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Development of a Simulation Model for the Provision of Freight Forwarding Services by a Logistics Company

Kravchenya Irina
Department of Road Transport and Traffic Management, Belarusian State University of Transport, Gomel, Republic of Belarus

Corresponding Author: **Kravchenya Irina**

Abstract
In the context of growing competition and the unstable economic situation, improving the efficiency of international cargo transportation is an urgent task. The article presents a simulation model for the provision of freight forwarding services by an international logistics company in the GPSS World simulation modeling system to determine the average processing time of incoming requests and the delivery time of goods depending on the type of customers (VIP client, regular client, one-time client). A comparison of the effectiveness of three directions of cargo delivery (Belarus, the European Union, Georgia); research and optimization of the workflow in a freight forwarding company; determination of the reliability of cargo delivery in three directions. The developed simulation model can be used to determine the optimal structure of the organization of the work of a logistics company in the provision of freight forwarding services.

Keywords: Freight Forwarding Services, Queuing System, Service Request, Simulation Modeling

1. Introduction

Recently, more and more large companies, when choosing a carrier, have resorted to the services of freight forwarding companies offering a wide range of services for the registration and delivery of goods. Since huge changes are taking place in the freight transportation market, the task of analyzing and improving the efficiency of the provision of services by freight forwarding companies is urgent.

In order to increase the volume of cargo transportation by road, high-quality freight forwarding services for potential customers are important, since currently the object of research on the transport market is the customer and his needs. The more profitable the transportation is, the more interested the customer is.

The main criteria for choosing a freight forwarding company are:

- The cost of transportation (total transportation costs, taking into account transport tariffs);
- Speed of transportation (total travel time: from the starting point of departure to the final destination);
- Reliability of transportation (delivery of cargo in one piece at the specified time and place).

In addition to the main criteria, the following additional criteria can be identified, which should also be taken into account when choosing freight forwarding companies:

- Quality of services provided;
- The possibility of providing special equipment for the transportation of certain categories of goods (dangerous, fragile, requiring a certain temperature regime of goods);
- Customer orientation (system of discounts and special offers);
- Possibility of delivery of cargo "door to door";
- Reputation in the transport services market (good customer history and positive feedback);
- Qualification of personnel;
- Cargo monitoring (the ability to track the transportation process);
- Compliance with the requirements and quality standards of the transportation process;
- Mandatory insurance compensation in case of loss / damage of cargo;
- Financial stability of the carrier;

- Availability of additional services to ensure an increased level of security of the transported cargo (insurance, information support, additional packaging);
- Many years of experience in the transport services market.

The most common aspects that are usually subject to constant reforms in freight forwarding companies operation are workforce and material-and-technical capacity management. Potential measures that are considered to optimize the staffing level in order to provide complex and timely freight forwarding service provision, as well as derive economic benefits from the operation are the assessment of costs, revenues, and profits generated from the activity [1].

Thus, the task of developing a simulation model for the provision of freight forwarding services, which allows conducting research and improving the efficiency of the provision of services by logistics companies, is urgent.

2. Simulation model of freight forwarding services by a logistics company

The aim of the work is to develop a simulation model of freight forwarding services developed in GPSS World simulation system [9-11] to;

- Determine the average processing time of incoming requests depending on the type of clients (VIP client, client, one-time application);
- Determine the total customer service time depending on the department;
- Investigate and optimize the construction of a workflow in a logistics company;
- Compare the effectiveness of three directions of cargo delivery (Belarus, the European Union, Georgia);
- Determine the reliability of cargo delivery in three directions;
- Explore and improve the efficiency of Logistics Company by optimizing the construction of the workflow for provision of transport and logistics services.

The input parameters of model *X* are:

- Incoming flow λ_i of receipt of requests for transportation depending on the type of customers (VIP client, regular client, one-time client) and directions of cargo delivery;
- The time of completion of the work $m_i \pm \sigma_i$ for processing the application by the manager, depending on the type of customers and the direction of delivery of the cargo;
- Priority Pr_i in servicing the incoming flow of requests for transportation from customers of different types and directions of cargo delivery;
- The number of managers *n* working with different clients;
- The processing time of the application on the exchange $a_i \pm b_i$.

The output characteristics – responses of model *Y* are the modeling statistics:

- Average time of service by the manager (preparatory operations) depending on the type of customers and the direction of cargo delivery (t_i);
- The average time of cargo delivery, taking into account preparatory operations, depending on the type of customers and the direction of cargo delivery (t_S);
- The average length of the queue to the manager for processing the application (η_k)
- The average waiting time for the client in the queue to the manager (w_k),
- The number of applications denied service (φ_k);
- Manager load factor (ψ_k);
- The average number of managers loaded (ρ_k).

As performance indicators that determine the goals of modeling – choosing the optimal structure for organizing the work of a logistics company, the following are considered:

- Average service time by a manager (preparatory operations), depending on the type of customers and the direction of cargo delivery;
- The average time of cargo delivery, taking into account preparatory operations, depending on the type of customers and the direction of cargo delivery;
- The average length of the queue to the manager for processing the application;
- The average waiting time of the client in the queue to the manager,
- The number of applications that received a denial of service;
- Manager load factor;
- The average number of managers loaded.

The limitations of the simulation model are related to:

- The conditions imposed on the incoming flow of incoming applications (it is assumed to be the simplest, there are no repeated applications),
- The absence of phenomena that change the patterns of application service time (failures and failures of equipment, etc.).

To justify the choice of the optimal structure of the company and optimize the processing of incoming applications, a mathematical model of queuing is proposed.

The mathematical model of processing incoming streams is shown in Fig 1.

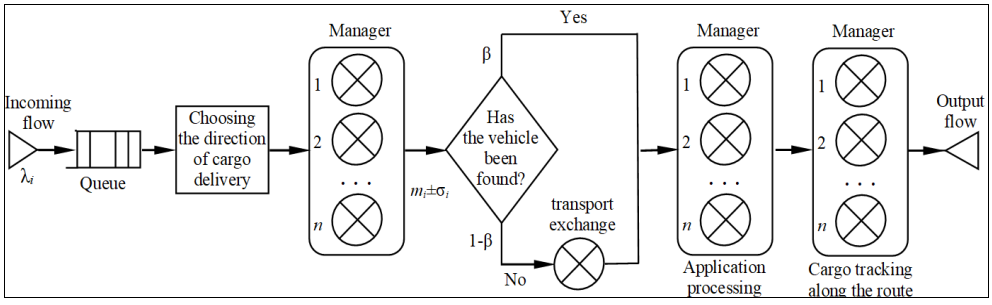

Fig 1: The scheme of modeling the processing of incoming application flows

The time intervals between the receipt of incoming flow for each manager to perform the application processing procedure have a Poisson distribution with intensity λ_i.

The received applications are awaiting service in the queue to the manager, subject to availability and approval of the application. If the request belongs to the type of one-time clients, a denial of service is possible if the queue length is more than *M* clients.

Regular carriers are called, if they do not have free transport, the application is placed on the transport exchange. After the end of the transportation, namely, the payment by the customer of the bill for transportation for unloading, an output stream of requirements is formed.

The average time for servicing customer requests of various types (VIP client, regular client, one-time client) is subject to the normal distribution law with an average value of m_i and a standard deviation of σ_i.

3. Simulation model of freight forwarding services by a logistics company

The proposed model for the provision of forwarding services was created in the GPSS World simulation automation package [9-11].

GPSS (General Purpose Simulation System), designed for simulation of discrete systems, is one of the most widespread and used in practice automation tools for simulation of queuing systems.

The text of the simulation model in GPSS World is shown in Fig 2.

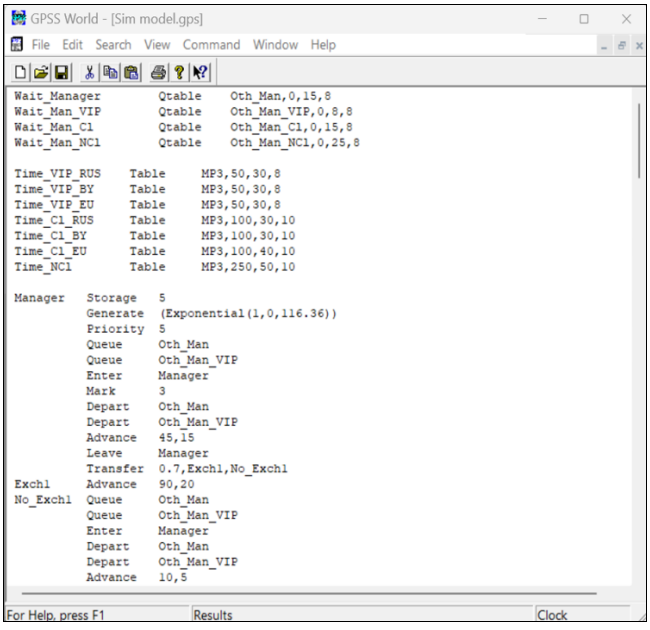

Fig 2: Program Listing

GPSS World implements step-by-step debugging of the model with simultaneous display of the processes of moving applications between blocks of the simulation model (Fig 3).

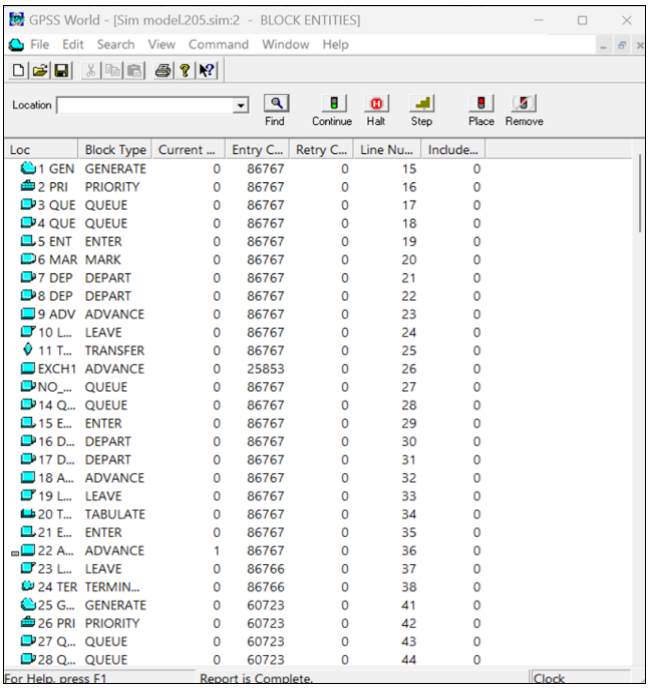

Fig 3: Step-by-step debugging window of the simulation model in GPSS World

The adequacy of the simulation model to the object of study was verified by matching the values of the characteristics of the functioning of the model with the data obtained by analytical calculation methods with a given accuracy.

As a result of the simulation, the following statistics on queues and devices were obtained (Fig 4).

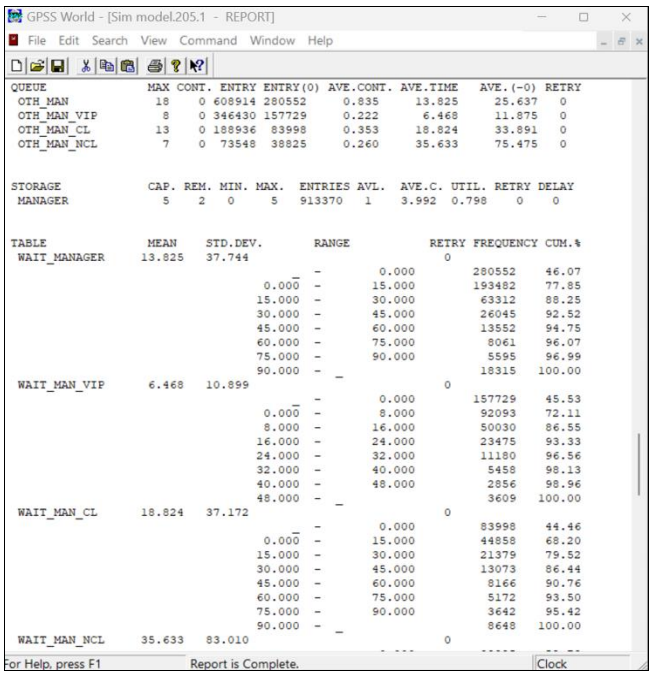

Fig 4: Simulation results

As a result of the simulation, the average service time of an incoming request is shown in Table 1.

Table 1: Application processing simulation results (preparatory operations)

Clients	Average maintenance time, min (MEAN)	Mean square deviation, min (STD.DEV.)
Belarus		
VIP client	96,567	57,597
Regular client	202,541	65,226
One-time client	310,767	113,001
Georgia		
VIP client	87,566	44,133
Regular client	93,634	53,977
One-time client	310,767	113,001
The European Union		
VIP client	95,122	53,110
Regular client	212,499	84,408
One-time client	310,767	113,001

Histograms of the distribution of the average service time (preparatory operations) of incoming requests from customers for the implementation of operations for the provision of freight forwarding services are shown in Figures 5-7.

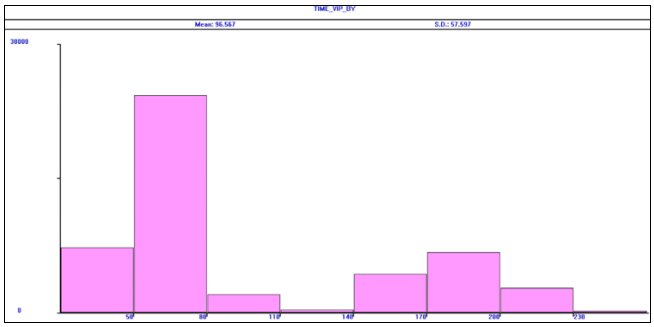

Fig 5: Distribution of VIP client service time (Belarus)

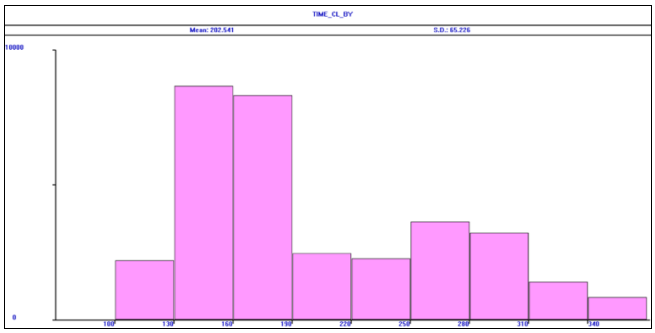

Fig 6: Distribution of regular client service time (Belarus)

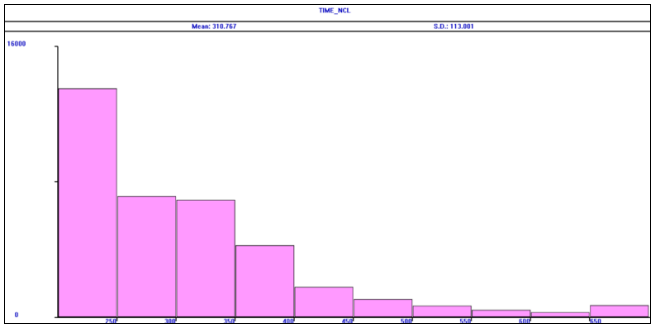

Fig 7: Distribution of time for servicing one-time client (Belarus)

From the analysis of the figures, it can be concluded that in order to reduce the maintenance time (carrying out preparatory operations), the manager needs to devote more time to searching for transport (without placing an application on the transport exchange).

As a result of the simulation, the average time of cargo delivery in the directions, taking into account preparatory operations, is shown in Table 2.

Table 2: Application processing simulation results

Route	Average delivery time, hour	Average time of cargo delivery, taking into account preparatory operations, hour
Belarus		
VIP client		
Gomel – Minsk	3,6	10,21
Gomel – Grodno	7,33	13,94
Regular client		
Gomel – Minsk	3,6	11,82
Gomel – Grodno	7,33	15,55
One-time client		
Gomel – Minsk	3,6	13,78
Gomel – Grodno	7,33	17,51
Georgia		
VIP client		
Gomel – Tbilisi	116	122,46
Gomel – Batumi	120	126,46
Regular client		
Gomel – Tbilisi	116	122,58
Gomel – Batumi	120	126,58
One-time client		
Gomel – Tbilisi	116	126,18
Gomel – Batumi	120	130,18
The European Union		
VIP client		
Mozyr – Vilnius	174,5	181,08
Mozyr – Gdansk	180	186,58
Regular client		
Mozyr – Vilnius	174,5	182,88
Mozyr – Gdansk	180	188,38
One-time client		
Mozyr – Vilnius	174,5	184,68
Mozyr – Gdansk	180	189,18

According to the reports obtained as a result of modeling the processing of incoming requests, the main indicators of the simulation results were determined and the amount of time lost for requests for service in queues was calculated (Table 3).

Table 3: The main indicators of modeling results for the manager's work

Output parameters	VIP client	Regular client	One-time client
The average length of the queue for processing the application (η_k)	0,222	0,353	0,260
Average waiting time for a client in the queue to the manager, min (w_k)	6,468	18,824	35,633
The number of applications that received a denial of service, % (φ_k)	0	0	22
The number of managers in the company (n)	5		
Manager load factor (ψ_k)	0,798		
Average number of managers loaded (ρ_k)	3,992		

Analyzing the simulation results obtained, we see that the "bottleneck" for this flow is the number of managers working with clients, the increase of which will allow serving more clients, reducing customer service time and reducing the number of applications entering the exchange.

4. Assessment of the reliability of cargo delivery in the following directions

The reliability of cargo delivery is related to the timeliness of cargo delivery, taking into account the performance of preparatory operations.

The late delivery of goods is associated with:

- Delays in the search for transport (placing an application on the transport exchange);
- Incorrectly executed documents,
- Delays in customs clearance,
- Downtime in queues at checkpoints,
- Limitation of the number of checkpoints, etc.

It is very difficult to trace all possible causes that should lead to a failure or malfunction in the delivery of goods, to assess their reliability based on the analytical methods used to analyze technical systems. In this case, it is advisable to use the simulation model of freight forwarding services developed in GPSS to assess reliability.

The reliability of cargo delivery in the directions is defined as an assessment of the probability of timely completion of preparatory operations and the entire cargo delivery process as a whole (Table 4).

Table 4: Reliability of cargo delivery in the following directions

Directions of cargo delivery	Reliability of cargo delivery *p*		
	VIP-клиент	Regular client	One-time client
Belarus			
Gomel – Minsk	0,92	0,91	0,89
Gomel – Grodno	0,9	0,89	0,88
Georgia			
Gomel – Tbilisi	0,87	0,83	0,70
Gomel – Batumi	0,83	0,79	0,68
The European Union			
Mozyr – Vilnius	0,65	0,60	0,57
Mozyr – Gdansk	0,63	0,58	0,52

The reliability of cargo delivery in this case is low due to the unsatisfactory reliability of its elements. In order to ensure a sufficiently high level of reliability of cargo delivery in general, it is necessary to ensure a fairly high level of reliability of each of its elements: preparatory operations and cargo delivery.

5. Conclusions

The developed simulation model can be used to determine the optimal structure of a logistics company in the provision of forwarding services.

In determining the optimal number of employees to work with service consumers, a company's management should take into account the quantitative and qualitative indicators of their activities, but the most important aspect of any logistics organization`s operation is, of course, financial indicators.

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