Service quality in the terminals joining magistral and urban transport

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ABSTRACT: On services quality in transport terminals, both engineers, economists, transport operators or sociologists have their own perspectives. Determinant remains the traveller's perception.

The quality of service is connected with the terminals inside design, illumination, ventilation and provided service standards (promptly information, personnel attitude, waiting time). The service quality level in terminals for local, regional and inter-regional transport is determinant for making public transport more attractive.

The paper focuses on aspects concerning the design and the capacity for ticketing and information systems in transport terminals. Different queue design possibilities are investigated under functionality, visibility equity and passengers spatial orientation. Analitical models for measuring performances of service are discussed in a critical manner. The non-stationarity of passengers arrival flows is outlined. Due to this, the classical analitical models provided by the queue theory are inappropiate for studying passengers service processes in transport terminals (ticketing, custom services, information).

Approximation with quasi-stationary regime is often used, but the necessary conditions can not be always accomplshed. Thus, the digital simulation remains the most used method for study systems with non-stationary arrivals.

A study case for the ticketing system in Bucharest North Railway Station, the biggest Romanian land transport terminal, is presented. The passengers arrival rates were computing through 3 months recording, separated for working days and weekends. Using a simulation programm written in ARENA 5.0, the main measures of performance (hourly average waiting time and the evolution of waiting passengers number) are determined, taking into consideration the changes in arrival rate and also a variable capacity of the system.

RÉSUMÉ : Les ingénieurs, économistes, opérateurs de transport ou sociologues ont leurs propres perspectives sur la qualité des services dans des terminaux de transport. Le déterminant reste la perception du voyageur.

La qualité de service est liée à la conception intérieure, l'éclairage, la ventilation des terminaux et les niveaux de service fournis (information rapide, attitude du personnel, temps d'attente). Le niveau de qualité de service dans des terminaux pour le transport local, régional et inter régional est déterminant pour rendre le transport public plus attrayant.

La communication porte surtout sur les aspects concernant la conception et la capacité pour la vente de billets et systèmes d'information dans les terminaux de transport. On examine des possibilités de conception de file d'attente différente en matière de fonctionnalité, d'équité de visibilité et d'orientation dans l'espace des voyageurs. Des modèles analytiques pour mesurer les performances du service font l'objet de discussions critiques. Le côté non-stationnaire des flux d'arrivée des voyageurs est mis en évidence. Pour cette raison, les modèles analytiques classiques fournis selon la théorie de la file d'attente ne sont pas appropriés pour étudier les processus de service aux voyageurs dans des terminaux de transport (la vente de billets, des services de douane, l'information).

Le rapprochement avec le régime quasi-stationnaire est souvent utilisé, mais les conditions nécessaires ne peuvent pas être toujours remplies. Ainsi, la simulation digitale reste la méthode la plus utilisée pour des systèmes d'étude avec des arrivées non-stationnaires.

On présente un cas d'étude pour le système de vente de billets à la gare ferroviaire au nord de Bucarest, le plus grand terminal de transport terrestre. Les taux d'arrivée des voyageurs étaient calculés d'après un enregistrement de 3 mois, séparant les jours ouvrables et les week-ends. En utilisant un programme de simulation écrit dans ARENA 5.0, les principales mesures de performance (temps d'attente par heure en moyenne et l'évolution du nombre de voyageurs en attente) sont déterminées, prenant en considération les changements du taux d'arrivée ainsi qu'une capacité variable du système.

1 INTEGRATION OF LOCAL, REGIONAL AND INTER-REGIONAL TRANSPORTS

On integrated transport modes are formulated different perspectives from the socio-political, economic, technical or ecological environment. But the most outstanding perception belongs to the passenger, the beneficiary of the transport services. The research studies identified security, reliability, frequency and the financial/spatial accessibility as major exigencies of the passengers (fig. 1).

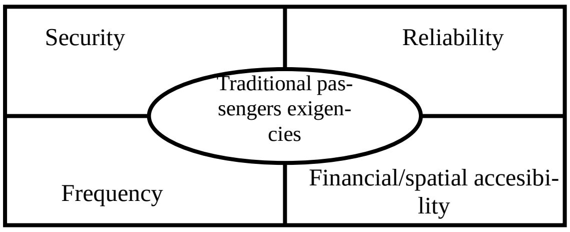

Fig. 1 Traditional passengers exigencies
(*Source: James, S. (2001) Put the Passenger First in Integrated Transport*)

Complexity, non-consistency and limited care facing the passengers are usual characteristics of the transport system, amplified by the diversity and the fragmentation of the ofertants individual interests. As a method for improving service quality, integration of local, regional and inter-regional transports represents a new step in providing a user focus service and bringing a high level of consistency, transparency and simplicity for travel actions (James, 2001).

The service consistency denotes a comfort for the user, but seems to be one of the greatest challenges of the integration, especially when some operators whish to set their own level of service. Co-operation among all parts is the key factor on which depends the success or the fail. A mutual reliability and autonomy transfer by assuming common values are necessary. These values prescribe levels of service for treating passengers in a consistent manner. They must overpass the egocentric desires, otherwise the daily experience can rapidly erode the system.

The data interchanges among operators lead to the identification of a common purpose in strengthen passengers transport system. This is easily observed in transfer points, where the schedules coordination minimizes the passengers discomfort and waiting times.

The transport operators, used to analyse performances through security, reliability and incomes, have new criteria for operating, although less familiar. These criteria allow them to find details in the whole system, without losing the integrated vision (fig. 2).

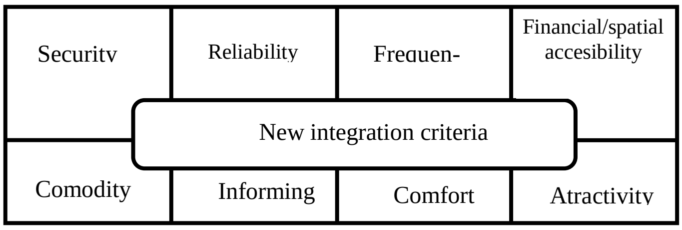

Fig. 2 New integration criteria
(*Source: James, S. (2001) Put the Passenger First in Integrated Transport*)

2. IMPROVING SERVICE QUALITY IN TRANSPORT TERMINALS – DESIGN ASPECTS

Transport terminals are junction points of the local, regional and inter-regional. The service quality there proves the success of the transport operators and infrastructures owners. The interoperability of the transport services is translated by the coordination of the transport schedules and minimization of waiting times for obtaining information, getting tickets, custom operation etc. Often, the waiting times cannot be avoided. There are many causes – stochastic arrivals/service process, nonstationary flows, servers limited capacity (Raicu & Maşală, 1981). These influence also the nature of the waiting lines – stochastic, predictable or permanent.

Beside the waiting time limitation, creating a pleasant environment has importance, too (Fruin, 1971; Flynn *et all*., 1973; Maister, 1985). The actions towards improving service quality have to combine physiological and psychological aspects (tab. 1).

Tab. 1. Aspects concerning service systems in transport terminals

Psychological aspects	Comfortable environment	➢ encourage customers to have collateral activities meanwhile waiting ➢ allow customers to leave and return later
	Information	➢ give reasonable waiting time estimates ➢ promptly inform customers ➢ remind customers permanently that the system is working

	Equity	➢ use FIFO discipline ➢ avoid special favours ➢ separate high priority from low priority customers ➢ do not rearrange the queue order
Physiological aspects	Noise	➢ eliminate loud and unpleasant noises by using absorbant materials
	Illumination and ventilation	➢ providing sufficient natural or artificial light, remove glare causes ➢ circulate air, prohibit smoking
	Crowding	➢ providing reasonable waiting space ➢ install queue barriers to protect customers places

An appropriate design allows gentle pass of customers flows and increases servers visibility. From topological point of view, service systems are of two major types:

- turn-back system – the customer and the server are frontal disposed; upon completion the customer exits by turning back
- flow-through system – the customer is adjacent to the server; upon completion the customer proceeds forward.

The service systems can act with single or separate queues. As for the waiting times, separate queues with jockeying minimizes the average waiting time and the variance only if the utilization level is high and there are significant differences among servers capacities.

With all their simplicity, turn-back systems with single queue have some inconvenients:

- crossing flows
- longer distance from customers to servers
- high separation angle.

Snaked queue improves visibility and reduces separation distance (fig. 3)

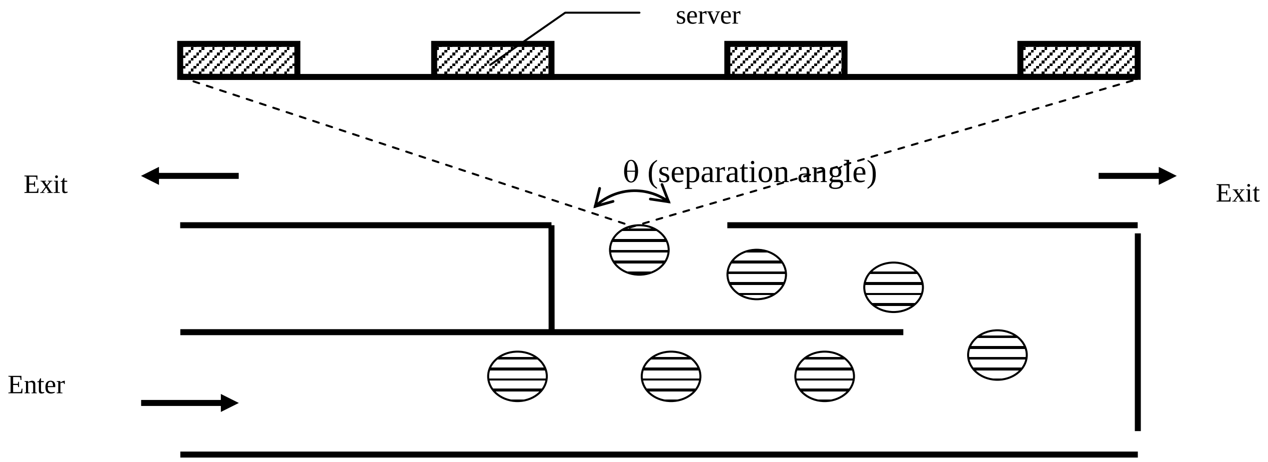

Fig. 3 Service system with snaked queue

The separation angle remains high and sometimes additional elements are used for increasing attention (acoustic/light signals, idle servers markers). Circular arrangements of servers provide optimal 90-degree sight angles, surveying the servers without head turn.

For separate queues, uniform servers' charging is important. Passengers use to set in the first queue they meet. If all of them arrive from a single direction, the first encountered server may have a permanent queue and the last server may be idle or feebly utilised. All servers should be visible for the new incomers and waiting lines should not be obstructive for servers visibility. The arrangement of servers in tandem allows lateral space to be used efficiently for flow-through systems (fig. 4).

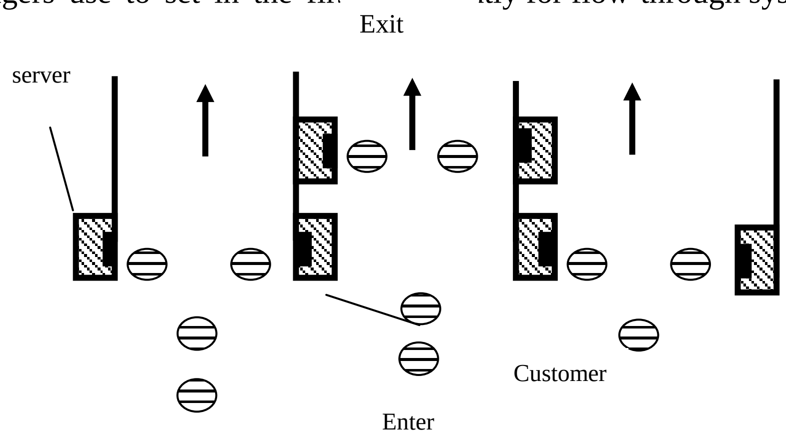

Fig.4 Tandem servers

3. QUANTITATIVE MODELS FOR MEASURING SERVICE QUALITY

Service systems literature uses simplified hypothesis concerning arrivals (stationarity, consecutiveness) for solving the state equations describing the systems. These hypotheses should be carefully used for passengers arrivals in transport terminals, and only for limited time intervals. Passengers flows have a stochastic component superposed on a predictable one, due to the connections with the vehicle schedule. More, passengers flows have temporal and spatial oscillations (Raicu & Maşală, 1981), due to economic causes, with long term influention (holydays periods, seasonal activities) or organizing causes, with daily/hourly influence (daily working period, weekends). Some phenomena are influenced by the passengers behaviour and induces changes in service measures of performance:

- rejection – refusing the service completion due to the great queue length at arrival
- reneging – leaving the system before service completion due to long waiting time
- jockeying – migration for a server to another hoping to minimize the waiting time.

There are two perspectives in analysing the quality of service. From passengers point of view, the waiting time, the time in system and predicting the completion of service moment are determinant. For the terminal administration the activity costs, the queue length and the rejection/reneging proportion are important. For stationary arrivals Little's relations (1961) are applied:

$$\begin{aligned} \overline{L}_q &= \lambda \overline{W}_q \\ \overline{L}_s &= \lambda \overline{W}_s \end{aligned} , \qquad (1)$$

λ represents arrivals rate.

For monetary evaluations, both for passengers and terminals, the optimum level of utilization corresponds to the minimum of an aggregated function of passengers waiting times and servers idle times (fig. 5).

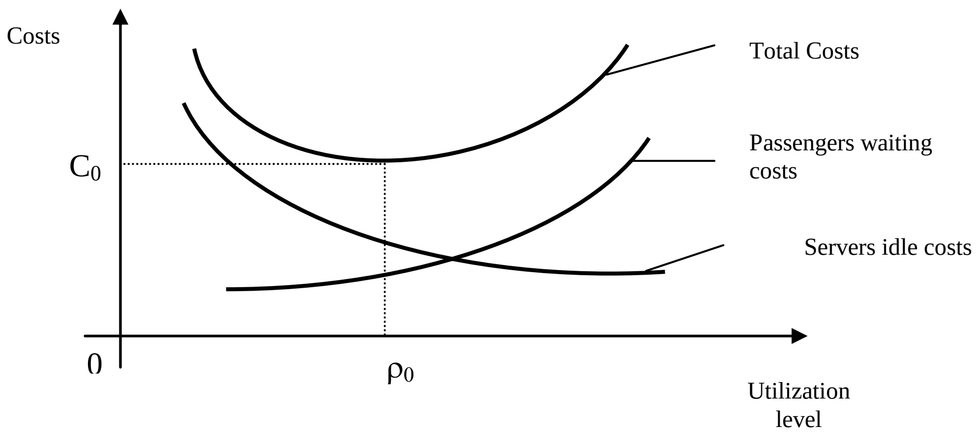

Fig. 5 Passengers waiting/servers idle time costs

If monetary evaluations are difficult or involve a high subjectivism, the harmonization levels technique is useful (Raicu & Popa, 1996).

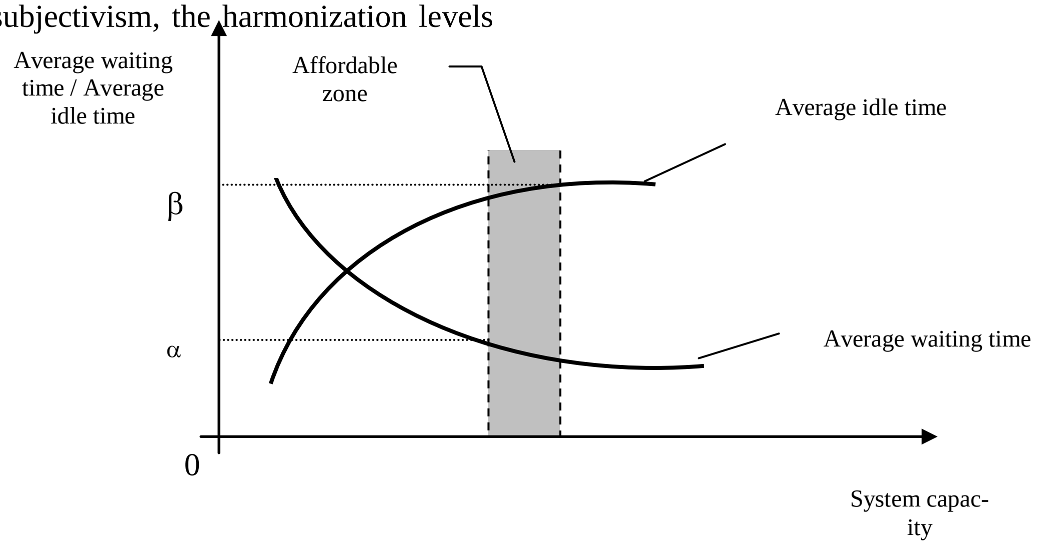

Fig 6 – Harmonization of levels

Besides the waiting time limit, the service standards may include different aspects:

a) setting an upper bound, p_{max}, for the probability that the passengers waiting time exceeds a specified limit (reneging control)

According to this standard, for a $M/M/s:(\infty/FIFO/\infty)$ system, the probability that the waiting time exceeds a value t, $P(W_q>t)$, should satisfy the relation:

$$P(W_q > t) = e^{-s\mu t(1-\rho)} \frac{(s\rho)^s}{s!(1-\rho)} p_o \le p_{max}, \quad (2)$$

where:

- s is the servers number
- μ - service rate
- ρ - system utilization
- p_0 - probability of empty system – $p_0 = \frac{1}{\sum_{k=0}^{s-1} \frac{\rho^k}{k!} + \frac{\rho^s}{(s-1)!} \frac{1}{s-\rho}}$.

b) setting an upper bound for rejection, p_{max}.

For service systems with limited queue space, $M/M/s:(b/FIFO/\infty)$, the rejection probability, $P(L_s=b+s)$, should not exceed p_{max}:

$$P(L_s = b+s) = \frac{(s\rho)^{s+b}}{s!s^b} p_o \le p_{max} \quad (3)$$

where:

- b is the upper limit for queue length
- p_o - probability of empty system – $p_0 = \frac{1}{\sum_{k=0}^{s-1} \frac{\rho^k}{k!} + \frac{\rho^s}{s!} \frac{1-(\rho/s)^{b+1}}{1-\rho/s}}$

A nonstationary arrival process acts upon measures of performance and implies changes in system capacity or servers allocation. Over capacity of the system assures completion of arrival flow during peak hours. Outside these periods, the utilization is poor. On the other hand, an arrival rate that exceeds on some long periods the service rate can block the system. Thus, an appropriate service capacity must realise equilibrium between these contrary aspects, transposed both in service or waiting costs and also in service standards.

If the arrival rate has a slow evolution and the system is not over saturated (quasi-stationary regime), the state equations for the stationary regime represent a good approximation for describing the system. Newell (1982) appreciates that the quasi-stationary regime is characterised by two conditions:

$$\Delta(t) = \frac{1}{\mu(t)[1-\rho(t)]^3} \left| \frac{d\rho(t)}{dt} \right| << 1 \text{ and } \rho(t) < 1. \quad (4)$$

For a $M/M/s:(\infty/FIFO/\infty)$ system in quasi-stationary regime, the queue length can be approximated by:

$$\bar{L}_q \approx \frac{\rho(t)^{s+1}/s}{s![1-\rho(t)/s]^2} p_0 \quad (5)$$

where $\rho(t) = \lambda(t)/\mu(t)$ is system utilization and p_0 the probability of empty system.

If the evolution of the arrival rate does not allow the system to be in a quasi-stationary regime, the digital simulation remains the only method of study.

4. CASE STUDY

"Gara de Nord" (The North Railway Station) is the greatest Romanian railway station and at the same time one of the biggest transport terminal of the country. The arrival flow is separated from the beginning in first class and second-class passengers. The most difficult problems arise from the second-class passengers flow, which has a greater rate. For this flow are dedicated 24 ticket offices, with different degrees of visibility. The non-stationary arrival process raises service capacity problems.

A digital simulation programme written in ARENA 5.0 was conceived for simulating the service process and computing the system measures of performance. A 3 months recording activity was deployed for collecting data concerning the arrival process. The arrival process for weekdays is depicted in Fig 7.

Fridays are the most solicitated days of the week, due to the transit flows and the great numbers of departures from Bucharest to the county-side in weekends.

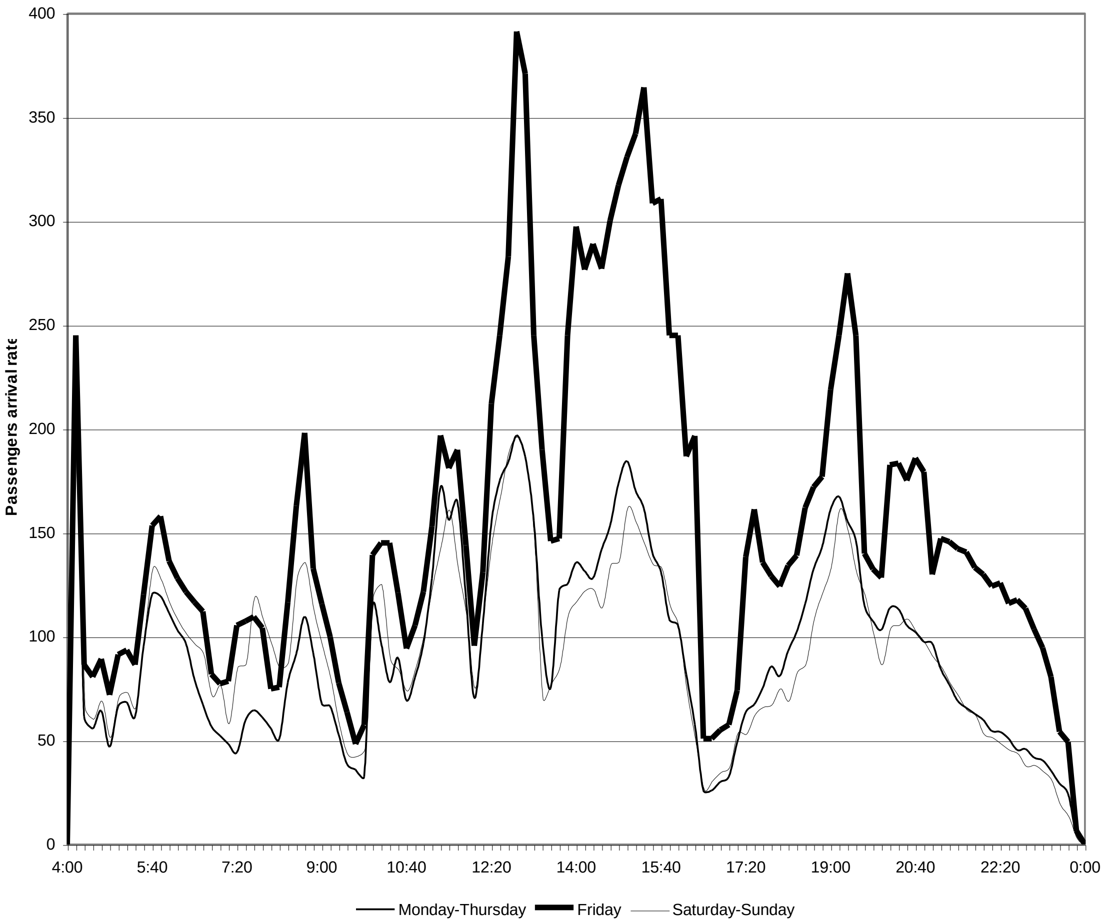

Fig. 7 Passengers arrival rate

Analysing the recorded data, we concluded that the stationary regime is not appropriate for the peak hours and especially on Fridays, as it can be seen in Fig.8 ($\Delta(t) >> 1$ for long periods of time).

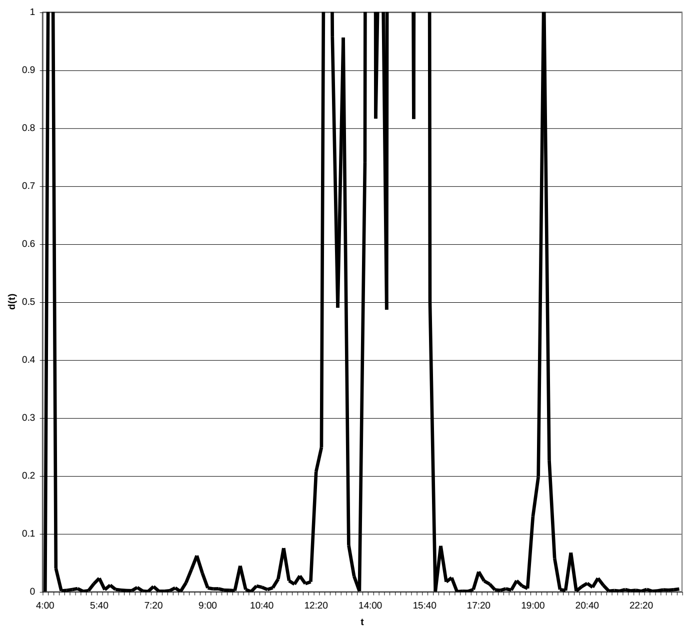

Fig. 8 $\Delta(t)$ evolution on Friday

The simulation experiments were conducted using 50 independent replications. The service capacity was variable along the day, considering the following ticket offices schedule: 12 offices opened between 4:00 and 11:00; 20 offices opened between 11:0 and 21:00 and 6 offices opened between 21:00 and 24:00. According to this schedule, the utilization of the system is less than 0.8 along the day. The average service time is 45 sec./passenger. Given these initial conditions, the hourly average waiting time is depicted in Figure 9 and the number of waiting passengers in Figure 10.

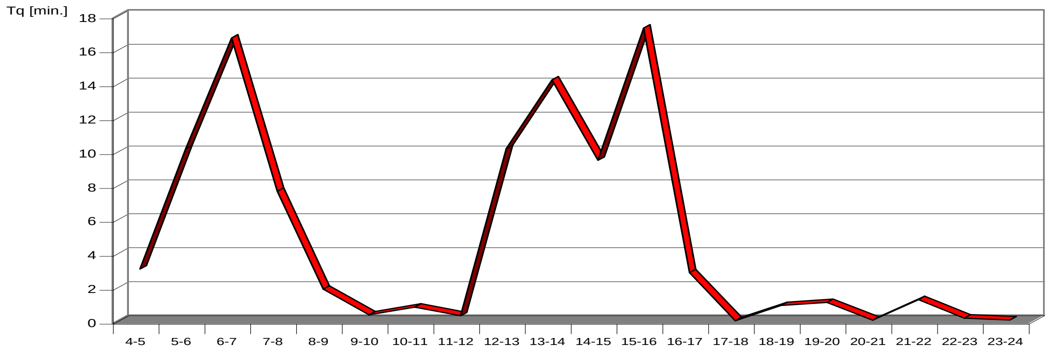

Fig. 9 Hourly average waiting time

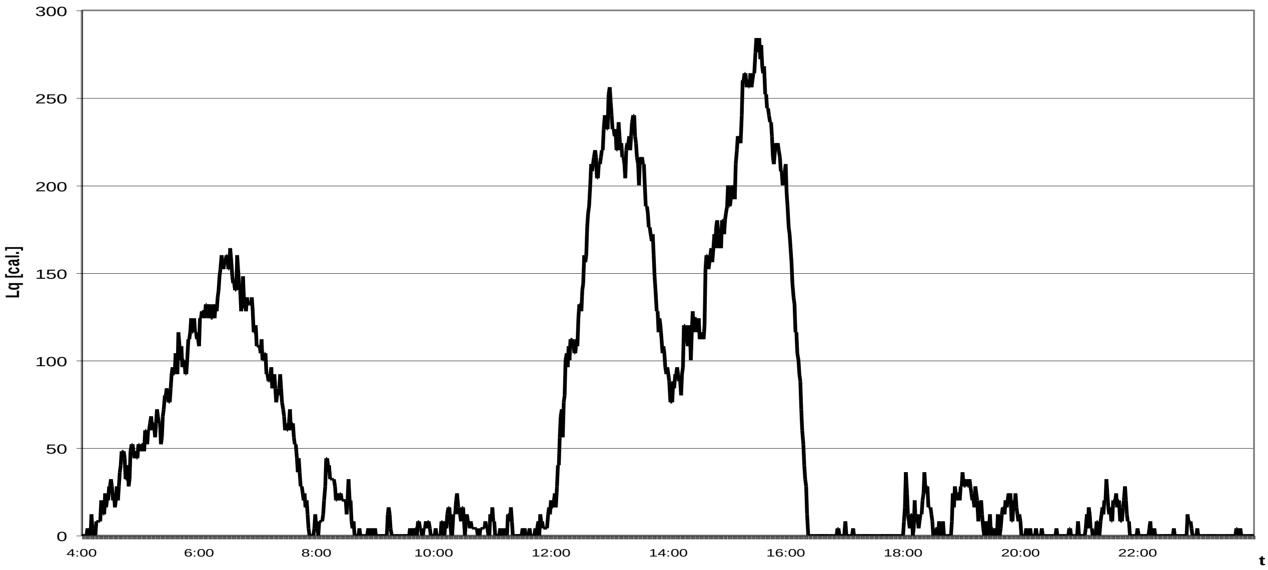

Fig. 10 Number of waiting passengers

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