The Modeling of Contact Center Dealing with Smart Objects of Internet of Things

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***Abstract*—The implementation of Internet of Things applications can transform contact centers by providing them with new streams of information and taking the customer service to the next level. However, the mathematical modelling of such systems is quite new direction and there are no concrete results in this field yet. In this paper the mathematical model of contact center with the Internet of Things implementation is constructed and analyzed. In the model multi-skilled routing based on usage of one group of operators capable of serving simple requests from smart devices and several groups of experts (consultants) handling more advanced topics is taken into account. Markov process that describes the model functioning is constructed. Main performance measures of interest are defined through the values of stationary probabilities of the model's states. The algorithm of characteristics estimation is suggested based on solving the system of state equations. It is shown how to use found relations for quantitative analysis of the model functioning. The usage of the model for estimation of required number of waiting positions and operators is considered.**

I. Introduction

The Internet of Things can be described as a network of multiple physical "smart" objects (vehicles, actuators, sensors etc.) which have ability to produce, process and exchange data without involvement of human beings. This technology offers new opportunities allowing to take existing business models to the next level. There is swift development in the field of the Internet of Things and it affects on different business processes including interaction with clients. Previously the Internet of Things and the customer service have not been directly linked but this state-of-art is changing rapidly. In future it's all going to be like connection between smart objects, smart services and human resources which help to provide great variety services, increase loyalty and get new customers [1].

Nowadays the main tool for delivering quick and efficient customer service is omni channel contact centers. Clients can contact the company via different channels – from traditional voice calls to email and social networks – and get all the necessary information or help from one of the agents of different skills. But new-age customers require more sophisticated service and that's why contact centers of the nearest future will be touched with the effect of the Internet of Things.

The call and contact centers have been in the field of scientific interest of both engineers and mathematicians for a long time. As result of conducted researches there is a huge number of mathematical models taking into account various features of contact center functioning. For the simple cases basic models Erlang-B and Erlang-C are used. Besides, there are models taking into account IVR (Interactive Voice Response) system, possibility of waiting for the service or repeating a request. Also, series of results were obtained concerning the generalization of basic features within one model [2-5].

The mathematical modelling of contact centers with Internet of Things implementation is quite new direction of scientific research at the initial stage. The conceptual similarity of processes of servicing requests from customers and smart objects allows using already known approaches based on Markovian models for preliminary analysis.

The aim of the paper is to construct an analytical framework for modeling the processes of servicing requests from smart devices in the contact center. There are three stages of servicing in the considered model – self-servicing, agents (or operators) and consultants. We suppose that the process of requests coming is described by Poisson model. The operators and consultants have finite number of waiting positions and maximum allowed time for requests to be in the queue is restricted. All random variables used in the model have exponential distribution with corresponding mean values. The formulated assumptions are based on the limitation of the model but it allows to perform mathematical modeling of the communication between smart devices and operators of the contact center. Using the model the main performance measures of interest are given through values of probabilities of model's stationary states. The model and derived algorithms of performance measures estimation are based on results of [6] and can be used for estimation of performance characteristics of contact center servicing requests from smart devices. The novelty of the paper is the construction and the analysis of mathematical model of the contact center dealing with the Internet of Things applications.

The paper is organized as follows. The second section presents an overview of the current state-of-art of customer service. The positive effect of the Internet of Things implementation into different contact-center features including skill-based routing, omni channel ecosystem and data collecting is also discussed in this part. A short overview of related works is given in the third section. The mathematical model description and the definitions of basic parameters are presented in the fourth part. The system of state equations is considered in the fifth part. Some numerical results of usage of

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the designed model are shown in the sixth part. The last section presents the main conclusions of the article and the directions for the future work.

II. The Internet of Things and customer service

A. The "new era" customer service

Initially, all customer service processes happened personally. Then the telephone was invented and it was used by the companies to interact with a large number of their customers. That is how the first call centers appeared. Further, the automation system IVR which will be discussed later scaled them to contact centers with option of self-service. The outsourcing model of contact center was offered for cost optimization. Its basic idea is that contact centers are organized in the cities or even countries where average salaries are lower then in region where headquarters of company are situated. But this strategy sometimes leads to disappointing experience mostly because of cultural and language differences. Thereby, modern contact centers have a real problem with personalization of the customer services that lead to the constant growth of the number of frustrating interactions. Such a situation is quite dangerous for the business because of the statistics. according to which 66% of consumers decide to switch companies due to poor customer service. Some 82% of those who switched companies noticed the brand could have done something to stop them [7]. The growth of social media allowed customers to share their negative experience online and it forces companies to improve the quality of service.

The contemporary product ecosystem gets more complex and service oriented and it requires for contact centers to shift focus from human resources and become more proactive in the Internet of Things reality era. While the products are becoming "smart", the customer service models needs to become "smart" too. The real worth of the Internet of Things is not just connecting devices, but the provision of integrated management platform driven by Big Data to take the customer service to the next level. Next we will consider the Internet of Things impact on different aspects of modern contact centers.

B. Agent skills and smart devices

In modern contact centers agents spend most of their time giving the requested information or handling the complaints of the customers. The most complex queries are redirected to the agents with improved skills known as experts or consultants. According to contact center size and specificity there can be one or several channels of interaction between company and customers including chat, social media, voice, SMS, and other mediums of omni channel environment.

The rapid rise of Internet of Things may change traditional servicing processes inherent to the contact centers into something new. The "smart" objects have the ability to detect their own problems.

Accordingly, an amount of requests from customers which can be resolved without human interaction will increase and that's why the companies can lower the expensive call volume on their voice channels and concentrate more on proactive and outbound communications and, of course, advanced queries. McKinsey research suggests that robots will be able to fully resolve 30 to 50 percent of all requests in future [8].

The Internet of Things technologies allow devices to inform manufacturer or service provider about malfunctions or other problems. The proper analysis and escalation of data from smart objects will make customer service more proactive due to prevention of the potential problems. This will lead to minimizing of overall volume of requests and waiting times. But, in the same time, percentage of complicated and nuanced issues will increase. And all of them will be handled by human resources via omni channel ecosystem. Thereby, the transformation of contact center agent from general complaint handler to the specialist with highly specialized knowledge seems to occur very soon. It means that agents will have to

- completely understand the products and the services which their company provides;
- get appropriate training for some specific situations (for example, malfunction of sensor);
- improve their social skills required to manage complicated interactions;
- be ready to act proactively that means quick responding to the Internet of Things data, timely escalation of stressful scenarios to the appropriate specialists and so on.

If the company is going to offer trouble-shooting support for Internet of Things devices, it's important to let agents use the devices themselves to check how they works and what technical problems can occur. Besides, there must be understanding of fact that average time of request handling will increase because agents need to understand the details of complicated technical problem first and then provide the customer with specific response [9].

C. Omnichannel ecosystem and data collecting

Nowadays customers can contact companies via ever-expanding variety of channels. In the current situation the Internet of Things is considered as challenge for the contact centers and their abilities to integrate smart objects into the customer service. The key aspect of this process is defining what experience clients can get in the contact center while its agents handle also the requests from the Internet of Things devices.

The rise of the Internet of Things means a rapid growth of connected smart objects and an explosion of data volumes which bring higher opportunities. This data if properly collected and analyzed can be used by contact centers to gain the efficiency of customer service. The accumulated statistics about frequently occurring issues helps to fix what is not working, avoid such problems in the future and, thus, increase customer satisfaction. Also, there is another way how data from the smart objects can be used in the contact center. For example, if a customer calls about an issue with his or her smart fridge, the agent can check data from the fridge itself to better identify the problem. The health devices, household devices and cars are one more example of products that displays customer's behavior. The companies can apply data from such objects to improve their marketing approaches, provide more proactive service and identify problems before they arise. For instance, the agents of the contact center of an insurance company using data from car can check how safely a customer is driving and give him an appropriate quote [9].

D. The next level of self-servicing

The Internet of Things is simply one of the best ways to expand the existence of self-service. According to the researches and experts' predictions of sensor market growth, the Internet of Things conception may propose many interesting implications for the contact centers. The moving to the more proactive approach is opportunity to improve standard service offerings. The Internet of Things transforms contact centers by giving them more control of customer services. This effect is achieved by means of different streams of information which are easy to implement into the current business processes [10-11].

Nowadays the main instrument of self-service in contact centers is IVR system. This is a technology that provides interaction between customer and company's host system via speech recognition or DTMF tone input with the use of keypad. In this case required information comes to customer through the IVR dialogue as pre-recorded or real time generated audio. Well organized IVR system can handle large inbound call volumes (up to the 70%) and decrease companies' costs. It's also used for the outbound calls. However, there are some aspects about IVR that receive critics from specialists. First of all, sometimes such systems are difficult in use and they can't satisfy customers' basic needs. Today all general information (for example, products, services or contacts) is available on companies' websites and most of the incoming requests are concerning complex problems and they require agent's answer. Customers no longer want to spent time hearing all the IVR menu items on and on, go through security questions and do other things which are necessary for the outdated self-service systems. This lack of personal touch is main reason IVR will soon lose its actuality and will be replaced by cloud and artificial intellect (AI) solutions, which have different features like data analytics. Even now one of the basic trends in the contact center industry is the replacing of agents with chatbots. It helps companies to satisfy customer need in quick and efficient services via smartphone in any time and in any place.

All the facts mentioned above indicate that in the nearest future the Internet of Things will become an integral part of contact center infrastructure. The implementation of the Internet of Things applications into existing business processes or the planning of a new contact center should be proceeded with the use of scientific research results obtained from mathematical modelling.

The self-servicing in contact centers with the Internet of Things implementation can be taking into account in the same way as it was in the case of IVR in previously published works [12-13]. Let us consider the following situation. The smart device sends to the company a message about problem. For example, a smart printer informs that color ink is running out. This problem is typical and does not require human intervention. With the use of data received from printer the cartridge delivery order is forming by the system. An employee responsible for the printer exploitation receives a notification about this issue. In the case of more complex problem, for example, damage, the smart device informs contact center agent. After processing this request agent makes an inbound call to the customer to give him instructions or to confirm the time of the technician coming. The functional model of contact center dealing with the Internet of Thing smart devices is depicted on Fig.1. It includes three stages of servicing – self-servicing, operators and consultants.

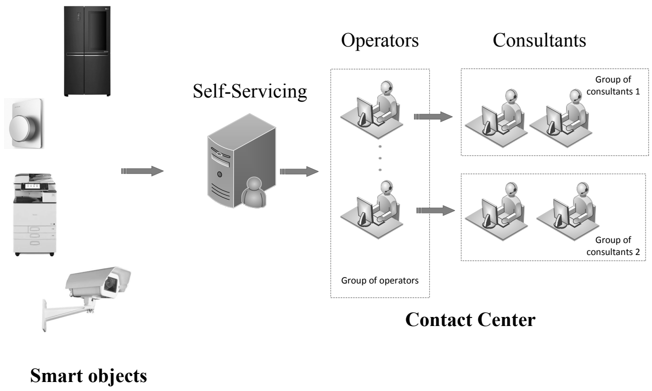

Fig. 1. The functional model of contact center structure dealing Internet of Things smart devices

III. RELATED WORK

The mathematical modelling of contact-centers dealing with smart objects of the Internet of Tings is quite new direction of scientific research and there are no concrete results in this field yet. However, the assumptions and the methods which are used in this paper are taken from previously published works. The basic one is [6] where the generalized model of arrival and servicing of calls in modern contact centers is considered. It takes into account the skill-based routing which means the divide of servicing staff into operators and consultants similar to how it was done also in [3] but with allowing to calls to be repeated. Another feature of generalized model is the presence of voice answering machines.

Basic principles of IVR functioning and mathematical modeling of self-servicing process can be found in [14]. In this paper authors propose and analyze a flow controlled network model to determine the number of IVR channels and agents required simultaneously. They assume Poisson arrivals, exponential processing time at the IVR and exponential talk time.

In all mentioned works the characteristics of call servicing are defined and different methods of their computing are considered. One of them is based on constructing and solving a system of statistical equilibrium equations [6]. This method as well as skill-based routing and principles of IVR are used in our article. The novelty of our research is the attempt to consider the processes of servicing requests from smart devices using existing algorithms and taking into account similarity with calls servicing. The obtained results are the first step to deeper analysis of such systems and processes.

IV. MODEL DESCRIPTION

Requests for servicing from smart devices enter the contact center via one of the access channels and further they are processed by self-servicing system or by operators and by consultants from selected group according to request type. Let us denote by υ the number of operators, and by υ_k the number of consultants in the k th group, $k=1,...,n.$ If operators or selected group of consultants are occupied then request waits the beginning of servicing. The number of waiting positions for the beginning of servicing is limited. Let us denote by w the number of waiting positions for operators, and by w_k the number of waiting positions for k th group of consultants, $k=1,...,n.$ To simplify the model, we assume that considered contact center processes only requests from the "smart" devices and doesn't deal with calls from customers.

Requests for servicing arrive according to a Poisson model with intensity λ . It is supposed that maximum allowed time of waiting the beginning of service by operator and time of waiting the beginning of service by consultant from the group of consultants number k, $k=1,...,n.$, has exponential distribution with parameter σ and σ_k correspondingly.

As was mentioned above, the process of servicing of a request from smart device may include three stages: self-servicing, processing by operator with basic skills and processing by a consultant of selected group number k, $k=1,...,n.$. We suppose that durations of the last two stages have exponential distribution with parameters μ and μ_k correspondingly. The selection of stages is described by fixed probabilities depending on the type of the request. With probability q a smart device with additional probability a_k is trying to get service at k th group of consultants, $k=1,...,n$ and with probability $a=1-\sum_{k=1}^{n} a_k$ is trying to get servicing at group of operators. With additional probability $1-q$ a smart device stops its attempts to get the information service and leaves the system unserved. After finishing of processing by operator service a smart device with probability cc_k is trying to continue service at k th group of consultant, $k=1,...,n$ and with probability $1-c$ a customer stops his attempts to get the service and leaves the system unserved.

Model's main parameters and the process of requests coming and serving are shown on Fig. 2.

V. MARKOV PROCESS AND MAIN PERFORMANCE MEASURES

Let us denote the state of the system by vector $(i,i_1,...,i_n)$ where the i is the number of occupied operators and waiting positions and i_k is the number of occupied consultants and waiting positions of k th group of consultants, $k=1,...,n.$. The components of the vector varies as follows

$$i=0,1,...,\upsilon+w; \quad (1)$$
$$i_k=0,1,...,\upsilon_k+w_k; \quad k=1,...,n.$$

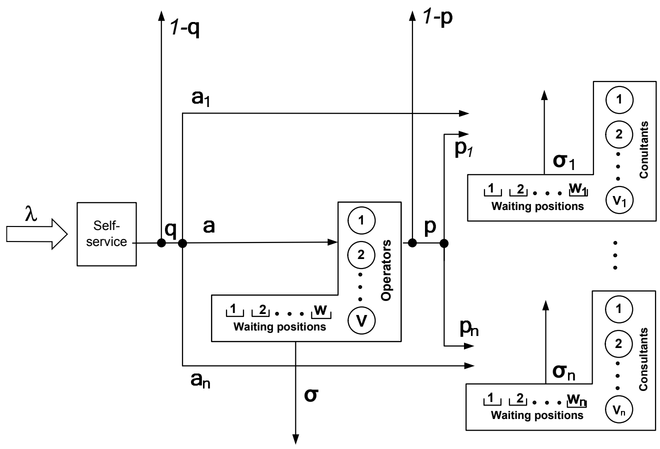

Fig. 2. The structure of contact center mathematical model

Let us denote by $i(t)$ the number of operators and waiting positions occupied at time t; by $i_k(t)$ we denote the number of consultants and waiting positions of k th group of consultants occupied at time t, $k=1,...,n.$ The dynamics of model states changing is described by Markov process

$$r(t)=(i(t),i_1(t),...,i_n(t)),$$

defined on the space of states S given by relations (1). The Markov character of $r(t)$ is due to the fact that durations of model staying at each state has exponential distribution and independent from each other just like transition probabilities from state to state.

Let us denote by $p(i,i_1,...,i_n)$ probability of stationary states of the model $(i,i_1,...,i_n)\in S$. The values $p(i,i_1,...,i_n)$ can be interpreted as the portion of time the model stands in the state $(i,i_1,...,i_n)$. Using this interpretation, we can introduce formal definitions for main performance measures of the analyzed model.

Let us denote by M_i and M_w the mean number of occupied operators and waiting positions correspondingly. Their formal definitions look as follows:

$$M_i=\sum_{\{(i,i_1,...,i_\upsilon)\in S|i\le\upsilon\}} p(i,i_1,...,i_n)i+$$
$$+\sum_{\{(i,i_1,...,i_\upsilon)\in S|i>\upsilon\}} p(i,i_1,...,i_n)\upsilon;$$

$$M_w = \sum_{\{(i,i_1,...,i_\upsilon)\in S | i>\upsilon\}} p(i,i_1,...,i_n)(i-\upsilon).$$

Let us denote by I_t and by I_k the intensities of requests coming to be serviced by operators and k th group of consultants correspondingly, $k = 1,...,n.$ The values of defined characteristics can be written in the following way:

$$I_t = \lambda qa; \quad (2)$$

$$I_{t,k} = \lambda q a_k + \sum_{\{(i,i_1,...,i_n)\in S | i\le\upsilon\}} p(j,i,i_1,...,i_n) i\mu c c_k +$$

$$+ \sum_{\{(i,i_1,...,i_n)\in S | i>\upsilon\}} p(j,i,i_1,...,i_n)\upsilon\mu c c_k.$$

$$I_b = \sum_{\{(i,i_1,...,i_n)\in S | i=\upsilon+w\}} p(i,i_1,...,i_n)\lambda qa;$$

$$I_{b,k} = \sum_{\{(i,i_1,...,i_n)\in S | i_k=\upsilon_k+w_k\}} p(i,i_1,...,i_n)\lambda q a_k +$$

$$+ \sum_{\{(i,i_1,...,i_n)\in S | i<\upsilon, i_k=\upsilon_k+w_k\}} p(i,i_1,...,i_n) i\mu c c_k +$$

$$+ \sum_{\{(i,i_1,...,i_n)\in S | i>\upsilon, i_k=\upsilon_k+w_k\}} p(i,i_1,...,i_n) i\mu c c_k.$$

Let us denote by π_t and by $\pi_{t,k}$ the portions of time when all operators and waiting positions are occupied and when all consultants and waiting positions of k th group are occupied correspondingly, $k = 1,...,n.$ Their definitions can be written in the following way:

$$\pi_t = \sum_{\{(i,i_1,...,i_\upsilon)\in S | i=\upsilon+w\}} p(i,i_1,...,i_n); \quad (3)$$

$$\pi_{t,k} = \sum_{\{(i,i_1,...,i_\upsilon)\in S | i_k=\upsilon_k+w_k\}} p(i,i_1,...,i_n).$$

Let us denote by π_c and by $\pi_{c,t}$ the ratios of lost requests coming to get service from operators and from k th group of consultants correspondingly, $k = 1,...,n.$. Their formal definitions looks as follows:

$$\pi_c = \frac{I_b + M_w\sigma}{I_t}; \quad \pi_{c,k} = \frac{I_{b,k} + M_{w,k}\sigma_k}{I_{t,k}}. \quad (4)$$

Let us denote by t_w and by $t_{w,k}$ the mean times of waiting or servicing of requests coming to get service from operators and from k th group of consultants correspondingly, $k = 1,...,n.$ The formulas defining the introduced characteristics can be written in the following way:

$$t_{w,k} = \frac{M_i + M_w}{I_t - I_b}; \quad t_w = \frac{M_{i,k} + M_{w,k}}{I_{t,k} - I_{b,k}}. \quad (5)$$

V. THE SYSTEM OF STATE EQUATION

The model performance measures are expressed through values of $p(i,i_1,...,i_n)$ that can be found from the solution of the system of state equations. Let us denote by $P(i,i_1,...,i_n)$ the unnormalized values of $p(i,i_1,...,i_n)$. After equating the intensity of leaving arbitrary model state $(i,i_1,...,i_n)\in S$ to the intensity of entering the state $(i,i_1,...,i_n)$ we obtain the following system of linear equations:

$$P(i,i_1,...,i_n)\times \quad (6)$$

$$\times\left\{\lambda q\left(aI(i<\upsilon+w) + \sum_{k=1}^{n} a_k I\left(i_k<\upsilon_k+w_k\right)\right) +\right.$$

$$+i\mu I(i\le\upsilon) + \upsilon\mu I(i>\upsilon) + \sum_{k=1}^{n}\left(i_k\mu_k I(i_k\le\upsilon_k) + \upsilon_k\mu_k I(i_k>\upsilon_k)\right) +$$

$$\left.+(i-\upsilon)\sigma I(i>\upsilon) + \sum_{k=1}^{n}(i_k-\upsilon_k)\sigma_k I(i_k\le\upsilon_k)\right\} =$$

$$= P(i-1,i_1,...,i_n)\lambda qaI(i>0) +$$

$$+\sum_{k=1}^{n} P(i,...,i_k-1,...,i_n)\lambda q a_k I(i_k>0) +$$

$$+P(i+1,i_1,...,i_n)\mu(1-c)\times$$

$$\times\left((i+1)I(i+1\le\upsilon) + \upsilon I(\upsilon<i+1\le\upsilon+w)\right) +$$

$$+\sum_{k=1}^{n} P(i+1,i_1,...,i_k-1,...,i_n)\mu c c_k I(i_k>0)\times$$

$$\times\left((i+1)I(i+1\le\upsilon) + \upsilon I(\upsilon<i+1\le\upsilon+w)\right) +$$

$$+\sum_{k=1}^{n} P(i+1,i_1,...,i_n)\mu c c_k I(i_k=\upsilon_k+w_k)\times$$

$$\times\left((i+1)I(i+1\le\upsilon) + \upsilon I(\upsilon<i+1\le\upsilon+w)\right) +$$

$$+\sum_{k=1}^{n} P(i,i_1,...,i_k+1,...,i_n)\times\left((i_k+1)\mu_k I(i_k+1\le\upsilon_k) +\right.$$

$$\left.+(\upsilon_k\mu_k + (i_k+1-\upsilon_k)\sigma_k I(\upsilon_k<i_k+1\le\upsilon_k+w_k)\right) +$$

$$+P(j,i+1,i_1,...,i_n)(i+1-\upsilon)\sigma I(\upsilon<i+1\le\upsilon+w).$$

By $I(\cdot)$ in (6) the indicator function is defined

$$I(\cdot) = \begin{cases} 1, & \text{if conclusion formulated in brackets is fulfilled.} \\ 0, & \text{if this condition isn't fulfiled} \end{cases}$$

The values of $P(i,i_1,...,i_n)$ should be normalized. Almost all elements of the matrix of the system of state equations are zeros. In this case the optimal approach to solve this system consists in using Gauss-Seidel iterative algorithm. Equations can be easily rewritten into the Gauss-Seidel recursions for calculation of the unknown probabilities $P(i,i_1,...,i_n)$.

VI. The usage of the model for practical purposes

The process of normal functioning of the contact center with the Internet of Things implementation may be disturbed by overload caused by increasing of the intensity of coming requests from “smart” devices. This raise is random and caused by happening of some reasons, for example, emergencies. Because of this it’s very important to find the optimal balance between the number of operators and waiting positions to process these requests with given values of service quality indicators.

By increasing the number of waiting positions contact center administration reduces the ratio of lost requests. Thus, the quality of service is improving without adding extra operators to the shifts. However, this way leads to service time growth. That’s the reason why the quality of service should be estimated with taking into account values of these two characteristics. On the first stage we find the minimal number of operators υ at which the ratio of lost requests does not exceed the value of π_{norm}. For this step we supposed that w=0. In the analyzed conditions the value of υ can be calculated with Erlang formula. On the first step of the second stage the value of υ decreases by one and, at the same time, the number of waiting positions is increasing by one. If π_c stays less than norm then υ decreases by one again and the number of waiting positions is increasing by one. Otherwise, the waiting positions are added by one at time. As result, π_c is decreasing and mean time of waiting for servicing by operator M_w is increasing. The increasing of waiting positions happens till π_c value becomes less than π_{norm} while fulfilling the condition $M_w < M_{w,norm}$, where $M_{w,norm}$ - normative value of delay of the servicing. Then these steps are repeated. For the contact center with parameters λ=1/3 requests per second, $1/\mu$=45 seconds the process of estimation of operators and waiting positions is shown on Fig.3 and Fig.4 correspondingly. The normative values of quality of service indicators are π_{norm}=0,03; $M_{w,norm}$=45 seconds. The result of the first stage is υ=22. The solution is υ=15 and w=28, thus, the norms are met. The subsequent increase leads to the M_w growth. The results show that the number of waiting positions is growing strongly with increase of number of estimations of number of the operators. The delay of servicing also increases. It’s clear that in such conditions we have to stop the process of υ estimation using limitations of delay time and number of waiting positions. These limitations are chosen individually for every project and they are not considered in this paper.

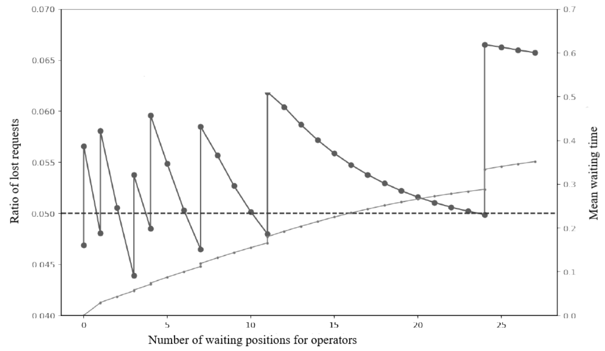

Fig. 3. The process of estimation of the number of operators

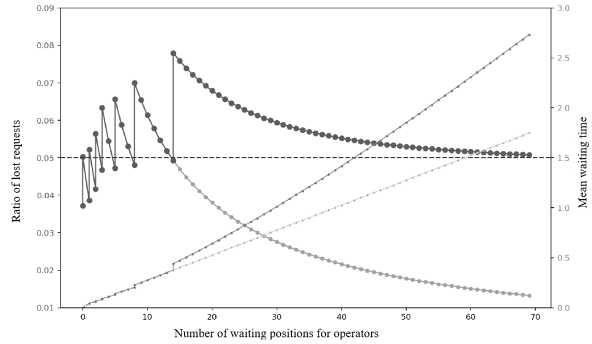

Fig. 4. The process of estimation of waiting position

VII. Conclusion

At the present time the excellent customer service is one of the best ways for the company to keep its positions in the industry. The Internet of Things implementation into business processes, especially into contact centers, can help to provide great variety services, increase loyalty and get new customers.

In this paper the mathematical model of contact center with the Internet of Things implementation is constructed and analyzed. In the model multi-skilled routing based on usage of one group of operators capable of serving simple requests from smart devices and several groups of experts (consultants) handling more advanced topics is taken into account. Markov process that describes model functioning is constructed. Main performance measures of interest are defined through the values of stationary probabilities of model's states. The algorithm of characteristics estimation is suggested based on solving the system of state equations. It is shown how to use found relations for qualitative analysis of the model functioning. The usage of the model for estimation of required number of waiting positions and operators is considered.

Further work could be devoted to more detailed analysis of contact center dealing with Internet of Things smart devices. In particular, it can be taken into account the possibility of repeating requests by the smart objects and different cases of overload.

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