Modeling Food Security Processes with Uneven Transportation of Goods and Economic Aspects

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Abstract. The article discusses the methodology of modelling the work of the warehouse complex, which allows you to optimize its operation. The experience of creating various simulation models in the simulation environment is analysed in order to optimize the operation of transport and logistics complexes, the results of which were increased productivity and reduced costs. Planning a warehouse complex is a key stage in this process. Mistakes made during planning can cause the inability to use a warehouse with a high level of efficiency and significant financial losses for an organization. The following stages, such as optimization and organization of the warehouse operation, also play an important role.

1. Introduction
Simulation modeling makes it possible to perform a description of processes at the distribution center, analyze various parts of the warehouse system, view statistics and system behavior over time, and replay scenarios of changes on the planning horizons.

Today, software products allow you to perform a series of computer experiments with a simulated system. At the same time, there is no disruption or interruption of current technological operations at the existing warehouse complex. In addition, various scenarios for the operation of the warehouse complex that is being designed are checked before it is used.

When the vehicle is ready for loading and unloading from the warehouse complex (the car service request is completed), and there is a free cell for processing the car in zone H, the car drives up to the free cell for loading. The average driving time of 2 min. If the request was completed before the arrival of the car and there is a free cell, the car can directly drive up to the cell, bypassing parking 6. The average time for servicing the car is 5 minutes.

Identified shortcomings in the warehouse under study: warehouse topology – the existing topology scheme has shortcomings, in terms of insufficient storage space for goods. The warehouse is organized in a room that is not equipped with the necessary cargo storage elements for the warehouse.

The construction of existing places for storing goods took place without using a scientific approach to calculate the required space. As a result, there is a lack of storage space for cargo.

The warehouse in question has:
5 sections,
4 lines,
floor storage is carried out in 1 tier.
Therefore, to increase the volume of processed goods, it is possible to install racks in two tiers.
Develop a new layout of the goods in the warehouse, in order to reduce the time spent working with the goods in the warehouse.

References—An address system for storing goods in a warehouse is an automated process designed to optimize the placement of objects on shelving systems.
Regardless of the size of the warehouse, a single numbering system for storage locations should be developed for the placement of goods. This will help not only eliminate shortfalls and over-sorting, but also reduce the amount of time employees spend searching for a particular product. To do this, each place is assigned an individual number (address), which means the number of the rack, the number of the section, and the number.

1. The serviced car on the terminal train arrives at the exit gate of Terminal J. The average driving time is 2 minutes.
2. After the inspection, the car leaves the terminal. The average inspection time is 2 minutes.

It is necessary to develop a simulation model and simulate the operation of the terminal for 8 hours. You need to define:
- the number of affected vehicles;
- average processing time per vehicle;
- the coefficient of processing cars by the terminal;
- indicators of the use of terminal elements.

In the model, motor vehicles should be submitted in applications. All other elements of the terminal (parking lot D, office E, lanes at gates F and J, seats at zones I and Z) are multi-channel devices (MCUs). We will give the MCU names according to the problem statement by adding an underscore, for example, D_.

Let’s introduce scaling: 1 unit of model time corresponds to 1 min, that is, for example, the simulation time is equal to 480 units of model time.

In the statement of the task for the development of the model, the average values of the time of receipt of cars and their processing are indicated. We assume that the time intervals in all cases are distributed according to the exponential law.

The decomposition of the warehouse complex and the composition of the model segments are determined by the developer. We will enter the following segments •
- input of the source data;
- the event part of the model;
- calculation of simulation results.

The property values are found in Table 1.

| Name  | Type | The default value | Name  | Type | The default value |
|-------|------|------------------|-------|------|------------------|
| D_    | int  | 10               | timeE | double | 10              |
| E_    | int  | 5                | timeF | double | 2               |
| F_    | int  | 5                | timeI | double | 5               |
| I_    | int  | 7                | timeZ | double | 10              |
| ZP_   | int  | 2                | timeJ | double | 2               |
| J_    | int  | 7                | timeA | double | 9               |
|       |      |                  | timeFH| double | 2               |
|       |      |                  | timeIJ| double | 2               |
The utilization factors of the warehouse elements are 0.8. The placement of the elements for input of the initial data and output of the simulation results is shown in Figure 1.

![Figure 1. Placement of elements for input of initial data and output of simulation results.](image)

The kolJ variable is introduced to count the number of transports processed. The timeSum variable is introduced to count the total processing time of all transports. The values of these variables are used to calculate the average TimeObr transport processing time.

The Source object generates requests of a certain type. It is usually used as the starting point of a process diagram that formalizes the flow of applications. In our example, requests will be requests for processing by the server, and the Source object will model their receipt [2].

Requests are objects that are produced, processed, serviced, or otherwise exposed to the simulated process: these can be customers in the service system, parts in the production model, vehicles in the transportation model, documents in the workflow model, messages in the communication system models, etc. In our example, the service of road transport acts as requests.

The results of the model can be seen in Table 2.

| Indicators          | Values of indicators |
|---------------------|----------------------|
| KolObrCar           | 53,294               |
| TimeObr             | 36,053               |
| KoeffIspl           | 1,000                |
| KoeffIspl_E         | 0,222                |
| KoeffIspl_F         | 0,044                |
| KoeffIspl_Z         | 0,554                |
| KoeffIspl_I         | 0,062                |
| KoeffIspl_J         | 0,032                |
| Queue _E            | 8                    |
| Queue _F            | 1                    |
| Queue _Z            | 16                   |
| Queue _I            | 17                   |
| Queue _J            | 1                    |
| Machine time        | 37                   |
Simulation results:
- number of cars processed within 8 hours (KolObrCar) - 53,294;
- the average processing time per vehicle (TimeObr) is 36.053 minutes.

We will create an optimization model in this software product.

The essence of this experiment is to conduct a multivariate analysis of variance in order to identify the degree of influence of various factors and their combinations (interactions) on the value of the target function (the response function, represented as a regression equation).

As a result, we will get the optimal values of factors and indicators of the functioning of the warehouse complex, which we will evaluate.

Objective: to determine the minimum processing time for a single motor vehicle.

The number of replications (runs) in a single iteration (observation) can be fixed or variable. A fixed number of runs, for example, with a confidence probability $\alpha = 0.95$, accuracy $\epsilon = 0.01$, and standard deviation $\sigma = 0.1$ can be determined by the formula:

$$N = t_\alpha^2 \frac{\sigma^2}{\epsilon^2} = 1.96^2 \frac{0.1^2}{0.01^2} = 3.8416 \cdot 100 \approx 400,$$

where $t_\alpha = 1.96$ is the tabulated argument of the Laplace function [3].

During the experiment, you can see on the graph the change in the value of the target function (vertical axis). After performing 25600 replication, the experiment will stop.

The results of experiments with a simulation model of the functioning of the warehouse complex are summarized in Table 3.

| Indicator, parameters | Values of indicators |
|-----------------------|----------------------|
| TimeObr               | 32,534               |
| timeA                 | 20                   |
| timeE                 | 10                   |
| timeF                 | 2                    |
| timeI                 | 5                    |
| timeZ                 | 10                   |
| timeFH                | 2                    |
| TimeObr               | 34,527               |
| timeA                 | 20                   |
| timeE                 | 10                   |
| timeF                 | 4                    |
| timeI                 | 5                    |
| timeZ                 | 10                   |
| timeFH                | 4                    |

In the experiment, the minimum processing time for a single image, as determined by the AnyLogic optimizer, is $\text{TimeObr} = 32.534 \text{ min.}$ for subsequent parameter values: $\text{timeA} = 20$, $\text{timeE} = 10$, $\text{timeF} = 2$, $\text{timeI} = 5$, $\text{timeZ} = 10$, $\text{timeFH} = 2$.

2. Conclusions

Summing up, we can conclude that using the simulation method, you can choose the best layout of the warehouse, make the necessary changes to the project, optimize the number of staff and the policy of
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