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AN APPROACH FOR MODELING COLLABORATIVE ROUTE PLANNING IN SUPPLY CHAIN SIMULATION

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ABSTRACT

Challenged by rising populations, modern cities are affected by the increasing effects of transportation such as congestion and greenhouse gas emissions. Collaborative route planning addresses this challenge by consolidating goods and optimizing transport routes to the customers within the urban area. This paper presents a modeling approach for collaborative route planning in supply chain simulation. A practical example for a collaborative planning implementation is presented using a discrete event simulation model. By comparing the delivery concept with and without collaboration on an exemplary supply chain, the potentials of collaborative planning in relation to the reduction of total transport distance are evaluated.

1 INTRODUCTION

The rising population in metropolitan areas is one of the major challenges of our time. By the end of the "Metropolitan Century", as the OECD calls it, the urban population will have increased from less than 1 billion in 1950 to roughly 6 billion in 2050. By 2100, it is likely to reach somewhere around 9 billion, corresponding to close to 85% of the world's population (OECD 2015). Logistics service providers operate in this environment of emerging cities. They are exposed to a variety of challenges resulting from the future development of markets, increasing environmental requirements, new technologies, and evolution of complex supply chains. A supply chain (SC) is defined as "the global network used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution, and cash" (Blackstone 2013). Supply Chain Management (SCM) is the control of the SC, or more specifically, the "design, maintenance, and operation of supply chain processes" (Ayers 2012).
The challenge lies in the increasing importance of costs and logistics performance (e.g. shorter delivery times, higher schedule reliability, and flexibility). Customers expect that the quality of services will rise, continuously. Thereto, city logistics service providers are embedded in complex supply chains, requiring the fulfilment of demanding customer promises such as tight delivery time windows in the environment of congested urban areas. This emerges for commercial customers (e.g. for timely deliveries in just-in-time production) as well as for consumers (e.g. in online retail or e-commerce activities). Also, increasing traffic within limited city space leads to negative effects in terms of emissions and congestion. Here, city logistics service providers compete against other road users for the scarce traffic space, which cannot be extended unlimitedly. Nonetheless, congestion is usually not considered in city logistics routing. Defiance of varying

infrastructure utilization may lead to lower service quality and higher costs of delivery (Ehmke 2012).

At the same time, looking through the urban environmental sustainability assessment carried out by cities and local authorities, the major impacts are generated by food transport, as confirmed by various "food miles" studies (Pirog et al. 2005; Coley et al. 2009). An increasing number of consumers prefer frequent, smaller-basket visits to neighborhood-based convenient stores instead of monthly shopping trips in big hypermarkets. Furthermore, consumers turn more and more towards quality food (e.g. organic food) and production origins (site-specific farming or preference for local producers). This is generally accompanied with a significant increase of online shopping, especially in big city centers, where consumers often request home delivery out of regular working hours. Thus, there is a trend towards having a larger number of smaller convenient and specialty stores in urban areas that need frequent direct-store deliveries of food products as well as more and more consumers requesting direct home delivery. These emerging trends create a new distribution landscape that calls for collaboration and consolidation of flows in order to control cost, traffic, and environmental burden in urban areas in order to achieve more efficient operations both environmentally and economically.

Therefore, collaboration concepts represent an excellent means to tackle future challenges of urban logistics. "Collaborative transportation and logistics pooling are relatively new concepts in research, but are very popular in practice" (Gonzalez-Feliu and Morana 2011). More and more companies see the potential benefits lying in such practices and express their interest in adopting them. The importance of reducing overall costs instead of just tackling individual costs is underlined both by researchers and the industry. All the participants should be aware of the other players' actions in order to achieve an efficient collaboration in one of the following ways: vertical relations among all the supply chain partners; horizontal collaboration among the shippers; transport and logistics outsourcing or sub-contracting to other companies; exchanging requests for transportation needs; sharing capacity (e.g. vehicles, warehouses) with other players; and sharing pick-up points or urban consolidation centers.

This paper presents a modeling approach for collaborative route planning in supply chain simulation., which shows the potentials in reducing both transport distance and therewith costs for the supply chain. The paper is structured as follows: The first part of the paper provides an overview of related work. In section 3, the authors list relevant literature which focuses on collaboration types in general. This section also exclusively addresses the applied simulation tool as well as literature on the subject of simulation of collaborations. The authors show that the presented approaches could not be used as a basis for the presented approach. Section 4 presents the modeling approach and an associated generation of an experimental sample. Section 5 closes the paper with a conclusion and an outlook on the potentials of the presented approach.

2 COLLABORATION IN SCM

The increasing complexity of processes encourages companies to work in teams or to form partnerships. A promising approach is the formation of collaborations. Building such relationships usually requires a slightly longer time than only to cooperate among each other. The following definition clarifies the aspect of shared responsibility.

"Collaboration is a process to reach goals that cannot be achieved acting singly (or, at a minimum, cannot be reached as efficiently). [...] Collaboration includes all of the following elements: jointly developing and agreeing to a set of common goals and directions; sharing responsibility for obtaining those goals; and working together to achieve those goals, using the expertise of each collaborator" (Bruner 1991, p.6).

Approaches to collaborative route planning deal with the question of how to exploit additional potential through the collaboration of several partners and resource sharing. The potential of collaboration lies in the division of costs, risks, and responsibilities to realize savings. By merging all redundant activities, further benefit advantages can be achieved. The motivation of this work is caused by the consideration that the collaboration of logistics companies in route planning can lead to a cost reduction and a higher delivery capability. In addition, collaboration offers an excellent opportunity to address the future challenges of city logistics and its impact protects both the environment and the infrastructure. The participation in collaborative models enables difficulties to be overcome in particular in the last mile. Thus, collaborations in logistics could reconcile economic, environmental, and social goals.

Lindawati et al. (2014) identified the motivations and barriers to collaboration in urban logistics that influence the decision to participate. The expected benefit is the essential influencing factor for participation. But, there are doubts that the costs and profits cannot be fairly shared among the partners involved. Collaboration participants also fear the loss of competitive intelligence through disclosure of information.

The scope of collaborations has been approached from various angles, resulting in different classifications. The following discussion distinguishes clearly between vertical and horizontal collaborations, resource sharing, and urban consolidation centers. In vertical collaborations, companies from different stages of the value chain and often from different kinds of business sectors work together. Horizontal collaboration denotes the cooperation between competitors in the same supply chain level offering similar or substitute products. This is usually the case when the collaboration participants operate in the same industry. In this case, competitive aspects have to be considered.

In the context of logistics, the main shared resources are information, infrastructure, management and planning tools, vehicles, and the staff. The sharing of information is regarded as a central component. Without exchanging information, other forms of resource sharing cannot be implemented. Infrastructure is the foundation for all processes, which on the one hand makes them possible, but on the other hand is also a framework for the planning and execution. A distinction is made between internal and external tools. For instance, internal tools include personal computers or the Intranets. External tools include AutoID technologies like barcodes or Radio Frequency Identification. An example for the sharing of one or more vehicles in the business environment is the "Corporate CarSharing". The staff comprises all actors who are necessary for the processing of the respective processes.

Logistics sharing in freight distribution is commonly observed in several real-life cases, but constitutes a less explored concept in the literature (Gonzalez-Feliu and Morana 2011). Most publications focus on information sharing in the context of vertical collaboration practices that enable independent members of the same SC to work jointly to plan and execute operations. For example, Ouzrout et al. (2010) try to answer the questions if there is a correlation between trust criteria and information sharing in a SC and if trust always increases the performance. With the help of a multi-agent simulation approach, the authors come to the conclusion that, in a SC, the level of trust directly impacts on the level and quality of information sharing, which improve performance.

An Urban Consolidation Center (UCC) is a logistics facility that is situated relatively close to the area that it serves (a city centre, an entire town, or a specific site from which consolidated deliveries are carried out within that area, cp. Allen et al. 2007). This concept is promising especially for large customers like hotels, hospitals, or airports.

3 DISCRETE EVENT SIMULATION OF COLLABORATIONS IN SCM

Discrete event simulation (DES) serves as an analytical and forecasting tool for complex systems. Collaborative logistics planning in the final stage of the supply chain is such a complex system due to the large number of variables. The challenges of collaborations have been discussed in detail in the previous section. By using DES, the benefits and the achievement of the aims of collaborations can be demonstrated. In this particular case, analytical tools and methods are not practicable. With the help of a simulation model, results of various scenarios can be investigated. This allows us for assessing which approaches promise a positive balance and keep losses low. The great advantage of utilizing distribution functions is the consideration of random variations, which can be integrated into the model, e.g., for delivery times and demands.

3.1 Literature Review on Simulation of Collaborative Logistics Planning

Nowadays, collaboration is a highly topical issue, but mostly with regard to upstream and downstream connections within a single supply chain (vertical collaboration). In these cases, the simulation of collaboration is used to reduce the Bullwhip effect or to support the configuration of a Vendor Managed Inventory (Hudnurkar and Rathod 2012).

Gonzalez-Feliu and Morana (2011) present an approach to evaluate the costs and benefits of collaborations within the urban freight distribution while combining simulation and optimization. An exemplary SC network is used to simulate four different scenarios. The network consists of five logistics providers, which have their own depot and in some scenarios their own satellite. Each of the total of 408 customers can be supplied by several organizations. In addition, there is a distinction between large and small distribution vehicles. Large vehicles are used for long distances; small vehicles are used for the delivery between satellites and customers. In the first scenario, as a starting point, no collaboration takes place. By slowly increasing the level of collaboration the author ends with the use of satellites for consolidation measures.

The author determines that the presented type of collaboration increase the distances. However, time savings were noted, but this can be attributed to the increased use of small vehicles which can be easily parked and better maneuvered through the narrow streets of downtown. As a conclusion it is noted that the simulation was not able to present any evident benefits of collaboration. Erdmann (1999) also deals with the consolidation of product flows in a handling warehouse. With the help of discrete simulation, the author quantified potential savings. The studies showed significant cost savings, emission reductions and also includes the issue of a fair cost allocation.

Another approach focuses on the exchange of customers' orders amongst last mile delivery service providers (Figure 1). Independent freight forwarders exchange shipment orders among themselves or sell them to each other when the individual contracts fit poorly into their own tour. Here, the exchange takes place before conducting a tour.

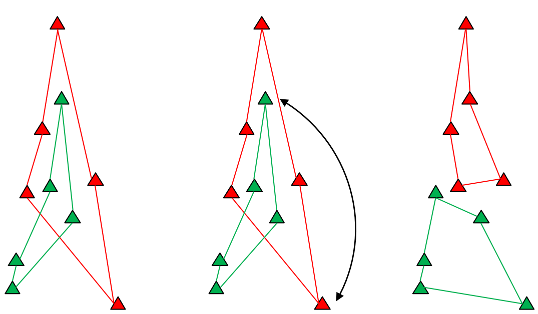

Figure 1: Exemplary exchange of customers' orders based on Schwind and Kunkel (2010).

A forwarder is considering the exchange of a customer's order, but only if he expects a benefit, e.g., that the expected revenue exceeds the cost incurred. Schwind and Kunkel (2010) have developed a simulation-based software solution named *KolOptNet* that enables route planning without predefined fixed delivery areas. This method enables short-term exchanges of contracts in order to optimize the routes and allows for taking into account the delivery restrictions.

3.2 SimChain

SimChain is a discrete event simulation tool, which has originally been developed as a class library for the simulation tool *Plant Simulation* under the name *ICON-SimChain.* The structure and the modeling approach of *SimChain* has been described by Alicke and Gutenschwager (2004).

SimChain consists mainly of three major parts: a graphical user interface used for model configuration, a database in which all configuration data and simulation results are stored and a DES supply chain simulation framework based on *PlantSimulation*. All model elements are generated automatically in *PlantSimulation* using building blocks from a predefined template library. The data model of *SimChain* contains database tables for all essential information that is needed to describe a SC. It includes basic tables and configuration tables. The information from the basic tables describes the general structure and layout of the logistics system (e.g. geographical information of sites, suppliers, and customers), whereas the configuration tables are used for the detailed specification of the dynamics of the system. This includes the allocation of Stock Keeping Units (SKUs) to sites or the customer demand for SKUs at a site (Rabe and Dross 2015).

Starting from production sites, SKUs are either transported directly or using a hub location. Transport volumes depend on the availability of SKUs at the sites and on the customers' demand. After the allocation of SKUs to resources, the SC nodes are sourced with SKUs considering the reliability of transport.

In order to instantiate different scenarios, a specific template combination is used with the aim to support SC decisions (Rabe et al. 2012). The sourcing routes are defined as sequences of transport relations in order to model different delivery strategies and by defining scenarios within the data model. Hereby, a scenario is defined as a set of configurations as shown in Figure 2.

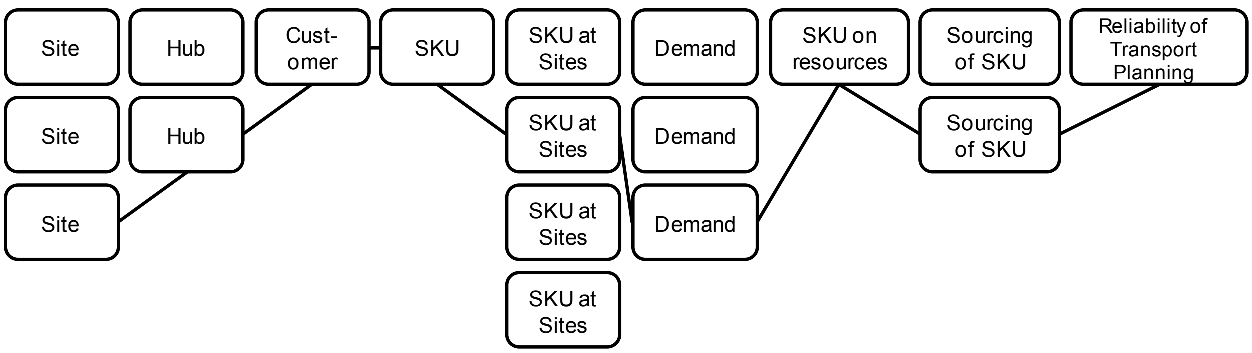

Figure 2: Exemplary setup of scenarios based on Fechteler and Gutenschwager (2014).

After allocating the sites to routes, *SimChain* offers two types of tour planning. The tour can either be determined within the data model or calculated dynamically. When there was no sequence defined in which order the sites should be driven to, the order is generated dynamically within the simulation run. The model uses the geo-coordinates from the database to calculate the route distance and calculates the shortest route using a savings algorithm.

4 MODELING APPROACH

In this section, various conceptual models are discussed in terms of a collaborative route planning to understand how the companies must organize themselves. As the different collaboration models depict realistic scenarios, the advantages and disadvantages regarding the implementation in practice can be captured. This is followed by considerations on the implementation of collaborative route planning in the tool *SimChain*. Using the simulation results, a statement can be made whether a collaborative cooperation of warehouse operators can achieve economic and environmental objectives.

4.1 Delivery Concept without Collaboration

For the initial situation, we assume that no horizontal collaborations exist. As briefly mentioned in section 2, this is a frequent case due to the non-existing trust in the potential collaboration partners. In order to verify the expected benefits of the collaborative route planning, an exemplary scenario of a supply chain is developed. It includes four warehouses in the suburban area each with five end customers, leading to 20 customers in the urban area. Figure 3 shows the current state. It is obvious that each warehouse acts on its own so that a full capacity utilization of the vehicles cannot always be achieved.

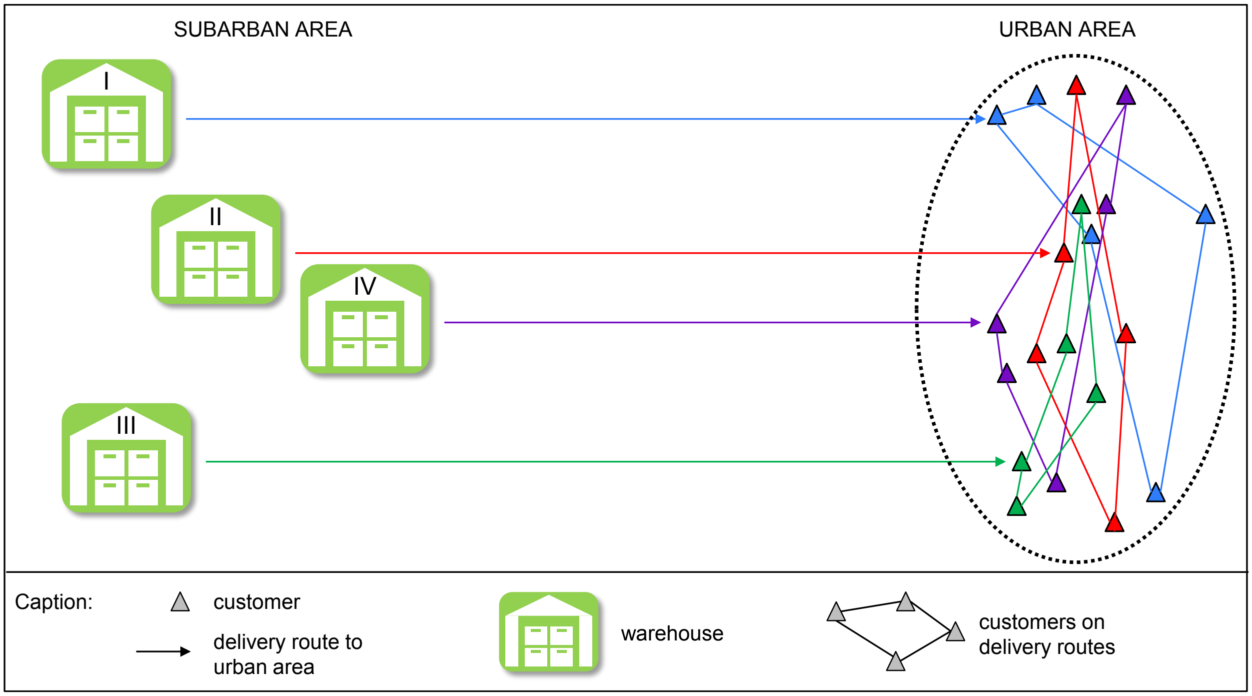

Figure 3: Current state of delivery concept without collaboration.

4.2 Modeling the Collaborative Route Planning

The idea of a collaborative route planning is demonstrated by Figure 4. In this scenario, a vehicle first heads for all warehouses in order to pick up the ordered products. Then, an optimal route is determined to reach all customers in the urban area. Through the collaboration, the number of operating vehicles, the number of required drivers, and the total covered distance can be minimized. In this paper, two collaboration models are introduced.

In the first model, each operator of a warehouse has its own vehicle fleet. The collaborative route is conceived to integrate all involved warehouses. Thus, there is the option to define each of the warehouses as a depot from where a tour starts and ends. The tour is completed with the corresponding fleet of the designated depot. The drivers of the vehicles remain entirely subject to the supervision of the warehouse from an organizational und legal point of view. The prerequisite for the realization of this collaboration is the merging of order information. From the point of view of equality and justice, the cost allocation between all participants takes place subsequently.

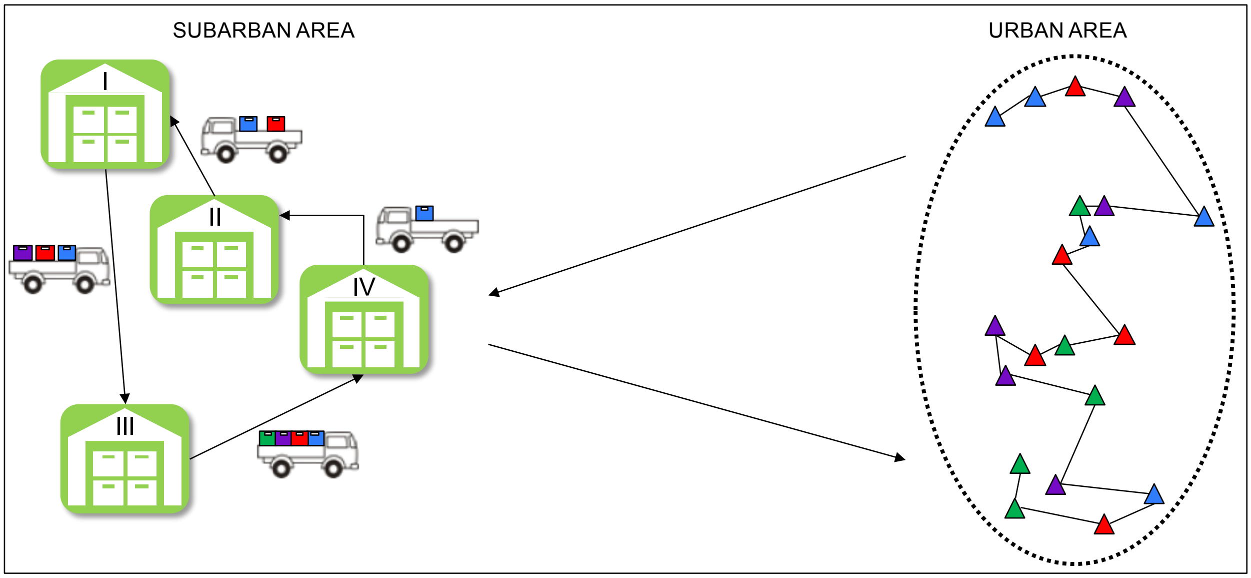

Figure 4: Target state of delivery concept with collaboration (case 1).

In the second model (Figure 5), a joint vehicle fleet exists for all companies. The fleet is located in a vehicle depot, which is located in the urban area. As the name “vehicle depot” already suggests, the vehicles are scheduled to remain at the depot at the end of the day. The vehicles are intended for joint use only. The vehicle drivers are associated to the collaborative community. The operators of the warehouses share the costs for the vehicles, the drivers, and the vehicle depot. The companies do not own additional vehicles. Thus, the joint vehicle fleet is the only possibility to satisfy the customers. The advantage of this approach is that the vehicles can have a neutral, or even a unified design.

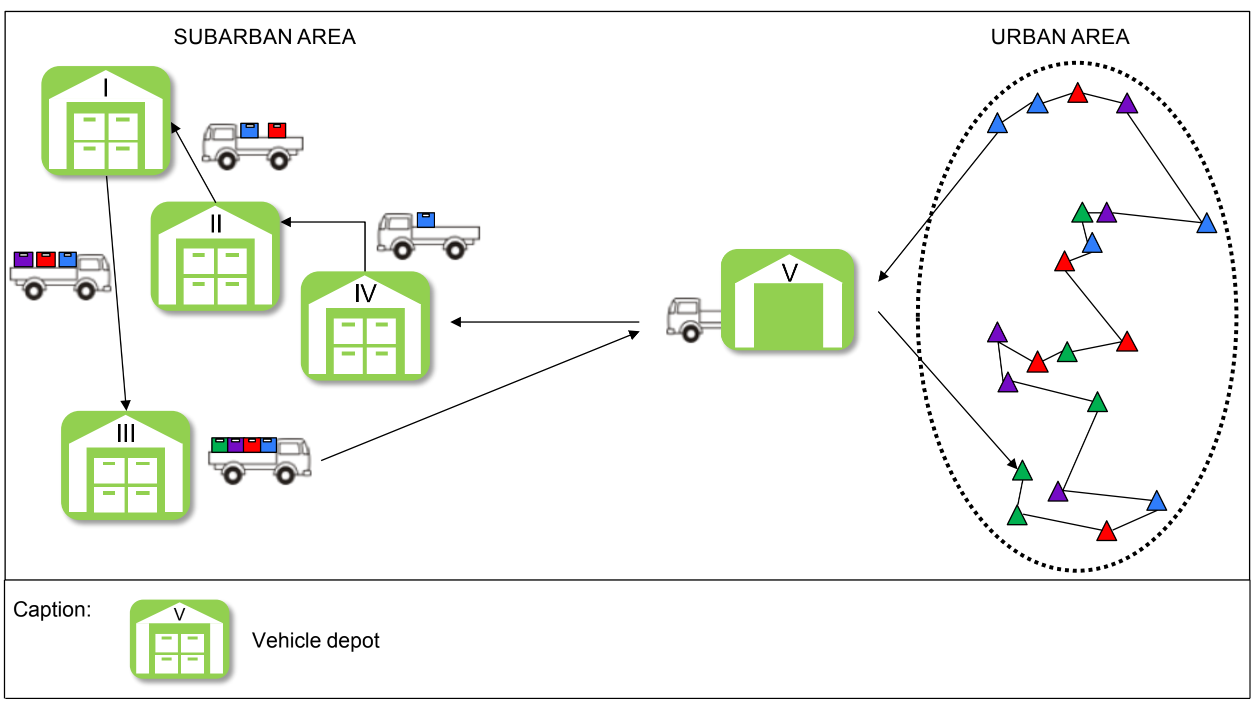

Figure 5: Target state with an additional vehicle depot (case 2).

4.3 Implementation

The next task is to implement the collaboration models in the simulation model and to execute these in order to obtain useful results. Through the simulation, the assumption that there is an enormous potential for cost savings and efficiency gains can be confirmed or rejected.

The collaboration approaches presented in section 3.1 are different to the shown collaboration situations (cp. Figure 4 and Figure 5). They either deal with the consolidation of material flows or with the exchange of customers' demands. A considerable amount of overlap between customers is necessary for the consolidation of material flows, but this fact cannot be assumed from the outset. The exchange principle is designed to achieve an improvement of the individual routes of the companies, but the routes are still isolated from each other. However, our approach aggregates all customers' orders with the aim of only one common route.

The first consideration is that the procedures illustrated in Figures 4 and 5 can be seen as a Vehicle Routing Problem (VRP). Thousands of companies and organizations are confronted with VRPs every day, once the delivery and pickup of goods or persons are concerned. If a warehouse is defined as a depot and the other warehouses as its customers, or a vehicle depot does exist, then we have a typical Traveling Salesman Problem (TSP). The collection of the goods can be treated identically to the delivery of goods, since this fact is only determined by the sequence of activities. For a pick-up of the goods, the vehicle is initially empty and is getting loaded step by step. For a delivery of goods, the order of activities is reversed. The number of vehicles, the capacity and other constraints are not affected thereby.

A wide range of optimization algorithms exist to solve a VRP and accordingly a TSP. For the collaborative route planning, we decided to use the Savings Algorithm. This method has already proven effective in terms of fast computing and its simplicity in numerous research activities and industrial applications. Probably, the Savings is the most widely used method in practice. Here, a route is created initially for each customer that leads from a starting point (depot) to the customer and back again. Then, tours are systematically linked, which allows for savings.

The key advantage of using the Savings method is the fact that these solutions have been implemented in the VRP block of *SimChain* for the route planning in terms of the end customer delivery. This algorithm does not need to be reprogrammed and the calculation instructions are fully maintained. This is due to the fact that a data-driven simulation is applied. The implementation of the collaborative route planning in the simulation tool SimChain can be managed with little effort; only the entries in the underlying data model have to be adapted. The data that are needed for the VRP method can be found as entities and attributes of the entity types *Routes* and *LocationsOnRoute.*

4.4 Simulation Results

In order to verify the potentials of collaboration, six different scenarios were simulated with *SimChain*. The experiment takes place in Berlin, Germany where we examine the distribution of food from online supermarkets. The warehouses are located as follows (longitude and latitude): Warehouse 1: 52.732095, 13.216268, Warehouse 2: 52.635709, 13.434967, Warehouse 3: 52.548969, 13.695370, Warehouse 4: 52.582775, 13.316428, and the Vehicle Depot: 52.572804, 13.427707. Overall 400 customers are considered, which are located in the city center of Berlin. In total, we generated 3725 orders for a simulated period of 3 months without a detailed look at weekends or holidays. For every customer, the probability to place an order is about 10 percent, which means that for all warehouses 40 orders exists per day. In addition, differences in the distribution of market share have also been considered. As we do not have the exact information about the traded products, we have decided to define the stock keeping unit as a delivery box. For the simulation, it is not relevant to know exactly what is inside. Having a normal distribution, the volume of orders per customer varies between 1 and 3 boxes. The capacity of the delivery vehicles is up to 100 boxes. An extract of the results of the simulation experiments is listed in Table 1.

Table 1: Simulation results.

Scenario	Description	Distance (km)	Deviation (percent)
No Collaboration	Current state	149	±0
With Collaboration Case 1	Warehouse I as Depot	155	+4
	Warehouse II as Depot	126	-15
	Warehouse III as Depot	147	+ 1
	Warehouse IV as Depot	124	- 17
With Collaboration Case 2	Vehicle Depot V	116	- 22

For obtaining a comparable value, we calculate the total route length of the current state (Figure 3). For the creation of the best route constellation, the respective customers are placed closely to the involved warehouses. As a result, the shortest transport route has 149 kilometers. Then, we run the model without the additional vehicle depot (Figure 4). The savings of the total covered distance due to joint route planning are considerable. Depending on which warehouse is selected as the depot, we obtain savings up to 17 percent of the covered distance. Stated in numbers, the routes are 124 km to 155 km long.

The calculated transport route of the collaborative model with a joint vehicle fleet (Figure 5) even achieves savings of 22 percent (116 km) compared to the best case of the current state.

5 CONCLUSION AND OUTLOOK

In this paper we have discussed the challenges of food distribution in urban areas and presented an approach for modeling collaborative tour planning to address these challenges. A modeling approach for collaborative tour planning was introduced using the a data-driven simulation framework *SimChain*. With an exemplary supply chain, the current state of food distribution in an urban area has been modeled with multiple transport relations. In a second scenario, the same example has been implemented with a collaborative tour using a common route. The collaborative tour planning was considered as VRP optimization problem and solved with a Savings algorithm. In order to evaluate the potentials of collaborative planning, both scenarios were simulated and the simulation results compared.

The collaborative tour showed the potentials in reducing both transport distance and therewith costs for the supply chain from 17 percent. In the next step, the route planning algorithm of *SimChain* will be modified since the currently used route planning algorithm calculates a round tour that finishes at the first depot which unnecessarily generates a route from the last customer back to the first depot. After that, the potentials of collaborative tour planning will be further examined on larger data sets, observing complex SCs over a longer period of time (e.g. one year).

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REFERENCES

Alicke, K.; K. Gutenschwager. 2004. “Supply Chain Simulation mit ICON-SimChain”. In: *Logistik Management*, edited by T. Spengler; S. Voß; H. Kopfler. p. 161-78, Heidelberg, Germany: Physica

Allen, J.; G. Thorne; M. Browne. 2007. “Good Practice Guide on Urban Freight Transport. Best Urban Freight Solutions.” Rijswijk, Netherlands. http://www.bestufs.net/gp_guide.html [Accessed March 20, 2016].

Ayers, J.B. 2012. *Encyclopedia of Supply Chain Management.* Boca Raton, FL: CRC Press Inc.

Blackstone, J. H. 2013 *APICS Dictionary*. 14th ed. Chicago, IL.: APICS.
Bruner, C. 1991. "Thinking Collaboratively: Ten Questions and Answers to Help Policy Makers Improve Children's Services." Vol. 3 Series on collaboration. Washington, DC: Education and Human Services Consortium.
Coley, D.; M. Howard; M. Winter. 2009. "Local Food, Food Miles and Carbon Emissions: A Comparison of Farm Shop and Mass Distribution Approaches." *Food Policy 34(2), 150-55.*
Ehmke, J. F. 2012. *Integration of Information and Optimization Models for Routing in City Logistics.* New York, NY; Springer Science+Business Media.
Erdmann, M. 1999. *Konsolidierungspotentiale von Speditionskooperationen: Eine simulationsgestützte Analyse.* Gabler edition Wissenschaft. Integrierte Logistik und Unternehmensführung. Wiesbaden, Germany: Deutscher Universitätsverlag.
Fechteler, T.; K. Gutenschwager, 2014. *SimChain: Technical Documentation.* Braunschweig, Germany.
Gonzalez-Feliu, J.; J. Morana. 2011. "Collaborative Transportation Sharing: From Theory to Practice via a Case Study from France". In *Technologies for Supporting Reasoning Communities and Collaborative Decision Making*, edited by Yearwood, J.; Stranieri, A., 252-271. Hershey, PA: Information Science Reference.
Hudnurkar, M.; U. Rathod. 2012. "Collaborative Supply Chain: Insights from Simulation." *International journal of systems assurance engineering and management* 3/2: 122-144.
Lindawati; J. van Schagen, M. Goh; R. de Souza. 2014. "Collaboration in Urban Logistics: Motivations and Barriers*." International Journal of Urban Sciences* 18/ 2: 278-290.
OECD 2015. *The Metropolitan Century – Understanding Urbanisation and its Consequences.* Paris: OECD Publishing.
Ouzrout, Y.; L. Chaze, L.; O. Lavastre, O.; C. Dominguez, C.; S.H. Akhter. 2010. "Simulation of Trust in Supply Chains." In *Supply chain performance,* edited by V. Botta-Genoulaz; J.-P Campagne,.; D. Llerena; C. Pellegrin. 267-315. London, Hoboken, N.J.: ISTE; Wiley.
Pirog. R.; A. Benjamin, 2015. *Calculating Food Miles for a Multiple Ingredient Food Product*. Ames, Iowa: Leopold Center for Sustainable Agriculture.
Rabe. M.; F. Dross. 2015. "A Reinforcement Learning Approach for a Decision Support System for Logistics Networks" In *Proceedings of the 2015 Winter Simulation Conference (WSC)*, edited by Yilmaz, L., Chan, W. K. V., Moon, I., Roeder, T. M. K., Macal, C.; Rosetti, M. D., 2020-32, Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.
Rabe, M., S. Spieckermann, A. Horvath, and T. Fechteler. 2012. "An Approach for Increasing Flexibility in Green Supply Chains Driven by Simulation" In *Proceedings of the 2012 Winter Simulation Conference (WSC)*, edited by C. Laroque, J. Himmelspach, R. Pasupathy, O. Rose, and A. M. Uhrmacher, 3144–55, Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.
Schwind, M.; M. Kunkel. 2010. "Collaborative Optimization of Last Mile Networks for Courier, Express and Parcel Delivery Services" In *Multikonferenz Wirtschaftsinformatik 2010*. Göttingen, edited by M. Schumann, 1961–1973. Göttingen, Germany: Univ.-Verl. Göttingen, c/o SUB Göttingen

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