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IMITATION MODELING OF SOPHISTICATED TRANSPORT SERVICING SYSTEMS

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ABSTRACT:
On the basis of the systems for emergency medical care and taxi transport some matters concerning the systems' imitation modeling are described.

KEY WORDS:
Bulgaria, Transport, Normative organization

1. INTRODUCTION

Big systems for transport servicing are inherent for every big town or city worldwide. Many of these systems have a big social importance. Sorts of such systems are the system for emergency medical care and the taxi transport system. Their investigation and optimization leads to improvements in the field of their management, but very often it is a very difficult task to be solved.

The examined systems in this paper consist from incoming flow, servicing system and outgoing flow.

The incoming flow is a totality of orders, which enter in the system and need to be served. The orders arise in different moments of time $t_1^{(1)}, t_1^{(2)}, t_1^{(3)}, ..., t_1^{(n)}$. The intervals between the moments of time are respectively $\Delta\tau^{1,2}, \Delta\tau^{2,3}, ..., \Delta\tau^{n-1,n}$.

Heaping of many orders at the system's entrance in particular moments of time is observed. Either they generate a queue or they leave the system without being served. When there are no orders that need to be served or the orders come in the system at long intervals of time, the system works not loaded enough or doesn't work at all.

The transport means represent the servicing system.

The outgoing flow is a flow that consists of customers who want to leave the system.

A great number of analytical methods and models can be used in order to solve such problems. One of their shortcomings is that they are connected with many suppositions and limitations. The suppositions and limitations are made solely in order to simplify the processes' description and the possible solution of the problems mentioned above. The analytical methods allow not only generalized description of the systems' servicing but also idealization and simplification of the systems' elements. The analytical models are static and can be optimized easy with different computer programs like Excel. Unfortunately analytical solutions not always exist or the one that exist not always can be found. Another method for solving such problems is the imitation modeling [3], which allows maximum approximation between the model and the real situation. The imitation model reproduces all elementary events, which take part in the investigated system functioning under conditions of time and under preservation of the events logical structure and successions.

Generally in case of sophisticated problems, when time and dynamic are important, the imitation modeling is a powerful mean for analyze.

2. INVESTIGATION OF THE INCOMING ORDER FLOW

The authors consider the behavior of the incoming flows of: system for calls reception in condition of taxi-cab company [1] and for emergency medical system [2] functioning in Ruse, Bulgaria.

The incoming order flows for taxi-cab transportation and emergency medical care determined for twenty-four hour period (A) and during the week (B) are shown respectively at figure 1 and 2.

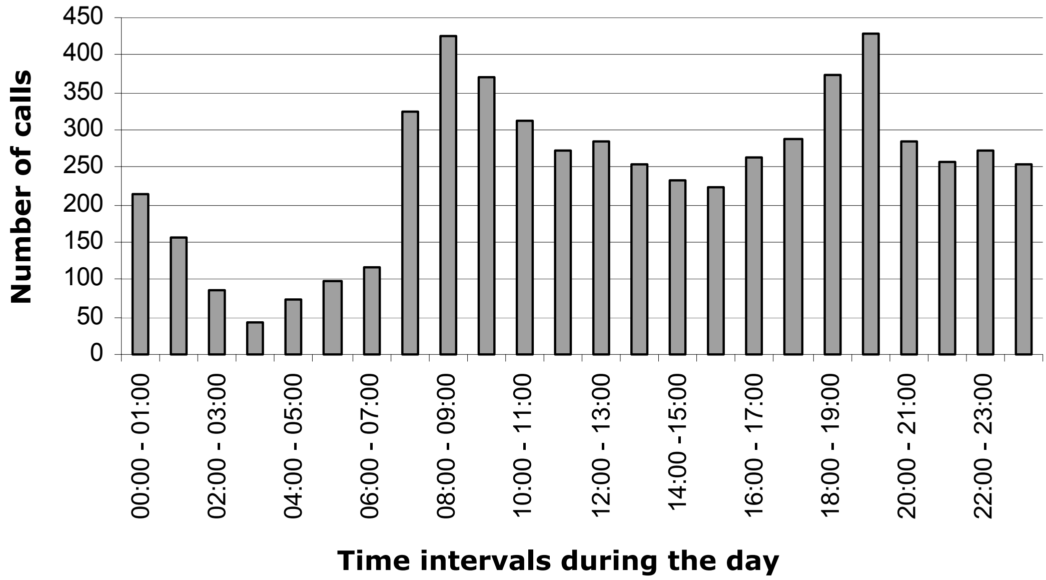

FIGURE 1. A. CALLS DISTRIBUTION IN ACCORDANCE TO DAY HOURS, FEBRUARY 2005

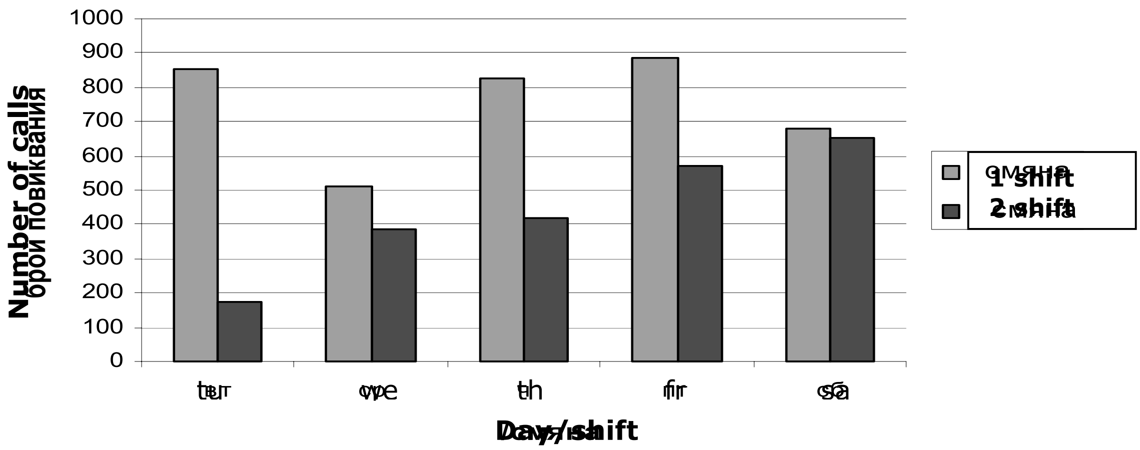

FIGURE1. B. CALLS DISTRIBUTION IN ACCORDANCE TO DAYS OF THE WEEK

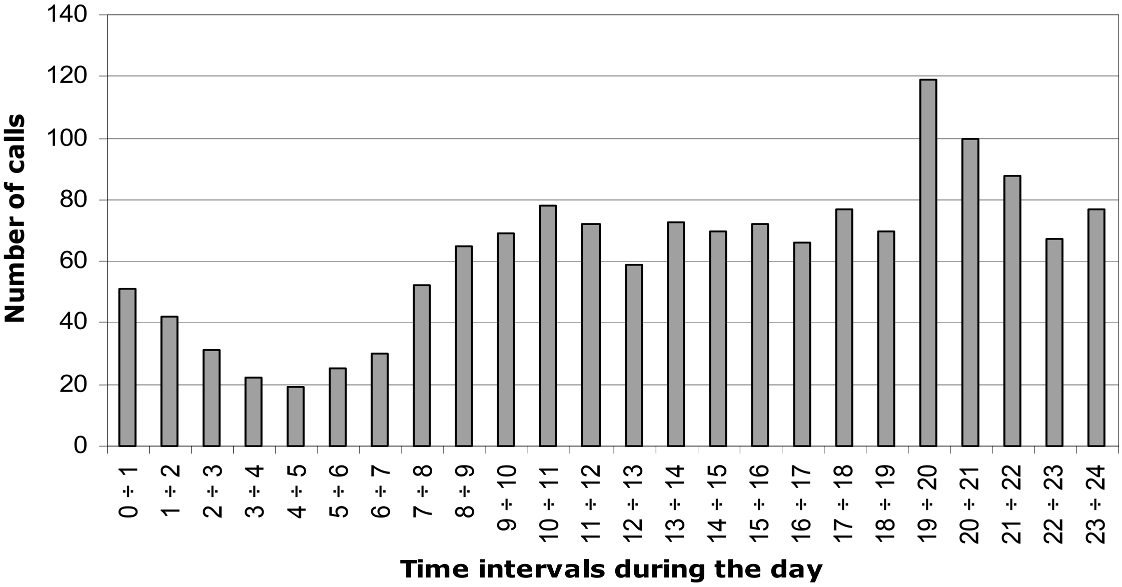

FIGURE2. A. CALLS DISTRIBUTION IN ACCORDANCE TO DAY HOURS, JANUARY 2004

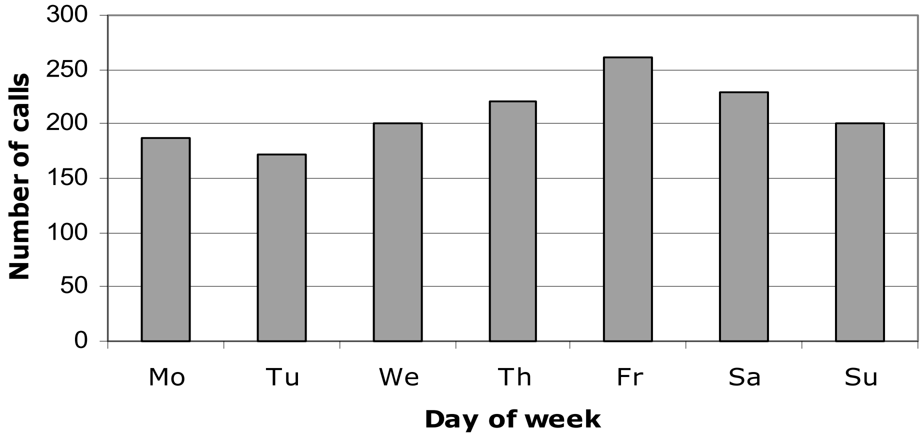

FIGURE2. B. CALLS DISTRIBUTION IN ACCORDANCE TO DAYS OF THE WEEK

The received average values concerning the incoming order flows will not be correct, because during peak moments the systems will be overloaded and not loaded enough during the rest of the time (table 1).

TABLE 1. IRREGULARITY FACTORS' VALUES FOR THE INVESTIGATED SYSTEMS

Irregularity factor	Emergency medical center	Taxi-cab system
week days	κ_{1emc}= 1,24	κ_{1ts} = 0,8167
twenty-four hour period	κ_{2emc}= 1,94	κ_{2ts}= 0,072395

$$k_{i(emc,ts)} = \frac{Q_{max}}{\overline{Q}}; i = 1,2,3,4$$

Q_{max} - maximum number of orders for the investigated periods of time (week days, twenty-four hour period);

$\overline{Q}$ - average number of orders for the investigated periods of time.

The incoming order flows are described with certain organization and a number of parameters: incoming orders (calls) intensity, i.e. the average incoming order number for certain period of time; distribution principle of the expected moments of time for orders' incoming in the system. Big importance in the theory of mass servicing has the ordinary flow consisting of similar events called Poisson flow. The Poisson flow has to be steady, homogenous, without consequences.

The flow intensity for different hours of twenty-four hour period is different and this can be seen at figure 1 and figure 2. If we define these parameters for every single hour, then we can say that the system will be constantly in transition process. Thus the incoming flow will be practically unsteady and with consequences, because the mathematical expectation of the ordinary number during different time intervals of day is not constant and the number of orders incoming in particular hour of day depends on their number in previous hours.

The work cycle of the both systems is one-year in view of the fact that the systems' characteristics vary during different seasons. Investigations conducted by the authors show that the peak under circumstances of taxi-cab transport is during winter, for the case of emergency medical care – winter and summer.

Furthermore work cyclic recurrence is observed according days of week.

This means that if the incoming flow is analytically described it has to be converted into a flow getting into account all necessary factors which influence on the given mass servicing system.

The flow becomes unsteady, not homogenous, with consequences and not ordinary. Model for formation of such a flow is shown at figure 3.

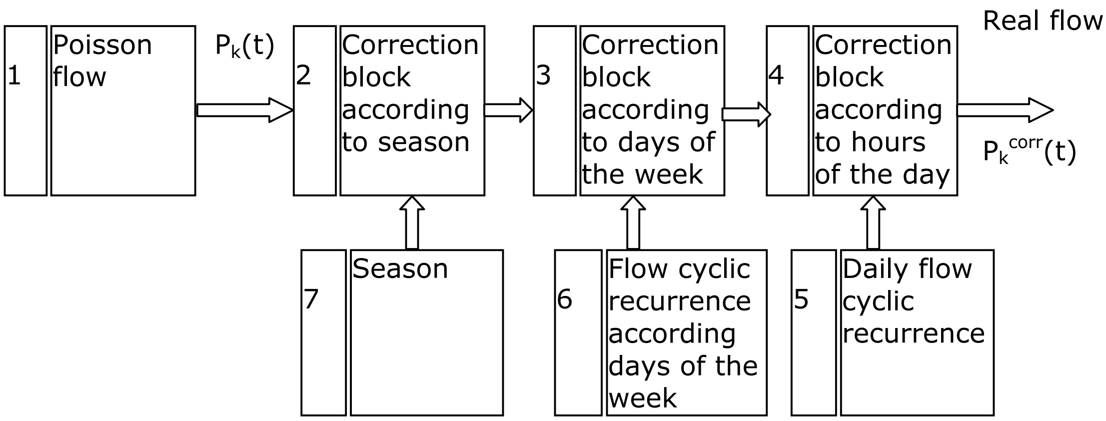

FIGURE3. MODEL FOR FORMATION OF REAL ORDER FLOW OF THE SERVICING TRANSPORT SYSTEMS

If we consider Poisson incoming flow then the probability for entry of k orders for period of time t is:

$$P_k(t) = \frac{(\lambda t)^k}{k!} . e^{-\lambda t} \tag{1}$$

Blocks 2, 3 and 4 have to influence in such a way on the parameters k and λ that the value of the corrected flow $P_k^{cor}(t)$ to depend from the month γ_1, the days of the week γ_2 and the hours of the day γ_3, i.e.:

$$P_k^{cor}(t) = Y[P_k(t), \gamma_1, \gamma_2, \gamma_3] \tag{2}$$

The specific kind of this dependence can be given analytically or in tabular shape. Only after such a transformation of the incoming flow is made it is possible to make an imitation modeling of the servicing systems mentioned above.

3. GENERAL PRINCIPALS CONCERNING THE IMITATION MODELING OF A SYSTEM

At figure 4 is shown scheme of imitation model of system with:

- incoming variables $x_1, x_2, \ldots, x_n$
- outgoing variables $y_1, y_2, \ldots, y_m$;
- characteristics of the system's condition $z_1, z_2, \ldots, z_l$;
- system's parameters $a_1, a_2, \ldots, a_K$.

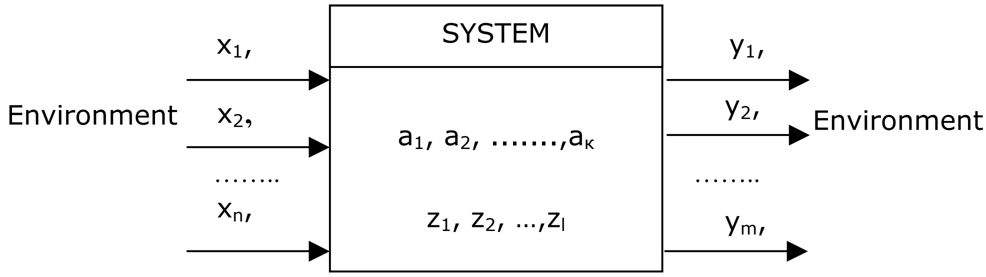

FIGURE 4. IMITATION MODEL OF THE SERVICING SYSTEM

The entrance (incoming variables) and the outcome (outgoing variables) accomplish the relation between the system and the environment. The conditions z_1, $z_2, \ldots, z_l$ fix all the transformation happening in the system as a result of the incoming variables and the internal system transformation.

The management of such systems is carried out like information process (collecting, processing and spreading of information). In this sense the system's condition transformation as a result of system's management is carried out on the basis of controlling incoming signals $g_1, g_2, \ldots, g_p$ (fig. 5). The controlling incoming signals modify the system's functioning. The alteration of the system's condition in the time as a result of the management is shown at fig. 6, where z_0, z_{n1}, z_{n2}, z_{n3} characterize the new conditions of the system, received for different intensity of the controlling signal.

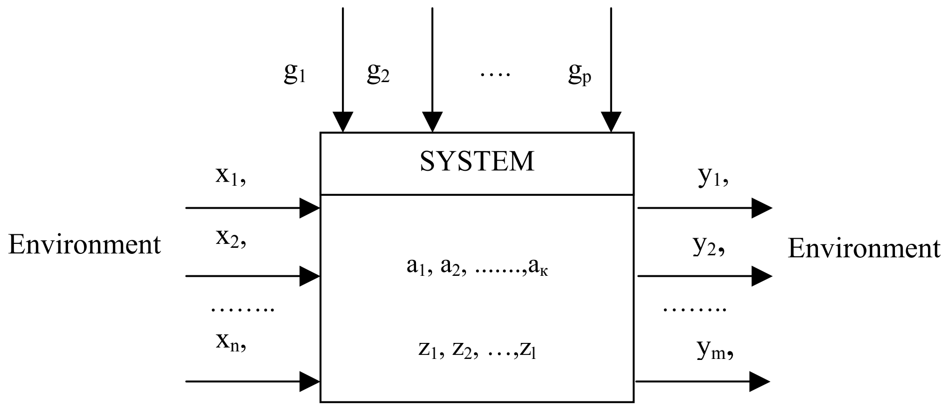

FIGURE 5. IMITATION MODEL OF THE SERVICING SYSTEM WITH PURPOSE CORRECTION

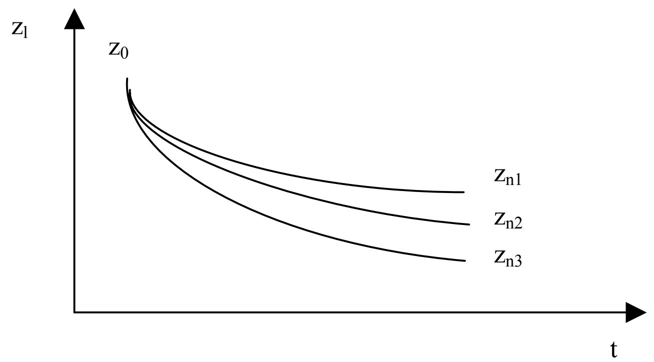

FIGURE 6. ALTERATION OF THE SYSTEM'S CONDITION AT DIFFERENT INTENSITY OF THE CONTROLLING SIGNAL

4. CONCLUSION

The discussed mass servicing systems are characterized with constantly varying parameters and distributions for the incoming flows and the systems themselves. Consequently during all the time the systems function in transition regime. The imitation modeling doesn't restrict the incoming flows to be steady, ordinary, without consequences and etc. It allows receiving adequate results corresponding to real systems.

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