RESEARCH OF CALL-CENTER OPERATION INDICES ON THE BASES OF QUEUEING THEORY AND SIMULATION MODELS

A. Latkov, P. Shamshina

Transport and Telecommunication Institute
Lomonosova Str.1, Riga, LV – 1019, Latvia
latkov@tsi.lv

The increase of road traffic in the European Union focuses for creating intelligent transportation systems of traffic control in local, urban and regional level. The possibility of using acoustic sensors for traffic intensity measurements are discussed in this article. Acoustic signal detector, such as an ordinary household microphone, is used as the most inexpensive sensor version for stationary and mobile traffic surveillance systems. The acoustic signals records from different types of road vehicles in various weather conditions examples are described here. The simplified modification of acoustic microphone's signals spectral processing algorithm and noise filtering are solved. Detection of moving road vehicles results, using records for their acoustic signals, is also discussed here. The restrictions of using acoustic sensors to estimate traffic parameters are established.

Keywords: call-center service, queueing system, analytical models, simulation models, load of operators

1. INTRODUCTION

Call Service Centers in the world today for many companies, such as telecommunications, insurance, retail and commercial banks, credit card system banks, hotels, and etc. are an indispensable means of communication and effective management of relationships with customers.

The greatest importance among all the subsystems of modern call-centers occupy collection subsystem, provision of statistical information on the functioning of call-center, as well as a subsystem of predicting the behavior of the system with increasing traffic, the modernization of the technical facilities, introduction of new processing Technologies of user requests, etc. [1] Subsystem for gathering statistical data and providing exactness are realized in most call-centers and there is a common conception of their implementation.

Subsystem forecasting the stream of input query depends on the logic and procedures of call-center. The most difficult for the analytical prediction models are:

– accounting of the heterogeneity of requests
– usage of a system of service priorities of requests
– records of user behavior during the processing of requests
– incorporation of new technologies for processing requests

Regardless of the complexity of call-center common parameters that characterize the quality of the work are:

– waiting time of processing of requests

– probability of failure in service.

As analytical models, describing the behavior of call-centers, and in planning, upgrading and prediction of their work, there are used models of the QS (queueing system). [2]

Thus, for call-centers that handle calls received over the telephone network for the prediction models is enough to accept the incoming call flow for a Poisson, but service time distribution - exponential. The simplest model of QS capable for evaluating the behavior of the call-center $M/M/N$ with unlimited number of waiting places, but it cannot take into account the blocking of calls in call-center.

For such call-centers most important is the ability to take into account the blocking call, due to lack of free lines. QS model of $M/M/N/L$ species known as the Erlangen B-formula allows you to find the probability of call blocking. [3]

$$P_k = \frac{\frac{\rho^k}{k!}}{\sum_{k=0}^{n} \frac{\rho^k}{k!}}, \quad (0 \le k \le n) \ , \tag{1}$$

where $\rho = \frac{\lambda}{\mu}$,

k – the number of service devices(number of operators, number of input lines),

λ – intensity of requests flow,

μ – intensity of service flow.

However, in call-centers it is needed to evaluate the delay, upon condition of no immediate call service. For such call-centers it is used an analytical model of the QS $M/M/m/B$ form, where m – is the number of service devices, and B – is the total number of places in the system. Models $M/M/N$, $M/M/N/N$, $M/M/m/B$ cannot consider the possibility of leaving a call from the queue, when user hangs up without waiting THE service. For accounting for this factor as predictive analytical models of QS, there are used model of $M/M/N+M$, as well as $M/M/m/B+M$, where the user's "patience"is taken into account (M- "patient"has an exponential distribution law).

2. THE DESCRIPTION OF THE REAL MODEL

To evaluate the accuracy of describing the behavior of call-center on these models it was investigated specific Information Service call-center. This center provides services of two types:

– Getting referential information

– Servicing the users cards and mobile communications.

Call-center has 9 workplaces for operators and one supervisor position.

The number of incoming lines from the common usage telephone network is 32. In the month call-center receives up to $50-80$ thousand calls, where $3-4$ thousand from them are disabled after listening to the message that all operators are busy. When handling real statistics were explicit:

– average call duration is 70 seconds

– the average time of customers patience is 40 seconds

– the specified quality criterion was the level of service equal to 90% answers within 15 seconds.

Was assessed predictive accuracy using these analysis modules and was made a comparison with obtained result of the system.

3. ANALYTICAL MODELING

In Figure 1 there are provided the results of analytical modeling and from the graphs it can be concluded that the model with blocking and repeated $M/M/N/N + c$ indicates result closest to the real system and reduces the number of working operators to 6, without compromising service indicators.

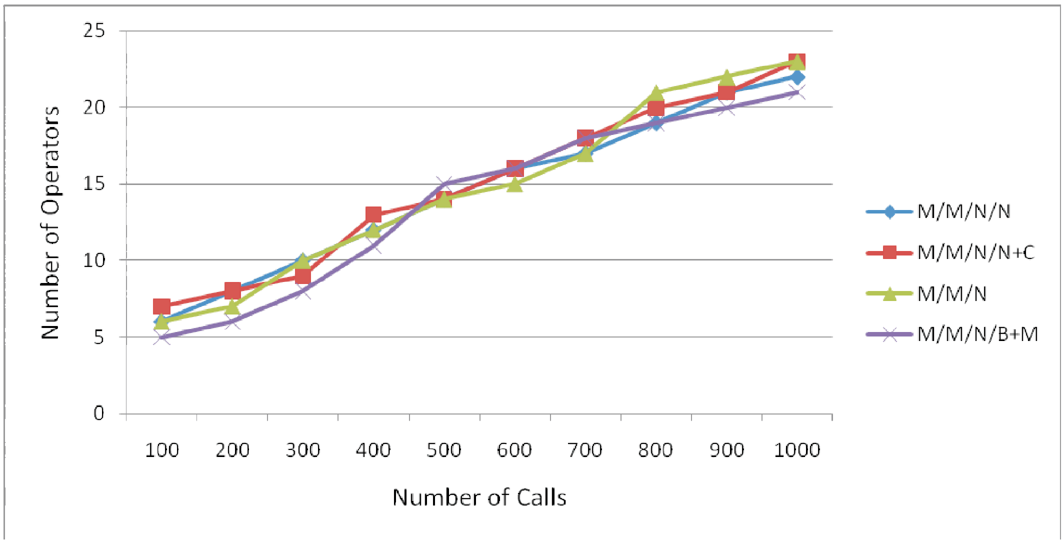

Fig. 1. Required number of operators to maintain the established level of service

Figure 2 shows a graph of the workload of the operators on the number of incoming calls.

From the graph follows that the model $M/M/N/M$ with locks at the same incoming flow of calls provides the least busy operators.

The results of analytical modeling are shown in Table 1.

Model type	λ (calls per hour)	q (average queue)	tq (waiting)	level of service	missed calls
$M/M/N/N$	193	0.22	4.1	90%	10%
$M/M/N/N + c$	229	0.25	3.9	90%	10%
$M/M/N$	179	0.23	4.7	90%	10%
$M/M/N/B$	179	0.23	4.7	90%	10%
$M/M/N/B + M$	215	0.19	3.2	90%	10%

The results obtained show that none of the models of the QS does not adequately reflect the work of call-center. The best approximation for the entire range of flow applications gives the research of the model with $M/M/N/N + c$ repeats.

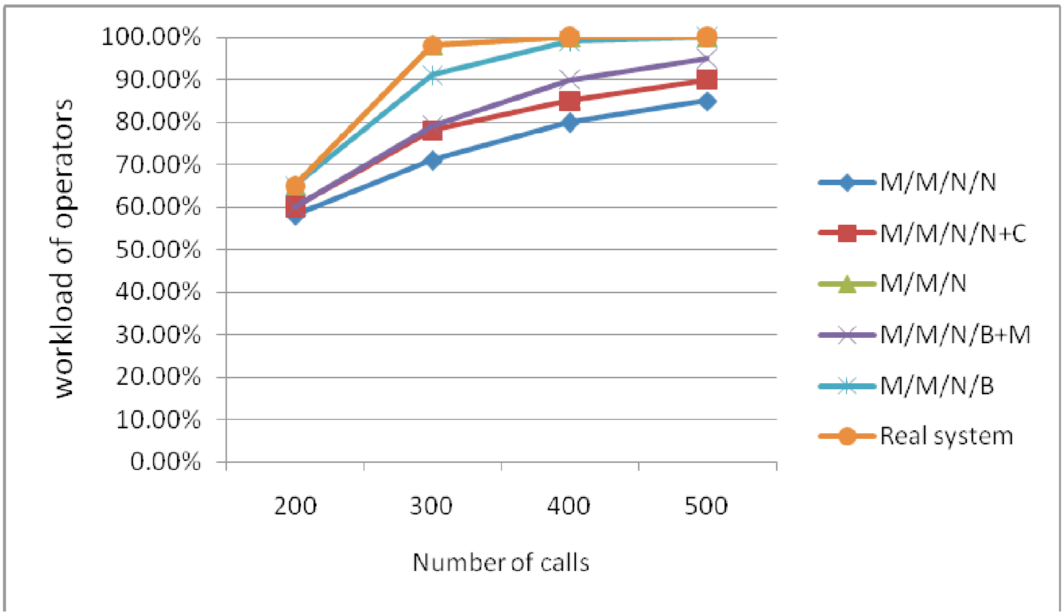

Fig. 2. Workload of 9 operators with different numbers of incoming calls

4. SIMULATION MODELING

Whereas none of the researched models of the QS does not give adequate results in real call-center in the whole range of workload, due to it is proposed as a predictive model to use a simulation model for call-center, implemented in a programming language GPSS.

Figure 3 shows a generalized scheme of the algorithm model.

In the research of a simulation model was presented a comparative analysis with the real system. The following parameters were recorded:

– the average waiting time,
– level of service.

For accounting the level of service was accepted quality standard for the call-centers, that is calculated by formula

$$L_s = \left(\frac{R_{15} + B_{15}}{R_\Sigma + R_B}\right) \times 100\%, \qquad (2)$$

where

- L_s - level of service,
- R_{15} - Calls answered after 15 seconds,
- B_{15} - Calls abandoned after 15 seconds,
- R_Σ - All answered,
- R_B - All abandoned.

Figure 4 are shown graphs of average waiting time in a real system and in simulation model.

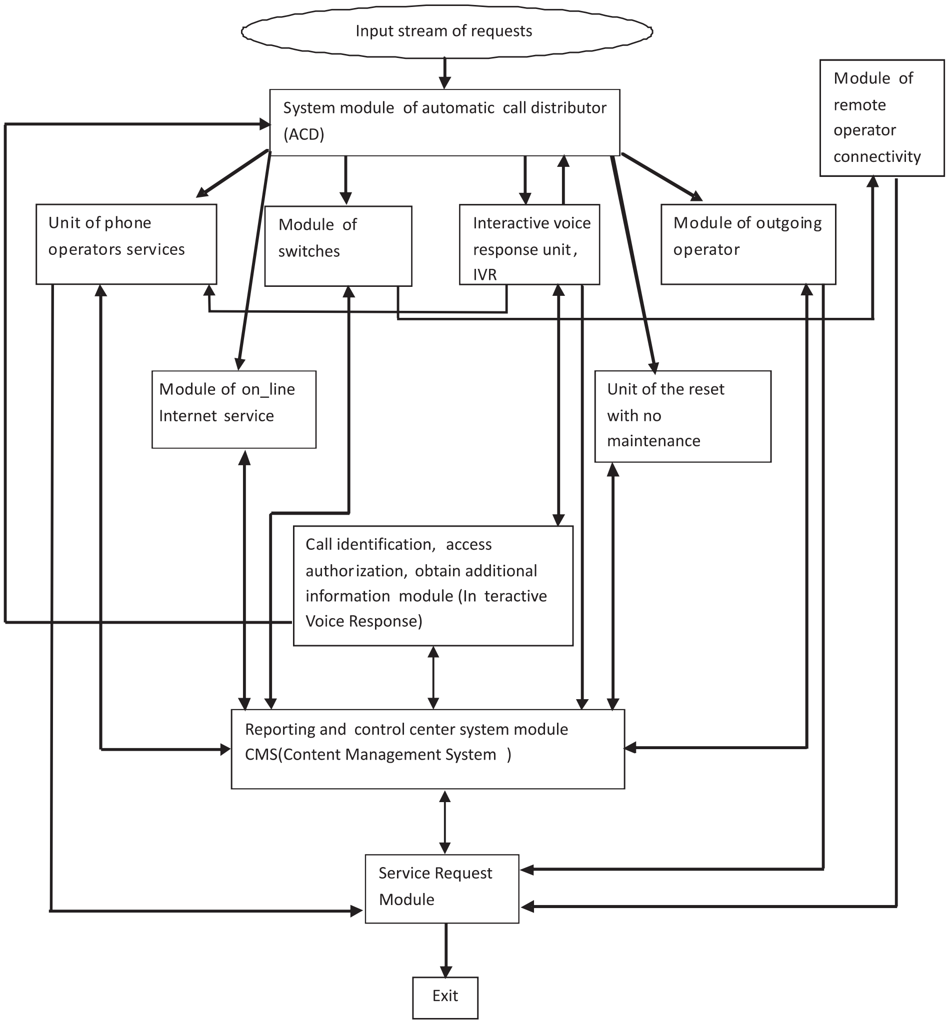

Fig. 3. Scheme of model algorithm

5. CONCLUSIONS

As can be seen from the graphs in Figure 4 simulation model allows accurately estimate the behavior of real systems, while the infelicity for the average not exceed 5-7%. The level of service L_s calculated by the formula (2) for a real system and simulation model in the range of 270-430 calls load is $L_s$rs = 95÷16% and $L_s$sm= 91÷9%, respectively. That's why, in spite of great difficulty and complexity of the model on GPSS, the need to adjust settings and parameters of the simulation model based on the results obtained on a realistic system, it is advisable to use the simulation model because of its flexibility and relevance to predict the behavior of call-center on all-band reception of load.

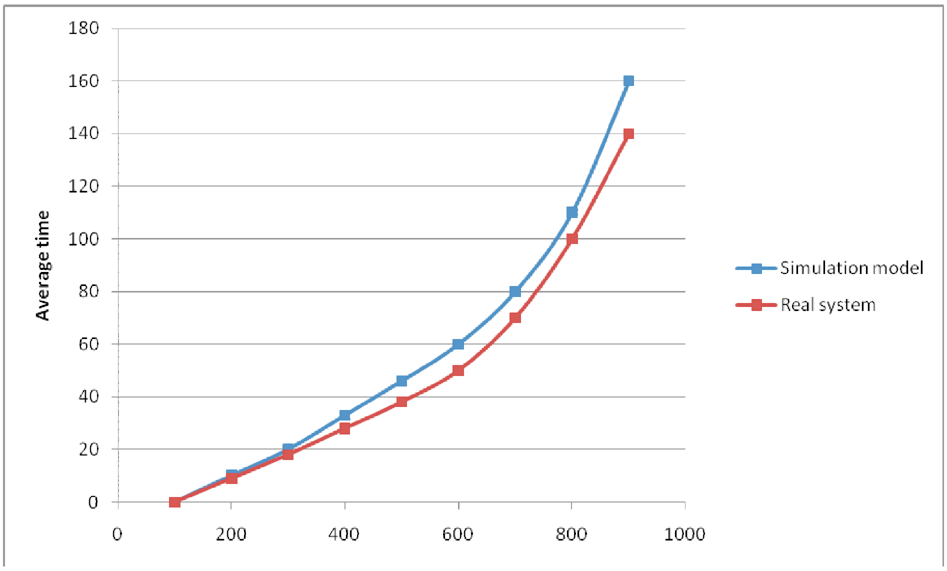

Fig. 4. Dependence of the average waiting time from loading

6. REFERENCES

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