ISNN 3030-3907

2026
MAY
ISSUE - 5
VOLUME - 3

DEVELOPMENT OF SCIENCE

scientific journal



Development of science

Ilmiy jurnal

MAY 2026
Issue - 5, VOLUME - 3

ISSN 3030 -3907

Ilmiy jurnal OAK rayosatining 2024 yil 27 sentabrdagi 361-son qaroriga asosan 02.00.00 kimyo fanlari hamda 2025 yil 12 fevral 367- son qaroriga asosan 05.00.00 texnika fanlari bo‘yicha falsafa doktori (PhD) va fan doktori (DSc) ilmiy darajasiga talabgorlarning dissertatsiya ishlari yuzasidan dissertatsiyalari asosiy ilmiy natijalarini chop etish tavsiya etilgan milliy ilmiy nashrlar ro‘yxatiga kiritilgan.

BOSH MUHARRIR:
Temirov Alisher Hoshim o‘g‘li – texnika fanlari falsafa doktori (PhD),Dotsent.
TAHRIRIYAT KENGASH RAISI:
Fozilov Sadriddin Fayzullayevich – texnika fanlari doktori, professor
TAHRIRIYAT KENGASH A’ZOLARI

TEXNIKA FANLARI/ TECHNICAL SCIENCES/ ТЕХНИЧЕСКИЕ НАУКИ

Bozorov G‘ayrat Rashidovich
Buxoro Davlat Texnika Universiteti, professor
Abdurahmonov Olim Rustamovich
Buxoro Davlat Texnika Universiteti, professor
Adizov Bobur Zamirovich
O‘zbekiston Respublikasi Fanlar akademiyasi Umumiy va noorganik kimyo instituti, professor
Hayitov Ruslan Rustamjonovich
Buxoro Davlat Texnika Universiteti, professor
Jumayev Qayum Karimovich
Buxoro Davlat Texnika Universiteti, professor.
Berdiyev Dorob Murodovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor
Maxmudov Rafiq Amonovich
Buxoro Davlat Texnika Universiteti, professor.
Tilloyev Lochin Ismatilloyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Raxmonov Qahramon Sanakulovich
Buxoro Davlat Texnika Universiteti, dotsent.
Barakayev Nusratullo Rajabovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor.
Jo‘rayev Xayrullo Fayziyevich
Buxoro Davlat Texnika Universiteti, professor.
Panoyev Erali Rajabboyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Ataullayev Sherzod Nabiullyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Malik Negmurodovich
Buxoro Davlat Texnika Universiteti, dotsent.
Axmedova Ozoda Bahronovna
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti.
Safarov Bahri Jumayevich
Buxoro Davlat Texnika Universiteti, dotsent.
Xaydarov Axtam Amonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Safarov Jasur Alijon o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.

KIMYO FANLARI/ CHEMICAL SCIENCES/ ХИМИЧЕСКИЕ НАУКИ

Axmedov Voxid Nizomovich
Buxoro Davlat Texnika Universiteti, professor
Umarov Baqo Bafoyevich
Buxoro Davlat Universiteti, professor
Kodirov Abduaxad Abduraximovich
Qarshi davlat Universiteti, professor
Qurbonov Mingniqul Jumagulovich
Qarshi davlat Universiteti, dotsent
Turemuratov Sharibay Naurizbaevich
O‘zbekiston Respublikasi Fanlar akademiyasi Qoraqalpog‘iston bo‘limi Bosh ilmiy kotibi, professor
Tursunov Kaxor Shonazarovich
Qarshi davlat Universiteti, professor
Do‘stov Hamro
Buxoro Davlat Texnika Universiteti, professor
Panoyev Nodir Shavkatovich
Buxoro Davlat Texnika Universiteti, dotsent.
Olimov Bobur Bahodir o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.
Kasimov Sherzod Abduazimovich
Termiz Davlat Universiteti, professor.
Aliqulov Rustam Valiyevich
Termiz Davlat Universiteti, professor
Tropov Xamza Tursunovich
Samarqand Davlat Universiteti, professor

IQTISODIYOT FANLARI/ ECONOMICS/ ЭКОНОМИЧЕСКИЕ НАУКИ

Nizamov Aslitdin Badreddinovich
Buxoro Davlat Texnika Universiteti, professor.
Boboyev Akmal Choriyevich
Buxoro Davlat Texnika Universiteti, professor.
Ergashxojayeva Shaxnoza Djasurovna
Toshkent davlat iqtisodiyot universiteti, professor
Saidaxmedova Nodira Ilxomovna
Toshkent davlat iqtisodiyot universiteti, professor
Muxsinov Bekzod Toxirovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shakarov Qulmat Ashirovich
Renessans ta'lim universiteti,dotsent.
Jumaeva Zulfiya Qayumovna
Buxoro Davlat Texnika Universiteti, dotsent.
Norova Salomat Yusupovna
Buxoro Davlat Texnika Universiteti, dotsent.
Avezova Shaxnoza Maxmudjonovna
Buxoro Davlat Texnika Universiteti, dotsent.
Jalilov Jamshid G‘anijonovich
Toshkent davlat iqtisodiyot universiteti, dotsent
Xasanova Gulruh Djumanazarovna
Buxoro Davlat Texnika Universiteti, dotsent.

PEDAGOGIKA FANLARI/ PEDAGOGICAL SCIENCES / ПЕДАГОГИЧЕСКИЕ НАУКИ

Siddiqova Sadoqat G‘afforovna
Buxoro Davlat Texnika Universiteti, dotsent.
Zoyirov Erkin Xalilovich
Buxoro Davlat Texnika Universiteti, DSc, professor
Gaffarov Feruz Hasanovich
Puchon Universiteti, *professor*
Ruziyev Davron Yuldashevich
Buxoro Davlat Universiteti, professor
Muradova Firuza Rashidovna
Buxoro Davlat Texnika Universiteti, professor.
Yunusova Gulandon Samiyevna
Buxoro Davlat Texnika Universiteti, professor.
To‘xtayeva Zebo Sharifovna
Buxoro Davlat Texnika Universiteti, professor.
Navro‘zova Gulchixra Nigmatovna
Buxoro Davlat Texnika Universiteti, dotsent.
Uzoqova Laylo Polvonovna
Buxoro muhandislik – texnologiya instituti, dotsent.
To‘raqulova Marjona Qiyom qizi
Buxoro Davlat Texnika Universiteti, dotsent.
Muradova Zarina Rashidovna
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Sanjar Aslonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shodiyev Jahongir Jo‘raqulovich
Buxoro Davlat Texnika Universiteti, dotsent
Gaffarov Laziz Hasanovich
Buxoro muhandislik – texnologiya instituti, dotsent.

Tahririyat a’zolarning to‘liq ro‘yxati jurnalning www.devos.uz saytida keltirilgan.

Tahririyat hay’ati a’zolarining tarkibini o‘zgartirish hamda qo‘shimcha kiritish yoki tahririyat a’zoligidan chiqarish bosh muharrir tomonidan amalga oshiriladi.

ISSN 3030-3907

Development of science ilmiy jurnali 2024 yil 15 aprel kuni №256445 sonli guvohnoma bilan Davlat ro‘yxatidan o‘tgan.

To‘plam elektron ko‘rinishda (pdf formatida) mualliflarga taqdim etiladi. To‘plamga kiritiladigan maqolalarning mazmuni, ulardagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligiga hamda har qanday fikr - mulohazalarga mualliflarning o‘zlari mas’ul hisoblanadilar. Talablarga javob bermaydigan maqolalar to‘plamga kiritilmaydi. Tashkiliy qo‘mita maqola matnini qisqartirish, qisman tuzatish kiritish, seksiyalarga joylashtirish huquqiga ega.

ISSN 3030-3907

REPLANNING OF URBAN BUS ROUTE NETWORKS AND ANALYSIS OF ROUTE SCHEDULING USING ARTIFICIAL INTELLIGENCE (A CASE STUDY OF TERMEZ)

Kuziyev A.U.
Teacher at Termez University of Engineering and Agro-Technologies
E-mail: kuziyev11@gmail.com
Komilov A.L.
Teacher at Termez University of Engineering and Agro-Technologies
E-mail: azamkomilov@gmail.com
Xudaykulov.R.Z.
Teacher at Termez University of Engineering and Agro-Technologies
E-mail: rustamxudayqulov@bk.com
Tashpulatov.B.B.
Teacher at Termez University of Engineering and Agro-Technologies
E-mail: reason761@gmail.com

Abstract. This article provides a scientific analysis of the application of modern approaches in the planning and organization of urban transport route networks, using the city of Termez as a case study. It also examines advanced theoretical frameworks and graph theory methods for modeling optimal route networks, as well as the integration of bus scheduling systems using artificial intelligence techniques.

Keywords: urban route networks, transport networks, transport zoning, route optimization, transit routing, network optimization, passenger demand, headway optimization, public transport planning, intelligent transportation systems (ITS), artificial intelligence, machine learning, smart mobility, data-driven optimization, bus scheduling, route allocation.

Annotatsiya. Ushbu maqolada Termiz shahri misolida shahar transporti yo‘nalishlar tarmog‘ini rejalashtirish va tashkil etishda zamonaviy yondashuvlarni qo‘llashning ilmiy tahlili berilgan. Shuningdek, optimal yo‘nalishlar tarmog‘ini modellashtirishda graf nazariyasi va ilg‘or nazariy yondashuvlar ko‘rib chiqiladi hamda avtobuslar jadvalini tuzish tizimlariga sun’iy intellekt texnologiyalarini integratsiya qilish masalalari o‘rganiladi.

Kalit so‘zlar: shahar yo‘nalishlar tarmog‘i, transport tarmoqlari, transport zonalash, yo‘nalishlarni optimallashtirish, tranzit marshrutlash, tarmoqni optimallashtirish, yo‘lovchi talabi, harakat intervalini optimallashtirish, jamoat transportini rejalashtirish, intellektual transport tizimlari (ITS), sun’iy intellekt, mashinaviy o‘rganish, aqlli harakatlanish, ma’lumotlarga asoslangan optimallashtirish, avtobuslar jadvali, yo‘nalishlarni taqsimlash.

Аннотация. В данной статье представлен научный анализ применения современных подходов к планированию и организации городских транспортных маршрутных сетей на примере города Термез. Также рассматриваются передовые теоретические подходы и методы теории графов для моделирования оптимальных маршрутных сетей, а также интеграция систем расписания автобусов с использованием технологий искусственного интеллекта.

Ключевые слова: городские маршрутные сети, транспортные сети, транспортное зонирование, оптимизация маршрутов, транзитная маршрутизация, оптимизация сети, пассажирский спрос, оптимизация интервалов движения, планирование общественного транспорта, интеллектуальные транспортные системы (ITS), искусственный интеллект, машинное обучение, интеллектуальная мобильность, оптимизация на основе данных, расписание автобусов, распределение маршрутов.

INTRODUCTION.

In the context of ongoing globalization and economic development, ensuring the stability and efficiency of the passenger transport system has become a significant scientific and practical issue. The improvement of transport service quality, increasing population growth rates, and accelerating urbanization processes are imposing complex and integrated challenges on the transport infrastructure of both large and small cities.

In particular, under the conditions of the continuous expansion of Termez city, the development of the passenger transport system and route networks requires a systematic approach. The current state of existing route networks does not fully correspond to the actual demand and mobility patterns of passengers, which leads to a decrease in the efficiency of transport services. As a result, imbalances occur in the operation of the transport system, reducing the efficiency of resource utilization and failing to ensure an adequate level of passenger service quality.

LITERATURE REVIEW AND METHODOLOGY.

For instance, the increasing population density in areas such as administrative and service facilities, commercial complexes, sports facilities, multi-storey residential buildings, and large residential districts necessitates the continuous development of route networks and the improvement of public transport efficiency. Taking these factors into account, it becomes essential to regularly enhance the public transport system and optimize its performance. According to data provided by the Surkhandarya Regional Statistics Department [2], the population of Termez city reached 201.6 thousand people as of 2024, with a rapid urbanization process being observed. This situation determines the

ISSN 3030-3907

relevance of the present study, as it is associated with the need to systematically analyze and generalize existing theoretical and practical approaches to the planning and organization of urban route network development. In this regard. According to the "Uzbekistan–2030" Strategy and the Decree of the President of the Republic of Uzbekistan dated 11 September 2023 (No. PD–158) [1], it is planned to deepen the integration of Uzbekistan into global transport and logistics networks, enhance the capacity of the national transport system, and ensure full coverage of urban and district areas with public transport services. In addition, the strategy envisages increasing the number of buses to 5,000 units and electric buses to 2,000 units. The aim of this study is to identify prospective theoretical

directions for passenger transportation in public transport based on a review of scientific literature and methodological approaches, as well as to generalize practical experience and existing studies related to the planning and organization of urban route network development.

The expansion of the territory of Termez city	
2018	2,78 ha
2019	1,561 ha
Jami	**4,341 ha**

The theoretical and methodological foundations of the study are as follows:

The scientific novelty of the study lies in the identification of new transport routes for the prospective development of public transport systems, taking into account the territorial expansion of urban areas, and in the planning of urban passenger transport route networks. In particular, the expansion of the territory of Termez city leads to an increase in demand for public transport services.

DISCUSSION AND RESULTS.

According to data from the Surkhandarya Regional Statistics Department, and based on the anticipated administrative changes, the territories of the "Manguzar," "Chegara," "Pattakesar," "Tinchlik," "Alisher Navoiy," and "Kokildor Ota" mahalla citizens' assemblies located in Termez district, as well as part of the "Nurli Diyor" and "Namuna" mahallas (with a total land area of 1,561 hectares), have been incorporated into the territory of Termez city [2].

In this regard, the process of planning and organizing the urban route network development should be carried out by taking into account the specific characteristics of urban infrastructure, as well as through the application of mathematical models and methods. In the formation and design of route networks, the primary objective is to establish an efficient urban transport system, where passenger satisfaction with transport services and the quality of provided services are key determining factors directly influencing system performance.

ISSN 3030-3907

Methodological foundations for improving the bus route network scheme.

The modern methodology for improving route network schemes is based on the conceptual approach presented in sources [1,4]. Its main essence lies in the integration of individual branches of the transport network and the formalization of alternative routes, which are subsequently incorporated into a rational system of route organization.

When analyzing the process of monitoring routes and forming a functional route scheme, the problem of ensuring efficient, fast, and convenient connectivity between urban microdistricts becomes a key issue. These connections are primarily shaped according to passenger flow distribution [5,6].

Through the revision and optimization of existing transport routes, the urban transport network can be represented as a graph model, which includes connection nodes between major transport hubs. In order to implement such a transformation, accurate information about the mobility needs of the urban population is required.

For this purpose, high passenger flow points between transport districts—such as major bus stops and origin-destination nodes located at transport junctions—are utilized.

Based on this data, passengers are distributed across different destinations within transport zones, and corresponding origin and destination points are identified for various routes. In the urban transport network, a specialized database is formed based on the shortest path calculations between each pair of nodes. This database includes precise information on the origin, destination, and intermediate points for each route, as well as the distance and travel time between them.

If multiple alternative routes exist between two nodes with similar travel times, all of them are considered. However, in the final selection process, only the most optimal variants are chosen. This approach plays an important role in increasing transport network efficiency and ensuring the optimal distribution of passenger flows.

The problem of selecting a bus route scheme, similar to the solution of the problem presented in the previous chapter, is based on mathematical methods of combinatorial analysis. This approach utilizes a directed selection method that enables the identification of an optimal solution among hundreds of alternatives in approximately 95–98% of cases. The method was proposed by V. A. Parshikov, and even if the obtained solution is not fully optimal, it is guaranteed that the final result deviates from the optimal solution by no more than 3%. Thus, this approach ensures a near-optimal outcome [7]. When planning a new route network or

ISSN 3030-3907

modifying existing ones, two main approaches can be applied. The first approach involves dividing urban public transport into primary and secondary routes, with subsequent sequential implementation of planning and organizational measures.

The main residential microdistrict transport network objects of Termez city include:

Industrial zones
Commercial and administrative areas
Zones with cultural and historical sites
Transport and logistics (warehouse) areas
Recreational and health-improvement areas

In the planning of urban transport systems, it is essential to identify primary stopping points within the street and road network that are suitable for public transport operations, as well as key nodes where passenger flows are generated within functional urban zones. Within each transport microdistrict, a principal passenger flow center must be defined to ensure an efficient distribution of mobility demand.

The delimitation of microdistrict boundaries is carried out based on an acceptable pedestrian accessibility range (0.5–0.6 km), while simultaneously accounting for natural and artificial barriers such as rivers, railway lines, and major arterial roads. This methodological approach ensures improved spatial accessibility for passengers, enhances the functional coherence of the transport network, and increases the overall efficiency of urban transport system planning. For the mathematical formulation and solution of the problem of selecting a bus route scheme, the following initial data are required: a city map that defines the nodes forming the transport network and the links connecting them, as well as the possible routes along which buses can operate. These nodes correspond to the origin and destination points of passenger transportation, i.e., urban transport microdistricts.

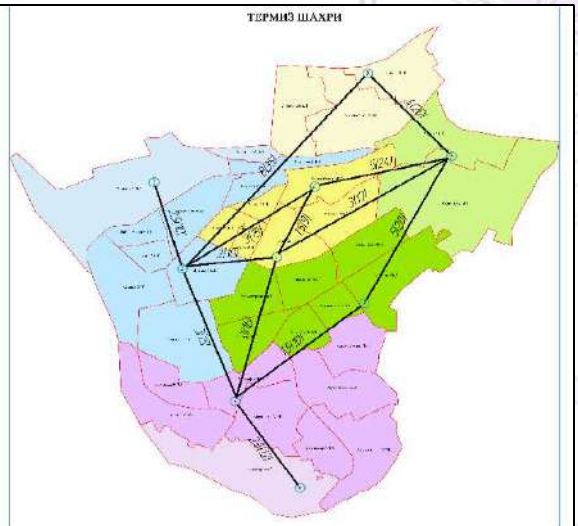
The route network is designed based on the distribution of regular stopping points and the zoning of the urban territory into functional sectors. Figure 1 illustrates the division of Termez city into microdistricts and the existing operational route scheme.

ISSN 3030-3907



The division of Termez city into zones.

1-Figure.

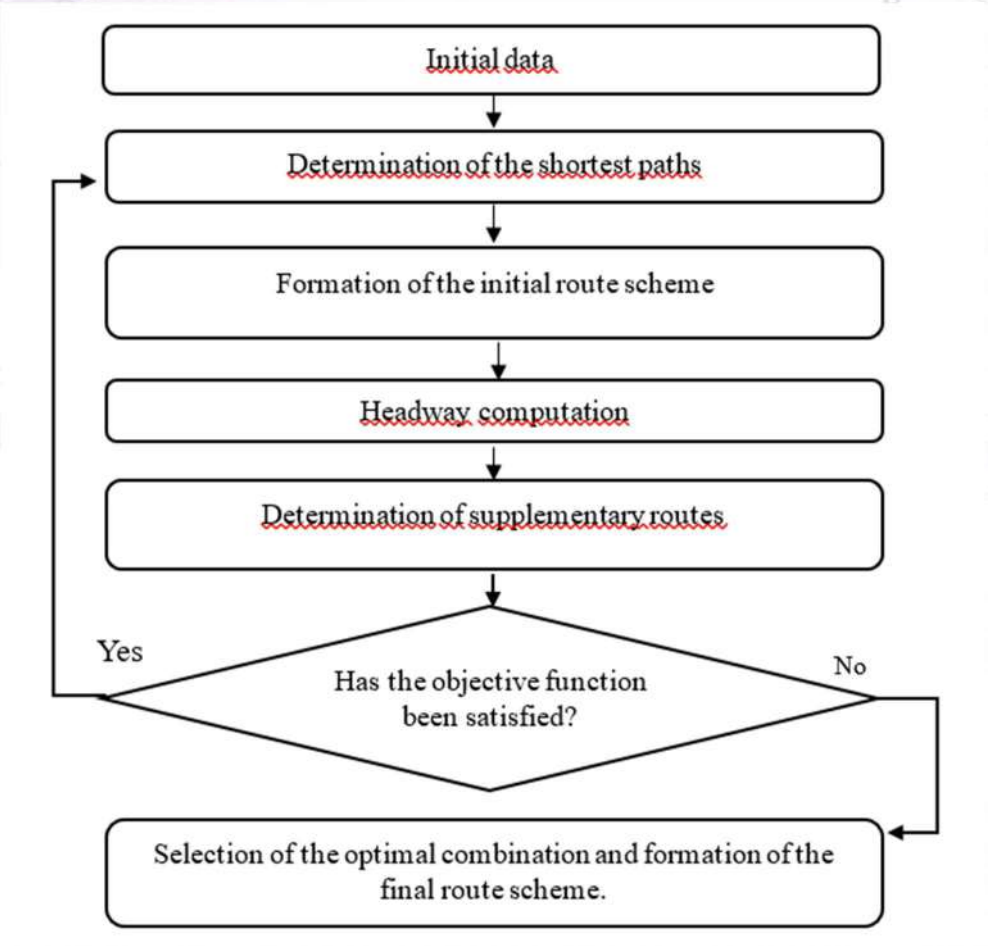


Public transport routes in the districts of Termez city

2-Figure

In the formation of a route network, in order to improve the quality of passenger service, the following indicators should be taken into account: the total travel time spent by passengers, the location and spacing of stopping points, the headway (service interval) of urban public transport, the number of transfers during passenger travel and fare cost, as well as transport safety, comfort, and ease of use, among other factors. 2-Figure. It shows the sequential stages of designing and optimizing the urban bus route network process.

ISSN 3030-3907



2-Figure. It shows the sequential stages of designing and optimizing the urban bus route network process.

The main advantage of the proposed public transport approach lies in its versatility. The methodology can be applied both to the planning of new routes and to the improvement of existing urban public transport route networks.

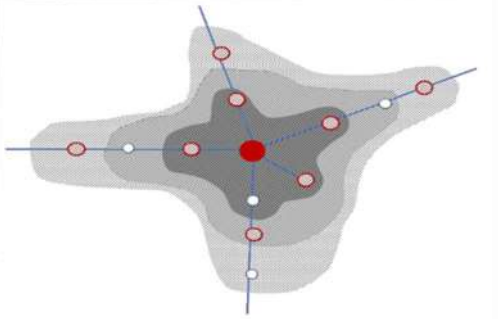
According to the method for identifying optimal route network configurations, researchers E.S. Tashlanov and V.A. Ignatyugin [8] (Tashlanov, Ignatyugin, 2019) considered a node-based approach in the planning of the public transport system using the case of Tyumen city.

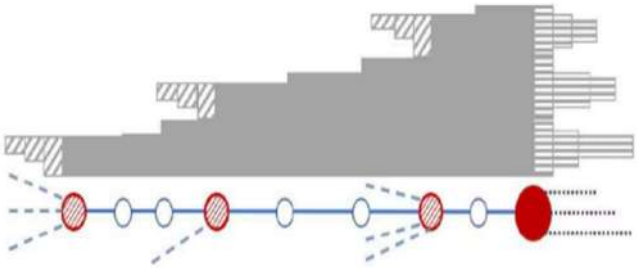
The authors noted that public transport networks are often developed based on the territorial origin of demand. For primary streets of the first category, the following requirements were applied:

the presence of passenger attraction centers;
historical significance;
the number of urban public transport routes;
the geometric layout of the street network.

Accordingly, in our scientific article, the schematic representation of the street network and high-flow areas of Termez city is illustrated in Figure 3.

ISSN 3030-3907





	- city center (main suburban bus station)
	stations and stops generating major passenger flows
	small settlements located in the railway line zone (stopping points)
	divided road sections (direction of main passenger flows)
	urban and suburban transport routes carrying passengers to the station
	core urban transport routes
	suburban passenger flow (passenger flow density)
	satellite passenger flow along the route corridor
	passenger flow along urban public transport routes of the city

The number of possible variants for constructing a route diagram is expressed by a very large value. The optimal solution is between two boundaries

m=[(n-1) n]:2, ***n*** - the number of microdistricts

Considering that there are a total of 12 microdistricts in the city of Termiz, a combinatorial method can be used to determine the number of possible route directions. In this case, the following formula is applied:

$$t = [(p - 1) \cdot p]: 2 = [(12 - 1) \cdot 12]: 2 = 20 \ (1)$$

This situation can be examined in the following table (Table 1) by considering the maximum possible number of routes depending on the number of microdistricts.

2- Table

Determining the maximum possible number of routes based on the number of microdistricts.

T/r	**Number of microdistricts, p (units)**	**Number of route directions, n (units)**
1	1	0
2	2	1
12	12	20
…	25	300
n	pn	nn

ISSN 3030-3907

The resources of the bus fleet are distributed across an excessively large number of routes, resulting in a small number of buses operating on each line.

Waiting time for passengers increases because the service interval (headway) on each route becomes longer.

Transport efficiency decreases, meaning that the bus occupancy (load factor) is low.

As an opposite extreme case, the simplest linear distribution is considered. In this case, routes are established only between neighboring microdistricts. If the number of microdistricts is $m = 38$ If there are p microdistricts, in this case only $m = m - 1 = 37$ only a certain number of routes are formed. Such a scheme is also not appropriate because:

A large number of passengers cannot reach their destination directly and are forced to make multiple transfers.

A significant portion of passengers' total travel time is spent waiting at stops or changing routes.

Methodology for calculating bus route schemes in cities. The methodology for forming bus routes in the urban transport system is considered based on a simplified, illustrative example. Although this approach does not fully account for all constraints and uncertainties that arise in real conditions, it provides a sufficiently solid basis for understanding the main principles and applying them in practice.

The considered example is represented by a hypothetical transport network. This network:

Circular nodes in the transport network represent the centers of microdistricts within the city, and each has its own identification number.

The arcs between the circles represent bus routes, and the numbers on them indicate the travel time of buses in minutes.

The values given in parentheses indicate the length of the corresponding routes in kilometers.

In the example conditions, the following assumptions are made:

The analysis is carried out for the peak load period — i.e., the busiest morning hours.

In this period, the passenger transportation volume is evaluated for a 1-hour time interval.

Data on passenger flow is provided based on Table 3, which represents the estimated passenger demand between microdistricts.

Based on this table, the necessary calculations for forming and optimizing bus routes are carried out. The main objective is to ensure the efficient use of transport vehicles and to minimize the total travel time of passengers.

ISSN 3030-3907

Table 3

Passenger flow

From where	Where to								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	-	358	152	112	189	183	345	253	198
2	289	-	221	156	289	153	187	241	95
3	235	158	-	112	336	148	215	356	201
4	251	189	83	-	194	211	156	245	158
5	349	210	189	156	-	192	194	215	125
6	189	389	201	199	125	-	89	174	102
7	356	275	189	193	341	121	-	349	101
8	346	389	323	112	359	123	245	-	98
9	125	189	298	123	101	79	79	56	-

The results of the calculations are systematically presented in Table 3, where the columns on the left indicate the origin points and the top row indicates the destination points. The cells contain the travel time (in minutes) and intermediate transfer points along the route. For example, to travel from point 1 to point 5, the shortest path passes through points 2 and 8, and the total travel time is 23 minutes (excluding transfer time).

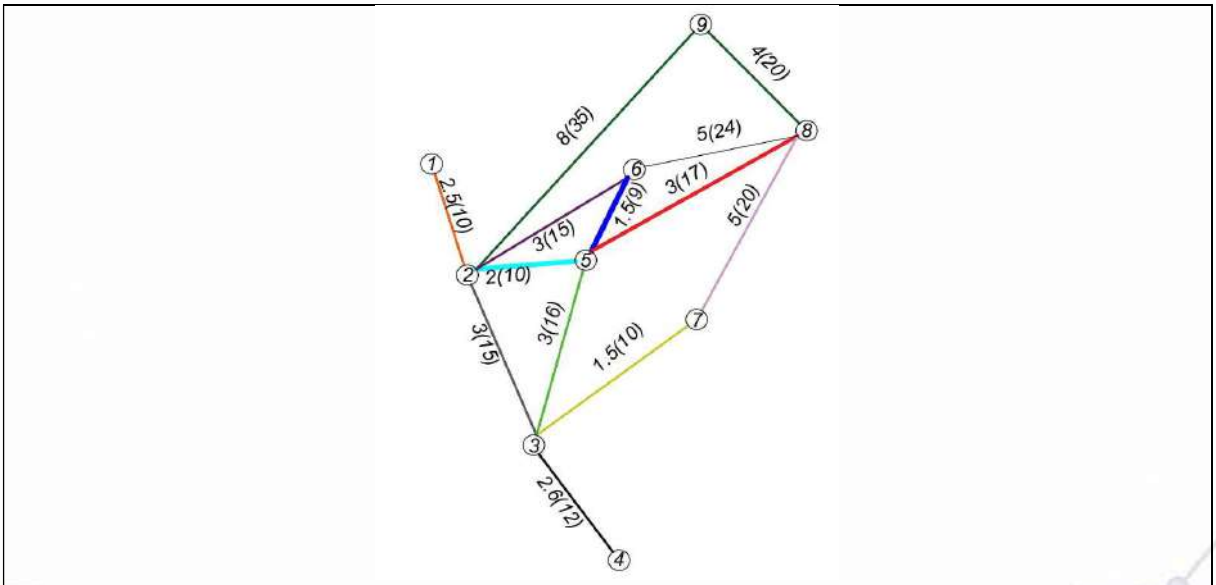


Figure 3. Scheme of the public transport network of Termiz city, with streets classified by hierarchy levels.

Using the same approach, each node is sequentially taken as the starting point, and the shortest paths to all other nodes are determined. The results are then compiled in the form of a table. This serves as an important source of information for identifying optimal routes within the transport network. It should be noted that within an urban agglomeration, passenger flows in each direction—suburban-to-

ISSN 3030-3907

urban and intra-urban—are formed from the local passenger flows of individual settlements. Upon reaching major hubs, these flows are redistributed in a "mixed" manner together with passenger flows arriving from other directions, as well as direct flows to the city center. This is illustrated in Figure 3. For the next category of streets, additional criteria are introduced alongside the existing ones (streets may merge into main roads, or certain routes may intersect or overlap).

Stage II. Determining the Initial Route Scheme

As the initial route scheme, routes are selected that include direct routes (i.e., those connecting several microdistricts) as well as local (sectional) routes that do not correspond to any direct route. A direct (through) route is a continuous line that connects three or more microdistrict centers in the shortest possible time.

A sufficient condition for assigning a direct route is expressed as follows: the waiting time for a passenger at the starting point of the route must be less than or equal to the time required for transferring to another route in the absence of such a direct connection. Based on the condition given above, the existing routes are analyzed:

$$\frac{c \cdot q \cdot T_p}{\rho} \cdot \frac{1}{P_{ij}} \leq t_{n_l} \quad (2)$$

For route 1–3:

$$\frac{0{,}5 \cdot 38 \cdot 60}{1{,}1} \cdot \frac{1}{112} > 9 \qquad (3)$$

The method of representing route-based passenger transport networks in the form of graphical models has been examined [7].

This approach corresponds to a typical graphical model of a transport network, which is supplemented by parameters describing the network nodes (stops) and the type of transport vehicles, as well as parameters that characterize the connections between these nodes.

The bus movement schedule can be analytically generated using the *Termiz Bus Simulator – Multi-Route OSRM Simulation* software. This program enables the modeling of route operations by incorporating multiple interconnected routes and real-world road network data based on OSRM (Open Source Routing Machine). Through this approach, it becomes possible to simulate traffic dynamics, evaluate route efficiency, and determine optimal movement schedules. The developed software serves as an effective tool for the analysis and improvement of urban passenger transport systems.

ISSN 3030-3907

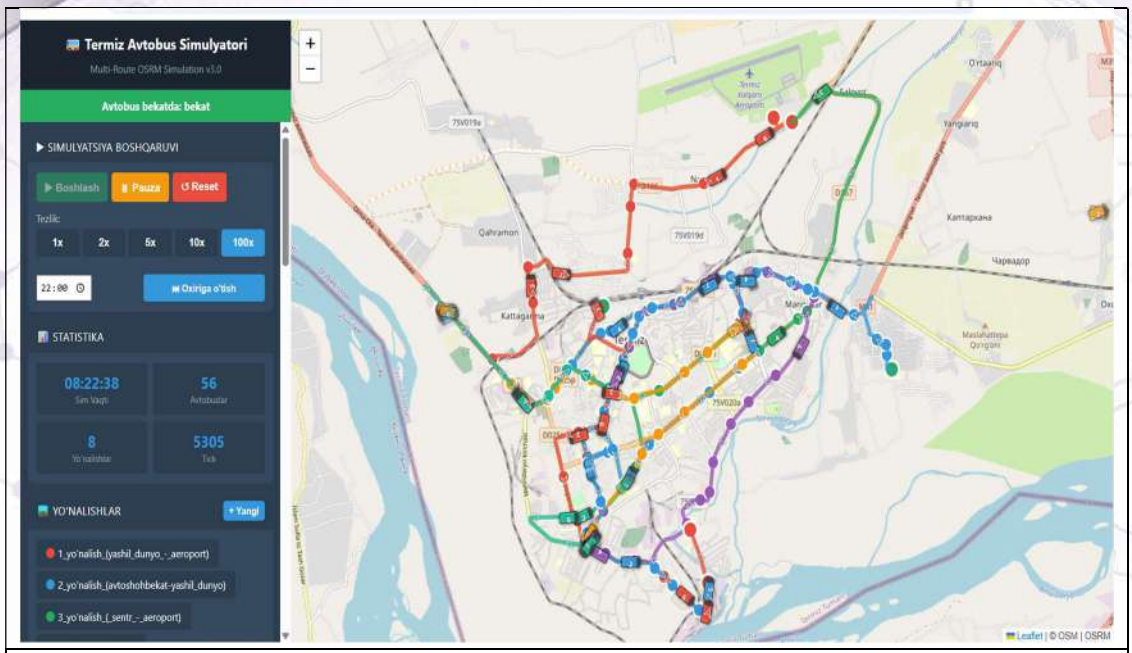


Figure 3. Based on geotracker-derived location data

Based on the software system, it is possible to rapidly and accurately obtain key operational parameters of bus movement, including headways, average speed, stopping intervals, and other performance indicators. Such an approach enables the evaluation of transport system characteristics under near real-time conditions, the analysis of route efficiency, and the optimization of passenger flow distribution. Consequently, it provides a robust scientific basis for the planning, modeling, and management of urban public transport operations.

Designing and evaluating transport networks and route systems in cities [8]

studying the specific characteristics of the city, including its spatial structure, land-use development patterns, and other factors influencing the existing transport framework;

determining the location of the main transport hub and analyzing the accessibility of residential areas in relation to it;

analyzing the existing street and road network and assessing its impact on the formation of urban public transport routes;

integrating artificial intelligence-based data analysis and geotracker location data to improve the accuracy of passenger flow assessment and mobility pattern identification;

defining the requirements for the urban transport system;

developing performance indicators for designing different variants of the urban transport system;

selecting the most optimal variant based on passenger flow coverage, AI-based demand forecasting, geotracker-derived mobility analysis, and efficient utilization of rolling stock.

ISSN 3030-3907

This approach can be applied in urban system design, and its implementation may improve both capacity and travel speed of passenger transport, even in small cities.

CONCLUSION.

The planning and development of urban route networks are based on appropriate theoretical methodologies and advanced practical experience. A balanced system for planning and developing transport transfer nodes contributes to improving population mobility and increasing the efficiency of public transport usage. Improving the efficiency of organizing urban route network planning involves addressing key challenges through the use of modern digital technologies. In particular, artificial intelligence-based analysis and prediction of passenger flows, as well as geotracker-based identification of real movement patterns, enable more accurate and efficient transport system design. The article discusses the main advanced methods for planning and developing urban passenger transport route networks. The advantages of the presented methods are reflected in their versatility, as they can be effectively applied even in small cities using artificial intelligence and geolocation (geotracker) data integration. This allows optimization of transport systems in areas with different population sizes, street-network structures, and passenger flow formation characteristics. As a result, the quality, safety, and efficiency of urban passenger transport systems are significantly improved.

REFERENCES

1. Decree of the President of the Republic of Uzbekistan, dated 11.09.2023, No. PF-158.
2. Lebedeva O.A. Issues of urban passenger transport functioning // Modern Technologies and Scientific-Technical Progress. 2013. Vol. 1, p. 40
3. Mamirov U.Kh., Soliev Kh.M., Turgunov Z.Kh. Efficiency of increasing the capacity of intersections on central streets in Namangan city // Mechanics and Technology. – 2023. – Vol. 1, No. 10. – pp. 66–71.
4. Lebedeva O.A. Indicators for evaluating the efficiency of public transport operation // Modern Technologies and Scientific-Technical ProgressPatakhanova M. Passenger transportation and passenger turnover by types of transport. – 2023.
5. B.L. Geronimus. *Economic-mathematical methods in planning in road transport*. Moscow: Transport, 1982.
6. Qo‘ziyev A.O‘., Komilov A.L. Analysis of the public transport network of Termiz city // Proceedings of the Republican Scientific and Technical Conference “Transport and Logistics: Digital Technologies in the Development of the Republic’s Transport-Transit Potential”. Tashkent, 2021, p. 1188.

ISSN 3030-3907

7. Komilov A.L. Analysis of the experience of designing urban passenger transport route networks (on the example of Surkhandarya) // *Oriental Renaissance: Innovative, Educational, Natural and Social Sciences*. E-ISSN: 2181-1784, www.oriens.uz, SJIF 2023 = 6.131, ASI Factor = 1.7, Vol. 3(4/2), April 2023.
8. Komilov A.L., Mirzaev A.Sh. Model of the capacity of a bus stop (on the example of Termiz) // *Oriental Renaissance: Innovative, Educational, Natural and Social Sciences*. – 2025. – Vol. 5, No. 3, pp. 154–163.
9. Komilov A.L., Khudaikulov R.Z. Selection of an optimal bus type for passenger transportation using mathematical methods.
10. Komilov A.L., Suyunov O.D., O‘rozov A.D. General technical requirements of bus stops and improvement of their logistic management // *Journal of Universal Science Research*. 2025. Vol. 3, No. 5, pp. 164–170. Retrieved from: https://inlibrary.uz/index.php/universal-scientific-research/article/view/99107
11. https://yandex.ru/search/?text=surxon+stat.uz&clid=275722295&win=695&lr=10338