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Systematic Logistics Service Engineering: Computer Simulation for Tender Management in Contract Logistics

Systematische Logistik-Dienstleistungsentwicklung: Computer Simulation für das Tender Management in der Kontraktlogistik

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Abstract: The paper at hand addresses the complexity a 'solution designer' faces during tender preparation in contract logistics. Taking into account the naturally high degree of uncertainty and inconsistency of the available data, the method of computer simulation is chosen to allow comparison of the multitude of possible solutions. The innovative character is given through the thematisation of the layout's influence on the quote resulting from a tender process. The developed decision support system is based on three main factors, which are temporal evolvement and respective distribution of data, implementation of a moderated process for systematisation, and modular structure to maintain flexibility. In cooperation with a large German logistics service provider, expert interviews were conducted and the computer simulation was validated. The result yields a simulation-based decision support system, which helps to generate a reliable, transparent, and competitive quote during tender preparation.

1 Motivation and Introduction

In Germany, contract logistics is with about 40% of the logistics market volume by far the largest sub-market in the logistics sector and accounts for ¼ of the European contract logistics market (Kille and Schwemme 2014). The term contract logistics describes logistics services that are customer specific and show long contract durations due to the high complexity of the service (Wecker and Otto 2007). Traditionally, contract logistics providers are selected by tendering. The framework process from the first customer contact to the business deal goes through various stages of decision and recalculation. Often the deadlines to submit tenders are rather short, which limits the possibilities to take all potential solution designs into account (Goetschalckx et al. 2001). This is especially critical, given the fact that there are a multitude of factors influencing quality and costs of a specific solution (Dallari et al. 2008; Gray et al. 1992). For the contract logistics provider this means that the tender preparation is a time-sensitive step, but a cost-critical, too. Wrong assessment of the actual costs can lead to a legally binding contract that is not cost-covering for the contract logistics provider in the long term (Wecker and Otto 2007).

Especially critical is the assessment of warehousing services and here particularly the aspect of order picking. Despite the fact, that automation and digitalisation make rapid progress nowadays, the number of warehouses that are operated manually, amounts to more than 80% (De Koster et al. 2007; Napolitano 2012). Within this, the most common configuration is the picker-to-parts strategy (De Koster et al. 2007). From the total operating costs in such a warehouse, about 55% of the costs arise from the order picking process. Thus, a miscalculation on this position can lead to great losses. Simultaneously, there is empirical evidence that factors like selected routing strategy and deviations from that strategy as well as influence of human behaviour like picker blocking and maverick picking can have great impact on the picking performance (Elbert et al. 2015 & 2017; Glock et al. 2017). According to Goetschalckx et al. (2001), the tender process in practice relies heavily on 'ad-hoc insight and experience' of the solution designers, which are the employees preparing the tender documents as response to the customer's request for quotation. A literature review by Rouwenhorst et al. (2000) confirms the lack of holistic decision support systems (DSS) that take into account the requirements of practical application like time-restrictions and usability. Resulting from the complexity and uncertainty of the decision problem, a solution designer cannot guarantee for the quality of the planning results. Establishing a systematic decision support is the logical step to handle this issue.

On the one hand, there is the growing market of contract logistics with extremely complex decision problems and highly individual customer demands (Prockl et al. 2012). On the other hand, there is research on distinct warehouse design problems and sophisticated simulation models with modelling periods of weeks. The research gap is presented by the obvious discrepancy between the need for an appropriate DSS in practice and the existing research. Having this in mind, the research goal of the paper at hand is: *Development of a simulation based DSS for practical application by solution designers in contract logistics tender management.*

In the first step we concentrate on the decision problems in the area of warehousing services, especially order picking. Emphasis is on the systematic consideration of the layout as the effects of different designs and assignment policies cannot be surveyed manually by the solution designer. The DSS is developed in a case study design with a large German logistics service provider.

The structure of the remainder of this paper is as follows: In section two, the literature on the topic at hands is reviewed. Subsequently, the framework conditions of the case identified in the focus group interviews are explained. The fourth section presents the simulation-based DSS including the underlying reasoning for the chosen design. It covers the description of the front end in form of Excel user forms as well as the interaction loop between user, front end and back end realised in the software Siemens Plant Simulation. The paper closes with a discussion of the developed DSS and gives an outlook on the necessary steps for empirical validation.

2 State of Research

In recent literature, there is a large body of research for the different aspects of warehousing services that play a role in contract logistics. Two issues of major interest can be identified. Firstly, there is a large database on warehouse design. Secondly, the management of warehouse operations is researched and discussed (Gu et al. 2007). The authors developed a framework to structure the decision problems within both categories. The aim is cost and throughput time minimisation while achieving high performance. In order to realise this goal, the most popular methodologies are mathematical modelling or computer simulation striving for optimisation of an objective function (Staudt et al. 2015). In conclusion, this leads to a wide range of research, optimising detailed aspects of an order picking system. Examples are given by Zhang et al. (2002) who propose storage location assignment with genetic algorithms as well as a work on the application of heuristics for routing by Roodbergen and de Koster (2001). Malmborg (2001) also uses heuristics for rack configuration. In their reviews, Gu et al. (2007 & 2010) find research papers to every of the above-mentioned subcategories. They assign them to one of the three methodologies of benchmarking, analytical and simulation modelling. Their conclusion is that the overall focus is rather on analysis than synthesis. Furthermore, they point out the need for integration of analytical and simulation approaches in order to combine the methods' respective strengths. The authors' call for decision support integrating the different decision problems in one model can be confirmed when looking at recent literature on the topic. Most research is focused on a segment of the whole warehouse design and operation problem or only one of the multiple decision problems. An example is given by Klodawski et al. (2018) who research the dependency of picker blocking on storage assignment and picking policy. They clearly state the necessity to consider various factors when analysing an order picking system, but limit their research by proposing 19 assumptions for their simulation model, only varying the above-mentioned factors.

Besides manually operated warehouses research also includes automated components in warehousing like efficient employment of AGVs (Ribino et al. 2016) and blocking effects in automated fleets (Roy et al. 2016). Overall, works taking into account multiple decision problems are comparatively rare. Andriansyah et al. (2011) discuss a holistic design approach for automated storage/retrieval systems using a modular simulation. Equivalently, Altarazi and Ammouri (2018) propose a simulation-based decision support for manually operated warehouses including several partial decisions. Bozer and Aldarondo (2018) give a comprehensive analysis of relevant influencing factors, too. In their work, they compare two goods-to-person systems for online retail with a clear focus on the practical usage context.

Nonetheless, the practical applicability of the research works at hands is questionable. Few show a clear connection to practice and even less meet the requirements of a decision process in business context as for example in tender management. As Gu et al. (2010) state, existing research does not take into account the time restrictions, contract logistics service providers are facing during the tender, thus leading to ponderous mathematical or simulation models with low flexibility and operability. The work of Kofjač et al. (2009) is an exception as it deals with a simulation-based DSS for order managers in the context of inventory control with focus on operability. With the help of a case study, they could confirm the easy to learn operability, which they find to be essential for the success of the system.

Although such examples are scarce, some of the mentioned papers take applicability of the research into account and go for more common order picking system configurations (de Koster et al. 2007). But even those application oriented works seem to neglect the key issue: time. While decisions in large investment projects are often supported by modelling and simulation, the case is different for contract logistics service providers. Building a simulation model from scratch with verification, validation and simulation experiments can take a lot of time, which is not available in the short tender process. Consequently, computer simulations are seldom used in contract logistics tender processes although presenting a highly valuable tool for logistics service design (Goetschalckx et al. 2001). Especially for complex decisions with a great deal of uncertainty, a systematic support is needed to successfully deal with the challenges of inconsistent data and reduced transparency, which arise from a non-standardised tender preparation process. The mentioned challenges from practice support the view that warehouse problems need to be addressed in a joint approach by research and practice in order to narrow the gap between academic and operational approaches to warehouse design (Gu et al. 2010).

3 Methodology and Approach

A case study is conducted with a large German contract logistics service provider focusing on highly customer specific solutions. A thorough analysis of the challenges solution designers are facing during the tender preparation was done by conducting interviews and referencing to historic data of the company. Based on the insights gained through the focus group interviews, a conceptual model was designed and validated within the focus group.

3.1 Case Study

The reasons behind the case study's objective were foremost the number of tender processes handled throughout a certain period and thus the existence of a tender management department. Furthermore, due to the size of the company and the strategic positioning, the focus is rather on customer specific requests than on standardised logistics services for only a distinct industry. This puts emphasis on the need to deal with highly individual tender preparation for each request. The case study included interviews with a focus group with a core of four employees in different positions of the logistics service provider and three academic members. Additionally, individual interviews were conducted with a warehouse manager and a dispatcher of the company's reference warehouse with a duration of 1h and 4h respectively. An overview of the core focus group is given in Table 1. We chose this mix of positions within the logistics service provider's company to include representatives of all concerned departments and functions that play a role either in processing of the tender or during implementation phase of the developed DSS. Thereby, different hierarchy levels and organisational areas as solution design, project as well as efficiency management and product design, are included in the development so that acceptance and usability is high throughout the entire department of concern. Furthermore, one warehouse manager and one dispatcher were interviewed and accompanied to gain insight in the order picking reference process planned in the tender. This was done to gain understanding of the operational challenges faced on operational level not only for planning but also for operation of the planned warehouse.

Table 1: *Description of focus group interviews*

Represented positions within company	▪ Head of Quality & Project Management ▪ Senior Solution Design Manager ▪ Vice President Efficiency Management ▪ Vice President Product Design
Research focus of academic staff	▪ Risk management in complex SC networks ▪ Systematic logistics service engineering ▪ Digitalisation of logistics services
Period of interviews	▪ October 2017 - February 2019 ▪ iterative, accompanying the development process
Number and duration of interviews	▪ 10 interviews; >4 members of the focus group; >2h ▪ 40 coordination meetings; >1 members of the focus group; 1h-8h; Ø: 2,5h

3.2 Conceptual Model

The main design issues identified as basic pillars for the DSS to be developed are threefold. Firstly, the advantages of a computer simulation shall be used, as it allows for consideration of the temporal component not viable in spreadsheet calculations and via intuition. Furthermore, complex scenarios with lots of parameters can be handled in a simulation. This is based on the first two focus group interviews, which emphasised the need to process large data sets and provide a reliable and comprehensible result. The second pillar is the implementation of a modular structure in order to pave the way for a flexible system capable to meet the individual requirements of the customers. As the focus group reinforced, the case study company is specialised in highly customer specific solutions, thus not two tenders are the same. This creates the necessity to break the modules down to the lowest common denominator. An example is the use of a basic layout module described in paragraph 4.3 in detail. This design is a result from focus group interviews three to five, which also dealt with other design decisions on modularity of the DSS. Thirdly, as the focus group members expressed concerns regarding operability of a computer simulation through the existing personnel, a way to enable them to use the DSS was needed. To overcome the challenge of acquiring new personnel or teaching the solution designers how to operate simulation software, an easy to operate interface guiding through a moderated process is employed.

After identification of the challenges for the overall design, the tender process has been analysed in detail to identify the contentual challenges. It was revealed in the focus group interviews, that the assessment of the layout design is both, critical for planning success and very challenging for solution designers. Therefore, a systematic consideration of design variations and assignment of articles takes centre stage in the DSS. The decisions of the focus group and findings from literature that shape the DSS are summarised in the following and displayed in Figure 1.

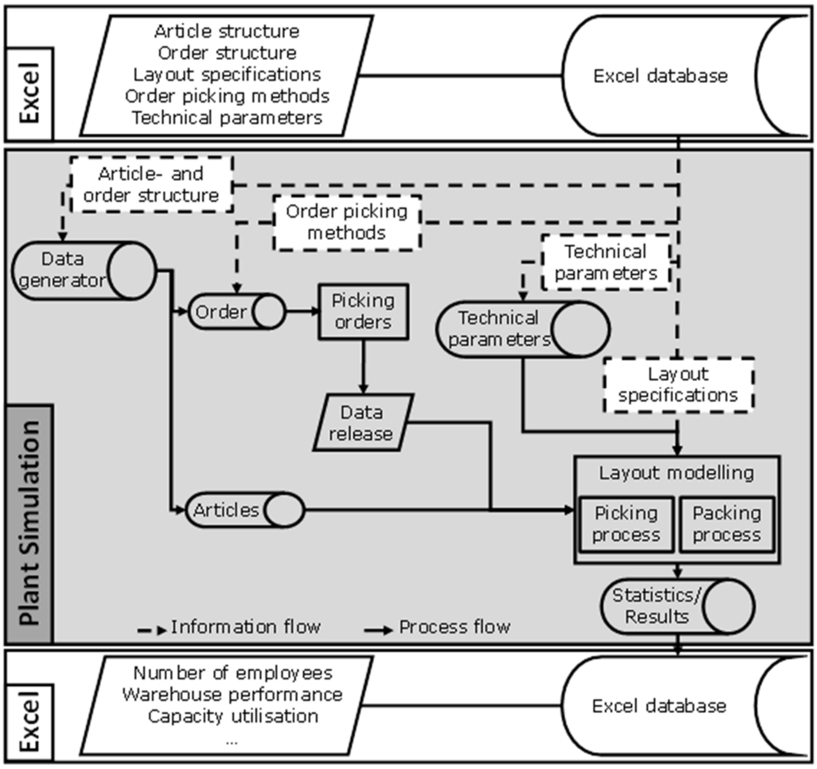

Figure 1: *Concept of the developed DSS*

- Unanimous decision of focus group for a front end realised in Excel as this is known to potential users, thus a higher degree of acceptance is expected
- Decision of focus group for a back end realised in Siemens Plant Simulation as this is a commonly used simulation software in industry
- Specification of input data for simulation following approaches from literature
- Clustering and hierarchical ordering of input data; Implementation of corresponding input boxes in front end and processing logic in back end
- Modular structure and orientation towards the steps of the tender preparation as reported in the interviews and literature likewise

It works as follows: The Excel interface presents the front end and puts a frame around the computer simulation, which represents the back end. After all necessary data is gathered through a moderated process in Excel and stored in a database it is directed to the respective modules of the simulation as shown in Figure 1. Several processing steps later, the data is merged and the results are prepared for transfer to the Excel database. From the database, the key performance indicators and selected graphs are loaded into the Excel interface again. The decision process was modelled using the software Plant Simulation. Modelling was done within a demarcated scope and under consideration of the currently applied decision process.

4 Simulation-based Decision Support System

Under consideration of the aforementioned challenges, the concept described was put into practice. In the following, its single registers are presented shortly. An overview over relations between registers is given as well as information to important assumptions made. Special emphasis is put on explanation regarding the layout as this is a crucial factor for a successful operational use of the DSS according to the focus group.

4.1 Front End

The interface consists of nine registers that are traversed in a fixed order. This is necessary, as there are dependencies between registers, so that jumping back and forth could cause inconsistent data sets. The first seven registers serve as gathering tool for the necessary input data. They are followed by a register which displays overviews of the data and a register showing the results. Data is transferred to the simulation after completion of the fourth register and again after checking all data in the eight register. To make the data readily accessible for the simulation software the data from each register is exported and imported via a single TXT file. It needs to be considered, that all data is structural data and only becomes specific after being handled by the data generator in the simulation software. Checking and correction function is given in every single register.

Register one deals with the *articles* to be stored in the warehouse. Here several article categories can be created and characterised. In the next register, information on incoming *orders* is gathered. Up to two of the article categories created beforehand can be assigned to the current order category. The third register contains the *first layout* step, which focuses on creation of storage areas as independent elements. A name for the storage area needs to be selected. Up to three of the created article categories can be assigned to one area. However, there is no limit in how many areas an article category can be assigned to. Aisle orientation, one-way aisle and overtaking option can be checked. Additionally, the number of aisles and number of compartments within one aisle horizontal and vertical need to be put in. To allow calculation of the compartment size the dimensions of the storage area is inquired. Register four completes the facility data with a *second layout* register. To determine a sink for the warehouse one of the storage areas has to be chosen and herein one of the corners. After confirmation of the sink, multiple connections between storage areas can be created. Established connections can be reviewed and changed in the register itself. With completion of this register, the data is transferred to the simulation software for the first time. The reason is that the data concerning article and order structure needs to be processed in the data generator in order to get lists of concrete material numbers and their storage location in the created storage areas that can be chosen for compilation of concrete orders. Based on this data set the simulation delivers input needed for the next register on *order picking*. The next register covers the *technical parameters*, in other words, data on equipment and staff. The focus of the seventh register is the *assignment* of order picking unit, storage area and order picking method. With completion of this register, the data input concludes. Register eight presents an *overview* and gives the opportunity to check again all data. If correction is necessary, the first seven registers need to be gone through again to guarantee error-free and consistent data. Only when the user confirms the correctness of the data, the final simulation is started. Therefore, an export process is started similar to the first one after register four. As soon as the *results* are available, the last register is called, which makes a graphical representations of various measures ready for analysis. Examples are resource utilisation, pick performance during the day and number of active pickers per hour.

4.2 Interaction Loop

The interaction loop between user, front and back end is described in the following paragraph. For explanatory purpose, we chose the example of layout generation. The whole loop is graphically presented in Figure 2. The solution designer starts with a rough sketch of the warehouse facility available for the tender at hand. Through knowledge of the article structure und resulting differences in storage and handling equipment needed, three storage areas are defined. Each of the areas is described in the register *Layout I* separately. Based on the description the areas are created in the simulation software using a basic module. This module represents an aisle with the length of one storage compartment. It consists of a rack element to both sides and the corridor in between as depicted in Figure 2. The implementation of such a module allows for flexible creation of storage areas in any size by adding modules up to the desired area size. Simultaneously, the created storage locations are systematically labelled. In the next step, the user, i.e. solution designer, defines the sink and connections between the storage areas in the register Layout II. Consequently, the connections are established in the simulation model and distance between any two points in the warehouse can be calculated. This enables the simulation of for example pick time and resource utilisation.

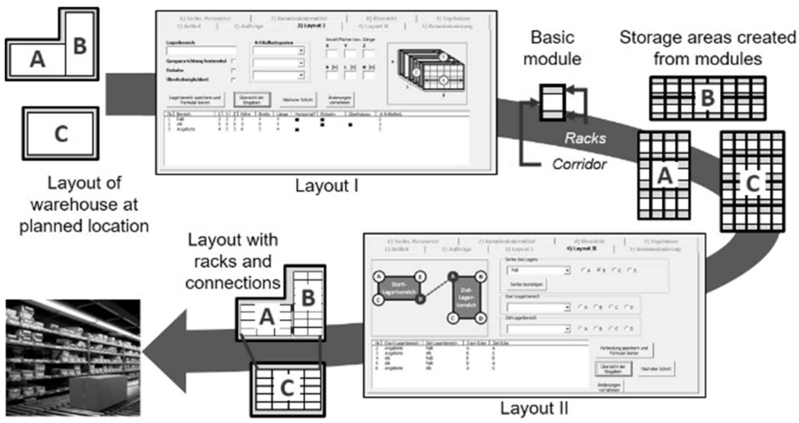

Figure 2: *Interaction loop*

5 Conclusion

All the solution designers' requirements are reflected in the DSS, which comes in the shape of a simulation model embedded in an Excel VBA user interface. Practical implications include the systematic gathering of data and their structured usage for a simulation model. The model is modularised to allow flexible design as needed for the tender at hand. The advantages are therefore improved transparency of tender preparation, ability to simulate complex relationships, and the opportunity to analyse performance of different solutions. All this enables the solution designer to choose a robust solution from multiple possibilities. Regarding the theoretical implications, a first step has been done to close the gap between research and practice by enabling the use of simulation within a complex decision process in contract logistics under consideration of conditions and challenges from practise. Thus, the resulting DSS presents an improvement for the decision process during tender management. Coming to the limitations, as the focus lays on the development of a holistic and systematic decision support useful for tender management in practice, the simulation model is rather basic and does not account for complex optimisation problems.

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