Modeling and Simulation of Technical Support Services Using ARENA®

Andrey Yonchev, Lyubomir Mirchev

***Abstract* — The publication investigates modeling of queuing processes simulated with the software Arena. In the beginning we consider Poisson queues and their performance characteristics. An application of the considered package Arena in representing the work of a real technical-economical queuing system will be investigated. The paper aims at creation a simulation model for simulation of entities coming into a technical organization and their optimal distribution to a proper team, which has to serve them. We will apply Arena software to build a model of tasks spreading to various working equips attepting to increase the service performance. First we will formulate the problem set up and then we will proceed with the solution approach. Finally we will present experiments and the obtained results.**

***Index Terms* — Queues, modeling, simulation**

I. Introduction

The queuing models depict a wide class of queues and everyday life cases. Queuing models have a great applications in manufacturing, service, transport systems and involve random demand. Queuing theory is said to be a very important methodology in production and operations management. The importance of queuing theory can be found in the possibility of considering arrival/departure processes and its randomness.

Queuing theory investigates waiting lines and queues and applies mathematical theory for its description. In [1], [2] and [3] not deterministic origin of the entrance and departures is considered using the queuing models. Many examples can be given to illustrate the queuing systems: patients waiting in a clinic, truck waiting to be uploaded or downloaded, cars waiting at a stop light, different jobs waiting to be assigned to a specific machine, planes circling in the sky waiting for a permission to land and etc. All these situations have something in common – "waiting". The queuing systems depict the nondeterministic origin of taking place of events entering a service system.

Quality investigations of the systems with queues can be performed applying performance measures – expected average waiting time of input elements in system and in queue, expected average number of input elements in the system and in the queue. The quantification of the performance specifications allows us in conducting a conclusion on altering the basis of the queuing system in sense of diminishing the waiting time in the system. To asses analytically the quality probability characteristics of the queuing systems, which exists only in steady-state mode, different kinds of Poisson flows have to be investigated.

The rest of the manuscript is organized in the following way. In Section 2 we in a brief way give the important aspects of software package *Arena*. Section 3 presents some theory of the models with queues. In Section 4 we model and simulate a specific real time queuing system and then end up in Section 5 with some finishing conclusions.

II. Important features of the software package ARENA

The software package *Arena* is used to model and simulate of discrete event systems in the production and operation management science – organizational, servicing, production plants and etc. The animation piece of *Arena* allows the created models to be graphically presented. The Rockwell system *Arena* is a package for simulations, based on the flow oriented simulation. It comprises of description of an existing situation as a series of processes and delays, through which the input flows goes [7]. Often the working process is represented using a diagram where using blocks and arrows the ongoing actions are presented (fig.1). The incoming objects to be processed are created from input flow resource, that has limited or unlimited storage. The input analyzer is an important part of the software package, which offers the possibility to investigate data obtained from experiments and to calculate elements of the considered probability spreading [4], [5].

The software product *Arena* exists under system *Windows*. The important structural libraries of *Arena* are: *Basic Process*; *Advanced Process* и *Advanced Transfer*. Interested readers can find more information about the considered package in [4].

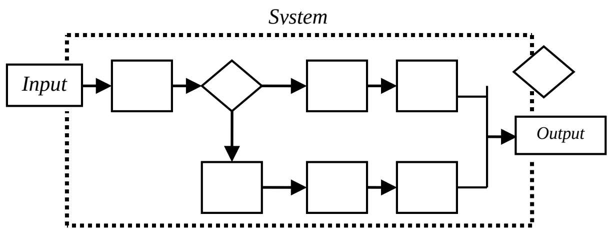

Fig. 1. Basic of flow-direction block structure of a queuing system

III. Queuing models

In queues representations of the input flow of elements and the time span of elements' service notions from probability theory are used. In the queuing theory such facts are *distribution of time between successive entities* and *entity service time distribution.* The behavior of the input and the output flow of entities is the most important element in the queuing systems functional description. There are some important performance elements that also exist in the analysis – service discipline, queue length, calling source. The arbitrary processes describing the input and the out flow in queuing models are denoted as pure birth and pure death

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processes, respectively. Usually it is assumed that the input and the output flow can be described using the Poisson spread [1]

$$p_n(t) = \frac{(\lambda t)^n e^{-\lambda t}}{n!}, \; q_n(t) = \frac{(\mu t)^n e^{-\mu t}}{n!} \quad (1)$$

here $p_n(t)$ is the probability that there are n entities in the system (in queue and in the service facility) for time period t, $q_n(t)$ is the probability n entities to leave the system for time period t, λ and μ are the rates of the input and the output flows. In the analysis of the time-invariant processes of the queuing systems some measures of performance. In the queuing models these steady-state probability characteristics in having c parallel servers can be calculated as follows [1]

- Average number of entities in the system

$$L_s = \sum_{n=0}^{\infty} n p_n \,, \quad (2)$$

- Average number of entities in the queue

$$L_q = \sum_{n=c}^{\infty} (n-c) p_n \,, \quad (3)$$

- Average waiting time of the entity in the system

$$W_s = W_q + \frac{1}{\mu} \,, \quad (4)$$

where $1/\mu$ is the average service time, and W_q - average waiting time of the entity in the queue. The following expressions are also valid

$$L_s = \lambda W_s \,, \; L_q = \lambda W_q \quad (5)$$

$$L_s = L_q + \frac{\lambda}{\mu} \,. \quad (6)$$

The steps of computation of the performance measures is presented below

$$p_n \to L_s = \sum_{n=0}^{\infty} n p_n \to W_s = \frac{1}{\lambda} L_s \to W_q = W_s - \frac{1}{\mu} \to L_q = \lambda W_q \,. \quad (7)$$

There are cases when the input rate is λ, but not all entities can enter the system – due to the limited places in the queue. Aiming to obtain the operational characteristics the effective average arrival rate has to be calculated. It shows the total number of allowed entities in the system for unit time:

$$\lambda_{eff} = \mu (L_s - L_q) \,. \quad (8)$$

3.1. Model (M/M/1):(GD/∞/∞).

This model means the following Poisson input and departure flow, one server, general discipline and unlimited entities can join the system [1]. A steady-state of this queuing system can be found if $\rho < 1$, where $\rho = \lambda / \mu$. The operational characteristics of the investigated system can be calculated as shown below

$$L_s = \frac{\rho}{1-\rho}, \quad L_q = \frac{\rho^2}{1-\rho} \quad (9)$$

$$W_s = \frac{1}{\mu(1-\rho)} \,, W_q = \frac{\rho}{\mu(1-\rho)} \quad (10)$$

IV. Simulation investigations

Example.. In the example below we will investigate modeling and simulation of entity services in a department of a technical company using the software package Arena. The simulation model which is going to be created is inspired by real service situation in a real existing IT company. The processes taking place here have not been modeled and simulated before. The model which is presented in this paper is based on the actual behavior of the service processes that take part in the considered company and is completely unique.

In the company that is investigated the technical support department contains some independent tiers each of them responsible for the excellent work flow with the others as it follows: Dispatch, Level 1 (L1), Level 2 (L2), Level 3 (L3) and Level 4 (L4). Dispatches are a global source responsible for logging in cases and managing delivering services. They are mostly needed in the beginning and end of case handling. Therefore as main levels come L1, L2, L3 and L4. Each one of them deals with different problems. L1 receives and first troubleshoot the case. They provide action plan, asking for Onsite details, assist remotely if able to and elevate if not. L2 handles the issue further and if not able to provide solution seeks one from L3. L2 are the main communication between L3 and customer/ L1. If even L3 can't find resolution, he is then obligated to involve L4. This Team works in labs and provides support by simulating and evaluating issue in real time and finds high end resolution, usually ending with bug fixes in the new updates.

The created model describing the real service processes in the technical support department is big that is why it will be presented in parts.

When a problem arises and a case must be logged there are 2 main branches how to generate it: automatic (IRS) and manual. Cases must be logged in under one of the 7 ways: Manager-Task, Amazon-manifest, Amazon-Invoice, Supervisor-Task, OSFS-Invoice, Picture-BOL and Customer-Invoice. The Create module models the process of arrivals. It is used to specify how many entities arrive at the process that is being modelled and the intervals of time at which arrivals occur. One Create module will be used setting an arrival rate for cases in the system.

There are 7 different emails that enter the system. As every other facility there are issues with high priority and low priority. A simulation is performed with the help of the software package Arena that shows every email that enters the system with given its unique priority.

Seven different create modules for each of the following ways are arranged by priority levels.

- Manager-Task.;
- Amazon-manifest.;
- Amazon-Invoice.;
- Supervisor-Task.;
- OSFS-Invoice.;
- Picture-BOL.
- Customer-Invoice.

The part-blocks regarding the email login is presented in figure 2.

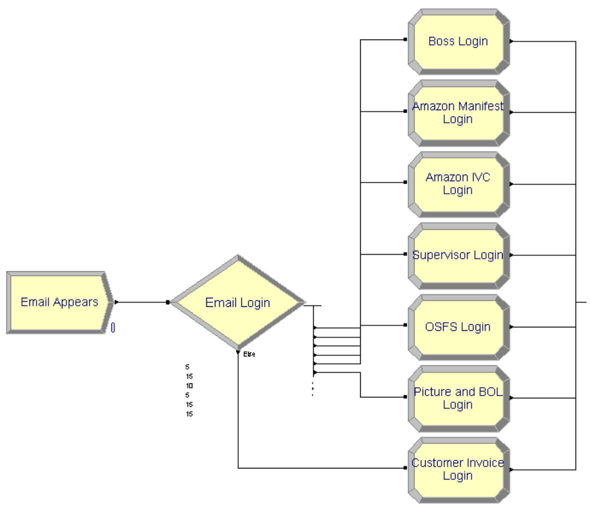

Fig. 2. Email login blocks

We know that an entity comes around every 20 minutes. Thus the arrival rate is described using a random distribution with mean value 20 minutes. One arrival per time and the maximum number of arrivals is equal to 3600.

Once the arrival rate is defined, then the email logs in the in the system as a ‘‘Email’’. We consider 7 kinds of login are applied by the means of structure block for making decisions set by given percentages of the whole case login volume.

When a problem is received a special prioritization takes place. There exist 7 types of priority – Priority 1 (Manager-Task), Priority 2 (Amazon-Manifest), Priority 3 (Amazon-Invoice), Priority 4 (Supervisor-Task), Priority 5 (OSFS-Invoice), Priority 6 (Picture and BOL), Priority 7 (Customer-Invoice). Priorities are attached to the case based on the significance of the issue.

Percentages of the provided data is shown below.

P1: 15, P2: 330, P3: 510, P4: 9, P5: 900, P6: 720, P7: 1116

where:
P1+P2+P3+P4+P5+P6+P7=3600/100=36

P1= 15/36 = 0.4%; P2= 330/36 = 9.2%; P3= 510/36 = 14.2;

P4= 9/36 = 0.2%

P5= 900/36 = 25%; P6= 720/36 = 20%; P7= 1116/36 = 31%.

Below the priority assignment block are presented in fig. 3.

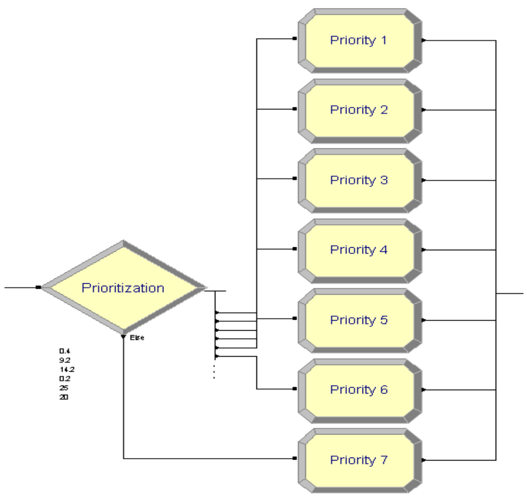

Fig. 3. Priority assignment blocks

Then each of the cases is entering into L1 Engineer Process to be processed:

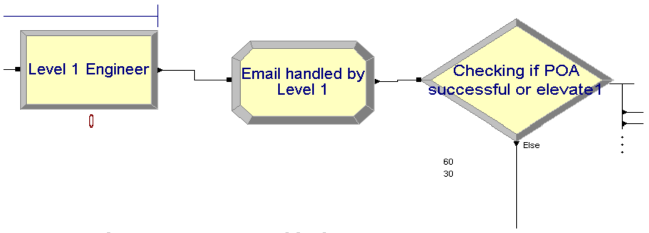

Fig. 4. Level 1 Engineer process blocks.

At this stage cases are in L1 queue waiting to be processed. If provided Plan of Action is successful and executed by Dispatch following scenario is met:

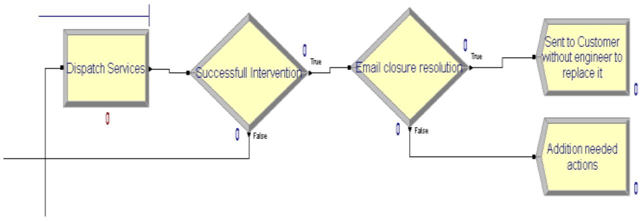

Fig. 5. Dispatch Disposal Services blocks.

Case enters Dispatch Services Process and a decide module is set to check if intervention is successful or no. If not case is brought back to L1 Engineer for further support. If intervention is successful case is transferred to case closure resolution which can be either sent to Customer without engineer to help or Addition needed actions.

If provided Plan of Action (POA) is successful and executed by L1 Engineer situation is the following:

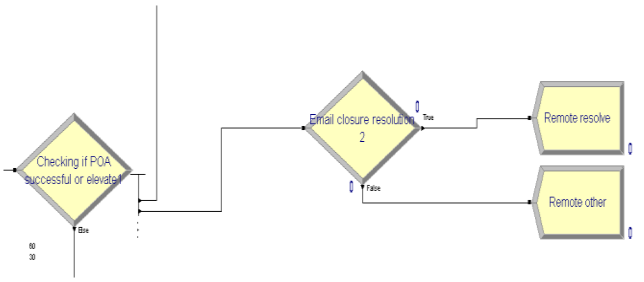

Fig. 6. Level 1 Disposal Services blocks.

In this path of the model case is being closed by the L1 Engineer. Process is straightforward – if POA is successful case to be closed. These are the two possible ways to dispose cases. But what if issue is not resolved by L1, nor Dispatch? In this case L1 is seeking for assistance from L2 - specialist whose knowledge on the supported product is deeper and they are able to provide dedicated analysis and resolution to customer in real time environment.

If provided Plan of Action (POA) is not successful case is to be elevated to L2:

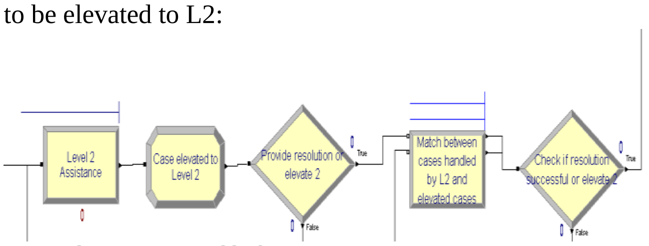

Fig. 7. Elevation Process blocks.

In this situation cases are coming from L1 Decide Module (fig. 1), processed by L2 and then he provides resolution or elevate to L3 assistance. If case is elevated to L3 he provides POA and then case is going back to L2.

Consequently same logic is applied when L2 cannot provide resolution – cases is elevated to Level 3 Engineer. If he is unable to provide solution as well then the case is proceed to the highest management level – Level 4 Engineers.

The simulation results are presented in the table below:

Simulation time		W_q	W_s
	Dispatch	0.0342	0.0002
80	Level 1 service	0.0539	0.0041
	Level 2 service	0.0066	0.0006
	Dispatch	0.0347	0.0092
120	Level 1 service	0.0553	0.0700
	Level 2 service	0.0070	0.1339

From the obtained simulation results i.e. expected waiting time in the system and in the queue have low values so the Technical Service system works with an acceptable performance. Further investigation on this matter will be related to reduction of the corresponding waiting time thus increasing the performance of the considered service system so that the clients are more satisfied.

The whole simulation model is presented on the figure below:

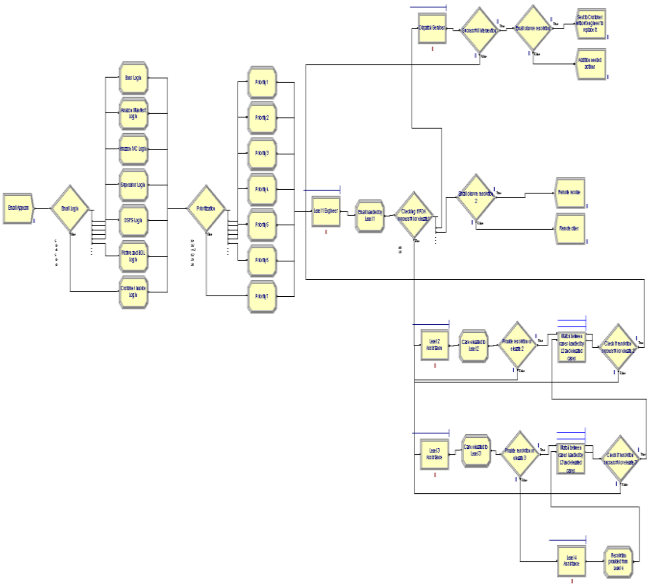

Fig. 8. Simulation model of the Technical Service Department in an IT Company

V. Conclusion

In the paper we considered the usage of the software package *Arena* in modeling and simulating a real technical-economical system. The model which was presented in this paper is based on the actual behavior of the service processes that take part in the considered company and is completely unique. The mentioned system is modeled and simulated with *Arena*. The obtained results are acceptable and can inspire our future investigations.

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