If you do the same way with other paths S_i, then, in the end, we get the full stream. Therefore, the algorithm for determining the maximum flow consists of the following steps:

an initial flow X^o is constructed;

it is checked whether the node X_n has fallen into the set of nodes *S* that are attainable over the unsaturated edges from X^o. If the node X_n does not hit, then it is considered that the constructed stream is maximal, and the calculation algorithm stops;

if the node X_n is in the set *S*, then the path S_j consisting of unsaturated edges and the leading loads from X_o to X_n are selected;

the flow through each edge of this path increases by the amount $\min(c_{ij} - \varphi_{ij})$;

a new flow *X* is constructed and proceeds to step 2.

As a rule, the network is specified by the bandwidth matrix $\sum = \|c_{ij}\|$ of all edges of the network *U*. Setting *k = 0*, then calculate the matrix of flux values on the arcs $X^k = \|\varphi_{ij}^k\|$ at the kth step. A matrix of differences $\sum - X^k = \|c_{ij} - \varphi_{ij}^k\|$ is constructed. In this matrix, the zero elements for the flux X^k correspond to the saturated edges, the non-zero elements for the unsaturated. Therefore, the calculation of the matrix $\|\sum - X^k\|$ is sufficient both for constructing the set of nodes over which the material from x_0 reaches along unsaturated edges up to xx_n, and for constructing a sequence of unsaturated edges.

The compilation of these lists is carried out according to the following technology:

make up a list of nodes, each leading an unsaturated edge from vertex i;

for each i-th node make up their own list of nodes, in each of which from the i-th node leads an unsaturated edge (with the exception of those nodes that have already entered the previously compiled lists), and so on.

this process of writing lists ends in two cases. Either the x_n node appears, which means the algorithm continues to work, or the node x_n is not included in the list of nodes written out, which means the end of the calculations [3].

Let us assume that it is required to play the discrete random variable X by the Monte Carlo method, that is, to obtain a sequence of its possible values x_i, knowing the distribution law of X:

Table 1

The distribution of the random variable X

	1	2		x_n
	1	2		p_n

We split the interval 0 <R <1 on the axis Or by points with coordinates p1, p1 + p2, p1 + p2 + p3, ..., p1 + p2 + ... + p_{n-1} on n partial intervals Δ1, Δ2, ..., Δ n, whose lengths p1, p2, ..., p_n, respectively. Thus, $|\Delta_i| = p_i$ (1) , where i = 1, 2, ..., n.

Theorem: if to each random number r_j ($0<r_j<1$), which falls into the interval Δ_i, to associate a possible value of xi, then the played value will have a given distribution law:

Since, when a random number r_j hits a partial interval Δ_i, the played value takes a possible value of x_i, and such intervals are only n, then the value played has the same possible values as X, namely $x_1, x_2, ..., x_n$. The probability of a random variable R falling into the interval Δ_i is equal to its length, and by $|\Delta_i| = p_i$, we find that the probability of falling into the interval Δ_i is equal to p_i. Consequently, the probability that the value played will take the possible value of xi is also equal to pi. Thus, the value played has a predetermined distribution law as shown in table 1.

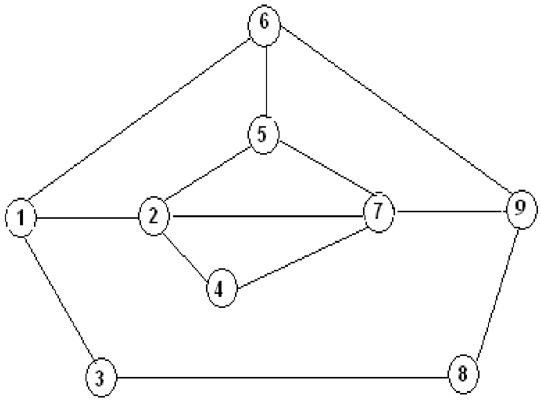

Fig.1. The graph of the railway network

In the formalized graph of the railway network model, the nodes are the cities through which the road network passes. Arcs are sections of the road that connect the respective cities. Each arc has its own bandwidth. In the network, in addition to transit flows, there are internal traffic flows, which significantly reduce the carrying capacity of the road network section. In each node processes of formation and disbandment of the compounds occur.

Suppose that there is one dispatch node and one destination node. It is required to determine the maximum flow in the network, taking into account the network structure and available parameters, with the minimum costs of all resources. Thus, the task is to determine with the help of the simulation model the maximum flow between the initial and final node of the graph, the search for bottlenecks in the network, the elimination of which will allow to achieve the optimal organization of flows in the railway network.

The averaged characteristics of the maximum flow and its "benefits" are obtained by carrying out N runs.

The probabilistic problem of finding the maximum flow in the network at the first iteration of the application of the Monte Carlo procedure turns into a classical one. In this case, the components of the capacity matrix are determined by computing $c_{ijl}=c_{ij}-v_{ijl}$, where v_{ijl} is determined from the distribution function H_{ij} (v) by finding a single lot of the third type.

When considering the effect of internal flows on network traffic situations, the following situations are possible:

there are no internal flows on the road section;

internal flows affect the throughput of the site in such a way that it decreases, but remains greater than or equal to the value of the flow in this section, i.e. $c_{ij}^{1} \geq x_{ij}^{0}$, where c_{ij}^{1} is the network bandwidth changed by internal streams (the Ford-Falkerson algorithm works and the maximum flow and its distribution along the branches of the network are located);

It follows that for each i-th node of the network, taking into account the given distribution-formation-distribution functions, the average time spent in the i-th node of the transport unit is calculated. As the initial flow, the values of the matrix X^{o} are chosen [4].

When using the Ford-Falkerson algorithm, at the k-th iteration (k is the iteration number in the Ford-Falkerson algorithm) using the modified bandwidth matrix, the very distribution of the flow over the network and its flow value are determined. According to formulas (2), (3), and (4), taking into account the distribution of flows, the generalized indicator of the "benefit" of this stream is determined. The values of the flow, the matrix of the values of the flow distribution by branches and the "benefit" indicator are stored in the model database (MDB). The iteration number of the Monte Carlo procedure (l = l + 1) is modified and all calculations are repeated first.

After completing N iterations of these calculations, the following samples are generated in the PM model: selection of the flow distribution matrices along the network branches, that is, for each element of the flux distribution matrix there is a sample; selection of maximum flow values; sample of integral indicators of the "benefits" of the flow.

For these samples of volume N, the mean values are formed, namely:

$$\overline{X_{xy}} = \left\|\overline{x_{\iota J xy}}\right\|; \overline{\varphi_{xy}}; \overline{\Phi_{xy}}$$

These values must be calculated and presented to the user upon completion of the program.Then, upon completion of the program, the following values should also be obtained: a matrix characterizing bottlenecks in the network, and a recommended bandwidth matrix for a given road network.

The algorithm of the model is based on the combination of the Monte Carlo procedure and the Ford-Falkerson theorem and the application of a single lot of the third type.

The algorithm of the model of the railway network is shown in Figure 1. The following input values must be set for the operation of the software:

$C_k = \left\|c_{ij}\right\|$- network bandwidth matrix;

$L_k = \left\|l_{ij}\right\|$- distance matrix between the node;

$Q_k = \|q_{ij}\|$- cost matrix between the node;

$H_k = \|h_{ij}\|$- time distribution function for the formation and disbanding of compounds;

$h_k = \|h_i\|$ - time vector for formation and disintegration of formulations;

p^r- number of program runs.

Let's consider the work of the model on the first run (i = 1). The software takes into account that in the network, in addition to transit flows, there are internal transport flows. These internal threads affect the network bandwidth. Thus, on each run the capacity matrix c [i, j] is changed by playing a single lot of the third type.

Based on the application of the Ford-Falkerson algorithm, the maximum flux maxflow, the distribution of the flow in the network f [i, j], is calculated, and the generalized indicator of the "benefit" of this flux Фzy is determined by formulas (2), (3) and (4). All these values are stored in the PC database.

And so if i<=pr, then the program continues the initial calculations. Otherwise (if i> pr), the following average values are calculated: maxflow maximum flow, f [i, j] flow distribution, and generalized "benefit" $Ф_{zy}$ on each run. The following are the bottlenecks in the network: [i, j] -c [i, j] and in those places where the matrix takes negative values by the amount of this difference, the capacity of the matrix c [i, j] increases to provide rational organization of the railway network flows.

Conclusion

A simulation model of the transport network has been developed, taking into account one input and one output in the network.

Thus, the following particular problems were solved:

the urgency of using the simulation model is to study transport network flows;

compilation of lists of input and output parameters of the simulation model of the railway transport network;

development and implementation of the simulation of model algorithm;

solution of test problems with the help of simulation.

Thus, a simulation model of the transport network was developed and software was implemented. That implements the model of the railway network.

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Темир йўл транспор оқимлари учун темир йўлни ташкил этишнинг имитацион моделлари

Ушбу мақолада темир йўл хабарлашувини бутун логистик занжир бўйлаб юкларни оптимал бошқаруви масалаларини ечиш, йўл харитасидаги максимал даражадан ошмайдиган ёки минимал даражадан камайиб кетмайдиган аниқ бир юкни юклаш ишларини режасини шакллантириш ва амалга ошириш жараёнларини ташкил этиш масалалари кўриб чиқилган. Бундан ташқари мақолада темир йўл тармоғида максимал оқимни топиш масаласи хар қандай транспорт тармоғининг максимал оқими унинг минимал ўтказиш хусусияти тенг эканлиги асослаб берилган. Агар оқим максимал бўлса, унда тармоқнинг ўтказиш хусусияти оқимнинг кучига тенг деган тасаввур пайдо бўлиши ва бу теорема Форд-Фалкерсон алгоритми қўлланиши билан исботланиши мақолада келтирилган.

Калит сўзлар: темир йўл тармоғи, материал ва ахборот оқими, граф модели, формаллаштириш, тузилма, ўтказиш хусусияти, максимал оқим, формирование.

UDC 004.942

Sh.B.Redjepov, S.Uguz, E.Acar

TRIANGULAR VON NEUMANN CELLULAR AUTOMATA OVER GALOIS FIELD GF(2)

The fundamental structure of cellular automata (CA) is a discrete special dynamical model, but the global behaviors at many iterative times can be close nearly a continuous mathematical model and system. It is known that CA theory is a very rich and useful dynamical model by focusing on their local information and neighboring cells. The mathematical view of the basic model shows the computable values of the mathematical structure of CA. In the present paper, it is investigated the structure of two-