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Analysis and Behaviour Understanding of a Production System

In production systems modelling usually acts to system simulation by discrete events. The present paper exemplifies this, using the Queuing System Simulation module of the WinQSB software.

1. Introduction.

In the economical practice appear numerous "waiting" situations due to the impossibility of temporal correlation of diverse activities, which are inter-conditioned.

Formation of a "pending event" or a "queue" is a phenomena usually found in the activity of an organisation.

Whilst the queue system theory can be used for simple systems analysis, the complex systems are analysed safer and easier by simulation, called more precisely "discrete events system simulation".

Generally, a queue phenomenon has the following characteristics:

1. there is number of solicitors for certain services;
2. it is not known precisely the moment when a service will be requested;
3. there is a number of serving stations or tellers which offers the requested service;
4. it is not known precisely the perform duration of the service;
5. there is incertitude regarding the costumers' behaviour after their arrival in the serving system.

In order to analyze such a system there are necessary information regarding:

- arrival process:
  - costumer arrival modality;
  - arrival in time repartition;
  - the costumer multitude type.
- serving mechanisms:
  - description of the necessary resources in order to realize the serving;
  - distribution of serving duration;
  - the number of available serving stations;

- the queues position up to serving.

- queue characteristics:
  - queue discipline, which may be „first in, first out" (FIFO), „last in, first out" (LIFO) or random serving;
  - the costumer type which can renounce at the service if the queue is too long or the pending time overpasses a certain limit, or which change the queue thinking that in this way they will be faster;
  - queue capacity.

2. Problem Data

An enterprise which produces military parts wishes to organise a processing unit.

The problem data are presented in table 1.

Table 1

Nr. crt.	Serving units	Unitary times [hours]
1.	Milling machine	0,05
2.	Lathe 1	0,09
3.	Lathe 2	0,1
4.	Manual Control	0,008
5.	Manual Packing	0,005

The interval duration between two consecutive arrivals is a probabilistic entity with 0,03 average normal distribution and 0,01 hour standard digression.

In practice, most of the times, the time interval between two consecutive arrivals and the service duration are random variables. Due to this fact, the analytical models are not operant, using instead the Monte Carlo simulation.

Table 2

Nr. crt.	Queues	Maximal Capacity [pieces]
1.	Queue 1	100
2.	Queue 2	100
3.	Queue 3	50
4.	Queue 4	50
5.	Queue 5	500

It considers that all parts are processed as FIFO, and the storage space for the parts that follows to be manufactured is limited, this being the reason for which is specified the maximum capacity for each queue (table 2).

It is requested to analyze and to understand the production system behaviour.

3. Solving the problem

The problem data are introduced in order to be processed (fig. 1).

Component Name	Type (C/S/Q/G)	Immediate Follower (Name / Prob / TransferTime, separated by ',')	Input Rule	Output Rule	Queue Discipline	Queue Capacity	Attribute Value	Interarrival Time Distribution	Batch Size Distribution	Service Time Distribution
Piesa	C	Coada 1						Normal/0.03/0.01		
Freza	S	Coada 2								Constant/0.05
Strung 1	S	Coada 3								Constant/0.09
Strung 2	S	Coada 4								Constant/0.1
CTC	S	Coada 5								Constant/0.008
Paletizare	S									Constant/0.005
Coada 1	Q	Freza			FIFO	100				
Coada 2	Q	Strung 1			FIFO	100				
Coada 3	Q	Strung 2			FIFO	50				
Coada 4	Q	CTC			FIFO	50				
Coada 5	Q	Paletizare			FIFO	500				

Figure 1. Problem Input Data

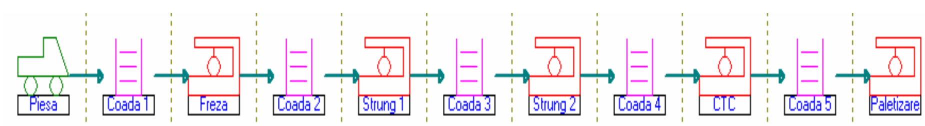

Figure 2. Graphical form for presenting the problem

The problem solution starts by using *Solve and Analyze* → *Perform Simulation* commands (fig. 3).

There were specified 100 hours of simulation. The simulation data collection starts with the 20^{th} hour of running, in order to eliminate the initial condition influence, when the intermediary stocks are null.

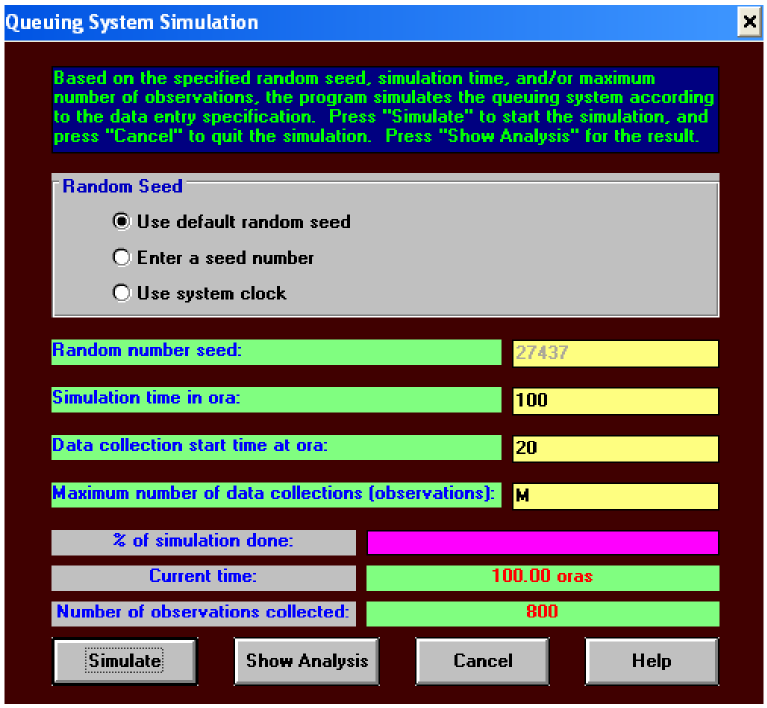

Figure 3. Queuing System Simulation window

4. Results Analysis

WINQSB offers three types of analysis:

- costumers analysis which entered in the system (fig. 4)

It can be observed that from the 20th hour of simulation up to the 100th hour, totally entered in the system 2.656 parts.

Dividing per hour, the average number of pieces was 248,5633, with a maximum of 254 parts.

Fully there were fabricated 800 finite parts.

The processing average time for a finite part was 0,253 hours, and the medium pending time was 22,9427 hours.

The average spent time in the system for a finite part was 23,2454 hours. Theoretically, the average spent time in the system for a finite part is equal to the average processing time added to the average pending time, meaning 0,253 + 22,9427 = 23,1957 ore. The difference of 0,0497 hours calculated by WinQSB is determined by the fact that the average spent time is not obtained by summarising the two other average times, but following the pieces itinerary in order to become finite parts.

06-25-2009	Result	Piesa
1	Total Number of Arrival	2656
2	Total Number of Balking	1828
3	Average Number in the System (L)	248.5633
4	Maximum Number in the System	254
5	Current Number in the System	253
6	Number Finished	800
7	Average Process Time	0.2530
8	Std. Dev. of Process Time	0
9	Average Waiting Time (Wq)	22.9427
10	Std. Dev. of Waiting Time	2.6849
11	Average Transfer Time	0
12	Std. Dev. of Transfer Time	0
13	Average Flow Time (W)	23.2454
14	Std. Dev. of Flow Time	2.6965
15	Maximum Flow Time	25.3125
	Data Collection: 20 to	100 oras
	CPU Seconds =	4.0630

Figure 4. Show Customer Analysis

- analysis of serving station use (fig. 5)

06-25-2009	Server Name	Server Utilization	Average Process Time	Std. Dev. Process Time	Maximum Process Time	Blocked Percentage	# Customers Processed
1	Freza	51.75%	0.0500	0.0000	0.0500	48.25%	828
2	Strung 1	93.15%	0.0900	0.0003	0.0900	6.85%	828
3	Strung 2	100.00%	0.1000	0.0002	0.1000	0.00%	800
4	CTC	8.00%	0.0080	0.0000	0.0080	0.00%	800
5	Paletizare	5.00%	0.0050	0	0.0050	0.00%	800
	Overall	51.58%	0.0509	0.0396	0.1000	11.02%	4056
Data	Collection:	20 to	100	oras	CPU	Seconds =	4.0630

Figure 5. Show Server Analysis*s*

The Lathe 2 is used in proportion of 100%, so this tool can be considered as a narrow place, called "bottleneck", because has the largest utilization time. But due to the fact that this lathe processed 800 parts, identically with the others tools, there is not necessary.

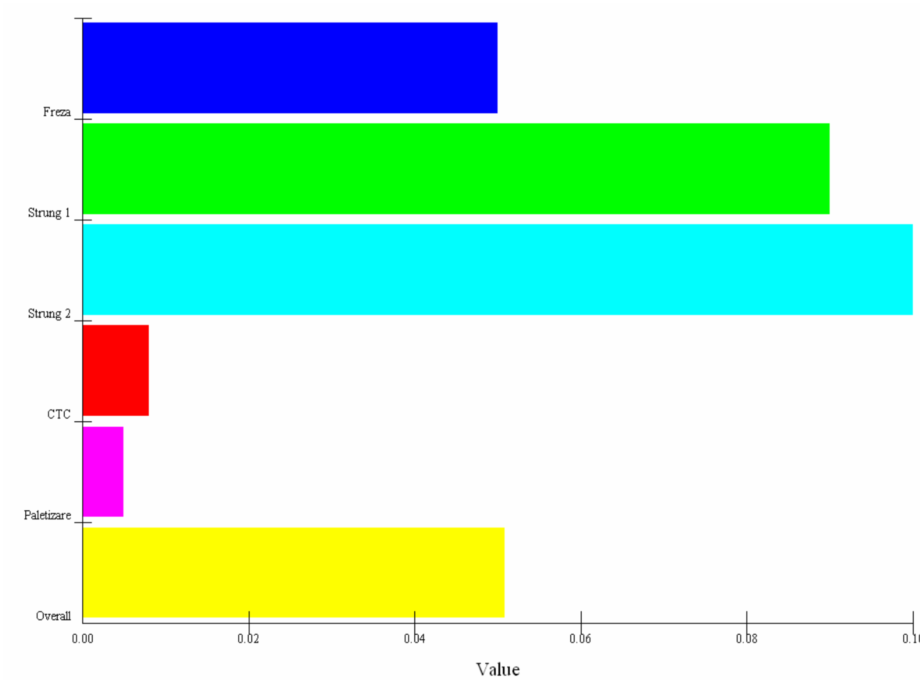

Figure 6. Average fabrication time in graphical form

- queue analysis (fig. 7)

06-25-2009	Queue Name	Average Q. Length (Lq)	Current Q. Length	Maximum Q. Length	Average Waiting (Wq)	Std. Dev. of Wq	Maximum of Wq
1	Coada 1	99.8265	100	100	9.5849	0.4696	9.9998
2	Coada 2	99.9476	100	100	9.6017	0.4676	9.9998
3	Coada 3	45.5781	50	50	4.4318	0.9049	4.9999
4	Coada 4	0	0	1	0	0	0
5	Coada 5	0	0	1	0	0	0
	Overall	245.3521	250	100	4.7909	4.3298	9.9998
Data	Collection:	20 to	100	oras	CPU	Seconds =	4.0630

Figure 7. Show Queue Analysis

The first costumers queue are used at almost at maximum, and the queue 4 and 5 are practically inexistent. (fig. 8). There is no need for stocks due to the parts processing times.

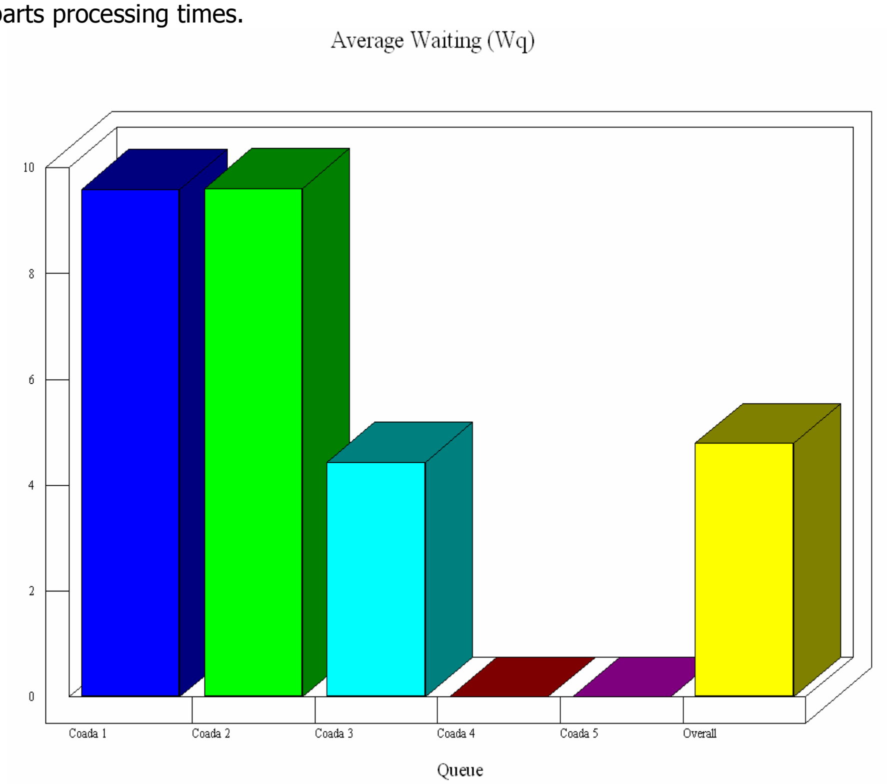

Figure 8. Queue Analysis from the medium pending time

4. Conclusions

There were performed three types of analysis, respectively:

- costumers analysis which entered in the system,
- analysis of serving station use,
- queue analysis,

these analysis revealing the following conclusions:

The Lathe 2 can not be considered "bottleneck", even it was utilised in proportion of 100%, so there is no necessity to introduce a supplementary lathe.

The stock spaces 4 and 5 are not necessary in the presented situation.

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