Optimal Distribution of Cargo Flows in the Multi-Network of Road and Rail Transport

Kuziev Abdimurat Urokovich Candidate of Technical Sciences, Associate Professor Termiz State University;

Makhsumov Isroiljon Akhmedovich Master's student, Termiz State University

ABSTRACT

An urgent problem is the development of freight flows with the best use of transportation means of automobile and railway transport, the transport network, as well as their development, taking into account the prospective growth of freight flows. This will allow to deliver products to domestic and foreign markets and reduce their cost. This article presents a method for solving the problem of optimizing freight traffic in an expanded unified transport network and developing a transport network that includes road and rail transport.

Keywords: Transport, logistics, security, automobile, railway, network, multiset, development, road scheme, optimality, criterion, cost, application, category, freight traffic.

The Surkhandarya region, which is in the southernmost part of Uzbekistan, borders Afghanistan in the south through Amudarya, the Republic of Tajikistan in the northeast, the Kashkadarya region in the northwest, and Turkmenistan in the west. Its location could create a new, alternative southern trade route for transiting through Afghanistan to the ports of Iran (Bandar-Abbas, Shahbahar), Pakistan, and (Gwadar, Karachi).

The rapid formation of joint enterprises and the start of their operations, as well as the expansion of the production sector in the province, necessitate the development of the technical and technological capabilities of the region's transportation system and the ability of various modes of transportation and networks to efficiently meet consumer demand for transportation volumes. In order to achieve this, it will be necessary to address pressing issues like the growth of transportation infrastructure, the region's primary networks and modes of transportation, the distribution of cargo flows according to these networks, and the development of the transportation infrastructure itself to its fullest potential. The surface transport system plays a crucial role in the economic life of Uzbekistan, as the geographical location consists of land [1].

A highly developed and efficient transport system is considered a key factor in creating logistics centers and attracting investments.

The author of the article [2] notes that the province of Silesia clearly stands out among the regions of Poland in terms of transportation provision as a result of continued development and consistent updating of its high-speed road network. The region's high level of transportation provision is not only attributable to the presence of major thoroughfares but also to the dense placement of road infrastructure. The fact that it can be determined is highlighted. In this situation, logistics companies are attempting to locate their investments in these regions to take advantage of the favorable circumstances.

The construction of transportation infrastructure, especially roads and railroads, is receiving special emphasis [3]. Numerous significant initiatives are being made to advance transportation communications in our nation to achieve this goal.

Scientists and specialists have long focused on the problems of the best placement and development of transport communications of an economic sector or region. The difficulties of looking for a logical solution for the expansion of the transportation network were not generally discussed in earlier scientific publications. Determining possibilities for the transportation network's future expansion necessitates extensive theoretical understanding, practical expertise, and engineering advancements.

The best strategy for the growth of the transportation system should adequately address the population's and economy's transportation needs while minimizing all associated expenditures for the usage of vehicles, networks, and their expansion. The criterion of this issue should reflect all aspects affecting the optimal development plan of production forces.

Additional capital investments will be required to boost the network's ability to transmit adequate cargo flows and transport vehicles in order to absorb future traffic volumes. The cost of additional capital funds and the cost of operating costs in the development of technical equipment of vehicles and networks are contrasted when assessing the economic efficacy of the distribution of cargo flows between transport types. Operational costs associated with and unrelated to the size of the movement in the process of transporting goods as well as capital funds required to improve the capacity of the sections to transfer cargo flows are considered in this case as a criterion for evaluating the optimality of the plan. This indicator, in our opinion, more closely corresponds to the optimum of production.

Additionally, it is important to remember that the increase in additional expenditures is not linear. As a result, the ratio of additional costs to load flow growth, or differential costs, was chosen as the optimality criterion.

The challenges of creating a transportation network with two different modes of transportation are discussed in the article. As a result, the expanded single surface transport multi-network $S^{\bullet}$ optimizes load flow. A single transport multi-network is distinct from a typical network in that it has additional (fictitious) nodes and multiple transport sections. It is produced in the order listed below. The graph's nodes represent the points that are accessible for each mode of transportation in terms of sending, receiving, economic-technical, throughput, and other indicators.

Destinations that are connected to various forms of transportation, or locations where passengers can transfer from one mode of transportation to another, are each represented as a separate destination. They are linked by arcs that establish the economic indicators of initial-to-final operation expenses. For instance, when two separate modes of transportation are merged, a single transport multi-network is used to represent the locations connected by road and railway (Figure 1).

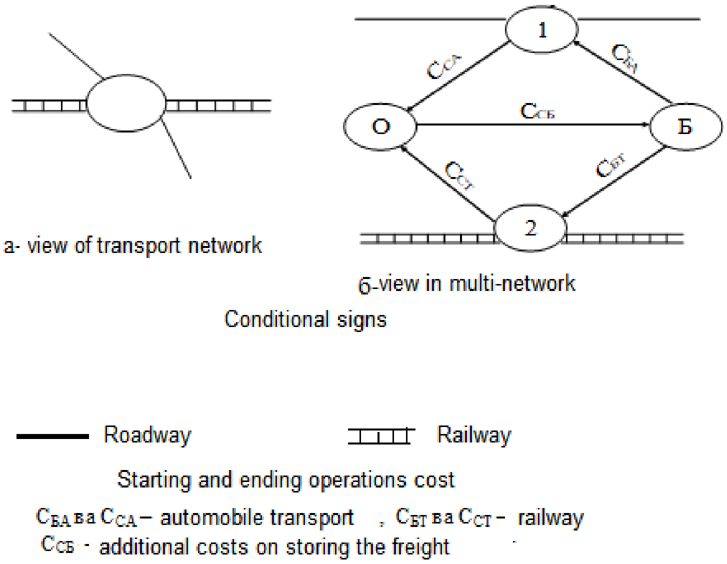


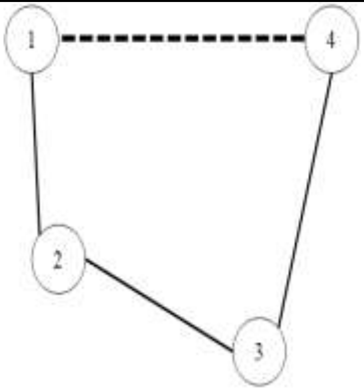
Figure 1. Points connected by road and rail transport network – view in multi-network

In this case, links 1 and 2 are conditional.

The real point where different types of transport are connected includes: Б - sender, О - receiver conditional and neutral links 1 and 2. The costs of the initial-to-final operation of the associated transport types as well as the expenses of switching from one kind of transport to another are reflected in the oriented arc between the conditional links. Therefore, $C_{БА}$ and $C_{СА}$ denote road transport, $C_{БТ}$ and $C_{СТ}$ denote the cost of initial and final operations on the railway, and $C_{СБ}$ shows the additional costs of cargo storage (Figure 2).

The distribution of cargo flows in this context is revealed as an example in Figure 3, to ensure that 22 units of cargo flow from 9b to 2c are transported with minimum costs. The result of the load current movement is shown in arrows along with the arc. Cargo flow can be carried out in two options, option 1: the cost of transportation in the direction of 9b-8-3-2s is equal to 2000+4100+2100=8200 units; Option 2: 9b-7-6-5-4-2s is equal to 60+2100+2100+2200+60=6520 units.

In this instance, the cost of transportation along the various routes is compared, and the cargo flow follows the second, more affordable alternative. However, in this option, section 6-5's carrying capacity only covers 10 units of load flow; the remaining 12 units of load flow must move in accordance with option 1. Then, for the 6-5 segment of the network, the arcs corresponding to the first phase of the highway reconstruction are transferred and filled with the load flow (an additional 5 units to the previous one). For option 2, network transportation costs are recalculated and contrasted. Cargo moves in the direction that is more affordable.



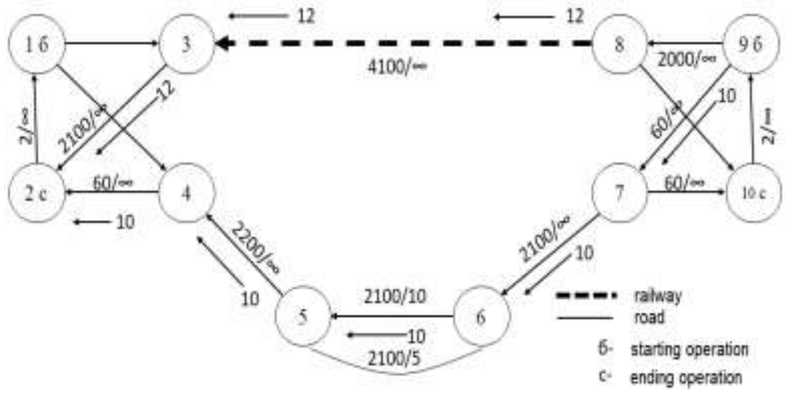


Figure 2. View of the transport network

Figure 3. A view of a transport network in multi-network

Schemes of step-by-step development of the capacity of transport network sections to transfer cargo flows.

One of the distinguishing qualities of transport is the constant growth of demand for increasing the carrying capacity of the section, and the increase of its carrying capacity can be in a short time (by jumping). One of the key problems in transport science is determining the best plan for improving the transport capacity.

Scientists and experts have long focused on the problems of the best placement and development of transport communications of an economic sector or region. The issues with trying to find a logical solution for the expansion of the transportation network are discussed in the earlier scientific publications [4, 5, 6, 7]. In these works, many recommendations are made regarding the choice and calculation of the low-level line step-by-step amplification scheme, or the ideal activity duration based on the starting conditions of the chosen technical parameters, etc. Determining possibilities for the transportation network's future expansion necessitates extensive theoretical understanding, practical expertise, and engineering advancements.

In order to shorten the travel time of the cargo flow from Eastern Europe and Asia, the article [8] analyzed the prospects of building roads in Slovakia to increase transport capacity, reloading stations ("Increasing transport capacity, building reloading stations in Slovakia"), and wide-gauge roads in Europe.

In most cases, it is anticipated that the construction of local road networks will be carried out gradually on individual nodes due to the limited financial resources. By switching from the low type of road pavement to the type of permeable pavement in this instance, the transport-operational characteristics of the transport networks are improved [9, 11].

Adoption of schemes for improving the level of road sections was based on the following considerations: each stage of road section development means either increasing the road category, or improving the pavement type, or both increasing the road category and improving the pavement type at the same time.

For the investigated area [10, 12, 13], schemes of development of the existing highway with different levels of development were adopted for the optimal distribution of traffic.

Optimal distribution of freight flows in the multi-network of road and rail transport. It is necessary to ascertain the cost characteristics of the initial-final operations of the arcs of the transport networks in the multi-network in order to solve the problem of the optimal distribution of freight flows transported in the multi-network of road and railway transport, as it is reflected in sources [3, 14].

The majority of the bulk products sent by the railroad do not arrive at its stations directly; instead, they are brought there from other locations, necessitating additional transportation of the goods after they arrive at the station. Therefore, in addition to the initial-final operation costs of the railway transport, the initial-final operations of road transport for carrying out the transportation of goods to the railway station and the transportation of goods from the station are included in the arc cost of the initial-final operation on the railway.

As previously noted, the basic information needed to solve the problem of load flow distribution in the extended network is the transport network and its dimensions. A cargo transportation matrix, in which the data is displayed for each of the network's shipping and receiving points, can be used to present the dimensions of transportation, i.e., the volume of production and consumption of various cargoes at specific points, or the transportation plan for the volume of all cargoes.

The issue of optimizing cargo flows can be formulated and resolved in a variety of ways. The first solution addresses the issue of a high number of items by optimizing load flows by distributing them to networks with constrained capacity. The practical solution of such a problem creates great difficulties, first of all, the difficulty lies in the enormous amount of work on collecting preliminary data.

In the second case, each row of the cargo transportation matrix can be considered as a "different cargo" in its category with one-point production. The problem of designing a practical road system is thus connected to the issue of network load flow optimization. The distribution of the cargo to the subsequent senders and receivers along the arc of these roads from one place to all other points will be more practical in this situation. This shortens the time it takes to address the issue and makes it possible to size the shippers and receiver's matrix more readily. Due to this, the shipping volumes are given in the form of a matrix. If a node in the network is considered "complex", that is, several types of transport are combined at this node, then production volumes (B) are considered to be concentrated at the "starting" point, and consumption volumes (O) at the "end" point.

A rough distribution of cargo flows is made in the surface transport multi-network, taking into consideration the restricted capacity of sections.

The problem is put as follows. In the shortest amount of time possible, it is necessary to ascertain the density of movement (Γ_{ij}) in each arc as well as the approximate distribution of the load current in the network. The following conditions must be satisfied in this instance:

$$F = \sum_{ij}^{m} C_{ij} \cdot \Gamma_{ij} \ \ or \ \ F = \sum_{st} C_{st} \cdot X_{st} \rightarrow \min \qquad (1)$$

This method works in this way. A system of convenient roads will be built, the capacity of the St route to carry the load flow will be determined, i.e. like $\mu(S,\dots i, j\dots t)$ $d_{st} = \min d_{ij}$.

The carrying capacity of the arcs through which this load passed will decrease together with the dispatch (distribution) of the following X_{st} load along the arcs of convenient roads. When the arc is fully satisfied, it is closed and excluded from further calculation. After each closed arc, a convenient road system is created again. The solution to the given problem in relation to the block diagram of the approximate distribution of load flows: the approximate distribution algorithm of load flows is obtained using a computer program developed on the basis of a block diagram.

The issue of creating a unified transport network for the Surkhandarya region was resolved using this technique on the basis of precise data. The surface transport multi-network of Surkhandarya region was constructed (the first attempt in the planning practice), the multi-network consists of 65 nodes and 204 arcs. Using a circle, the network nodes' order is displayed.

The suggested approach should help the designer. It can be applied to other calculations if required..

Regarding the improvement of the current transport system and flow distribution in the Surkhandarya region, the following conclusions were developed:

- based on the inclusion of additional arcs in the multi-network, and according to this scheme, it is possible to take into account the costs of the initial-final operations, it is recommended to represent the activity of reloading cargo from one type of transport to another at the destination where the road and railway transport networks are interconnected;

- justified the plan for the gradual development of the existing transport network to master future load flows in a multi-network way;
- solved the issue of the optimal distribution of freight flows in the region by road and rail transport of the studied area by type and networks. The peculiarity of this option is that the optimal plan was created with the cooperative and coordinated participation of several travel modes. Therefore, at the same time, a near-optimal plan for the development of transport types and networks was obtained.
- The actual application of these study's findings enables the equitable allocation of capital funds allotted for the planning, creation, and management of potential regional transportation networks.

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Reference

1. Botaev Sh.A., Sidiknazarov Q.M., Murodov A.S., Kuziev A.U. (2012) Logistics (Management of flows in the supply chain).-Tashkent: Extremum-Press. -pp.577.
2. Macioszek E., Staniek M., Sierpinski G. Analysis of trends in development of freight transport logistics using the example of Silesian Province (Poland) - a case study/ https://www.sciencedirect.com/science/article/pii/S2352146517309237
3. Kuziev A. Formation of territorial transportation network for optimization of load flows in the region. Academicia an international multidisciplinary research journal, Vol. 10, Issue 8, August 2020 Impact Factor: SJIF 2020 = 7.13, pp.331-339, file:///c:/users/pc/desktop/academicia-july-2020-full-journal-%20part%202.pdf.
4. Babkov V.F., Andreev O.V. Design of highways translated by A.R. Kadirova. - Tashkent: - 2001. – p.423.
5. Nesterov E.P. Transport problem of linear programming. – M.: Transport, 1971.-p.234.
6. Alikariev S., Kovshov G.N. On the method of developing a unified transport network. Magazine "Automobile Roads" №2, 1972.
7. Livshits V.N., Belousova N.I., Bushansky S.P. Improving the theoretical foundations, models and methods for optimizing the development of the road network// Computer audit, №3. 2004-pp.114-120.
8. K.S. Tchumlyakov, D.V. Tchumlyakova, The national transit capacity in the system of International transport corridors, Bulletin of transport information. 11(245) (2015) pp. 8-13.
9. Zhukov V.I., Kopylov S.V. Substantiation of a mathematical model for designing a local road network in the conditions of the Republic of Sakha (Yakutia) // Fundamental Research. - 2015. № 3. - pp.63-67; URL: http://www.fundamental-research.ru/ru/article/view?id=37085
10. Kuziev A.U., Urokov A. A. Development of Multimodal Transport Network in the Region/ International Journal of Innovative Analyses and Emerging Technology, Volume: 1 Issue: 7.
11. Muratov A.Kh., Kurbanov A.T. (2021). Improving the process of delivering scattering loads to the construction objects by using automobile transport. Harvard Educational and Scientific Review, 1(1). pp.107-117. https://zenodo.org/record/5670145#.Yl0ze8jP3IU

12. Kuziev A.U., Muratov A.Kh. Improving the method of delivery of construction cargo in auto transport. ACADEMICIA: An International Multidisciplinary Research Journal Vol. 11, Issue 8, August 2021. pp.207-216. https://indianjournals.com/ijor.aspx?target=ijor:aca&volume=11&issue=8&article=038
13. Kuziev A.U., Muratov A.Kh. Application of Logistical Principles in the Development of Directions in the Region. The American Journal of Engineering and Technology. Volume-03 Issue-05. May 31, 2021. pp.143-149. https://theamericanjournals.com/index.php/tajet/article/view/472
14. Muratov A.X. Statement and Mathematical Model of the Problem of General Service in the Transportation of Cargo by Motor Vehicle. European Multidisciplinary Journal of Modern Science. 6, (May 2022), pp.288–291. https://emjms.academicjournal.io/index.php/emjms/article/view/392