

The quality of service in passenger transport terminals

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Abstract. The quality of service in transport terminals is differently perceived by engineers, economists, transport operators and sociologists. The traveler's perception is nevertheless decisive. The quality of service is well connected with the inside design of terminals, with the facilities in terminals and with the provided service standards. In order to provide a high level of service, the activities taking place in the public transport terminal and the maximum travelers flow size must be carefully analyzed and dimensioned. The purpose of modelling is to find the best route for each traveler from origin (entrance) to destination (exit) through all the intermediate service points, taking into consideration the instant network conditions. In developing the model we consider the walking, the waiting and the serving time. Using a simulation program written in ARENA we determine the waiting time. For validation, the model is used to evaluate the performance level in Bucharest Basarab station. By comparing the total walking distance for the possible routes and the utility function that describes the utility of all activities from entrance to exit we can find the optimal route.

1. Introduction

Transport terminals represent junction points between local, regional and interregional transport [1]. The main objective of a terminal is to serve transport demand by maintaining the travelers' safety, convenience and comfort [2], [3]. When a terminal is designed, all the actors and activities that contribute to the size of the flows into the terminal must be taken into consideration. Despite the modern means of purchasing tickets prior to travel, there are still traditional travelers that buy tickets from tickets offices in terminal. Furthermore, plenty of other activities in the terminal, other than purchasing tickets, take place prior to travel and at the end of it, the terminal becoming a multifunctional center. The study from the present paper is limited to the transport-related activities and not to other functions that modern passenger terminals have today. Future researches will expand the model presented in this early stage.

A pedestrian flow in a terminal is formed by: travelers (for whom the terminal represents their origin; for whom the terminal represents their destination; for whom the terminal represents their transfer station); attendants; employees (employees in the commercial and technical area, cleaning staff etc.). The different areas of the terminal are linked through corridors (walkways), stairs, escalators, lifts or moving walkways. In table 1 the activities from a transport terminal, the actors that execute them (the users) and the needed facilities are centralized.



Table 1. Activities in a passenger transport terminal [4]

Activity	Actors	Facilities
Access, entrance	travelers, attendants, employees	doors, gates, tourniquets, train/bus/plain/etc.
Information	travelers, attendants, employees	boards, electronic displays, signs, arrows
Movement	travelers, attendants, employees	corridors, stairs, escalators, lifts
Waiting	travelers, attendants	waiting areas, platforms, queues
Buying tickets	travelers	tickets offices, tickets machines
Shopping	travelers, attendants	commercial areas
Exit	travelers, attendants, employees	doors, gates, train/bus/plain/etc.

2. Improving service quality in transport terminals – psychological and physiological aspects

The terminal operator must maintain a high level of service inside the terminals reflected through the fluidity of travelers flow and by inducing a sense of concern for their safety, convenience and comfort.

A pleasant waiting environment must be created focusing on the users' psychological (waiting/in service time perception, information and equity) and physiological aspects (noise, lighting, climate and ventilation, available space) [5].

Psychological aspects

The most important cause of stress in our days is induced by the lack of control [6]. Because the waiting time in a queue can't be controlled by users, it represents a very unpleasant experience for them. By giving them the control and by offering them activities that they can do while waiting (something to read, to eat or to watch), information regarding the estimated waiting time, providing FIFO serving discipline avoiding queue re-ordering, their stress can be diminished. A proper social behavior is the key to a waiting tolerated by users [7], [8].

Physiological aspects

The waiting space can contribute to the traveler's mood. The waiting area should have a pleasant architecture and should be nicely decorated. Furthermore, this should be designed so that noise, illumination, climate and ventilation are adequate.

Noise: A noisy environment, especially one with intermittent, high frequencies or low frequencies sounds, is not only annoying but it also can influence health. Studies have shown that noise favors aggressive behavior of passengers [9], [10], [11]. In a waiting area the accepted noise level is 40-48dB. The ambient noise resulted from the conversations can be covered by background music.

Climate and ventilation: The travelers comfort also depends on air ventilation and on temperature and humidity. For the travelers that wait the indicated temperature in winter is between 200 and 240C and in summer between 220 and 270C (taking into account the clothes corresponding to each season). The humidity in summer should be between 20% and 30% and in winter between 50% and 80%.

Illumination: Can influence the travelers' state of mind and their ability to use constructively the waiting time. To create a pleasant environment for the travelers, the illumination in a big room should be irregular for relaxation, while in a small room it should be uniform to create the space impression..

Space: Every person that stands needs space for not feeling embarrassed by the others. The level of service for queuing areas is presented in table 2 [12].

Table 2. Level-of-service criteria for queuing areas (P/m^2)[12]

LOS	Space (P/m^2)
A	≤ 0.83
B	0.83 – 1.11
C	1.11 – 1.67
D	1.67 – 3.33
E	3.33 – 5.0
F	≥ 5.0

3. Travelers' behavior models

3.1. Choosing the servers

To complete activities in terminals (table 1), the passengers have two options in choosing the servers [13]: pre-trip choices and en-route choices. For a pre-trip choice, the total route is established by the traveler at the moment he enters into the system. For en-route choice, the optimal route may change during the walking trip, according to the step by step experience of traveler.

A choice model is characterized by:

- *Choice's characteristics* - the entrance and the exit of the travelers, a list of activities that they are going to perform and the alternative locations of each of these activities;
- *The set of alternatives* - all the O-D routes;
- *The choice variables* - walking time between the activities, waiting time, service time, total walking distance, and attractiveness and familiarity of the activity

The utility function $U_R(t)$ that describes the utility of all activities from entrance to exit, for a traveler that enters the system at time t is (considering the simplified version in which we take into account only the walking time to a certain service „point“/server, the waiting time in queue and the serving time in a certain service „point“/server):

$$U_R(t) = \alpha \sum_{\substack{a \in A \cup M \cup L \\ a \in R}} T_a^{walk}(t) + \beta \sum_{a \in (C^i \cup P \cup B)} T_a^{wait}(t) + \gamma \sum_{\substack{a \in C^i \cup P \cup B \\ a \in R}} T_a^{serve}(t) \quad (1)$$

Where

a represents a link of R route;

T_a^{walk} - walking time on a link;

T_a^{wait} - waiting time;

T_a^{serve} - serving time;

α, β, γ - the weights given to each of the corresponding attributes;

3.2. En-route choice model

The model identifies the optimal route from entrance to exit taking in consideration the instantaneous system conditions. The route choice is based on a variety of factors. It aims the modeling of the movements in a public transport terminal at peak hours and to estimate the travelers' density and comfort in limited capacity conditions [14].

The en-route choice model is characterized by:

- *Choice's characteristics* - consists in identifying the actual position of a traveler, his exiting point and all locations of intermediate stops in terminal at a given moment;
- *The set of alternatives* - consists of all feasible routes from his actual position to exit.;
- *The choice variables* (time-dependent travel time) - the walking time, the waiting time and the service time. Other potential variables are traveled distance (L_r), pleasantness (p), habit (h), pollution and noise levels (L_{noise}), safety (F), trip motive (M_i^{trip}) of pedestrian etc.

The en-route choice model consists of three separate modules:

- Shortest path module - this module calculates all shortest paths at moment t , taking in consideration the travel times at that moment - it may be called "instantaneous shortest path".
- Individual route module - this module determines the next link to be followed by a traveler arriving at a route decision point (a node in the network).
- Walking module - this module calculates individual travel times for every traveler, depending on the current conditions in the link.

The logical diagram for en-route choice model, in which the interaction of these modules is indicated, is shown in figure 1.

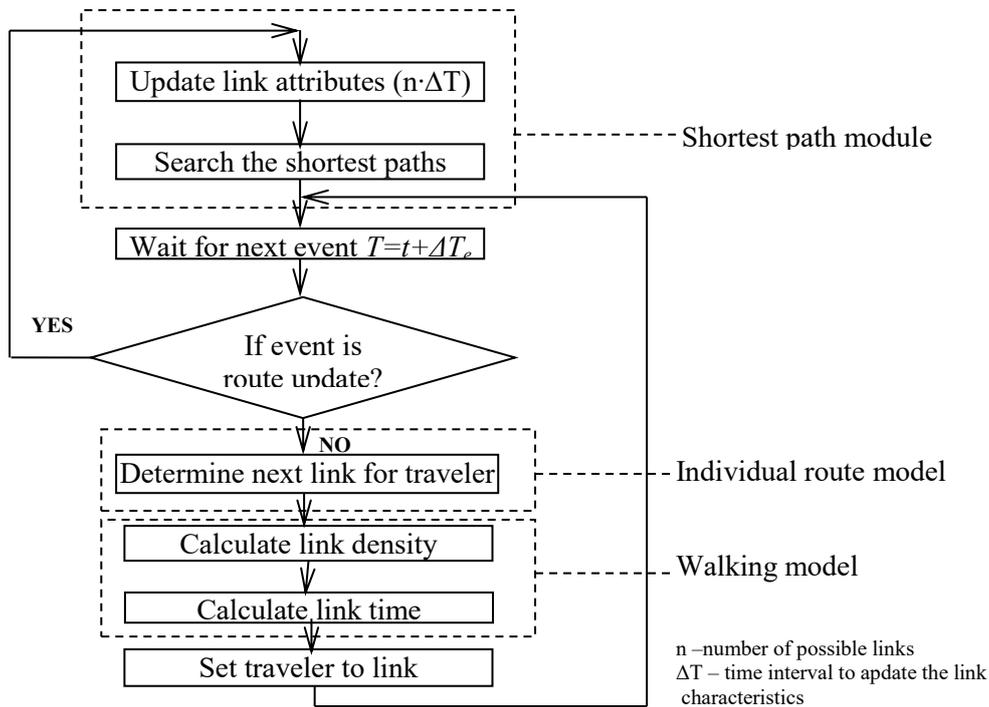


Figure 1. The logical diagram for en-route choice model (Source: [12])

4. Case study – Bucharest Basarab railway terminal

We consider Bucharest Basarab railway terminal with its facilities (figure. 2). To distinguish the areas inside the terminal, different hatchings are used. For modeling the flows inside the station one considers the station hall, the location of the facilities (figure 2) and the travelers flow formalization (figure 3).

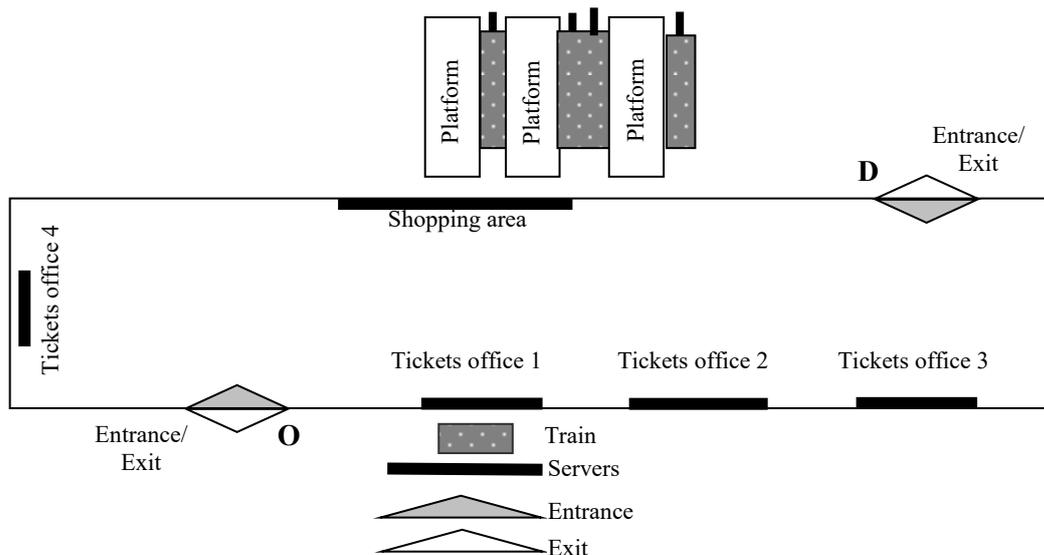


Figure 2. Bucharest Basarab railway terminal

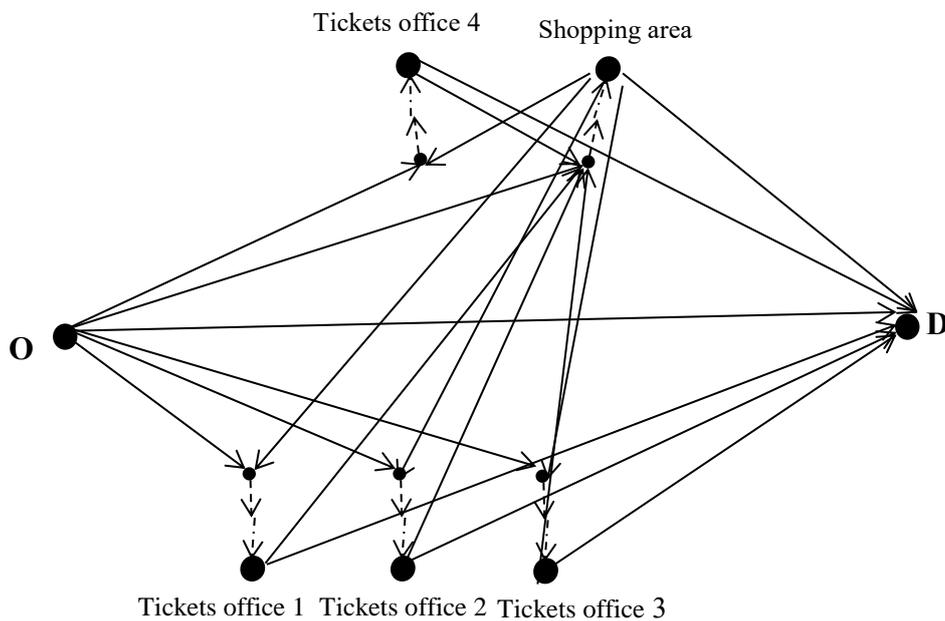


Figure 3. Travelers flow paths

One considers a traveler that enters into the system in node O and exits through node D. He has to fulfill two activities: to buy a ticket from the tickets offices and to buy a cup of coffee from the shopping area. He has four alternatives for the first activity and one alternative for the second activity. The purpose of the model is to choose the servers so that the total time from entrance (origin) to exit (destination) to be minimal. The first step is to identify the possible paths between origin and destination so that the traveler will buy a ticket and a coffee.

The network resulting from these activities (executed in mentioned order) is presented in figure 4.

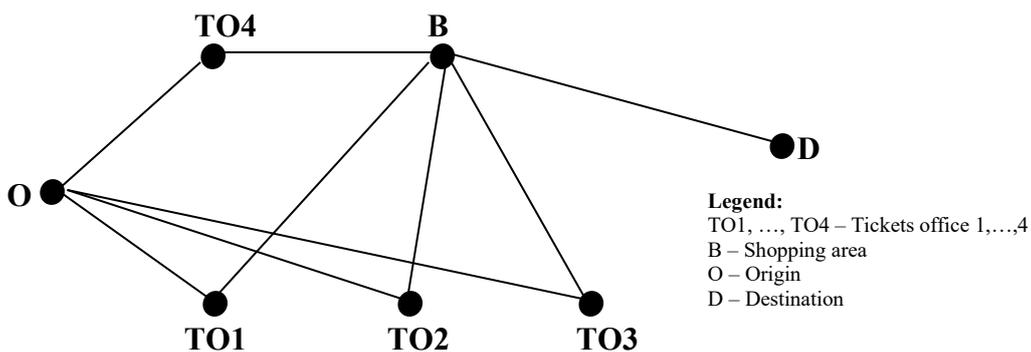


Figure 4. Travelers flow network

Further one identifies the possible paths between origin and destination and determines the total time for these paths.

A traveler needs time to walk from a server to another and because of the changes that appears in the system, the initial minimal route might change. That is the reason why the model should be repeated after every activity.

An important factor is the weight given to each of the corresponding attributes (walk, wait, serve). These weights are considered to be equals.

4.1. The walking time

The walking time at moment t , for the traveler i that walks with speed v_i (dependent on density k) on a link a characterized of distance L_a is:

$$T_i^{walk}(t) = \frac{L_a}{v_i(k_a(t))} \tag{2}$$

If the travelers' density is less than 0.5 travelers/m², the walking speed is considered 1.6m/s [15]. The distance and time matrixes are shown in tables 3 and table 4.

Table 3. The distance matrix

d[m]	TO1	TO2	TO3	TO4	B	D
O	6	8	10	5		
TO1					9	
TO2					10	
TO3					12	
TO4					6	
B						8

Table 4. The time matrix

t[s]	TO1	TO2	TO3	TO4	B	D
O	4	5	7	4		
TO1					6	
TO2					7	
TO3					8	
TO4					4	
B						5

For determining the waiting times and the serving time at servers a computer simulation model using ARENA software was realized (figure 5). The travelers arrive random (exponential with intensity of 2 travelers/minute) and 30% of the travelers are supposed to buy a coffee in the shopping area. Two situations were considered:

- a) the tickets office is randomly chosen (figure 6.a));
- b) the tickets office with minimum queue is chosen (figure 6.b)).

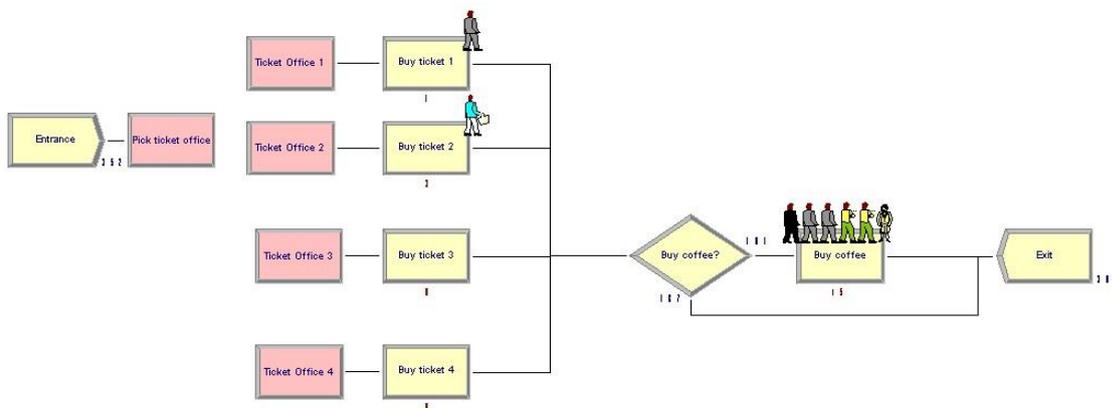


Figure 5. ARENA simulation

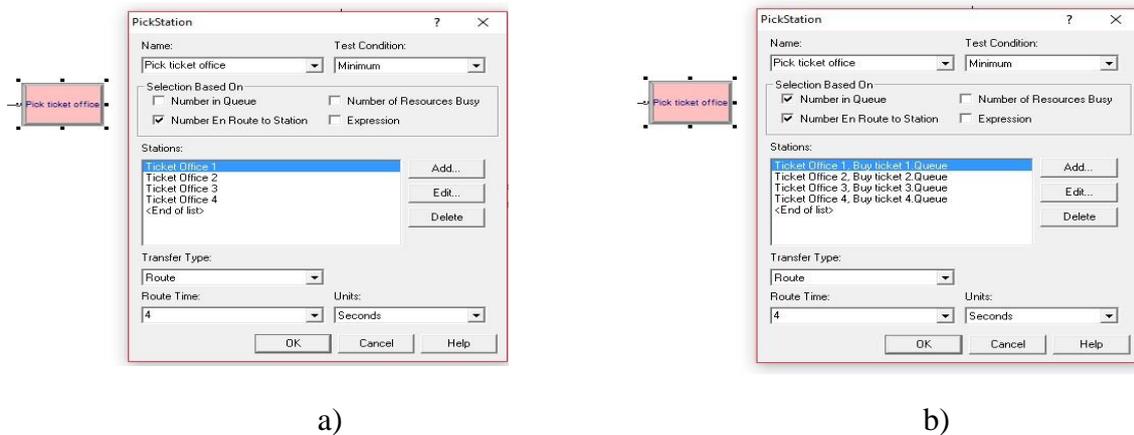


Figure 6. ARENA simulation
 a) – choosing the tickets office randomly
 b) – choosing the tickets office with minimum queue

4.2. The serving time

The servings follow a uniform repartition with minimum and maximum intervals of 0.5 minutes and 1.5 minutes at tickets offices and 1 minute and 2 minutes at shopping area. In the model the average values $T_{serve}^{TO1...TO4} = 60$ s, $T_{serve}^B = 90$ s are considered.

4.3. The waiting time

The waiting times after simulation (25 replication in peak hours: 7 a.m. – 10 a.m.) are:

(i) the tickets office is randomly chosen:

$$\begin{aligned} T_{wait}^{TO1} &= 324 \text{ s;} \\ T_{wait}^{TO2} &= 360 \text{ s;} \\ T_{wait}^{TO3} &= 360 \text{ s;} \\ T_{wait}^{TO4} &= 396 \text{ s;} \\ T_{wait}^B &= 792 \text{ s} \end{aligned}$$

(ii) the tickets office with minimum queue is chosen:

$$\begin{aligned} T_{wait}^{TO1} &= 288 \text{ s;} \\ T_{wait}^{TO2} &= 324 \text{ s;} \\ T_{wait}^{TO3} &= 360 \text{ s;} \\ T_{wait}^{TO4} &= 396 \text{ s;} \\ T_{wait}^B &= 792 \text{ s} \end{aligned}$$

As it can be seen, the waiting time values are smaller in the second situation. Those values will be considered further on. The utilities (Eq.1) for the possible paths between origin and destination are:

$$\begin{aligned} U_{O-TO1-B-D}(t) &= 415 \text{ s;} \\ U_{O-TO2-B-D}(t) &= 427 \text{ s;} \\ U_{O-TO3-B-D}(t) &= 440 \text{ s;} \\ U_{O-TO4-B-D}(t) &= 450 \text{ s} \end{aligned}$$

The total walking distance measured in travelers \times meters in the morning peak hours (3 h) is:

$$\begin{aligned} O-TO1-B-D: & 7291; & O-TO2-B-D: & 8242; \\ O-TO3-B-D: & 9510; & O-TO4-B-D: & 6023. \end{aligned}$$

The best O-D route from utility point of view is O-TO1-B-D and from total walking distance point of view is O-TO4-B-D. To improve these parameters one proposes the shopping area to be adapted so that two sellers can work simultaneously. Going through the same steps as above we obtain:

$$\begin{aligned}U_{O-TO1-B-D}(t) &= 263 \text{ s;} \\U_{O-TO2-B-D}(t) &= 276 \text{ s;} \\U_{O-TO3-B-D}(t) &= 301 \text{ s;} \\U_{O-TO4-B-D}(t) &= 310 \text{ s}\end{aligned}$$

The total walking distance in the morning peak hours will be the same because the distance between the facilities and the number the travelers are the same.

5. Conclusions

As it was described above, the quality of service is connected with the terminals' inside design, illumination, ventilation and provided service standards (promptly information, personnel attitude, waiting time). Moreover, the quality of the service results from the time spent into the system by the traveler. Two quality indicators were determined: total walking distance and the utility.

A solution to improve these quality indicators (the shopping area should be adapted so that two sellers can work simultaneously) was proposed. The utility indicator improved for all four possible routes. The best O-D route from utility point of view remained O-TO1-B-D. The weights given to each of the corresponding attributes (walk, wait, being served) in the utility function were considered to be equals. Taking into account some papers in literature [9],[16], where the waiting time is indicated to be the most unpleasant one, a study that considers this should be developed.

It is obvious that by increasing the number of servers, the waiting times decrease. It is interesting to know if in the time intervals between trains' departures and arrivals, the operating regime of the servers is perhaps one with inactivity. In this case the simulation should be adapted to suit an operating regime with interruptions.

Operating on flexible intervals may be a step in future research. Furthermore, different types of intervention (investing in new facilities, using the existing spaces for different activities etc.) analyzed separately or in combinations can lead to reorganization decisions to increase service quality in the passenger terminal.

6. References

- [1] Raicu S, Dragu V, Popa M, Burciu Ş. 2009 About the high capacity public transport networks territory functions *15th International Conference on Urban Transport and Environment* (Bologna) Ed. C.A. Brebia (Wessex Institute of Technology Press, Southampton, U.K.) pp 41-50
- [2] Anas A, Arnott R, Small K A 1997 Urban spatial structure *UCTC* **357**, <http://www.socsci.uci.edu/~ksmall/JEL%20Paper.pdf>, accessed: 20.02.2016.
- [3] Ştefănică (Oprea) C, Dragu V, Burciu Ş, Ilie A, Dinu A 2015 Planned traffic stability on a rail network *Applied Mechanics and Materials* **809-810** pp 1073-1078
- [4] Ştefănică (Oprea) C 2012 *Integration Of Transport Modes And Technologies In Large Urban Areas* PhD theses (Bucharest)
- [5] Dragu V, Roşca E, Ruscă F 2004 Service quality in the terminals joining magistral and urban transport *CODATU XI* pp 123-129
- [6] Bateson J E G 1985 Perceived control and the service encounter *The service encounter, managing employee/customer interaction in service businesses* J.A. Czepiel, M.R, Solomon and C.F. Surprenant (Eds.) (Mass.: Lexington Books, Lexington) pp 67-82
- [7] Larson R C 1987 Perspective son queues: social justice and psychology of queuing *Operations Research* **35** pp 895-905
- [8] Maister D H 1985 The psychology of waiting lines available at: <http://davidmaister.com/wp->

- [content/themes/davidmaister/pdf/PsychologyofWaitingLines751.pdf](#) accessed: 14.11.2015
- [9] Hall W R 1991 *Queuing Methods* (New York: Prentice-Hall Inc) p 476
- [10] Jones D M and Broadbent D E 1987 Noise *Handbook of human factors* ed G Salvendy (New York) pp 623-649
- [11] TRB 1999 *Transit Capacity and Quality of Service Manual* (Washington, D.C.) p 35
- [12] Daamen W 2004 *Modelling Passenger Flows in Public Transport Facilities* (Delft: DUP Science) p 404
- [13] Cascetta E 2001 *Transportation Systems Engineering: Theory and Methods* (United States: Springer) p 710
- [14] Banos A and Charpentier A 2007 *Simulating Pedestrian Behavior In Subway Stations With Agents* Proceedings of the 4th European Social Simulation Association Toulouse (France) pp 611-621
- [15] Mahmassani H S et al 2009 *Incorporating Weather Impacts in Traffic Estimation and Prediction Systems* (University of Virginia) DTFH61-06-D-00005 p110
- [16] Guo Z and Wilson N H M 2004 Assessment of the transfer penalty for transit trips: A GIS-based disaggregate modeling approach *Transportation Research Record* **1872** pp 10-18