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DEVELOPMENT AND EFFECTIVE USE OF REGIONAL MULTIMODAL TRANSPORT NETWORKS OF TRANSPORTATION

Abstract: This article presents a general scheme for solving the problems of developing multimodal transport networks, and the solution to the problem is shown in the construction of road infrastructure based on graph theory and also in the appropriate use of an intelligent transport system for optimizing and controlling traffic flow.
Key words: automobile transport, logistics, transport network, knot, arc, section of the transport network, optimal, throughput, task, solution, cargo flow, program, intelligent transport.
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Introduction

Transport is the most important structure of the country's economy. The state of the transport system linking each region of the territory is closely related to the sustainable development of the national economy. Reliable and high-tech transport infrastructure can meet the growing demand for the transportation of goods and passengers in society. In this case, the "optimal distribution" of cargo flows within each type of transport network will give only the "local optimum" in this traffic. The main essence of the task is to achieve a "global optimum" based on the optimal distribution of traffic in various transport networks. Based on this, it is necessaryto thoroughly and comprehensively study the compatibility of road and rail transport networks in a complex.

As a result of improving the living standards of the population, increasing freight and passenger traffic between regions, an increase in the intensity of vehicles on the country's roads is observed. As you know, in large cities and on highways with large traffic flow there is a high probability of emergency situations. Despite the fact that modern vehicles are equipped with ultramodern technologies, driving, as before, remains dangerous. This system depends on numerous elements; if nothing is done in this regard, the prevention of unpleasant situations will be difficult. Nevertheless, there is always an opportunity for positive changes, as well as a way out of risky situations and minimize negative impacts. However, this is a short-term quantitative solution to the

problem, and there will also be no way to eliminate it, as the number of cars on the highway increases.

The development of safe and best (minimum costs) transport networks that meet the requirements of domestic manufacturers to export their products to domestic and foreign markets is an urgent problem.

The identification and development of a transport network in a region without a scientifically sound base appropriate for the region is difficult, but at the same time very relevant. To optimize the transport security of settlements, it is advisable to use a scientifically based methodology for optimizing cargo flows in transport networks and developing a transport network. In addition, with the introduction of intelligent transport systems, the opportunities for the development of a multi-modal transport network and the efficient use of the network will be expanded.

Analysis of Subject Matters

Experts have proposed several methods for solving the above [1]:

- construction related to the construction of road infrastructure;

-intensive, use of an intelligent transport system (ITS) to optimize and control traffic flow;

According to many authors [2] on the construction of a ramified road infrastructure, such a modern infrastructure of the transport services market is a multimodal transport network, including international transport corridors.

Multimodal transportation is transportation within the country by at least two modes of transport [3]. Multimodal transport combines the advantages of several modes of transport (road, rail, sea) and plays an important role in reducing carbon emissions during transportation, and this is called the ecological transport model.

The main characteristic of the transport system is its availability. Accessibility is determined by the geographical location of the territory (district, city or corridor) for all regions [4].

Questions on optimizing traffic flows and transport networks and their optimal development in the future, development or selection of methods for substantiating and solving a mathematical model are relevant issues of today.

[4] - [7] Petri Net (E-Net) Firework articles analyze the possibilities of evaluating changes in transport networks based on a regional development plan to solve multimodal transport network problems using regional transit multimodal transport and other simulation programs.

The methodological foundations of design and throughput of a multimodal transport network are considered [8].

The article [9] analyzes the ways to increase the capacity in Slovakia, transshipment stations ("increase the throughput in Slovakia, the construction of transshipment stations") as well as the construction of future broadband access roads in Europe to reduce the transit time from Eastern Europe and Asia.

It is recommended that the best transport network is determined by graph theory. Here, the existing points of the types of automobile and railway transport (sending, receiving, technical and economic, throughput and other indicators) are indicated in the form of graph nodes. The places where various modes of transport are connected, that is, the possibility of reloading from one mode of transport to another, are illustrated respectively. They are associated with arcs that determine the economic costs of the initial-final operations (Fig. 1).

This method is based on the optimization of cargo flows in the transport network [5,6], which imultaneously addresses the issues of optimizing cargo flows in the network and the development of the transport network.

To pose the problem and develop the model, we present the basic concepts and indicators in the transport industry.
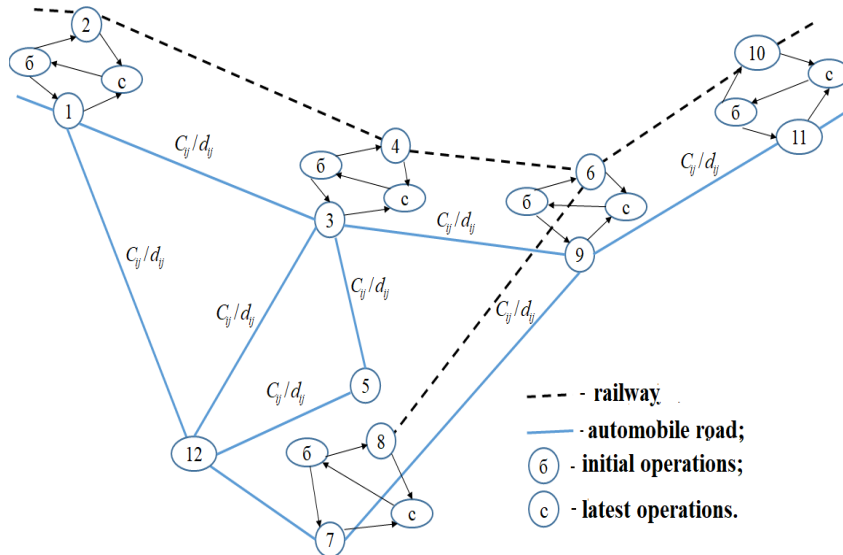
Figure 1. Scheme of the road network of the territory under study.

The basic concepts of the automobile and railway networks are the nodes from which various road connections originate. Such points are called nodes (vertices). A node (top) is consignees or senders who transfer goods from one mode of transport to another, crossing railway or road networks in different directions. In the future, launching industries of the consignor or consignee that also transfer goods from one mode of transport to another can be taken as a node.

Thus, a set of N available or possible nodes (peaks) is specified, which represents the current or future state of the transport network in the economic zone. This sets contains varieties of sender (S) and receiver (t), that is, S, $t \in N$.

A large-scale transport-transit system is presented in the form of graphs representing ordered pairs, such as the restriction of the sets of peaks (airport, railway, car, bicycle stations and other terminals) and the restriction of the sets of arcs (transport lines between different terminals) [10].

We denote the parameter variable that characterizes the magnitude of the flow l-type of cargo on the site ij or p- type of cargo on the site $X_{ij,l}^p$: where is ij - oriented link connecting the node i with a knot j the network, l - types of cargo for this flow or correspondence number if transportation information is given in the form of a chessboard, p- possible level of development of the transport network section.

For each node $i = 1,2,\ldots,n$ - sender address index, $j = 1, 2, \ldots, m$ - recipient address index, a_i^l - volume of cargo dispatch from point i, b_j^l - volume of cargo arrival at point j l varieties of cargo where

$l = 1,2,\ldots,k$ - sets of indices indicating the type of cargo.

Now we turn to the analysis of the characteristics of the transport network arcs in terms of throughput of cargo flows. One of these parameters is the value, the cost of transporting a unit of cargo across the site or development level. As a rule, as a criterion of optimization, the sum of the elements is the sum of transport costs for l-types of cargo in all arcs of the network.

However, it is necessary to differentiate the content of the parameter, depending on what level of development of the transport network is considered for P. For example, if the problem is solved for the existing network, that is, $P = 0$, then $C_{ij,l}^p = C_{ij,l}^{p(\text{эк})}$ .. In $C_{ij,l}^{p(\text{эк})}$ this case, the cost of transportation at current costs per unit volume of transportation. And vice versa, if then, $P > 0$ it consists of the sum of current costs $C_{ij,l}^p = C_{ij,l}^{p(\text{эк})}$ and $C_{ij,l}^{p(\text{эк})}$ capital investments per unit volume.

Another important aspect in formulating the mathematical model of the problem [11] is that $X_{ij,l}^p$, it is necessary to optimize to ensure that the cargo flows in the arcs ij do not exceed the permissible value established for each arc of the transport network in accordance with its level of development. This restriction is represented by various parameters for each type of transport.

For example, the level of development of the automobile road network is determined by the categories of roads; in each category of ij road sections, it is characterized by the permissible maximum number of vehicles $D_{ij}^{p\max}$, traveling on average per day. To illustrate this limitation in the model, the maximum number of vehicles passing

through the arc per day should go to where the load flow parameter is. This transition can be expressed in the following expression, $X_{ij,l}^{p} \cdot \dfrac{1}{Д_к \cdot q_{ij}^{p}} \cdot K_{ij}^{p}$, here

q_{ij}^{p} – average carrying capacity of vehicles passing through an arc at the - ij level of development, t;

K_{ij}^{p} – coefficient reflecting the weight of vehicles, in contrast to trucks, in the flow of vehicles passing through this section;

$Д_к$ – calendar days.

The maximum throughput for the arcs of railway transport of this section per day is characterized $Q_{ij}^{p\,max}$, which limits the flow of goods. Due to various restrictions on the flow of loads in the arcs of various transport networks, the arcs of the region should be divided into IJ for each type of transport, that is, arcs $IJ_{AЙ}$ -arcs of roads, $IJ_{TЙ}$ —arcs of railways. Thus, the question and the mathematical model are as follows; determination of non-negative freight traffic l – freight traffic through $X_{ij,l}$ inter-nodal arcs ij in the territory of the economic zone, this

$$X_{ij,l}^{p} \geq 0 , \ ij \in IJ \quad (1)$$

also, the intensity of the flow passing through the highway network will not exceed $D_{ij}^{p\,max}$, to maximize traffic in this area

$$\sum_{l=1}^{k} X_{ij,l}^{p} \cdot \frac{1}{Д_к \cdot q_{ij}^{p}} \cdot K_{ij}^{p} \leq D_{ij}^{p\,max}, ij \in IJ_{AЙ} ; \quad (2)$$

freight traffic for all types of goods transported along all arcs of the railway network, the maximum throughput of cargo passing through this section does not exceed $Q_{ij}^{p\,max}$

$$\sum_{l=1}^{k} X_{ij,l}^{p} \leq Q_{ij}^{p} , \ ij \in IJ_{TЙ} ; \quad (3)$$

The volume of flows sent from nodes in all arcs is equal to the volume of flows received in arrivals

$$\sum_{i} a_i = \sum_{j} b_j \quad \begin{cases} i = 1,2,...,n; \\ j = 1,2,..m; \end{cases} \quad (4)$$

$i = 1,2,…,n$ for each node, and $l=1,2,…,k$ - for each load;

$$\sum_{j} \sum_{l} X_{ij,l} - \sum_{j} \sum_{l} X_{ji,l} = \begin{cases} a_i, if, i \in S; \\ 0, if, i \notin S, t; \\ b_j, if, i \in t. \end{cases} \quad (5)$$

Current costs $(F_Ж)$ or full (F_T) for territorial freight transportation are minimal.

$$F_Ж = \sum_{ij} \sum_{l} C_{ij,l}^{p(Ж)} \cdot X_{ij,l} \to MIN \quad (6)$$

$$F_T = \sum_{ij} \sum_{l} C_{ij,l}^{p(ЖК)} \cdot X_{ij,l} \to MIN . \quad (7)$$

Such a formulation of the problem of the optimal development of the transport network provides an opportunity to take into account the reconstruction activities at the links of the existing network and various options for new construction. The network has the ability to include lines of various modes of transport. In fact, a section of any type of transport can be included in the model as a link ij with an appropriate cost. It is only important to be able to correctly determine these costs.

In solving this problem, specific difficulties arise, the most important of which are: a lot of variation; large dimension; the nonlinear nature of the change in the function of the cost of transporting goods from the volume of freight traffic; the need to solve the problem in dynamics; the difficulty of calculating comparable costs for the transportation of goods over parts of a network of interchangeable modes of transport.

Research Methodology

Therefore, it is necessary to solve the problem in a somewhat simplified form. For example, the dimension of the problem can be reduced if we take the average values of some variables: type of cargo; utilization rate of mileage; car loading capacity; type of rolling stock; transportation distance; type of car; the ratio of the empty run of cars to the loaded; the use of wagon capacity and a number of others. Naturally, the values of the selected variables that are averaged should not affect the optimality of the solution plan. If they influence, then this influence should be so small that the value of the target functional differs from the optimum within the permissible error limits.

The main reason for the complexity of this task is the linearity and nonlinearity of the functions of transport costs associated with freight traffic.

The growth of traffic flows in the economic zone stimulates the development of capacity and, accordingly, crosses and transports transport networks and objects. The existing capacity of the transport network and compliance with the required levels is an ever-changing factor. Thus, the task of optimal development of the transport network is considered a very variable system.

Optimal distribution of freight traffic on road and rail multi-networks.

Determining the optimal (economic) transport networks and their development for a region without an appropriate science-based base is complex, but at the same time relevant. It is advisable to use a scientifically based methodology to improve the transport provision of the population of the region, to

optimize the cargo flow in transport networks and to develop transport networks [12].

As noted, in solving the problems of distribution of freight traffic of an expanded network, the transport network and transportation volumes are the primary data. The volume of transportation, that is, the volume of production and consumption of various goods at certain points or a plan for the transportation of all goods can be presented in the form of a matrix for the transportation of goods, where data is displayed for each point of the sender and receiver.

The task is posed as follows. It is required for as short a time as possible to approximately distribute flows on the network while simultaneously obtaining a "density" of movement on each arc that minimizes the functionality [10].

$$F = \sum_{ij}^{m} C_{ij} \cdot \Gamma_{ij} \ or \ F = \sum_{st} C_{st} \cdot X_{st} \rightarrow \min \qquad (8)$$

The idea of this method is as follows. A tree of profitable paths is being built, the throughput of the route is determined as $\mu(S,..i, j..t)$ как $d_{st} = \min_{ij \in \mu} d_{ij}$. When distributing the next correspondence of each X_{st} line along the arcs of the most advantageous path, at the same time, the throughput capacity of the arcs making up the path is reduced by this value st. When fully saturated, the arc closes and is excluded from further consideration. After each arc closure, a new tree of profitable paths is built.

In the process of solving the problem, the characteristic of the arcs connecting the settlements (nodes) in the transport network is distributed over the sections and the passage of the cargo flow (transport) through the shortest arcs is ensured. The solution to this problem is carried out using computer software.

Analysis and results

Based on this method, rational road networks are identified and a plan for their phased development is determined. The development of the transport network is carried out accordingly with the transport operational condition of the roads. This ensures a rational distribution of investments allocated for the development of the regional transport network. As a result, convenient transportation links are created between the regions of the region and the cost of freight and passenger transportation decreases. It also makes it possible to increase the transit potential.

Foreign governments use an intensive method to solve transport problems. Intelligent Transport System (ITS) is an effective and safe level important in traffic flow capacity on roads. The United States Government is actively developing and supporting ITS. Because, unlike the standard method of building roads, this method is considered effective.

In optimizing and managing traffic flow, the maximum use of the intelligent transport system of the transport network provides increased efficiency and traffic safety, improved levels of comfort for passengers and drivers, and quick access to emergency medical care. It also makes it possible to reduce the cost of building road infrastructure. As a result, consumers are provided with a lot of information and security, and the quality of interaction between participants in the movement improves. Developed countries such as the USA, Japan, Germany, France, China widely used these technologies in transport management 20-30 years ago.

The introduction of intelligent transport in practice provides a comprehensive improvement of socio-economic interests in several links, including its advantages [13]:
•reduced travel time, reduced labor resources of drivers and traffic jams.
• environmental protection;
• the cost of building road infrastructure is reduced;
• The development of industry provides employment opportunities for many workers.

Intelligent transport system (ITS-intelligent transportation system) - representing a complex engineering structure, it is considered an innovative approach in the modeling of transport systems and in the management of traffic flows.

Currently, Termez State University is also working on a project based on the ERASMUS + 586292-EPP-1-2017-1-PL-EPPKA2-CBHE-JP program "Intelligent Transport Systems: New ICT based Master" in Uzbekistan.

The above makes it possible to widely introduce intelligent transport systems in the country on the basis of European standards in the field of training leading specialists in this field, minimizing and targeted use of resources, as well as creating the full potential and transport network of transport services in the country.

Based on the conclusions drawn from the study, it can be seen that the Darband-Boysun-Denau highway is optimal for providing automobile communications in such districts of Shurchi, Denau, Oltinsoy, Sariasia and Uzun oblasts. As well as international transit cargo transported by the Surkhondar region to the Republic of Tajikistan, it is carried out in the direction of Darband-Sherabad-Denau. If you carry out these transportation in the direction of Darband-Boysun-Denau, the length of the route is reduced by 85.6 km. The Darband-Boysun-Denau route creates opportunities for the realization of transit potentials. But the current technical condition of the studied section of the road is not enough to ensure the prospect of traffic flow. This requires a major reconstruction of the investigated section of the road.

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