TRANSPORT AND
TELECOMMUNICATION
INSTITUTE

System Analysis and Modelling

Practical Assignment 2

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INTRODUCTION

This project implements simulation of client service office of internet shop using AnyLogic software and Agent's technique. That office includes 3 types of services that are provided by the office that can be manually selected by the customer by the e-queue registration device. Every service has different queues for different services that are linked to the specific service points with some additional logic of customers priority. More detailed information about linking between queues, service points and registration device will be described in the specific section of the current report.

It's required to analyze the activity of the office and understand if there are enough points of different services of the client service office and it's not generated big queues, or it may be too much for the current office with their number of clients and the number of points can be decreased.

More details about simulation model development are provided in the next section of the current report.

DESCRIPTION OF THE SYSTEM

Model goal
The goal of the simulation is to analyse loading of the client service office per day and decide is it required to increase resources to provide better service for customers or the amount resources spend on that office is too much and the costs of that office can be decreased by decreasing amount employees and service points.

Objective related to the main goal
To investigate the loading of the services points and decide is it required to change amount of service points to decrease cost of customer service office and save the acceptable loading level.

Components of the system
That model includes different logical blocks. Here is 1 agent-based component, 4 queue-based components 8 delay-based components.

1. Customer (Agent-based) – different customers of e-shop. A prototype of persons that enters the customer service office by different reasons to receive something from e-shop accessible services in current customer service office. Different customers have different time that they spend for selecting a service type by service selector device and different time for communication with employee on the service point
2. Queue selector device (Delay-based) – the terminal with 3 buttons with provided variant of the service type that can be operated by the current client service office. That device registrate customer in the specific queue linked to the selected service type. That device

gives a ticket to customers with their number that will be show on the tablet in front of the service point then it will be his turn

3. Services queues (Queue-based) – these components simulate the e-queue that is linked to the specific service of current customer service office. Registration in the queue happens by selecting the variant of the service by the customer. Each queue is linked to some specific service points. In some cases, one queue has priority then another queue.
4. Queue for registration device (Queue-based) – prototype of the queue for registration that can appears. In most cases that queue is empty but is required element for simulation.
5. Issuing orders points (Delay-based) – these components is a prototype of the service point that issuing the orders of the customers.
6. Issuing/returning orders point (Delay-based) – that component has the same functionality as "Issuing orders points" prototypes but that prototype have additional linked service. The second connected queue has a priority of tasks solving.
7. Support points (Delay-based) – that component is a prototype of service point that operates with customers guarantee cases. These points are linked to the one queue and operate with "guarantee" service only.

Main processes

1. **Customer appears:**

The moment then the new agent appears. They appear with different time periods and the time required for registration and service execution time generates and contains to the attribute of current agents. That agent is used throw all simulation tasks.

2. **Join queue to the registration device:**

The agent of type "Customer" joins to the queue to the registration if it exists and waiting for its turn for registration operation.

3. **Registration:**

The agent interacts with registration device and spends time to understand which service is required. The interaction time is previously generated and contains in the attribute of the agent.

4. **Service selection:**

The agent selects the type of service that is required and automatically joins e-queue of current service and receives a ticket with a specific number that will be shown on the service point on its step. The service selects by randomness 0.65|0.3|0.05 (Get order | Return order | Guarantee)

5. **Waiting for turn:**

The agent waiting for his turn in the waiting room and check the numbers shown on service points.

6. **Selection of the next customer:**

The system selects the next customer depends to the priority. That process happens in the Get/Return service point case only.

7. **Service point selection:**

The one of the service points call the number from one of the queries. In the current simulation model, the agent goes to the first not busy point (if empty points amount bigger than 1 then selects point smaller number of point) that operates with service that is previously selected.

8. **Service execution:**

The employee operates with agent to execute the selected service. The time with different agents gets from the agent parameter that is defined previously.

9. **Customer disappears:**

Customer leaves the office and with this operation leaves the system.

CONCEPTUAL MODEL

Figure
The figure with conceptual model contains the logic of the path selecting by the agents. The values calculation will be skipped on this moment and will be described in the next part of "Conceptual Model" segment. The figure is provided below.

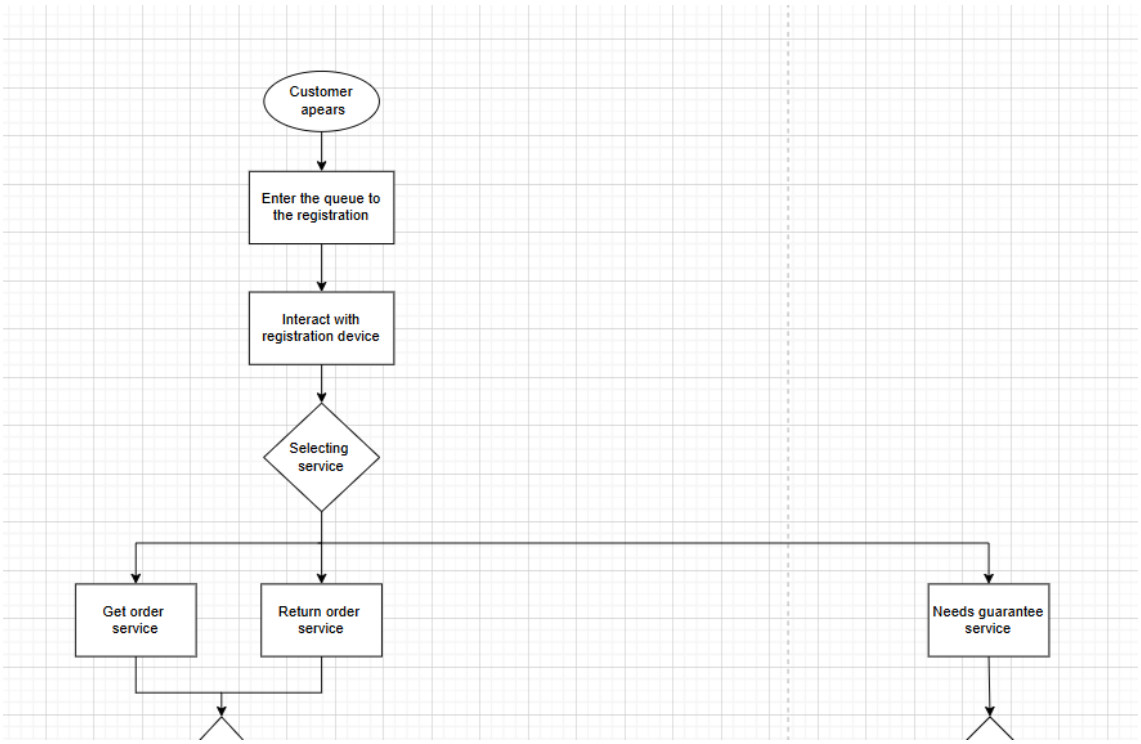

Fig. 1 – Conceptual diagram of the system (part 1)

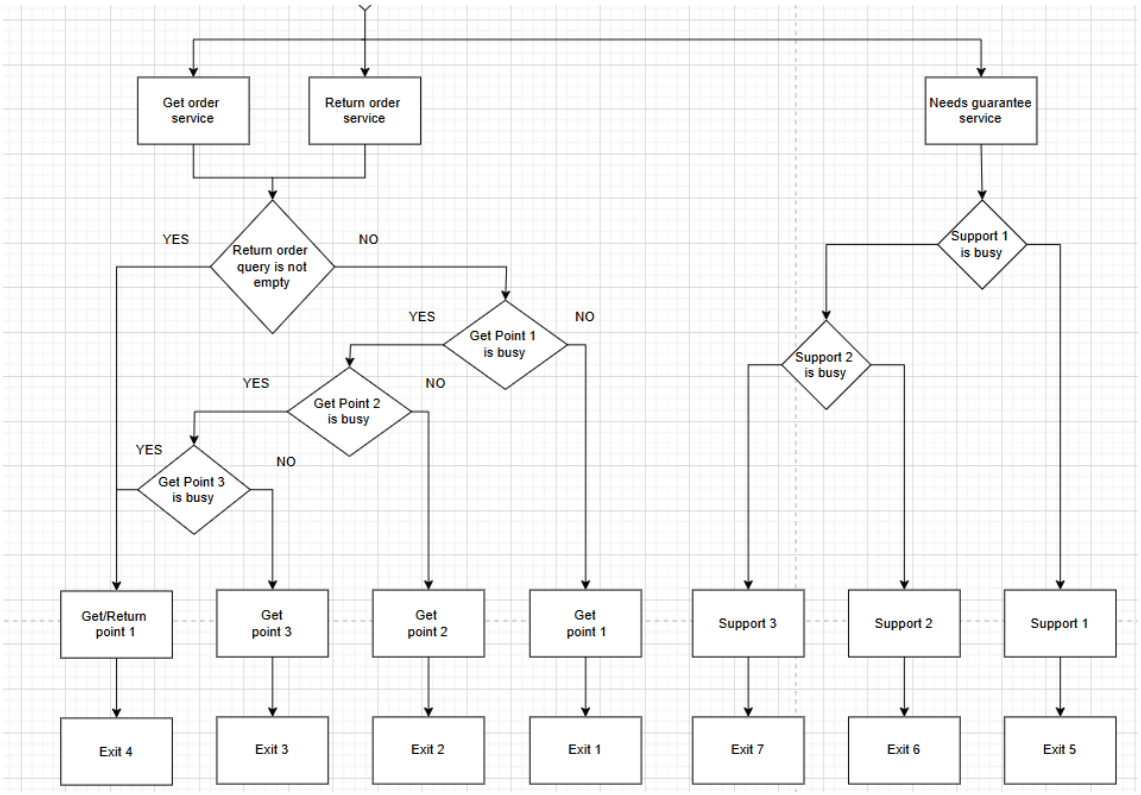

Fig. 2 – Conceptual diagram of the system (part 2)

Agent characteristics

- **Agent type: Customer**

Attributes:

- ticketSelectTime: time that is required to select a ticket by current agent. The triangular distribution is used. (min: 0.5; peak: 1.5; max: 2)
- operationSolvingTime: time that is required for solving the selected service. The normal distribution is used by replacing all values smaller than 0 to 0. (mean: 8; variance: 1)

States:

- Waiting: placed in the queue and waiting for his turn.
- Service usage: Communication with employee and trying to receive result from selected service.
- Ticket chooses: Agent choosing the variant of the service that is required.

In-dependent variables:

- Arrival time: the time of agent arriving periods difference. That time calculates by exponential distribution. (rate: 0.5)

SIMULATION MODEL DEVELOPMENT

The simulation developed by AnyLogic software, which provides good set of tools that can be used for simulation model development.

Additionally, it provides pre-defined blocks with user friendly UI that makes simple the simulation model development.

Simulation model and environment configuration

AnyLogic provides opportunities for full configuration of the environment and model visualization by that reason it requires to be configured.

- Time units: minutes - All random values generate as minutes in the model by that reason the time units are configured as a minute.
- Start time: default date (date of initialization of the project) and default time (00:00:00) – here is no reasons specifically configure the start time because the model sim ulates the activity per one weekday.
- Stop time: 480 minutes = 8 hours – that model simulates day activity in the office, by that reason time is limited by default workday time.

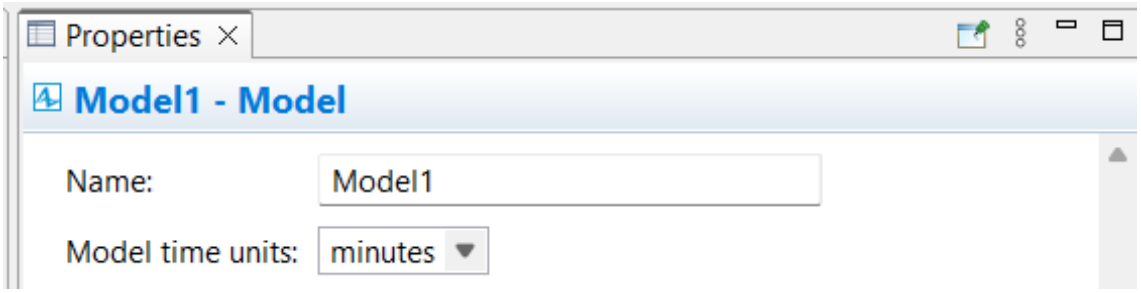

Fig. 3 – Simulation model configuration

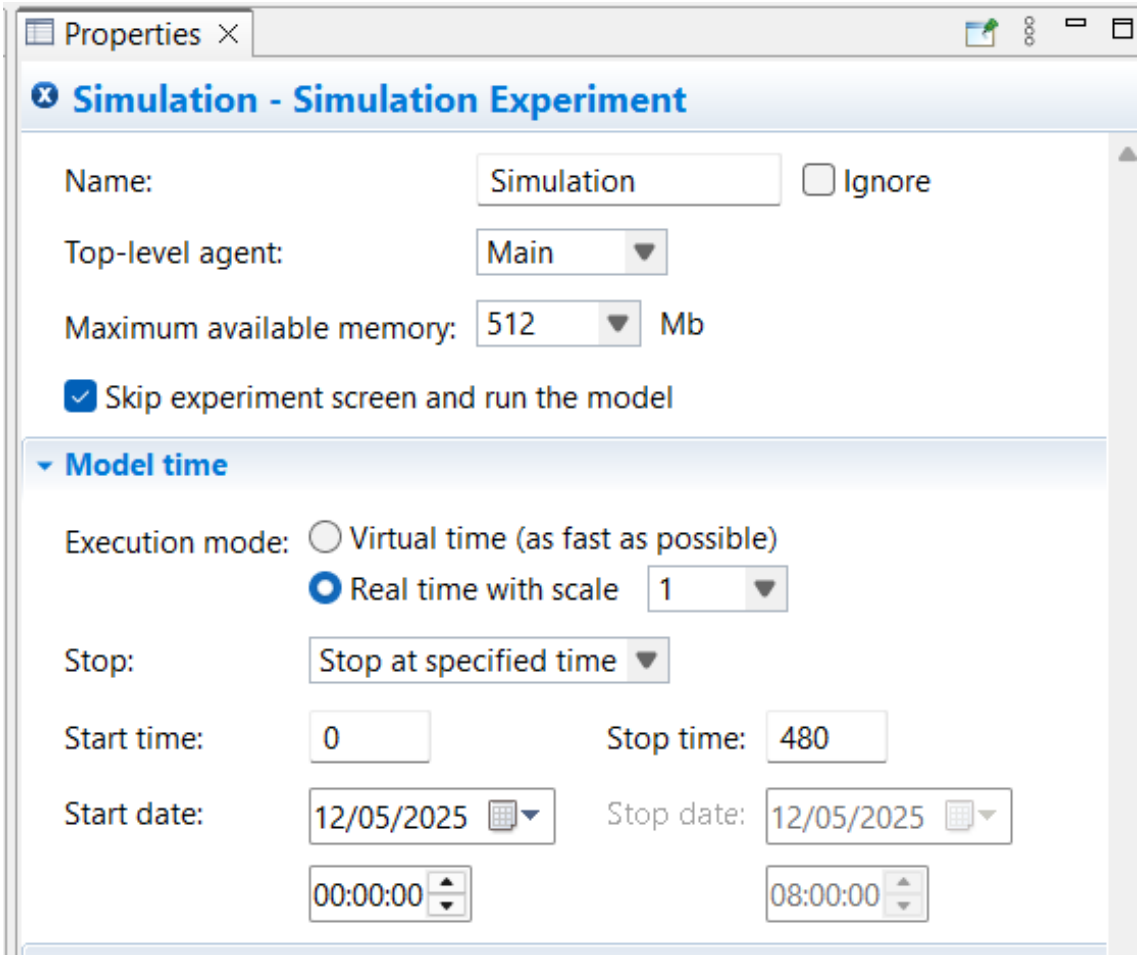

Fig. 4 – Simulation environment configuration

Agent appearance step

Agent appearances controls by specific time duration random generator that use exponential distribution. In that step agent receive values to the it's attributes. The attributes use in other steps of the simulation.

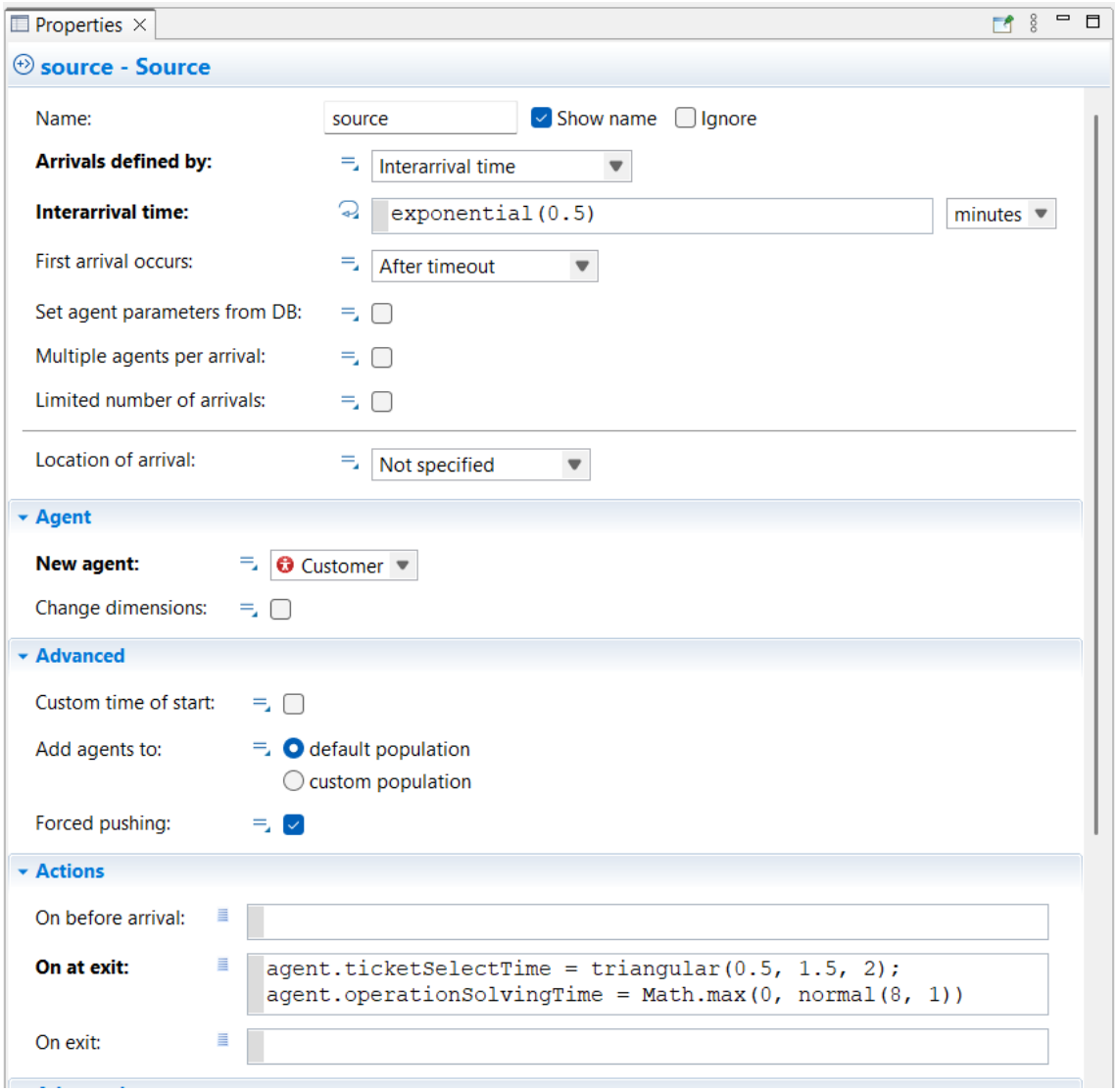

Fig. 5 – Simulation environment configuration

Agent structure

"Customer" type of agents is very simple. It has 2 attributes only.

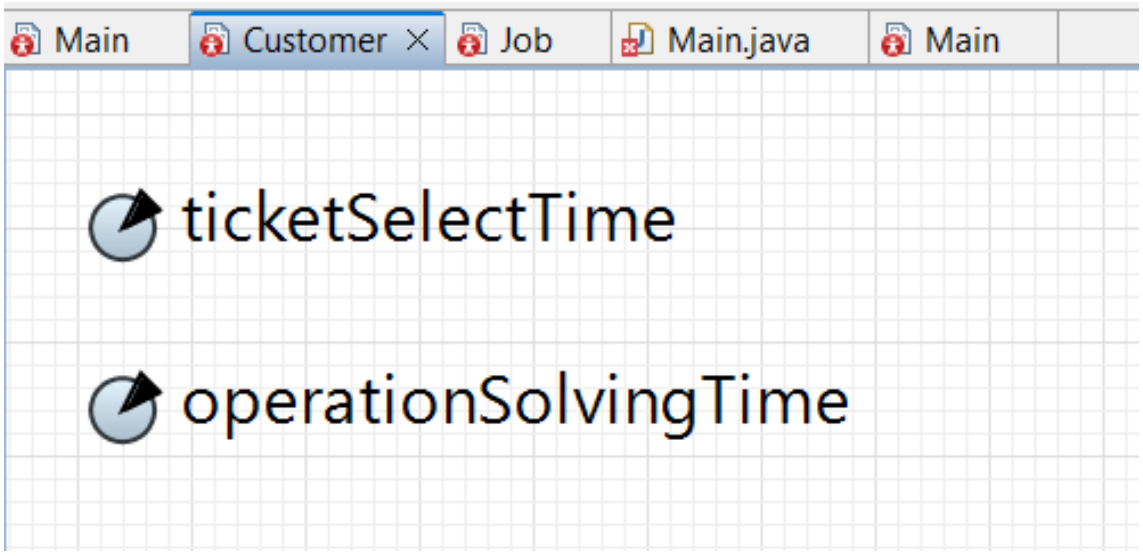

Fig. 6 – Structure of "Customer" type of agents

Query selector

The query selector has specified logic of selectin the queue. The query selects randomly depends to probability of every query selection configured in the select output module.

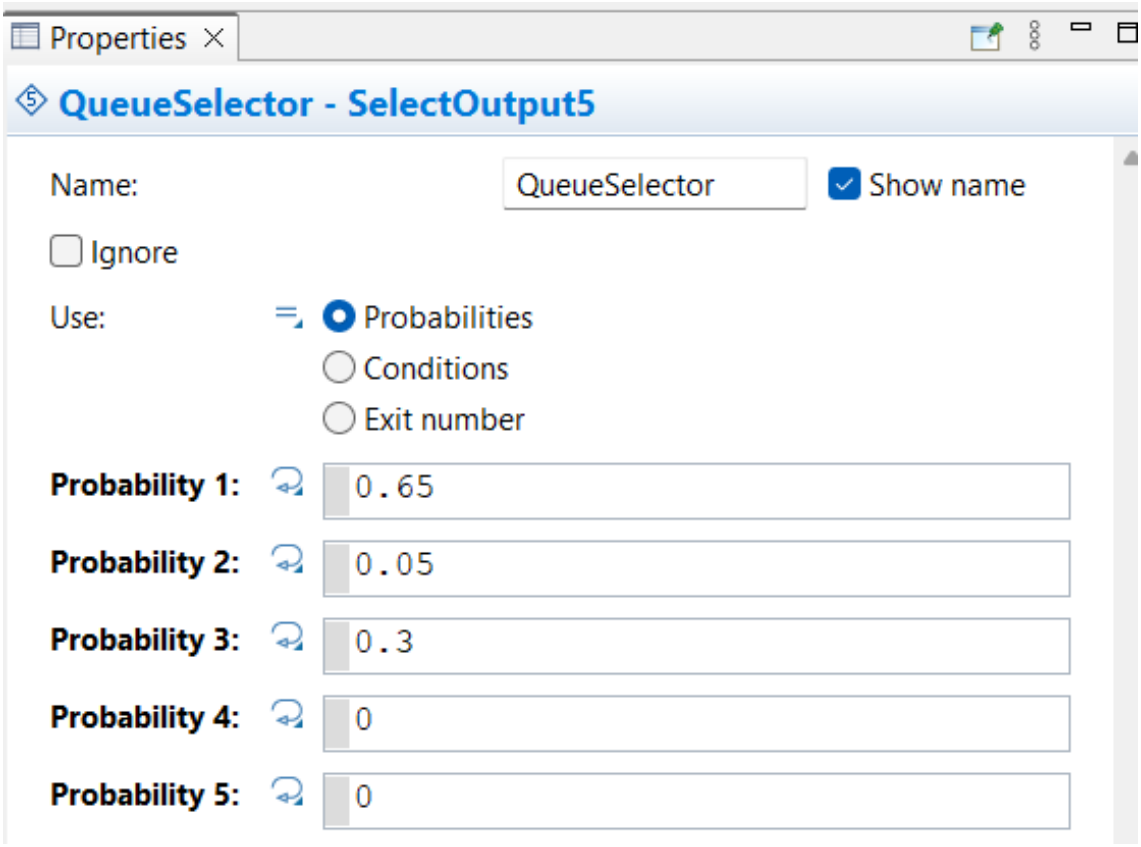

Fig. 7 – configuration of queue selector

Service point selectors

The selectors of service points have specific logic. The first service point select operates with 2 queues by that reason it has specific logic that includes custom checks. That selector should select first not busy service point, or if the queue with priority is not empty then it should send agent from that queue to the last service point

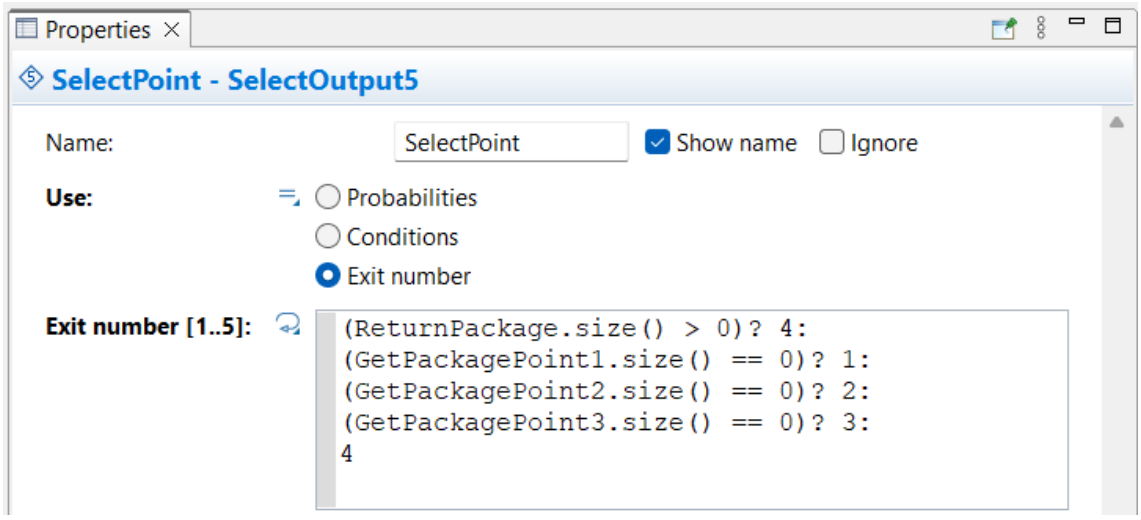

Fig. 8 – configuration of first service point selector (works with Get/Return order)

Second service selector operate with one queue, but it also has a specific logic for correct selection of the service point. It should select first not busy service point connected to current selector.

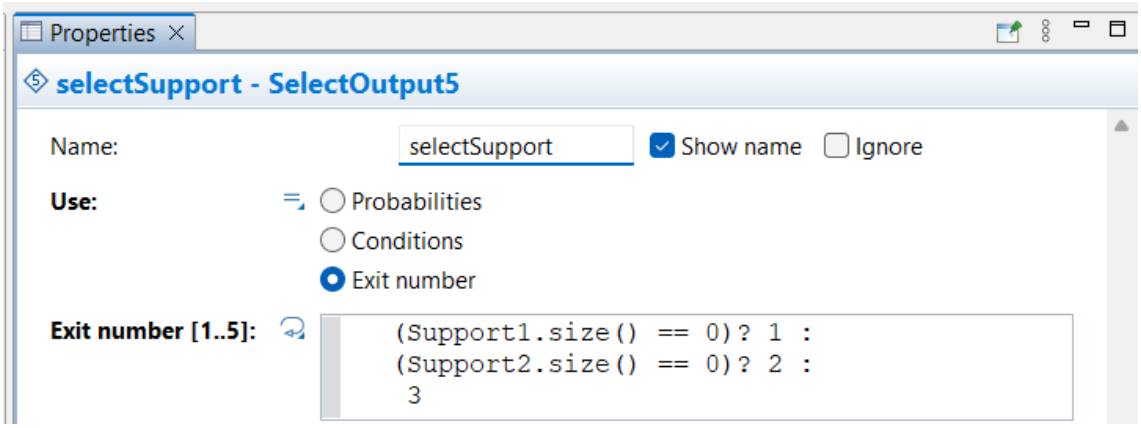

Fig. 9 – configuration of second service point selector (works with guaranteed cases)

Queues

AnyLogic limitation set a requirement to set maximum count of agents in the queue. By that reason every queue receives the maximum count of agents in the queue equals to 100. By default, rule of any queue with people it's rule queuing is FIFO.

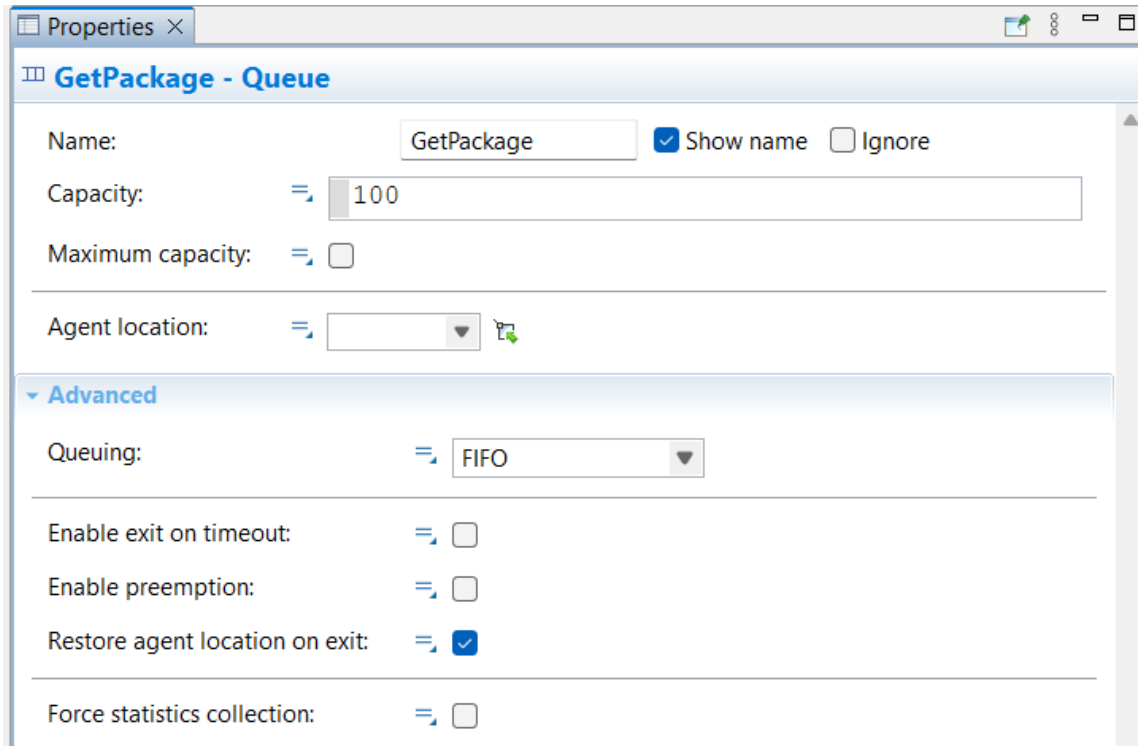

Fig. 10 – configuration of get order service queue (all queues have same configuration)

Service decision making

The process of selecting service is divided to 2 parts. Selection of the service happens in the next block of the simulation model, but that block simulates the time that is required by agent to decide of the service.

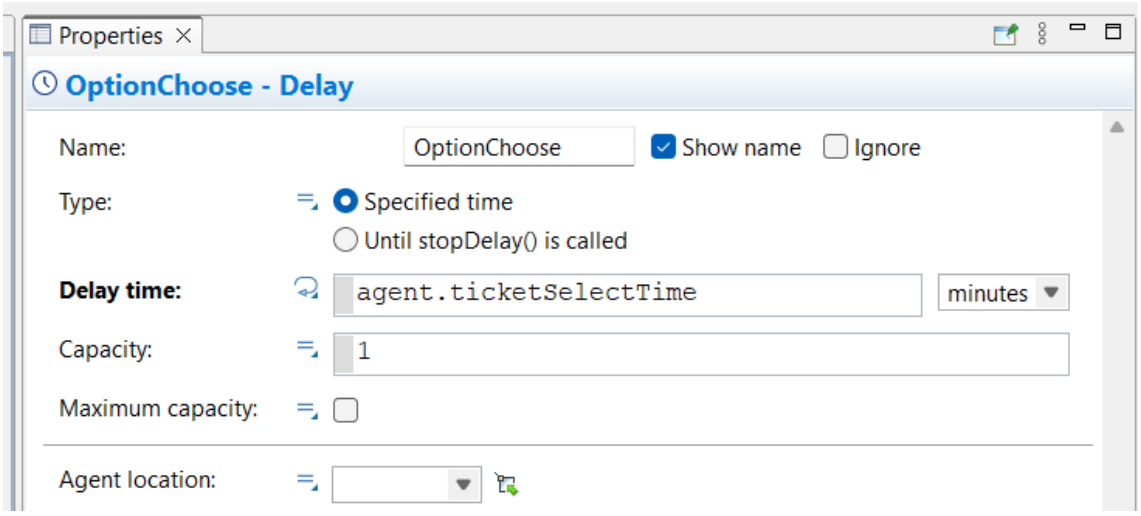

Fig. 11 – configuration of get order service queue (all queues have same configuration)

Service points operating time

The process of operating and solving the customer problem. These blocks simulate problem solving by simple delay block that use values from attributes of agents. And that time represent like communication with service point time.

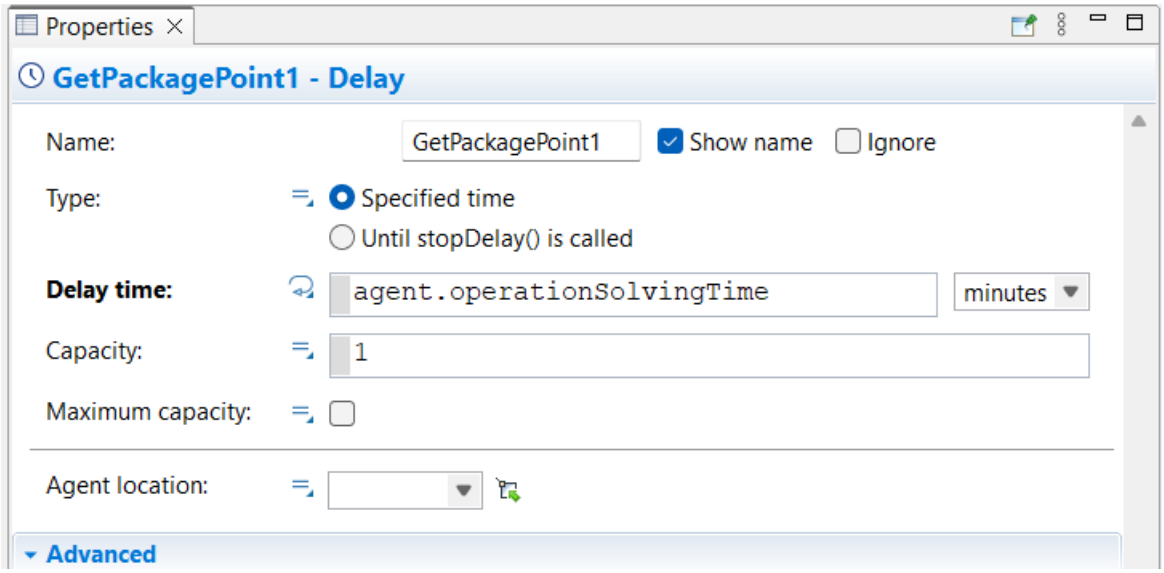

Fig. 12 – configuration of service point operating (all points have same configuration)

Full view of the model

The developed model hasn't the detailed visualization. The logical model has the simple visual effects in the simulation process. Some statistical graphs are created for results of simulation analysis additionally to the main simulation model.

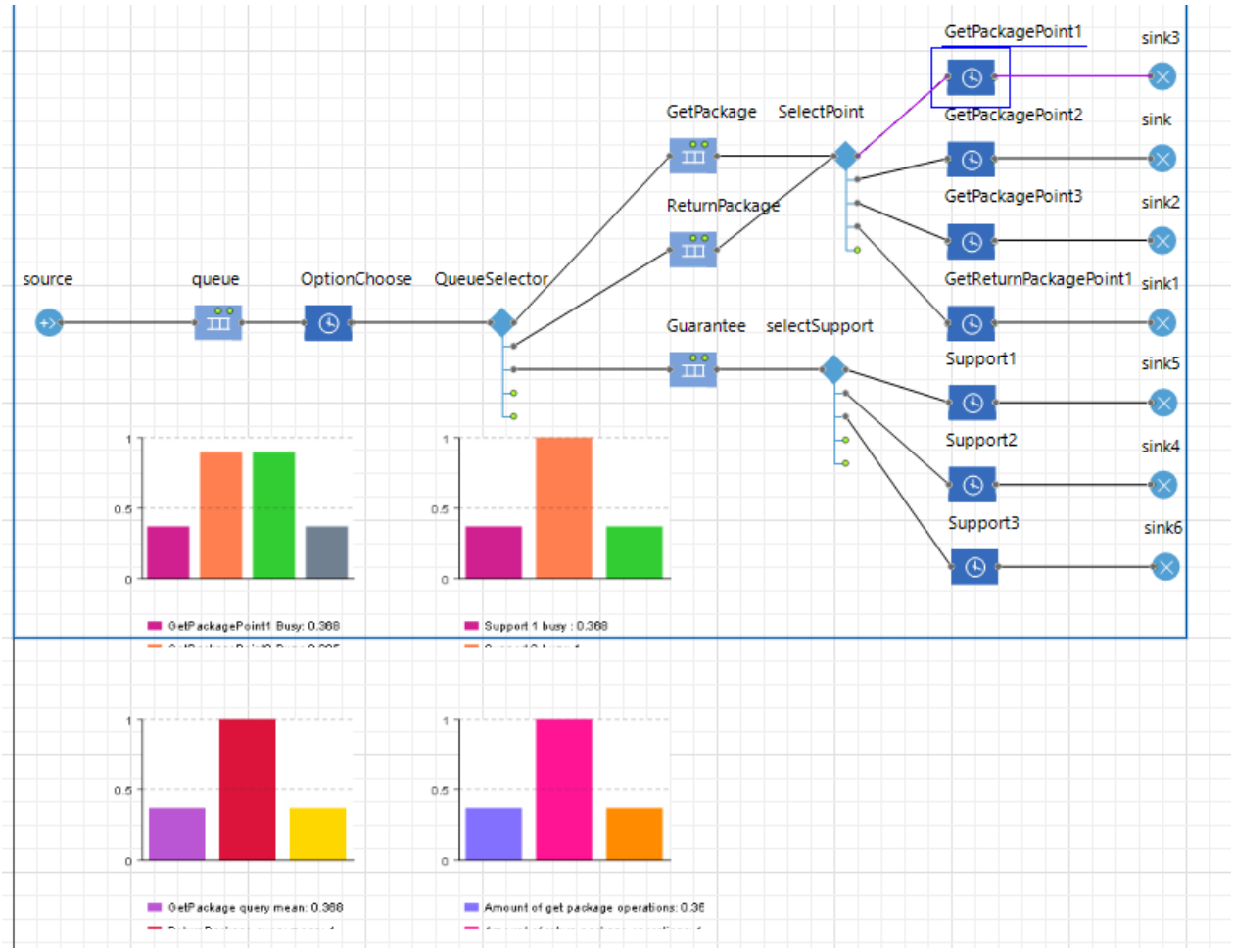

Fig. 13 – developed simulation model with statistical graphs

SCENARIOS DESCRIPTION

Measures of effectiveness

1. Uptime factor of “Get” points [1… 3]
2. Uptime factor of “Get/Return” points [1]
3. Uptime factor of “Support” points [1… 3]

These variables are the part of all workday time that current point is operates.

4. Mean of count of actors in the “Guarantee” queue
5. Mean of count of actors in the "Return Package” queue
6. Mean of count of actors in the “Get Package” queue

What-if scenarios

SCENARIO	DESCRIPTION	FACTORS VALUES
Base scenario	Simulation of real customer service office	Get service points = 4 Get/Return service points = 1 Support service points = 3
Remove 1 Support point S-01	What if one of the Support points will be removed? The cost will be decreased but what about service operating speed?	Get service points = 4 Get/Return service points = 1 Support service points = 2
Remove 1 Get point S-02	What if one of the Get points will be removed? The cost will be decreased but what about service operating speed?	Get service points = 3 Get/Return service points = 1 Support service points = 3
Remove 1 Support point and Remove 1 Get point S-03	What if one of the Support points and one of the Get points will be removed? The cost will be decreased but what about service operating speed?	Get service points = 3 Get/Return service points = 1 Support service points = 2
Remove 2 Support point and Remove 2 Get point S-04	What if remove all points except 1 Support point, 1 Get point and one Get/Return point? The cost will be decreased but what about service operating speed?	Get service points = 1 Get/Return service points = 1 Support service points = 1

Table 1. List of What-if scenarios with main changes and description

These What-if scenarios simulation the client service office workload with different amount of service points with different types. The What-if scenarios with code “S-04” is added latter to the What-if scenarios set because the results of previous scenarios shows that changes in these scenarios do not have big impact in the office workflow.

Result collection

SCENARIO	Get Point			Get Return Point Uptime	Support Point Uptime			Queue Mean Guarantee	Queue Mean Get	Queue Mean Return
	1	2	3	1	1	2	3			
Base scenario Run 1	0.45	0.39	0.22	0.48	0.45	0.17	0.11	0.07	2.66	0.08
Base scenario Run 2	0.53	0.35	0.18	0.33	0.35	0.07	0	0	0.8	0.04
Base scenario Run 3	0.57	0.36	0.17	0.08	0.24	0.11	0	0	0.02	0
C-01 Run 1	0.5	0.41	-	0.37	0.37	0.2	0.03	0	0.49	0.05
C-01 Run 2	0.45	0.28	-	0.29	0.35	0.2	0.03	0	0.26	0
C-01 Run 3	0.48	0.3	-	0.27	0.45	0.18	0.1	0	0.29	0.02
C-02 Run 1	0.58	0.33	0.18	0.26	0.46	0.25	-	0.13	0.39	0.04
C-02 Run 2	0.53	0.28	0.2	0.15	0.37	0.18	-	0.11	0.13	0.01
C-02 Run 3	0.63	0.32	0.14	0.13	0.36	0.21	-	0.58	0.04	0.01

C-03 Run 1	0.57	0.36	-	0.4	0.33	0.2	-	0.06	0.76	0.02
C-03 Run 2	0.52	0.3	-	0.2	0.35	0.21	-	0.15	0.11	0.05
C-03 Run 3	0.51	0.38	-	0.3	0.31	0.14	-	0.03	0.18	0.04
C-04 Run 1	0.45	-	-	0.6	0.8	-	-	1.73	2.4	0.14
C-04 Run 2	0.46	-	-	0.65	0.54	-	-	0.45	2.36	0.04
C-04 Run 3	0.53	-	-	0.62	0.54	-	-	0.85	2.28	0.03

Table 2. Result of runs of simulation model with different scenarios.

Result analysis

Mean value of MoE Stats per scenario	Base	C-01	C-02	C-03	C-04
Get point 1	0.51	0.48	0.58	0.53	0.48
Get point 2	0.36	0.33	0.31	0.35	-
Get point 3	0.19	-	0.17	-	-
Get/Return point 1	0.3	0.31	0.18	0.3	0.62
Support 1	0.35	0.39	0.4	0.33	0.63
Support 2	0.12	0.19	0.21	0.18	-
Support 3	0.04	0.05	-	-	-
Queue mean “Guarantee”	0.02	0	0.27	0.08	1.01
Queue mean “Get”	1.16	0.35	0.19	0.35	2.35
Queue mean “Return”	0.04	0.02	0.02	0.04	0.07

It seems that removing one point of service with specific type of service does not make any impact to the office workflow. By the result of simulations, the decision can be made that 1 Get point and 1 Support point can be removed. But if to remove second point of Get service then the queue of Get service will be bigger than 2 times. If the second Support point will be removed, then the queue mean will increase bigger than 10 time then in another scenarios except scenario C-02 but mean of "Guarantee" queue of C-04 is bigger than C-02 is 2 times.

The best decision to decrease the cost of the office is to remove 1 Support point and 1 Get point or have these points closed in most cases. It will decrease the number of employees who should wait for customers on the points, but the difference in loading of other points will not be too big and the queue mean length will not be bigger than in base scenario.

CONCLUSION

The simulation model has achieved the goal of simulation model development. The Decision is made that the customer service office has enough resources for low workflow and doesn't take much time from customers by queues. But it seems that the office has bigger service points that is required for good productivity because the decreasing of it not gives big impact in the stats of workflow and queues length. It means some points can be removed or closed to decrease the amount of resource required for current office. But it known that removing of more than 1 service points with same type will has impact to the number of customers in the waiting room. On this moment queue has mean length = 0 if 2 service points with same time will be removed then mean amount of people in the waiting room will increase to 2-3 customers.

It seems that the base scenario has a bigger number of agents, or all agents appear with short periods of time. By that reason base scenario has big difference from another scenarios. It's required to conduct more runs of every scenario to reduce the probability of current distortion.

Here are some comments about visual part of developed simulation models. The simplest visual method is used in the current simulation model. The reason is the difficulties with the visual part of AnyLogic tools. Visual parts like 3-D and 2-D animation require specific addition configurations of animation environment that take a big amount of time. Additionally, the e-queues have a place in the simulation model. The visualization of the customers that wait for their turn in the waiting room can't correctly show the queues logic and connectivity to the support points and can confuse in understanding of queues logic. The 3-D and 2-D is skipped by these big disadvantages of 3-D and 2-D visualization. Of course, the visualization can be shown in 2 types, visualization of the office in the 2-D or 3-D and the logic of the queue's connectivity. But biggest part of MoE can't be visualized by 3-D and 2-D in current case, the 3-D and 2-D visualization can provide additional information about queue to the registration device only by visualization of the customer position in that queue, but the analysis of the queue to the registration device is not the goal of the simulation, by that reason the visualization of that process can be skipped.

Source of code

The models is placed on GitHub in current repository: https://github.com/CROKMOLE/assign-1-SAM.git