

**PROBLEMS OF SYNCHRONIZATION THE PUBLIC TRANSPORT SCHEDULE  
IN THE CITIES OF UKRAINE**

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Efficient transport is a crucial element for the functioning of cities, agglomerations and countries. Uncontrolled and inefficient traffic can lead to congestion, delays and inconveniences for passengers. Therefore, the problem of ensuring passenger mobility with an adequate level of comfort in the context of accelerated urbanization remains relevant. Long waits at bus stops, inconsistencies with schedules, and uncertainty about the arrival of a vehicle are commonplace for public transport passengers in Ukraine. One of the most effective ways to improve the efficiency of public transport is to synchronization its timetables.

Synchronization of public transport is one of the most important problems faced by many cities around the world, including Ukraine. It should be noted that despite the uniqueness of the urban passenger transport system, Ukrainian cities face similar problems. The practical development of synchronized traffic schedules on urban transport routes is a difficult task for a number of reasons.

One of the main reasons for the problems of synchronization public transport in Ukraine is the lack of scientifically based approaches to create optimal timetables in real time. Most Ukrainian enterprises use outdated timetable development methods. Creating coordinated public transport schedules is a complex and important task [1]. Recently, there has been an increase in the number of works on timetable synchronization using a multi-criteria objective function. Researchers have identified the need to minimise the number of vehicles required and maximise passenger comfort.

There are four methods for optimising the schedule synchronization problem, namely: genetic algorithm [2-4], variants of integer programming [5,6], annealing modelling [7,8] and other methods [9,10]. The most common is the genetic algorithm. Existing methods for rationalising timetables for certain sets of routes or relatively small urban transport networks allow obtaining solutions that are better than the baseline, but assessing the quality of these solutions and determining the possible reserve for further improving the efficiency of the public transport system is usually methodologically impossible, since it is impossible to determine the optimal timetable in real time due to the complexity of the optimization problem. Therefore, current models and approaches to timetable synchronization are imperfect and require further development. To solve the problem of synchronization public transport timetables in practice, it is necessary to develop effective heuristic methods that allow obtaining solutions in real time.

The second reason for the problems of synchronization public transport in Ukraine is the lack of centralised the transport system management. For example, in the city of Dnipro, passenger transportation is provided by the metro (1 metro line), 1 tram depot (14 tram routes), 2 trolleybus depots (21 trolleybus routes), and 22 motor transport enterprises of various forms of ownership (125 bus routes) [11]. Local authorities cannot significantly influence the quality of passenger service, and there are no effective mechanisms for coordinating the work of public transport operators. Local authorities regulate transport activities mainly by influencing tariff policy, stimulating competition and ensuring social protection of city residents. Transport companies have a diverse structure and ownership and do not coordinate their operations. Each carrier makes its own timetable for the route based on its own interests and capabilities.

In addition, the lack of centralised the system management is exacerbated by the lack of modern traffic monitoring and control systems. Currently, Ukrainian cities are implementing automated dispatching systems, installing GPS-trackers that generate data sets for monitoring and analysing public transport operations. However, their availability has not had a qualitative impact on the efficiency of public transport due to the lack of a single dispatch centre. Drivers and dispatchers mostly receive information from colleagues through telephone conversations or chats they create. Limited accurate data on the location and movement of vehicles complicates the work of dispatchers

and drivers, leading to unreasonable delays and inefficient use of the transport system's potential. In the city of Dnipro, vehicle dispatching is carried out separately for each type of passenger transport and consists only of information provided to the relevant department of the city council on the number of vehicles and flights made on the routes [11]. Insufficient communication between the dispatch services of different types of transport makes it difficult to synchronize public transport schedules.

The use of a unified monitoring system will help to identify potential congestion and predict the arrival of vehicles at their destination. In Dnipro, information boards and mobile applications (e.g. EasyWay) are used to provide information about the current situation on the roads. These tools are intended to increase passenger information when making a decision on route choice and do not contribute to the synchronization of public transport schedules. Thus, the lack of unified control and monitoring of transport significantly reduces the level of public transport management. This leads to the absence of a common strategy and plans for the public transport development and the synchronization of its movement.

Effective synchronization of public transport is impossible without a systematic study passenger demand, which includes collecting data on passenger flows, conducting passenger surveys, analysing timetables and forecasting demand. Due to limited funding, these studies are not given enough attention. Lack of information on passenger satisfaction with transport services and incorrect passenger flows estimates leads to the development of irrational routes and timetables.

Another problem is the lack of funding for the public transport development and infrastructure development in many Ukrainian cities. Lack of funds for the purchase new buses, trolleybuses and trams, as well as for the modernization and improvement of infrastructure, means that local transport companies cannot provide an adequate passenger service level. The transport infrastructure of Ukrainian cities is characterised by a mismatch between the capacity certain sections of streets and roads and the volume of traffic, a limited number of car parking spaces, irrational public transport stops location, etc.

Thus, the priority measures to solve the problem of synchronization public transport schedules should be

- development of new approaches to synchronization passenger transport timetables for the large cities route systems, allowing real-time determination a set of timetables close to the optimal solution the problem;
- introduction unified management of all types mass passenger transport;
- coordination of public transport operations through a single central control centre;
- systematic survey of passenger flows on all types of transport operating in the city;
- modernization of infrastructure, etc.

Unfortunately, the war in Ukraine, limited funding, and other factors are slowing down the implementation of the proposed measures. However, the current situation should not fundamentally affect the development of methods for improving the quality of transport services the population through the use of traffic synchronization models adapted to the real conditions of Ukraine. The development of such models is based on the use heuristic methods and simulation modelling. The use regularities of changes in the time parameters of traffic in accordance with real conditions, which can be established during simulation modelling, makes it possible to improve existing genetic algorithms for finding optimal options of synchronization timetables in accordance with the real conditions of technological operations on passenger routes.

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