Science, Engineering & Education, 9, (1), 2024, 91-95

Example of Three-Step Modelling and Optimization with Goods and Transport Management in AnyLogistix Environment

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Received 13 October 2024, Accepted 30 October 2024
DOI: 10.59957/see.v9.i1.2024.12

ABSTRACT

This paper presents a concrete supply chain as analysed in the AnyLogistix environment, which includes network and transport optimization; analysis of the impact of inventory control and transportation policies, and creation of a three-tier supply chain model. An analysis of the elements of the interaction of their supply chain according to the assigned agents was made.

Keywords: *Agent-based modelling and simulation, supply chain, logistics system, Any Logistix.*

INTRODUCTION

Supply chain optimization is a complex dynamic model of the dynamic relationships between individual agents with production centers, warehouses, distribution centers, retailers or trade chains and mathematical modelling of supply chains by levels with a view to efficiently meeting customer demand.

Analytical modelling, which uses optimization models to study supply, while simulation modelling, which uses a set of objects and rules that describe their dynamic behaviour and their interaction to represent the supply chain.

AnyLogistix uses optimization and simulation, which makes it possible to solve real tasks such as planning:

- The location of facilities;
- Capacity of distribution bases;
- Inventory control;
- Sourcing and its policies;
- Transport, packaging and sales;

Thus, with set key performance indicators, information can be obtained through software simulation on:

- The best locations for warehouses and objects with different operational purposes;
- The best policies for replenishment, supply and transport;
- What is the cost of changing inventory policies, distribution center capacity, changes in demand, shortages, or new product introductions.

Thus, a global supply chain and management is oriented [1] to determine the best location for a distribution center, which is a common method for determining optimal locations for new facilities [2]. These "gravity models" choke the

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location to minimize all incoming and outgoing transport [3].

The design of the sample supply chain considered in this article consists of an analysis of the location of the relevant production and warehouse facilities, how the supply chain should be designed to satisfy the demand of each individual market [4] and the objective function is formulated:

$$Z = \sum_{s \in S} f_s \cdot y_s + \sum_{s \in S} \sum_{m \in M} C_{sm} \cdot x_{sm}$$

where f_s is the sum of annual costs if a new region is discovered, and the sum of (annual) costs is minimized by varying the values of the decision variables ys as well as χ_{sm}, which solutions set a characteristic network optimization as a set of interdependent binary solutions regarding the opening of the locations.

If each market is to be served by exactly one facility, it is necessary to ensure that:

$$\sum_{s \in S} x_{sm} = 1, \forall m \in M$$

.

If this is not fulfilled at least one market in M remains unserved.

Using optimization and simulation in supply chain design to find optimal locations for facilities and associating customers to those locations depicts the fundamental interdependencies between parameters in supply chain design.

Minimizing the function $Z(p_x;p_y)$, which is known as the object function of the distances $d((p_x;p_y);(x_i;y_i))$ between the location of the i-customer and the warehouse to calculate the transportation costs is done by:

$$Z\left(p_x; p_y\right) = \sum_{i=1}^{N} d\left((p_x, p_y);(x_i, y_i)\right) \cdot D\left(x_i, y_i\right) \rightarrow \min \tag{1}$$

And so, the determined object function (1) sets an option to calculate the optimal coordinates of the distribution center:

$$p_x = \frac{\sum_{j=1}^{N} \frac{D\left(x_j; y_j\right) \cdot x_j}{\sqrt{\left(p_x - x_j\right)^2 + \left(p_y - y_j\right)^2}}}{\sum_{j=1}^{N} \frac{D\left(x_j; y_j\right)}{\sqrt{\left(p_x - x_j\right)^2 + \left(p_y - y_j\right)^2}}} \tag{2}$$

$$p_y = \frac{\sum_{j=1}^{N} \frac{D\left(x_j; y_j\right) \cdot y_j}{\sqrt{\left(p_x - x_j\right)^2 + \left(p_y - y_j\right)^2}}}{\sum_{j=1}^{N} \frac{D\left(x_j; y_j\right)}{\sqrt{\left(p_x - x_j\right)^2 + \left(p_y - y_j\right)^2}}} \tag{3}$$

Thus, in the presence of the initial information necessary to implement the model for minimizing the transport costs of delivery. This basic information is:

- Who are the users and what are their locations;
- What are the products and their measurement units for quantitative characterization;
- What are the products sought by customers;
- What about the costs per kilometer for transport;
- What about the distances in the delivery network.

RESULTS AND DISCUSSION

A simulation model of an enterprise from the milk processing industry, based in northeastern Bulgaria, was examined. The subject of activity is the purchase of raw cow, sheep and goat milk and the processing and production of high-quality dairy products, such as white brine cheese, yellow cheese, yogurt, sour cream, fresh milk, ayran, processed cheese, cottage cheese

The enterprise has its own cow farm built and meeting all the requirements of the European Union.

The dairy products of the dairy have a traditional, authentic Bulgarian taste and excellent quality, which makes the company an established partner on the domestic and foreign markets. Modern, modern systems for control of the production process and production quality management are applied in the enterprise, and several international certificates for quality and food safety are maintained.

The proposed model is based on the following assumptions:

Geographical location

The production base is located about 34 km. southwest of the city of Silistra. The enterprise uses both its own production and buys it from the whole region of Silistra region.

The main customers are in Razgrad district - 2 large customers, Targovishte district - 2 large customers, Dobrich district - 2 large customers and Silistra district - 2 large customers. These are warehouses of both well-known retail chains and local merchants.

Optimization task

To determine the locations of distribution centers (warehouse bases), while minimizing transport costs.

To determine the locations of the distribution centers (warehouse bases) based on the consumed quantities of production and the net income on an annual basis.

Sequence of steps when creating the model;

Creating a scenario and determining the structure and parameters of the supply chain.

Defining consumer demand, transportation and supply chain procurement.

Parameterizing locations and policies.

Analysis and determination of the best locations for one or several warehouses.

Establish a database and collect supply chain performance statistics.

Simulate the supply chain design with the new warehouse locations and determine the impact.

The implementation of the optimization model contains several sequential calculation procedures for minimizing the transport costs based on the consumed quantities of production and the net income on an annual basis.

As a result, the number and locations of the two main storage bases for durable products from the product range (cheeses and yellow cheeses) were determined, presented in Fig.1.

According to the main customers, two distribution warehouse bases (distribution centers) were determined based on distance optimization:

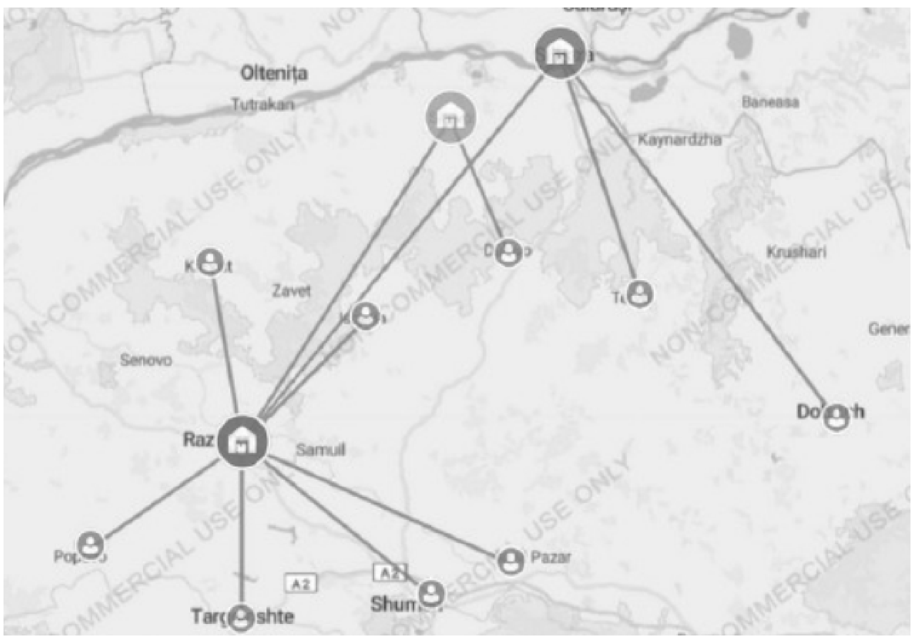

Fig. 1. Geographical distribution of warehouse bases and the main customers of the enterprise.

1) Razgrad warehouse base to serve: Razgrad region, Targovishte region and Dobrich region - a total of 6 large customers and

2) Silistra warehouse base to serve Silistra region - 2 large customers.

The block diagram of the supply chain is presented in Fig. 2

After determining the distribution centers, the scenario of the expected cash flows from the turnover on an annual basis is modelled (Fig. 3).

As a result of the modelled scenario, the company's management can assess the optimal location of its warehouses and distribution centers, bearing in mind that for this it is mandatory to set correct statistics on revenues and transport costs to date, as well as to a medium-term forecast has been made for the expected cash flows from the turnover.

CONCLUSIONS

In this article, a specific enterprise is presented, with assigned agents in an agent-based simulation model in the AnyLogistix environment. The specific block diagrams of the main elements and processes are set, and an analysis of the interaction of the set agents is made, as well as the

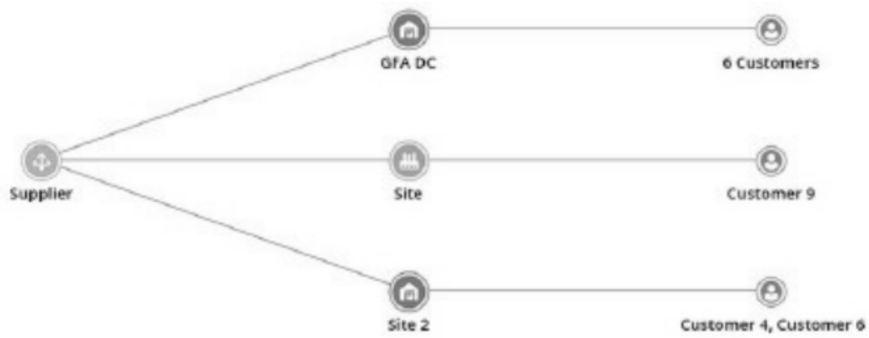

Fig. 2. The block diagram of the supply chain.

PRODUCT FLOWS

#	From	To	Product	Period	Flow, kg	Distance, km	Flow Cost Es
	filter	filter	filter	filter	filter	filter	filter
1	GFA DC	Добрич	айран	Time Period	740	98.951	73,223.584
2	GFA DC	Добрич	бяло саламурено си...	Time Period	740	98.951	73,223.584
3	GFA DC	Добрич	заквасена сметана	Time Period	740	98.951	73,223.584
4	GFA DC	Добрич	извара	Time Period	740	98.951	73,223.584
5	GFA DC	Добрич	кашкавал	Time Period	740	98.951	73,223.584
6	GFA DC	Добрич	кисело мляко	Time Period	1,480	98.951	146,447.168
7	GFA DC	Добрич	прясно мляко	Time Period	740	98.951	73,223.584
8	GFA DC	Добрич	топено сирене	Time Period	740	98.951	73,223.584
9	GFA DC	Дулово	айран	Time Period	740	54.557	40,372.464
10	GFA DC	Дулово	бяло саламурено си...	Time Period	740	54.557	40,372.464
11	GFA DC	Дулово	кашкавал	Time Period	740	54.557	40,372.464

Fig. 3. Distribution of turnover, according to distance and expected cash flows on an annual basis.

general options for modelling logistics processes in the context of minimizing transport costs.

The model approach and solution of a model task for optimizing the supply chain of a specific enterprise in the AnyLogistix environment is demonstrated. A distribution of the turnover was made, according to the distance and the expected cash flows on an annual basis.

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