Multimodal Processes Approach to Supply Chain Modeling

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Abstract. The paper presents the results of conducted research works which concern one of the reference models for transport operations in supply chains. The research focuses mainly on defining the multimodal approach to supply chain simulation. In the paper, five basic models for a transport organization are defined. One of them, the relay model, is the base for the case study. Authors propose multimodal approach to prepare a simulation model. According to the defined approach, the procedure of analyzing and building a simulation model is described in detail.

Keywords: supply chain, transport, multimodal process, modeling, simulation.

1 Introduction

A supply chain is defined by the Council of Supply Chain Management Professionals [14] as follows: “Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology.”

Transport enables cooperation between companies that constitute a supply chain. It is one of the most significant factors affecting lives of the whole communities. Since 2011 the European Commission has been promoting a new transport policy, published in the new White Paper on Transport. The goals of this new policy are set into four main directions [6]:

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- reduction of the greenhouse gases emission by 60% by 2050 comparing to the 1990 level;
- efficient core network for multimodal intercity travel and transport;
- clear urban transport and commuting;
- creating global hubs in the European Union for long-distance travel and intercontinental flights.

Achieving these objectives requires joint (common) action of both producers of means of transport (eg. environmental aspect [8]) and their users, but especially companies providing transport services.

The organization of transport is a very complex issue which includes many aspects, such as route selection, modes of transport, problems with coordination. According to customers' requirements concerning the time and price, companies find new solutions. The analysis of activities performed in a supply chain enables evaluation and improvement of some aspects. Taking into consideration the solutions of organizing transport tasks we can define 5 basic models [11]: swinging model, swinging-continuous model, radial model, circular model, relay model. These models are the foundation of building and creating appropriate types of a supply chain. The conducted investigations concern the simulation models of the defined models of organizing transport tasks. Based on these models and using modern simulation technologies, we can perform experiments with different rules of management and coordination. We introduce the multimodal process approach to building simulation models of organizing transport tasks. This approach is used in other application like distance learning netowrks, e-learning [7]

The present paper concentrates mainly on:

- the new approach to analyzing transportation tasks,
- the definition of multimodal processes,
- using multimodal processes as the main idea of building a simulation model.

The article is divided into 5 sections. Section 2 refers to multimodal transport in a supply chain. In this section multimodal networks and multimodal processes are defined. Section 3 defines five models of organizing transport tasks and section 4 focuses on the case study based on a more complicated model, the relay model, which is most commonly used in supply chains. Finally, section 5 provides conclusions and suggestion for the further stages of the project.

2 Multimodal Processes in Supply Chain

This section discusses issues related to the analysis of supply chains using multimodal approach. A supply chain is actually a complex and dynamic supply and demand network [13],[10]. This network is formed by suppliers and companies which are connected with use of different kinds of transport. The identification of ineffective processes in both internal and external flow chains requires proper tools for the analysis and decision making.

Both logistic practice and literature on the subject provide various interpretations of intermodal and multimodal networks and transport [3]. These notions are similar in their scope and meaning, yet there are two significant differences between them. According to the Convention on International Multimodal Transport of Goods [12], the multimodal system of transport is defined as an internally integrated system of carrying goods along with accompanying services provided with use of at least two modes of transport on the basis of a multimodal transport contract. The multimodal transport contract is concluded by a multimodal transport operator who takes the responsibility for its performance. In case of intermodal transport, also at least two modes of transport are involved, however its specific feature is the fact that in the whole freight lane only one unit load is used.

The advantages of limiting the use of intermodal transport are as follows [9]:

- the possibility of offering combined freight services so that benefits can be derived from various modes of transport,
- the possibility of reducing the cost of moving goods without deteriorating the quality of freight services,
- the possibility of reducing damages and losses as well as handling and storage of goods by using pallets and containers,
- increasing the elasticity of deliveries by providing customers with better availability of services over time and space.

In simple words, we can assume that an intermodal chain of deliveries is a specific kind of multimodal logistics, which is characterized by a unified load unit, constant in the whole freight line. In the logistic practice, the most commonly used multimodal solutions are sea-air transport and rail-air transport. The multimodality in transport results from the development of containerization: various modes of transport have become more closely related due to fact that the modes of freight, storage and loading of unified load units had to become similar[1].

In the context of transportation networks, a multimodal network is the one in which two or more types of transportation modes (such as walking, riding a train, or driving a car) are modeled. Alternatively, with utility networks, a multimodal network may consist of the differing transmission and distribution systems [4].

The considerations presented above lead to the definition of multimodal processes, i.e. processes executed along the routes consisting of parts of the routes of local processes [2],[5].

3 Models Organizing Transport Tasks

A model, in which a means of transport runs regularly between two points (loading and unloading) is a swinging model. An example of such a model is the daily delivery of fresh meat to the company's butcher shop and then returning an empty vehicle to the base [11].

The swinging-continuous model of transport is a model, where a means of transport is not expected at a loading and unloading place. When it comes to the point, it takes a loaded or empty semi-trailer, trailer, container, body interchangeable and goes to another place. An example of such a model is the delivery of auto parts from subcontractors to a factory. These parts, for better protection, are often shipped in special boxes and containers. A subcontractor provides a full container of specified elements to the factory (the place of unloading), and takes empty containers that are transported to the loading place [11].

When goods are delivered by a means of transport from one place of loading to a lot of places of unloading, it means that we are dealing with the radial model. After unloading at a given point, a means of transport goes back to the place of loading, where it is re-loaded and products are transported to other collection points. An example of such a model is the delivery of products from a central warehouse to regional warehouses, which handle further distribution tasks [11].

Loading at one point and then delivering to the next unloading points is called circular model. It is characteristic for the courier and distribution activities [11].

Another model is the relay model (Fig. 1). It is also called cross-docking. In this model, transport is organized from a loading point to the final point of unloading with use of transshipment points. Goods are usually delivered to the reloading point in a large batch (by vehicles 33-trucks, trains or ships), and then reloaded to the lower means of transport and delivered to the customer [11].

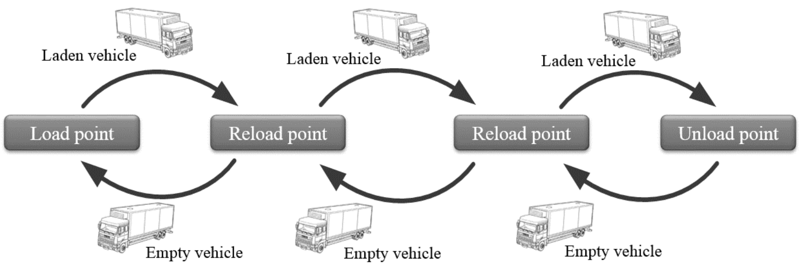

Fig. 1. Relay model. Source: [11].

4 Case Study – Relay Models

According to the definition, multimodal processes are processes consisting of local processes. The implementation of local processes determines the execution of multimodal processes.

In case of the relay model, we can distinguish one multimodal process (PM), whose goal is the delivery of goods from the point of loading to the point of unloading, taking into account the intermediate points – points of reloading – Fig.2. This process consists of three local processes:

- transport of goods from the load point to the reload point no. 1 (PL1),
- transport of goods from the reload point no. 1 to the reload point no. 2 (PL2),
- transport of goods from the reload point no. 2 to the unload point (PL3).

No	Resource
RA	Load point
RB	Reload point no 1
RC	Reload point no 2
RD	Unload point

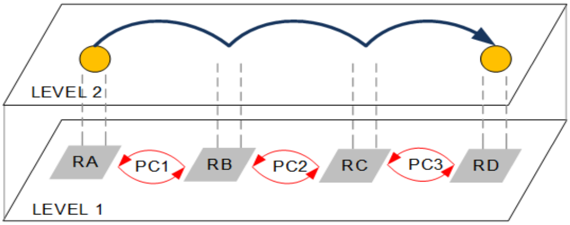

Fig. 2. Relay model – multimodal and local processes

It should be noted that Figure 2 does not show all the processes carried out within the framework of the planned supply chain. When discussing the issue of delivering goods from point A to point B, it is necessary to take into account the activities in the various points of loading, handling and unloading. For example, while analyzing the time of transport service, the time of loading and unloading at specified locations must also be taken into account. Therefore, for each of the highlighted points, it was crucial to present the processes that take place there and affect the transport tasks.

At the loading point, we take into account processes occurring between the part of the warehouse, where the goods are stored as part of the loading. In order to send goods to a customer it is necessary to download them from the storage, deliver them to the loading ramps, and then load them onto a means of transport. Goods can be transported by an employee with no use of equipment or with use of equipment such as a forklift. All these activities have an impact on the whole organized transport task, which directly affects the time of departure from the starting point. Here, we can distinguish two cyclic processes – Fig.3:

- transport of goods from the storage to the temporary storage in the loading parts of a warehouse (PC1),
- transport of goods from the temporary storage in the loading parts of a warehouse to the trailer vehicle.

No	Resource
RA	Warehouse – storage place
RB	Warehouse – place of temporary storage
RC	Load ramps – vehicle of trailer

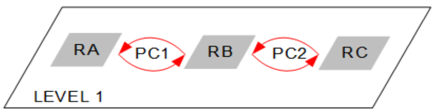

Fig. 3. Loading point – cyclic processes

Other places for consideration are reloading points. Depending on the role of a reloading point, we can distinguish different patterns of action. For the purpose of the present work, the following patterns of action, depending on their functions, can be defined:

1. unloading goods in unloading points and loading goods onto a means of transport, without storage operations (case 1),
2. unloading goods, temporary storage of them and then loading them onto means of transport (case 2),

3. unloading goods, reloading them, and then loading onto a means of transport, without storage operations (case 3),
4. unloading goods, reloading them, temporary storage of them and then loading onto a means of transport (case 4) – Fig.4.

No	Resource
RA	Unload ramps – vehicle of trailer
RB	Warehouse – place of temporary storage
RC	Warehouse – repackaging part
RD	Warehouse – storage part
RE	Warehouse – place of temporary storage
RF	Load ramps – vehicle of trailer

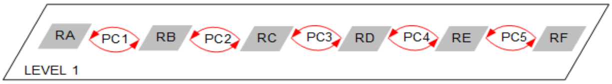

Fig. 4. Cyclic processes in a loading point – case 4

At the point of unloading, we should take into account the processes occurring between the unloading part (vehicle-trailer on the unloading ramp) and the storage area where goods are stored – Fig 5.

No	Resource
RA	Unload ramps – vehicle of trailer
RB	Warehouse – place of temporary storage
RC	Warehouse – storage part

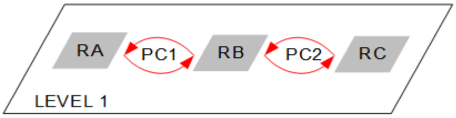

Fig. 5. Cyclic processes in unloading point

For this relay model, we decided to consider the largest number of activities (reloading points are responsible for repackaging and storage). Therefore, the processes are presented with use of the 4-layer approach [5]; Using this approach four levels are considered: business processes (layer 3), multimodal processes (layer 2), local cyclic processes (layer 1), resources (layer 0).

The presented analysis of the processes shows the influence of the operation at one level upon the activity located at a higher level. Therefore, it is possible to map operations that do not create any added value from the standpoint of the object of the process (in this case goods delivered from a company to a customer) yet, they are necessary for the functioning of the process. An example of such a situation is the return of a means of transport from the reloading point to the company or selected rides forklift.

The purpose of a supply chain is to transport goods from a supplier to the end customer (business process level).

The analyzed transport consists of one multimodal process. This multimodal process consists of a number of cyclic process (local), for example:

- load point - get the goods from the storage and transport them to a temporary storage (with a forklift or only an employee),

- the transport of goods from the load point to the reload point no. 1 (using means of transport)
- reload point no. 1 - the transport of goods from a trailer to TMS (with a forklift or only an employee),
- etc.

The lowest level represents resources that are involved in the next stages of the operations throughout the analysis process. Resources are as follows: place of storage in a warehouse (place of temporary storage/rack); place of temporary storage in a warehouse; place of temporary storage in a warehouse; unloading ramps, vehicle trailer; reloading point; loading ramps, vehicle trailer; transport routes at the point of loading; public transport routes etc.

Figure 6 shows the supply chain model as a multilayered model of the system behaviors of concurrent cyclic processes

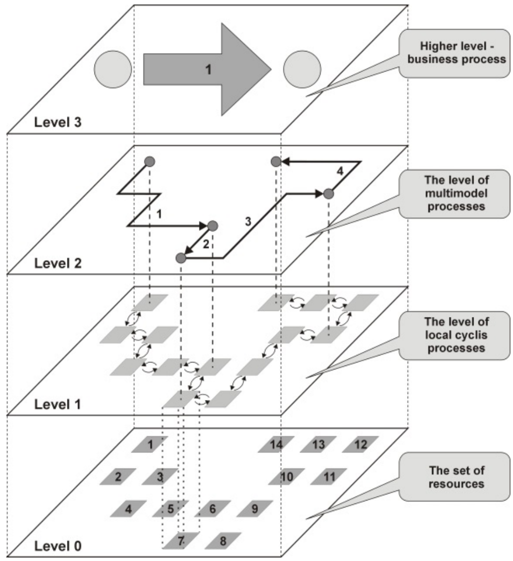

Fig. 6. Four levels approach to process analysis. Source: [5].

5 Conclusions and Further Investigations

The article presents the results of current investigations on developing multimodal approach to building simulation models of organizing transport tasks. A special emphasis was put on deploying the idea of multimodal processes. Based on this approach we analyze and build a simulation model of a logistics center where all transportation tasks are designed with use of multimodal approach. Figure 7 presents the whole simulation model built with use of FlexSim simulation program. Blue arrows present local cyclic processes, red arrows present multimodal processes.

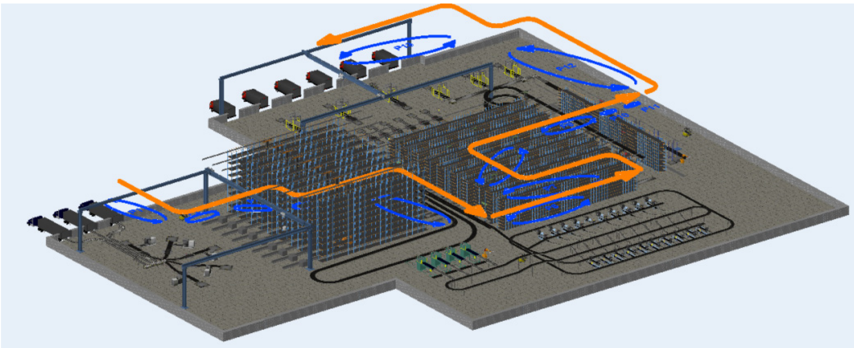

Fig. 7. Logistics Center simulation model constructed on multimodal 4 level approach

The main conclusions are:

- Specification of local processes and multimodal processes (there can be many) makes it possible to analyze every of them independently. It means that we can observe their behaviors independently with no necessity to observe other levels. We can specify the production tact time for every multimodal level and cycle time for a local process.
- It is easy to specify relations between the levels: to evaluate how behaviors of multimodal processes depend on behaviors of local processes and, on the other hand, how behaviors of local processes depend on multimodal processes.

Further stages of investigations will include extending this approach in order to build a complete supply chain simulation model based on the data from practice.

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