POSSIBILITIES OF SIMULATION OF BULK SERVICE PROCESSES IN METALLURGICAL PRODUCTION

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Abstract

An expression of economical, technical and technological processes by means of models consists in a selection of such facts which can be expressed with help of mathematical tools to provide us a suitable possibility of simpler descriptions or predictions of changes.

A situation can occur that a functional expression is not possible or invokes so complicated mathematical relations that their explicit solving is not possible. Some numerical approximations are then attempted or simulated of the processes elements. The simulation procedure is used in a situation where it is not possible to handle analytical expression appropriately.

The paper will be focused on a simulation procedure, which will be applied to a certain process of the metallurgical production. The goal is to find the warehouse operator's workload, the average wait time in the queue, and possibly to suggest further recommendations for optimizing the process.

Keywords: Process simulation, bulk service, metallurgical production

1. INTRODUCTION

Simulation represents a numerical method of “complicated” probabilistic dynamical systems with help of experimenting with a model with the use of computer equipment. The searched variable will be obtained without mathematical algorithms but with help of imitation of a real system by computer [1]. The created real model cannot be solved with a mathematical procedure, respectively it could be a very time-consuming process. The simulation, first of all, is devoted to dynamical systems since they are complicated for using of a mathematical apparatus for solving [2]. We perform experiments on the model (set different parameters) and investigate its mode of behavior. It is a static experiment within the simulation; the result of the simulation is an estimation. It would be impossible to carry out the simulation on models without computer equipment.

The simulation serves for solving theoretical and practical problems. A computer simulation is one of many methods used for the solution of particular tasks of managerial decision-making. In case of comprehensive and complicated tasks, it is usually an only possible method of solution. It can be used for [3]:

- The determination of a mode of behavior of complicated real systems with the use of computer equipment.
- A sensitive analysis of the solution for a change of input parameters.
- System optimization.
- The replacement of the real experiment by a computer-based experiment.

The most frequently used simulating method in the tasks of bulk service is Monte Carlo [4]. It is a numerical solution of the probabilistic and deterministic tasks with help of frequently repeated stochastic attempts. The simulation is one of the most frequently used methods between engineers and managers of manufacturing enterprises.

2. RANDOM NUMBERS

Values of the random numbers have to be generated for the Monte Carlo simulation experiments. While obtaining random values, we can use a table of random numbers, which are more likely applied for the mechanical simulation. The most frequently used method of obtaining random numbers for the purpose of computer simulating are arithmetical generators [5]. Random numbers are being obtained by means of mathematical operations with help of earlier obtained previous numbers. Since these operations are a result of calculations but not of a random, such obtained numbers are called pseudo-random. At present, the random number generators are usual part of the spreadsheet programs. Some software, such as the Excel spreadsheet program, generate random numbers with help of the RAND() function.

3. THE CREATION OF THE SIMULATION MODEL

The basic aspect of simulation is its algorithm, which, thus, becomes a computer program. The program itself must catch up [6]:

- Model structure,
- Model dynamics,
- Model probabilistic character.

The most important input for the development of the simulation model algorithm is which method will be used to catch time [7]. In the simulation models of the metallurgical processes, we work with continual time of all values because a request for the service of the equipment can come whenever.

Another level of time concept is whether the state of the model changes continuously or just at certain times. In the above example, the number of incoming cars in the queue remains the same for a certain moment and changes only in discrete moments.

Implementation of the algorithm can be demonstrated on a one-line operator system. There are 2 events: *P* - the arrival of the request, *D* - the completion of the operator. For each event, the time for the next occurrence is given: *CP* - the time of the next completion of the operator, *CD* - the time of the next service completion. If the time of the next event is unknown, the *X* value (such as displaying the largest value in the computer's memory) is loaded. The number of queued queries will be monitored in the variable *F* (at the beginning is $F = 0$). *S* variable 0 (operator not implemented) or value 1 (operation started). At the beginning of the simulation run, initial conditions are set and the time of first arrival in the system is generated. Then the program evaluates which type of event occurs first from the moment. The program sets a new time value and performs the connection activity with the selected event. When the selected event is the arrival of a request (*P*), it will assign the request to the queue ($F = F + 1$) and generate the next arrival time. Then the program asks for the value of the S variable to determine whether the operator is free or busy. If the operator is free, the operator starts ($S = 1$) and generates the completion time of the operator (*CD*). When the operator completes (*D*) as soon as possible, the service line is released. The program queries F to see if there is a queue in the queue. Otherwise, it will set *X* in the time for the completion of the operation. The program returns to determine the time closest to the next event. This cycle is repeated until the simulation program stops.

4. EXPERIMENTS WITH THE MODEL AND RESULTS EVALUATION

The first thing which we must focus on is a consideration whether the used simulation is an adequate method for the solution of the given problem of managerial decision-making. Another, equally important, thing is an economic aspect (costs of information collection, model developing, benefits resulting from new knowledge about system functionality, etc.).

Provided we make a decision to realize the given problem of the managerial decision-making by means of the simulation method, it is necessary to go through the following phases of the modelling process:

- Problem specification,
- Aims determination,
- Limitation of the problem and its surrounding,
- Identification of the structure and mutual relations between the elements.

The most usual situation is when a system structure and relations between elements are known; the problem is that there is no unified approach how to solve it by a usual mathematical apparatus. We, thus, use a simulation, for example, for the calculation of complicated bulk service systems. The simulation model is most frequently used for cases when a part of the model is unknown for us (so called "black box"), for which we only know inputs and outputs. In such case, the simulation serves for the verification of hypotheses about the structure of the system and its surrounding. As far as the structure of the black box enables outputs for the corresponding inputs, the model is considered to be reliable.

Work with the results (analysis and interpretation) is the most important part of the simulation itself [8]. It is mostly depreciated because the attention is usually paid to the separate creation of the simulation model and its realization by computer instead of the results.

5. SIMULATION LANGUAGE, APPLICATION AND PLUG-INS

Finally, the simulation model is transferred to a form of a computer program. The computer program can be written in a general programming language or in a simulation language (for example, GPSS/H). The first possibility represents a bigger freedom while creating a model, but the process of simulation itself is more challenging for the user. Another group of the products consists of already pre-prepared applications (WITNESS - a product designed for industrial enterprises), or plug-ins for the spreadsheet programs (@RISK). Since the group of users using a simulation they are focused on falls into the category of managers, it would be most suitable to use for the simulation either a spreadsheet program or a plug-in installed into the spreadsheet programs. Another aspect why to use a spreadsheet program is that at the present it is a basic part of the software equipment of computers, which managers use for their daily professional life.

6. AN EXAMPLE OF APPLICATION OF A SIMULATION MODEL ON THE PROCESS OF DISPATCHING STEEL BILLETS

Three customers per hour arrive to the storehouse of the metallurgical enterprise with sheet billets. This is a Poisson distribution that is equivalent to exponential one with a mean value of 20 minutes. The service time has an exponential distribution with a mean value of 18 minutes. The task is to determine a load of the storekeeper and the mean time of customer’s waiting in a queue.

6.1 The procedure of solving

Firstly, create a model in a spreadsheet program (see **Table 1**).

Enter proper formulas into separate cells. Copy the formulas and create a sequence of customers. Add "zero" to the formula for generating an arrival for the first customer because the second customer is linked to the previous customer.

The calculation of the mean values was carried out just for the customers from No. 3 to No. 26, because the first two of them are being omitted. These customers come into the system when there is no queue in it, that's why the time of staying in the system and in the queue can be depreciated. The first customer doesn't wait in a queue at all. 30 experiments were performed by means of a data table with one input (see **Table 2**).

Table 1 Simulation model in the MS Excel spreadsheet program

Costumer	Arrival	Personnel	Start	Finish	Stay time	Queue
1	106.29	0.25	106.29	106.54	0.25	0.00
2	146.78	11.42	146.78	158.20	11.42	0.00
3	165.27	34.16	165.27	199.43	34.16	0.00
4	173.93	0.58	199.43	200.01	26.07	25.49
5	186.15	10.70	200.01	210.71	24.56	13.86
6	261.66	10.05	261.66	271.71	10.05	0.00
7	262.19	4.81	271.71	276.52	14.34	9.53
8	325.35	26.69	325.35	352.04	26.69	0.00
9	338.33	10.00	352.04	362.05	23.71	13.71
10	367.17	18.10	367.17	385.28	18.10	0.00
11	370.19	3.96	385.28	389.24	19.05	15.09
12	370.87	2.70	389.24	391.94	21.07	18.36
13	405.87	20.38	405.87	426.25	20.38	0.00
14	413.28	4.12	426.25	430.36	17.09	12.97
15	463.85	51.73	463.85	515.58	51.73	0.00
16	492.55	44.40	515.58	559.98	67.43	23.03
17	494.71	6.58	559.98	566.56	71.85	65.27
18	505.20	18.88	566.56	585.44	80.25	61.37
19	518.66	2.49	585.44	587.93	69.28	66.79
20	533.97	17.25	587.93	605.18	71.21	53.97
21	624.70	8.05	624.70	632.74	8.05	0.00
22	661.23	23.78	661.23	685.01	23.78	0.00
23	693.78	8.57	693.78	702.34	8.57	0.00
24	804.10	43.71	804.10	847.81	43.71	0.00
25	844.24	8.78	847.81	856.59	12.35	3.57
26	874.71	22.31	874.71	897.01	22.31	0.00
Average		16.78			32.74	15.96

Table 2 Simulation with help of a data table with one input

Attempt	Personnel	Stay time	Queue
1	16.78	32.74	15.96
2	24.26	92.37	68.11
3	18.70	52.55	33.85
4	16.86	28.19	11.34
5	19.39	72.92	53.53
6	16.42	67.50	51.08
7	13.39	19.94	6.55

Table 2 (continue)

Attempt	Personnel	Stay time	Queue
8	20.10	45.05	24.95
9	18.64	69.47	50.83
10	12.57	33.15	20.58
11	21.45	43.19	21.75
12	16.76	78.42	61.66
13	20.54	58.53	37.99
14	13.80	29.42	15.62
15	21.36	40.70	19.33
16	16.19	37.84	21.65
17	20.07	76.27	56.21
18	20.57	65.50	44.93
19	16.56	36.86	30.30
20	16.18	64.87	48.69
21	16.29	33.15	16.86
22	17.13	33.51	16.38
23	17.07	50.95	33.89
24	21.37	75.62	54.25
25	17.19	33.08	15.88
26	20.49	88.59	68.09
27	12.87	18.88	6.01
28	13.59	30.93	17.35
29	17.46	83.76	66.30
30	14.88	34.16	19.28
Average	17.63	50.94	33.64

It is possible to deduce from the table that a customer will be averagely in the queue of 33.64 minutes, wait for the operating staff for 17.63 minutes and remain in the system for 50.94 minutes in total.

7. CONCLUSION

The simulation is a tool which can be used for the calculation of service system indicators. The management uses this information for the proposal of a service system and for the improvement of its activity. The main reason of the origination of a queue, even in the case when an average rate of the operating staff is quicker than the average rate of the arrival is that the both rates fluctuate with an unpredictable way. The consequence of it are short-term changes both of the rates of arrivals and rates of servicing. It brings to non-using of the capacity in certain time periods and to waiting in another time periods. As appears from the examples, it should be suitable to enforce the storehouse by another storekeeper.

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