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THE USE OF MULTIMODAL SERVICE LEVEL AND ARTIFICIAL NEURAL NETWORKS FOR THE IMPROVEMENT OF PUBLIC TRANSPORT

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Rezumat

Majoritatea orașelor moderne ale lumii se confruntă cu probleme din cauza condițiilor de trafic. Cu toate acestea, în ultimul deceniu gradul de motorizare combinat cu urbanizarea crescută și densitatea populației provoacă depășire a capacitaților de circulație în orele de vârf pe străzile principale ale orașelor deja aglomerate. În aceste circumstanțe, transportul public ar trebui să ofere o alegere fiabilă și alternativă pentru călătoriile zilnice. Articolul este axat pe dezvoltarea unor modele de cuantificare a mediului în care operează transportul public și a calității serviciilor. De asemenea, utilizarea rețelei neuronale artificiale ca instrument de analiză asistată a tuturor componentelor traficului, poate ajuta autoritățile locale să îmbunătățească performanța serviciului de transport public. În plus, îmbunătățirea fiabilității serviciului de transport public poate reduce costurile de călătorie și modifica repartiția modală.

Cuvinte cheie: nivel de serviciu, analiza transportului public, rețele neuronale artificiale

Abstract

Most of the major modern cities of the world face problems due to traffic conditions. However, in the last decade the degree of motorization combined with increased urbanization and population density causes excess traffic capacity during peak hours on the main streets of already congested cities. In these circumstances, public transport should provide a reliable and alternative choice for daily travel. The article is focused on the development of models to quantify the environment in which public transport operates and the quality of services. Also, the use of artificial neural network as a tool for assisted analysis of all traffic components can help local authorities to improve the performance of public transport service. In addition, improvements in the reliability of public transport service can reduce travel costs and change the modal split.

Keywords*:* level of service, public transport analysis, artificial neural networks

1 INTRODUCTION

The development policies of cities have been based, for decades, on the growth of road infrastructure, combined with the increase in the degree of motorization. In consequences such transport strategies have led to the expansion of the street network, often having negative urban consequences and ultimately leading to increased traffic jams. In order to attempt a quantification of traffic conditions, in 1965, a group of researchers created one of the first traffic manuals (Highway Capacity Manual), in which the theoretical foundations of a new parameter were laid: service level [1].

By its definition, the level of service presents a framing of the traffic conditions in an intersection/street segment using, depending on the calculation methodology, as evaluation parameters delays, speed, the ratio of flow/traffic capacity for a vehicle, for one lane or several intersection branches. The use of the level of service only provides information from the driver's perspective and cannot lead to a differentiated appreciation of multimodal trip types.

Although a theoretical element was invented and should have evaluated traffic congestion, it indirectly led to the valorization of road infrastructure projects that were accompanied by increasing the level of segregation of communities, increasing for a limited period the speed of traffic, the increase in road accidents and the decrease in the quality of life. Criticism of the service was that it put too much emphasis on the car, compared to other means of transport.[1]

Modern road traffic planning methods prioritize reducing pollution in big cities, reducing car congestion, improving mobility between neighborhoods/centers of interest, reducing fuel consumption and travel times, increasing life expectancy, etc. This attracted the attention of public authorities to switch to journeys made by public transport, by bicycle or by foot.[1]

2 LITERATURE REVIEW

2.1 Existing state of practice

The research presented in NCHRP Report 616 sponsored by the American Association of State Highway and Transportation Officials for the Highway Capacity Manual (HCM) represents one of the first attempts to develop a multimodal performance algorithm. The HCM provides an estimation procedure for calculation of the level of service (LOS) applied to auto, transit, bicycle, and pedestrian modes. Further in the Transit Capacity and Quality of Service Manual, (TCQSM), 3rd Edition [2] is described a method to measure transit comfort, availability and convenience from the passenger point of view. Also, there are certain differences in estimation between fixed-route transit services and demand-responsive transit. For the comfort and convenience there are highlighted factors like passenger load, reliability and travel time, while the availability dimension considers hours of service, frequency and coverage.[3]. Although the document offers a lot of relevant information the effect of traffic congestion on transit service is not analyzed. Furthermore, in the case study realized by Xin et co., the authors discovered that in TCQSM manual travel time components have same importance while in the reality the perception of passenger may be different. [4]

Another approach is presented in Quality/Level of Service Handbook produced by Florida Department of Transportation. This document provides methodologies for the estimation level on service on different transportation modes, including transit, cycle and pedestrian.[5]. For the evaluation of the bus transit are taking into account bus frequency and the street crossing difficulty for pedestrian. Hence for estimation of public transport transit the methodology does not contain any effects regarding traffic signals or traffic flows. Also, on all above mentions manuals safety and economic factors were not included.

Other research regarding transit LOS were orientated on development a certain index or indicator in the attempt to describe the environment in which the transit service operates. Hence the focus was orientated on the perceived total travel time by transit as compared to auto travel time for the trip.

Fu and other developed a performance indicator called Transit Service Indicator in order to measure the quality of service [6], while Hesher et co adopts a Service Quality Index from passenger travel options [7].

Other opinion is presented in an article published by Furth et co., in which the authors pay attention on the real cost of waiting and the failure to evaluate the effect of unreliability on passengers. In practice the cost of waiting involves not only the mean time spent waiting on the platform, but also potential waiting time required to budget [8].

Also, it should be mentioning the efforts of City Council of Charlotte, North Carolina, materialized through the Urban Street Design Guidelines [9]. This manual is mainly presenting a methodology for evaluation of pedestrian and bicycle level of service based on numerical score. This manual has a limitation in that only intersections are taken into account [4].

From the analysis of specialized literature, solving problems in public transport with the help of artificial intelligence are focused on the following areas:

- the prediction of the arrival of public transport [10,11],
- the forecast of travel times with public transport [12],
- the prediction of the choice of travel routes [13],

- the prediction of passenger flows [14],
- prediction of waiting times [15].

3 PROPOSED METHODOLOGY

The purpose of this study is to develop a methodology for calculating the level of service that includes the characteristics of public transport and the environment in which the service operates. Also, another goal is to address a computational algorithm that can easily be used by artificial intelligence (AI). In addition, the LOS rating was adapted to local travel conditions in Bucharest, the capital of Romania.

Following the field studies in the city's urban mobility plan, it is absolutely necessary that such an assessment includes the requirements of the main consumers and their impact on the decision to travel by public transport. Every major urban agglomeration has some particular aspects of corporate culture, climate, leadership behavior or geographical boundaries that are totally different compared to other countries. For example, the climate in Romania is characterized by mild to medium temperatures in winter and hot to very hot summers. Therefore, the presence of air conditioning in transit vehicles is an important factor in the decision to travel with public service vehicles.

For this study, a service level model is proposed to predict the average quality of transit service. The main parameters in transit LOS evaluation are the following:
- availability and accessibility of the service for pedestrians;
- reliability of the public transportation line;
- the perceived comfort of the transit service trip;
- public transport travel time.

In order to quantify an overall level of public transport service, weights will be assigned to each factor mentioned above. Regarding the accessibility of the service by pedestrians, a score based on the distance from the starting point of the trip to the public transport station, as well as existing pedestrian facilities, was considered. Similarly, the reliability score depends on the progress of the transit service.

In order to evaluate the comfort of travel, it is proposed to highlight the facilities of the transit station (shelters, banquets, lighting, etc.), the loading of passengers and the existence of air conditioning. Next, in order to estimate the travel time, it is necessary to accumulate the actual travel time, as well as the waiting time of the passenger at the station.

The proposed formula, tested on the public transport network in Bucharest, based on origin - destination surveys, for calculation of the transit LOS score is following:

Transit LOS score = Availability of service factor x 0.15 + Accessibility of the service by pedestrian's factor x 0.12 + Frequency of transit factor x 0.2 + Travel time factor x 0.25 + Passenger load factor x 0.1 + Amenities of transit station x 0.05 + Existence of air conditioning x 0.13 (1)

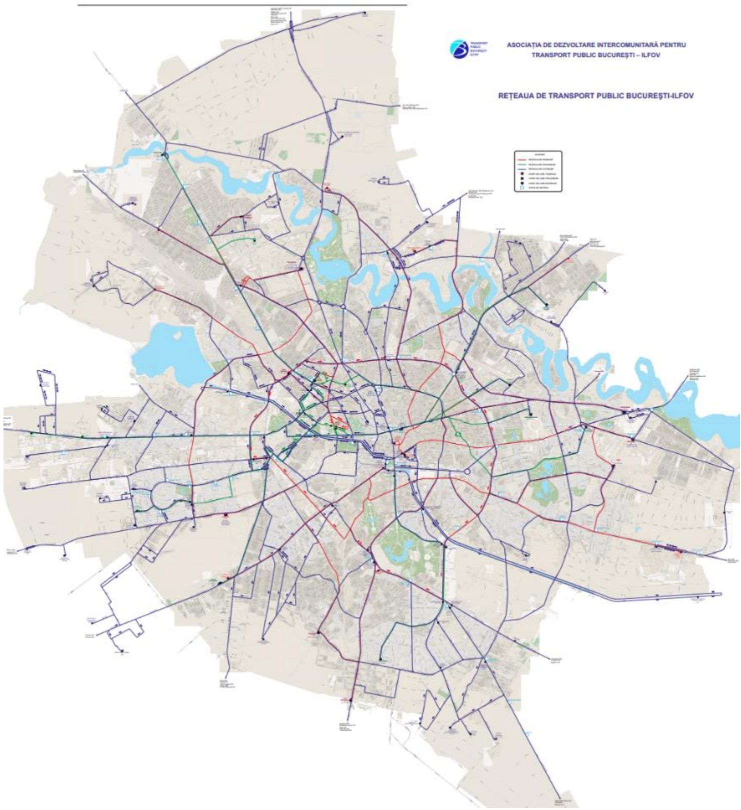

Figure 1. Public transport network from Bucharest [16]

In the next stage the computed level of service is converted to a letter using the equivalencies from the below table no. 1:

Transit LOS evaluation [1]

LOS transit score	Level of service
Over 11 points	A
Between 9.5 and 11 points	B
Between 7.5 and 9,5 points	C
Between 5.5 and 7.5 points	D
Between 2.5 and 5.5 points	E

LOS transit score	Level of service
Below 2.5 points	F

Based on the methodology described above, an evaluation of the proposed transit model was carried out. Homogeneous segments of different types of transit lines were considered in the calculation. The main resulting conclusions are the following:
- for similar transit lines equipped with dedicated lanes, the frequency of vehicles is better, if the control method at intersections is able to prioritize public transport;
- the comfort of the trip may lead to a change in the level of service;
- the existence of overground or underground passages has the role of improving travel conditions;
- to make a relevant change in mode sharing and make transit more attractive compared to the personal car, public transport travel times must be shorter. In addition, the assignment of public transport routes must be based on the origin and destinations of mobility resulting from a macroscopic city model, together with the adjacent metropolitan area;
- the operation of modern transport vehicles leads to the improvement of the service level. Lack of quality and comfort during travel have a relevant influence on transit LOS. Therefore, the financial efforts made by the public transport operator to introduce more vehicles during peak hours or the municipality to improve the road infrastructure may not bring more passengers.
- calculating the transit LOS of the service on a large network is able to show the relevant weaknesses and opportunities of public transport.

For the second part of the study, the authors propose the implementation of artificial neural networks (ANN) for the online assessment of the service transit level. The logic diagram of this algorithm is presented in figure no. 2.

In step number 1, information will be collected regarding the travel times of the vehicles, the frequency of arrival at the station, the number of passengers in the transport vehicle or even at the station.

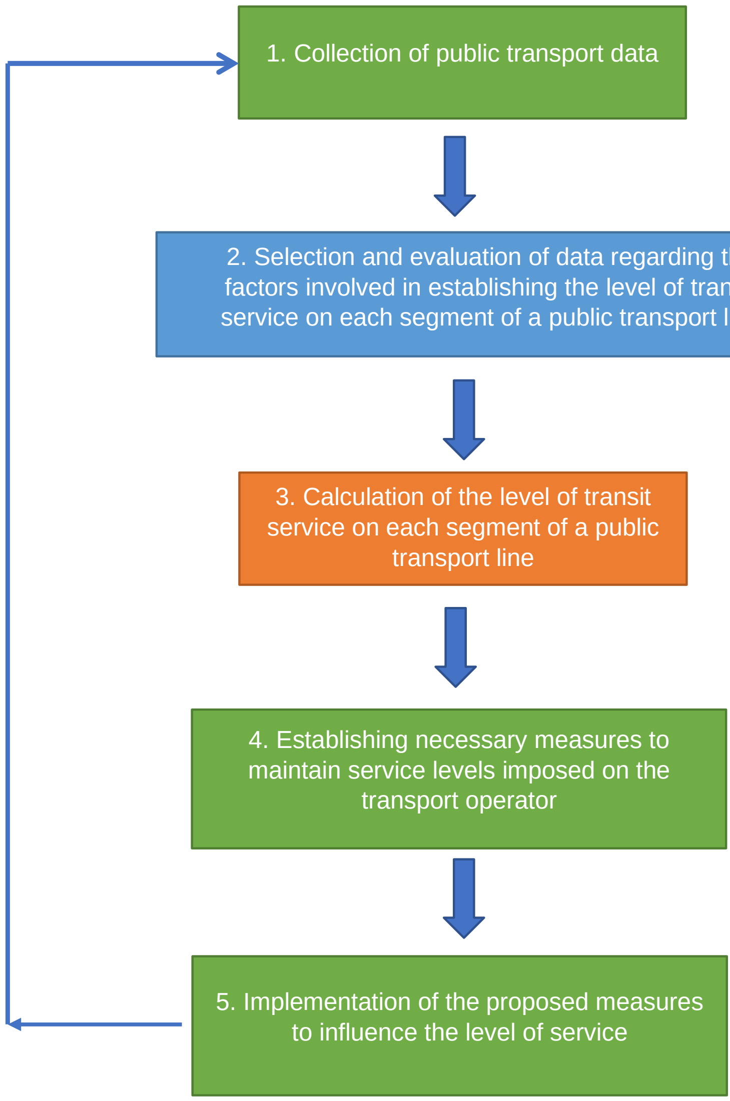

Figure 2. Logical scheme for online calculation of intermodal service level [1]

After calculating the level of service, specific measures can be established in a "real" way, taking into account all traffic on the transport routes, including that generated by traffic participants other than public transport, to maintain a specific LOS of the analyzed public transportation lines.

The advantages of using ANN are as follows:

- the number of additional transport vehicles on a certain route can be estimated depending on the analyzed peak hour;
- over-prioritization of a transport line can be avoided. In the case of large urban agglomerations, a number of intersections run at the limit of traffic capacity, being often oversaturated. Due to the excessive prioritization of a transport line, delays

may occur in road traffic represented by other transport lines on opposite traffic flows;
- avoid the decrease of headway between the public vehicles. A frequent example in rush hour in Bucharest is the arrival at a station of two or even three public transport vehicles of the same line.

4 CONCLUSION

This article proposes a methodology to evaluate the level of multimodal service, especially on public transport. The proposed methodology considers a number of seven factors and allows the calculation of a public transport score, which offers the possibility to frame the travel conditions to a certain level of service.

Combining this methodology with the use of artificial neural networks as tools for assisted analysis of all traffic components can help local authorities to improve the performance of public transport service. In addition, enhancing the reliability of public transport service can reduce travel costs and change the modal split.

The implementation of Artificial Neural Networks (ANN) allows online assessment of the transit level of the service, but requires modern traffic management equipment equipped with artificial intelligence elements.

Multimodal service level expresses not only the performance of a public transport network, but also the perception of the traveling public in relation to it.

In conclusion, by calculating the level of multimodal service, a series of measures can be established to improve the travel conditions as follows:
- identifying transport routes that require mandatory segregation in relation to other means of transport.
- determination of junctions or networks of intersections, which require the modernization of traffic management equipment to be able to be introduced into a traffic management system.
- determination of the necessary equipment for public transport vehicles or the related stations, in order to increase the attractiveness of this mode of transport.
- verifying the accessibility or connectivity of public transport lines.

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