Simulation in Logistics Network Context: Theoretical Approach of the Optimization Process

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Abstract

The aim of this paper is to demonstrate the complexity of the network and facilitate its design. Nowadays network cooperation is very prevalent but as for its development there are not any common design methods, so we try to identify the general factors which can improve the efficiency of the network. With a simulation program we can take different adjustments regarding the elements of the network (suppliers, customers, distribution centers and the network centre) in order to achieve minimum lead time, minimum cost, maximum efficiency and maximum benefits. For example in case of suppliers the following adjustments can be made: the interval time (the time during which it can fulfill the order), batch size leaving this object, capacity of the manufacturing line, the cost of the products (cost/unit and capital costs), the quality of the products.

Key words: logistics network, efficiency improvement, communication system, simulation, optimization

Introducing the Network Form

The network form is an integrated business model for logistics management. It covers the flow of goods from suppliers through manufacturing and distribution chain to the final consumer. Virtual organizations create a network of suppliers, manufacturers and administrative services to accomplish specific objectives, such as flexibility and responsiveness.

The network form is a developed cooperation form, which can provide numerous advantages for its members:

- multiplication of resources,
- reducing and sharing costs,
- more complex services,
- higher and more reliable incomings,
- cheaper purchasing,
- more intensive communication,
- getting more information for the market environment,
- faster innovation.
So, the network can operate as a complex company also providing numerous advantages for companies who have resorted to its services:

- more accurate transit times;
- more reliable transit quantities;
- providing continuous material supply;
- quality improvement;
- meeting the requirements comprehensively with the help of the online connection.

The basis of the network cooperation is the confidence between the members. Owing to the Internet, accessing information is easier than before, so people have much more possibilities to communicate and the geographical barriers of the information flow have ceased.

For the sake of feasibility and promptness of the network, the first aim of the network should be determined. Many industries have the possibility to form a network but now we will get involved in companies offering or requiring logistics services. The network of companies is coming together to exploit fast-changing opportunities. The network of companies is based on various strategic considerations and resource requirements, which include:

- strategic plan.
- human resource management;
- management of technology;
- purchasing;
- computers kills;
- barcoding and scanning technology;
- warehousing exhibition;
- fleet utilization systems;
- inventive management systems.

The members of the network start from market/customer demands and continue until these demands are fulfilled.

The potential members of the network are as follows:

1. Logistics center – having management and organizational tasks,
2. Logistics service companies – providing logistics services like transportation, storage, letting of means of transportation,
3. Manufacturing companies – manufacturing raw materials, semi-finished goods or parts,
4. Assembly companies – producing finished products,
5. Services companies – providing services (not logistics services),
6. Innovation centre – performing researches (like universities),
7. Local governments, chambers of commerce – can influence the operation of the network.

Among these elements we have to emphasize those which influence directly the reliability of the continuous material supply.

The tasks of the logistics network management are the following:
Determine, collect and process data which are necessary for choosing the members of the VLC;

Join the manufacturers and the costumers and join the logistic service companies and its client together;

Support the member companies to provide their products and services in high standard;

Possess the necessary information, thus help member companies to win tenders;

Work out the management structure (centralized, decentralized);

Determine and operate the controlling technology and the information background;

Has the right to allow a company to join the VLC or to disqualify a company;

Reduce the total expenditure of the supply chain by using effective marketing, production and distribution strategies;

Reduce the response time to fluctuations of customer demands and other changes;

Approach of the shortest term between producing and sale for the last consumer/customer;

Exploitation of the competitive advantage arising from the effective supply;

Operate the VLC, coordinate and supervise the customer-supplier relationship.

Strategies of the traditional customer-supplier relationship include:

Quality: The supplier is responsible for the meeting the customers specifications. The customer is responsible for the acceptance and must check the meeting of the Specifications.

Cost: The customer chooses a supplier, where quality is sufficient, primarily according to the lowest prices, following the law of supply and demand.

Delivery: The customer awards a contract stating desired product, quantity and delivery due date. Safety stock is necessary in order to avoid the problems caused by delivery delays.

Flexibility: The customer aims for multiple sourcing through finding new suppliers. If the transaction costs become too high, a make-decision is made.

The relationship between the companies in a logistic network: Starting from row-materials and standardized parts, it is the customer who develops all products and processes in the logistics network.

The customer delegates the manufacturing of semi-finished goods or parts of the manufacturing process to suppliers. The customer controls the quality of first deliveries. (Dávid Römer, 2002)

During the resource course a logistics network have been revealed to solve these problems mentioned above. The network consists of the logistical and informational elements extending from the demands of marketplace to the customer at the other. The network form allows interaction between customers, network trading partners and suppliers.

**Information Flow within the Network**

A central database should be created through which the communication can be possible. The internet plays a very important role in the networked economy. Information is used not only for operational ordering purposes, but also as a strategic, long-term resource for competitiveness and further innovation in the network. The database has to meet serious security regulations so that incompetent people could not reach it. This database will contain static data (for example:
the name, address or management of the company, etc.) and dynamic data (for example: scope of activities, resources, capacity, etc.), which can serve a reliable basis to the Logistics centre in taking its decisions. These data should cover a wide range of supplier information, including the following:

- Total number of suppliers;
- Geographic location and diversity (of production and shipping centers, as well as headquarters);
- Production capacity;
- Production flexibility – for example, can the supplier manufacture the company’s product line at multiple locations? (SAP-Understanding and Managing Supply Chain Risk, 2006).

The difficulty of concentrating information is caused by the large number of service providers using different transportation modes. The information is owned by the service providers. Due to the lack of a universally accepted, specific and complete communication standard it is not possible to implement automated computer to computer communication between each of these providers. IT architecture must be created which can integrate as many providers as possible, because this - along with several intelligent elements - is the foundation for the competitiveness of a logistics centre. Many of today’s supply chains, whether they are virtual or real-world, are not correctly measuring their performance. Some are not measuring it at all.

**Logistics Network Design**

Logistics optimization is currently the greatest opportunity for most companies to significantly reduce costs. Companies have made tremendous strides in automating transaction processing. Logistics, data capture related to logistics operation is neither easy, nor cheap. But for most logistics operations there is an opportunity to reduce cost from 10% to 40 % by making optimized decisions. Ten rules were found to be essential requirements for successful logistics optimization:

1. Objectives – objectives must be quantified and measurable. Objectives represent the ways in which we specify what we want to accomplish.
2. Models – models must faithfully represent required logistics processes. Models are the way in which operational requirements and constraints are translated into something the computer can understand and process.
3. Data – data must be accurate, timely and comprehensive. Data is what drives logistics optimization.
4. Integration – Integration must support fully automated data transfer: Integration is important because of the large amount of data that must be considered for logistics optimization.
5. Delivery – optimized plans must be delivered in a form that facilitates execution, management and control.
6. Algorithms – algorithms must intelligently exploit individual problem structures. The biggest differentiators among logistics optimization technologies are the algorithms.
7. Computing – computing platforms must have sufficient power to find optimum plans in the available time. Because of the enormous number of possible solutions in any real-world logistics problem, problems of any significant size require significant computing power.
8. People – People must ensure that the data and models are correct and that the technology is working as designed.
9. Process – business processes must support optimization and have the ability to continuously improve. Logistics optimization requires significant ongoing effort.

10. ROI – Return on Investment must be provable considering the total cost of technology, people and operations. It requires significant expenditures for technology and people. (Don Ratliff, 2003)

A Logistics Network Design initiative is a strategic analysis of your entire supply chain. Some of strategic questions must be asked as follows:

- Do we have enough facilities to ensure we can meet future capacity requirements?
- Which facilities should be closed and/or consolidated?
- Is there an opportunity to make changes to the network to reduce logistics costs?

In order to answer these complex questions, it is necessary to set a deadline. The duration of this designing period depends on the quality and availability of data from the systems. Here is a list of other key factors that need to be analyzed into the designing period:

1. Creation of the current financial model

Before you can make sensible decisions which can modify the design of the network, a ‘base case’ financial model needs to be developed. It should include the costs of all logistical activities such as warehouse costs, transportation costs, inventory costs, order processing costs and administrative costs, etc.

2. Data Gathering & Validation

This is one of the key drivers to a successful project. It is imperative that the data from your current data warehouse (transactional data) be accurate. So Information is used not only for operational ordering purposes, but also as a strategic, long-term resource for competitiveness and further innovation in the network. This data should cover a wide range of supplier information, including the following:

- Total number of suppliers;
- Geographic location and diversity (of production and shipping centers, as well as headquarters);
- Production capacity;
- Production flexibility – for example, can the supplier manufacture the company’s product line at multiple locations?

The difficulty of concentrating information is caused by the large number of service providers utilizing different transportation modes. The information is owned by the service providers. Because of the lack of a universally accepted, specific and complete communication standard it is not possible to implement automated computer to computer communication between each of these providers.

3. Create the Growth Plan

Typically, a strategic analysis should meet the objectives of the network for a long term period. Although it is difficult to predict the future with absolute certainty, growth rates should be estimated. Ensure that representatives from every major areas.

4. Analyze Current State of Operations

A throughput and capacity analysis should be completed for the existing operations. This will help determine if there is additional capacity in the existing facilities or if there is excess capacity available.
5. Model Validation

Once the project team has gathered all of the pertinent data it is time to create and validate the model. This is crucial as if the model does not reflect reality.

6. Develop Scenarios

Once the ‘base case’ has been validated, then the scenarios may be modeled. The results will show whether or not it is more economically feasible to do so. Once the scenarios have been run, the results should be analyzed for accuracy and feasibility.

After these steps, listed above, have been completed with high degree of accuracy leading to the realization process of the network, logistics managers can start their job.

Logistics managers must be capable and more responsive to design logistics networks more frequently to operate at the lowest costs while providing the best customer service. Security requirements, new trade agreements, shifting labor rates, space costs, supplier and customer locations, new carriers and products, lane congestion, and fuel costs play significant roles in network logistics design. Optimal network design/redesign minimizes inventory carrying, warehousing, and transportation costs while satisfying customer response-time requirements, according to Frazelle. Specifics include the network’s distribution levels and centers, location and mission of each facility, assignment of supplier and customer locations to each center, and inventory deployment. To create an optimal network design/redesign, Frazelle recommends a 10-step logistics network design process:

1. Assess/evaluate the logistics market, the supply and the demand.
2. Design and populate network database by right of the available data.
3. Create network design alternatives, such as more or fewer hierarchies, multi-commodity flows, merge-in-transit, direct shipping, cross docking, and supply-flow optimization concepts.
4. Develop network models.
5. Choose network optimization tool.
6. Implement network model in chosen tool.
7. Evaluate alternative network designs.
8. “Practicalize” recommended network structure.
9. Compute reconfiguration cost.
10. Make go/no-go decision.

Fig. 1. The decision making process using data from the central database
Every decision involves an analysis of possible future events (costs, outcomes, markets, etc.) and selection of a choice among competing alternatives. Making a decision is making a selection. Decision analysis is the process of dismantling a decision so as to determine the inputs and processes that went into arriving at a decision. It follows that the better our information and the more balanced and thorough the analysis, the higher can be the quality of our decisions. Better decisions are informed, reasoned, and balanced. Making better decisions means living with less risk. Every decision involves the analysis of available information and ultimately the selection of a choice among alternatives with varying degrees of uncertainty. High quality decisions are not the best decisions in hindsight. They are the best decisions in foresight. A high quality decision may not prove to be the optimum choice that could have been made. Instead, it is the best decision that could have been made given the resources and information available at the time of the decision. Decision making process can be seen in Fig. 1.

It is necessary to understand the four steps (broadly speaking) involved in making a decision.

1. Identify a problem;
2. Identify options or choices;
3. Comparative analysis;
4. Make a decision or choice. (*Brian Denis Egan, 2006*)

The database have been built up according to the principles of hierarchic data model, in which information is stored from companies (i.e. the manufactured raw materials, semi-finished goods or parts, manufacturing capacity, quality of the products, storage capacity, types of means of transport, other services). In connection with the material supply of a company questions are emerged as follows:

- which companies can manufacture the required raw materials, semi-finished goods or parts,
- what is the price and the quality of the products being manufactured by them,
- how far are the manufacturing companies from the client’s company,
- what is the capacity of these companies,
- are there any company being able to produce the whole amount of the required products,
- if there are not any companies being able to produce the whole amount of the required products, which group of companies can provide it,
- which logistics company or group of companies can transport the required quantity at the lowest price.

Logistics optimization is currently the biggest opportunity for most companies to significantly reduce costs. Companies have made tremendous strides in automating transaction processing. Logistics, data capture related to logistics operation is neither easy, nor cheap. But for most logistics operations there is an opportunity to reduce cost by 10% to 40 % by making optimized decisions.

**Logistics Simulation**

In the industrial area, simulation has been mainly used for decades as an important support for production engineers in validating new lay-out choices and correct sizing of a production plant. But now simulation programs are getting widespread among the logistics companies and they are used for more and more purposes. Simulation processes and models have many advantages and can provide several possibilities to logistics companies:

- it can model the material- and information flow of a complex logistics network;
using the simulation results the performance of the network can be evaluated, critical factors can be determined which mostly influence the network operation;

- the consequents of the decisions can also be analyzed;
- the effects of a factor can be tested without any consequents;

Optional influential factors can be defined in the simulation model, which can be classified according to the following:

- Controllable (departure schedule of trucks, sequence of loading) or uncontrollable (capacity and speed of trucks);
- Quantitative (capacity, loading time) or qualitative (physical capacity of a truck, priority of trucks).

The direction of the information and material flow can be seen very well in this figure that is the central management gets all the information, so it can take its decisions with great reliability and accuracy knowing the requirements of both clients and suppliers. This is the reason why a central database should be created through which communication can be possible (the decision making process can be seen above in Fig. 1.).

The first step of the simulation is to design the network, to which a few aspects should be taken into consideration:

- Scalability: the network should be unambiguous with its nodes and connections;
- Reliability: it means the redundancy of a network;
- Security: first we have to clarify the objects of the network (for example distribution network).

Secondly we have to determine those parameters we would like to measure and adjust the initial values.

Thirdly we have to adjust the upper and lower limit of the influential parameters and then we run the simulation process for many times and listen to the results. After the simulation we can use the results in the optimization process.

The main application area is the logistics planning, but these simulation models allow the analysis of logistics systems, determination of operational parameters. General operational
parameters can be the followings:

- Reveal of the bottle necks of logistics processes;
- Determination of the transportation safety parameters;
- Parameters of spooling-, time out- and waiting times;
- Analysis of the proportion of the incorrect and waste materials etc.

Operational parameters of production systems are as follows:

- Implementation of production devices into new systems;
- Determination, planning, developing and controlling the production capacity, analysis of the feed time;
- Determination of stocks necessary to the production process;
- Determination of the necessary maintenance capacity;
- Analysis of the incoming material according to different aspects;
- Determination of the production scale.

Controlling parameters are as follows:

- Analysis of investments and the efficiency of them and estimate the profitability;
- Business process reengineering;
- Determination of the human resource requirement;
- Consequents and effects of the controlling instructions to the operation of the logistics system.

A simulation model of a logistics network can be designed and realized either traditionally as a whole single model reproducing all nodes, or using more integrated models (one for each node), which are able to run in parallel mode in a single co-operating simulation.

**Conclusion**

In order to simulate the operation of a logistics network first we have to determine the objects of the network and then design the network and adjust the parameters. It is very complicated because there are numerous influential parameters, so we have to select those which are important to us. According to the results of the simulation process the decisions can be taken with great definiteness and the results can provide the data for the optimization process. Currently, it is common for a single logistics company to handle a package throughout its transport. With a simulation program the traveling time, traveling capacity, the shift patterns, the efficiency, the breakdowns, etc. can be determined.

By using the results of the simulation the requirements can be prevented with a relatively good punctuality because during the simulation process we can consider many influential random factors (for example breakdown of trucks, accident, etc.). The connections between the members can be registered and tracked and the requirements and the flexibility of the companies can also be tested and estimated. The large numbers of the network can be handled with simulation program, according to which we can examine whether the network is economical or not.
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Simularea în cadrul rețelelor logistice: abordări teoretice ale procesului de optimizare

Rezumat

Articolul își propune să demonstreze complexitatea unei rețele și să faciliteze designul său. În zilele noastre predominantă cooperarea în rețea însă nu există multe metode de design în ceea ce privește proiectarea sa, astfel încât este necesară identificarea factorilor generali care pot îmbunătăți eficacitatea rețelei. Printr-un program de simulare se pot efectua diferite ajustări cu privire la elementele rețelei (furnizori, clienți, centre de distribuție și centru de rețea) pentru a estima timpul total minim, costul minim, eficiența maximă și beneficiile maxime. Spre exemplu, în cazul furnizorilor, se pot efectua următoarele modificări: intervalul de timp (timpul necesar realizării comenzii), mărimea lotului, capacitatea liniei de producție, costul produselor (unitate de cost și costul indirect de investiții), calitatea produselor.