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Modelling the IT and Business Process Landscapes at Inland Intermodal Terminals

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Purpose: A wide range of customer relationships, services and organizational interfaces characterizes inland intermodal terminals, which are hubs of combined transport. The purposes of this paper are twofold. The first is to highlight challenges of small and medium-sized enterprises (SME) at the time of digitalization. Secondly, approaches to illustrate the IT and business landscape are presented.
Methodology: This paper is based on a literature analysis as well as interviews and identifies aspects of SME- and branch-specific IT and business process landscapes of inland terminals. Moreover, approaches to visualize those landscapes are highlighted and a distinction is made between different software map types.
Findings: Inland intermodal terminals often use a variety of different small, sometimes self-developed IT solutions. Findings show a lack of means of communications and IT equipment as well as the interlinking of systems, which lead to media breaks and inefficient information flow. Therefore, approaches to visualize relevant processes and their application landscapes are presented.
Originality: Most literature focuses on larger terminals, which use terminal operating systems (TOS) to manage and link computerized applications efficiently. Due to the effort required to adapt TOS to operational conditions as well as resulting costs, these are often not an option for small and medium-sized terminals. This paper provides a basis for SMEs to systematically visualize and improve their IT and process landscape.

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1 Introduction

Economic growth and rising international trade is leading to growing transport volumes worldwide and thus to an increased load at transshipment hubs (UNCTAD, 2020). Seaport terminals as well as inland intermodal terminals, in which loading units are transferred between different modes of transport, are particularly affected. Inland terminals, as the interfaces of intermodal and combined transport, are challenged to meet the increasing demand for high-performing and cost-efficient operations (Ruile, 2018).

Inland intermodal terminals are often characterized by diverse customer relationships, services and organizational interfaces and, especially regarding small and medium-sized enterprises (SMEs), heterogeneous application landscapes using individual IT solutions. The challenge for many SMEs is to achieve a better and more coherent use of IT systems, aiming at integrating diverse business functions (Pighin, 2016). Therefore, IT and business process landscapes are to be further developed in the sense of a future-oriented digitalization. Within the framework of enterprise architecture management (EAM), various approaches to holistically consider the application and business process landscapes and their connections exist. First, the aim of this paper is to highlight general potential for improvement regarding the application landscapes at inland intermodal terminals. Then, adequate approaches to systematically represent complex application landscapes in SME companies are briefly discussed and selected tools are classified.

The paper is structured as follows. In Section 2, a brief overview of functional areas as well as IT landscapes within inland intermodal terminals is given. Then, Section 3 briefly touches on the methodology. In Section 4 the state of research and practice is addressed. Some approaches and tools to represent application landscapes are presented, before pointing out SME- and branch-specific requirements. Finally, further research perspectives are discussed.

2 Theoretical Background

The present paper is a preliminary result of a research project which aims at developing an IT reference model especially for SMEs in the field of application of inland intermodal terminals. Such a model is intended to support terminals in independently pursuing a systematic development of their IT and process landscape. The project therefore includes the identification of need for improvement, the derivation of recommendations and the development of suitable procedure models and tools in order to visualize and systematically improve the IT and process landscapes.
In the following Section 2.1, the basic functional areas within inland intermodal terminals are emphasized. Section 2.2 further deals with application landscapes.

2.1 Functional Areas within Inland Intermodal Terminals

The term intermodal transport defines the "movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes" (UNECE, 2001, p. 17). Combined transport describes intermodal transport where the main course of the journey is by rail or waterway and the pre- and/or post-carriage of the transport is by road (UNECE, 2001).
Inland intermodal terminals provide the operational environment, the space as well as the equipment for transferring transport units between the connected transport modes. Besides, the terminals can offer very different services, ranging from solely providing the transfer between two or three modes of transport (hence bi- or trimodal terminals), to providing various

value-added services (e.g. storage, empty depots, maintenance and repair). (Ballis and Golias, 2002) In addition, terminals also have a buffer function, i.e. they can store and retain goods for a certain period of time, which promotes flexibility in transport networks.

Moreover, several companies can be involved in a terminal. A distinction is usually made between owners, terminal operators and personnel service providers. Furthermore, affiliated companies or business partners, such as rail operators or haulage companies, can also be users of organizational interfaces. For more details, exemplary processes (e.g. pick-up by truck and delivery by train) can be found in Schwientek, et al. (2018). They conducted a desk research (based on websites of relevant logistic nodes as well as studies and reports) and visited intermodal terminals revealing significant differences between the functionalities as well as complexity.

Generally, there are different functional areas within an inland intermodal terminal, which can mainly be divided between the container yard as well as the operational areas (including the entry and exit area) for each of the modes of transport that are associated (Hervás-Peralta, et al., 2019). Figure 1 illustrates a generic representation of different functional areas.

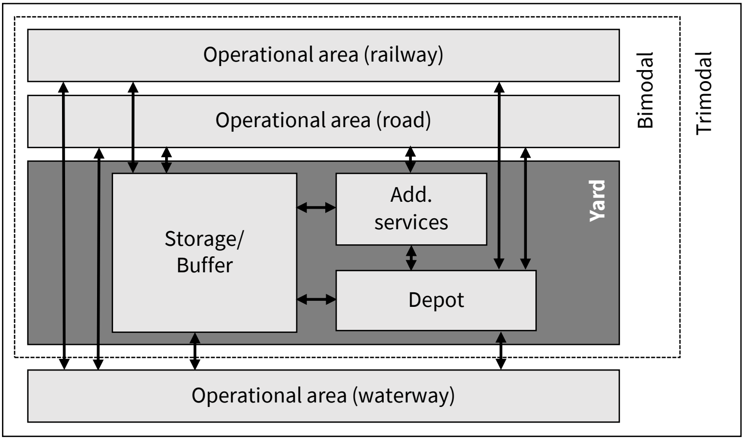

Figure 1: Functional areas within a terminal (based on Böse, 2007 according to Kaffka, 2013)

The functional areas may also cluster business operating activities. Ruile (2018) defines four clusters: order intake, resources, order execution and optimization. Order intake comprises "products and services offered to the market, the customer interface, as well as the sales process". Resources include inter alia the yard layout, handling equipment as well as financial and personal resources. Order Execution covers all necessary activities (processes) to fulfill the customer order. The planning and control systems of the terminal is described by optimization.

2.2 IT Landscapes at Inland Intermodal Terminals

The variety of tasks and services at terminals result in a complex process landscape, which, in SMEs, is often covered by individual IT applications and thus further increases the complexity of the IT landscape. Ruile (2018) highlights, that even though the primary activities of terminals seem to be simple (load, unload and buffer) complexity rises considering the coordination of resources (people, equipment and space). Inefficient information flows in need of improvement result in inefficient operations. He points out that "the modularization of processes, the availability of smart communication technologies and the capability of module configuration offers opportunities for future process designs and related terminal operating systems."

In the following, core areas for terminals as well as exemplary areas of application for IT systems within are mentioned (Buhl and Schwientek, 2016):

(1) Storage (e.g. storage management)

(2) Input / Output (e.g. crane scheduling, gate operations, rail and barge operations, stowage planning)

(3) Administration (e.g. human resource planning, invoicing)

(4) Internal transport (e.g. resource planning and control)

(5) Management and IT (general support functions, e.g. information technology, decision support systems)

In recent years, a few comprehensive systems that control, monitor and handle processes at intermodal terminals were developed. While large companies are more likely to use a single terminal-wide IT system, a so-called Terminal Operating System (TOS), many SMEs use individual IT applications for various tasks. TOS may be considered as part of the Enterprise Resource Planning (ERP) family. However, they are rather specialized to the requirements of terminals than general ERP systems as they aim to bundle all administrative and operational tasks of the terminal in one system (Buhl and Schwientek, 2016).

There have been efforts in practice, especially in large companies, to deal with the management and strategic development of IT for some time. Since EAM developed simultaneously in different scientific disciplines in the early 1990s it does not yet have a generally valid definition. Lapalme, et al. (2016), for example, propose to understand enterprise architecture (EA) as consisting of the essential elements of a socio-technical organization, its relationships with each other and with its environment, and the principles of design and development of the organization itself. They define EAM as the continuous activity of describing and updating the EA in order to understand its complexity and manage its change. Within the framework of EAM, the application landscape, i.e. the IT systems, business processes and their interactions, are recorded and holistically documented.

3 Methodology

The general methodology of this paper is based on a desk research as well as on qualitative interviews to review the current state of research and practice.

A selection of search terms regarding keywords such as inland intermodal terminal (and similar terms like combined transport terminal, inland port, (container) handling terminal, transshipment terminal, multimodal terminal or inland waterway terminal) and their combination with further keywords like IT or software landscape and enterprise architecture, was used for database searching to review academic publications. The applied literature review framework is based on Moher, et al. (2009) by filtering after abstract and full-text reading and extended by snowballing search. The empirical research applied in the course of the underlying research project include group discussions, interviews and process mapping. Currently applied IT systems and processes were gathered on site at two terminals. In addition, further interviews with representatives and experts of the sector as well as a literature research provide an overview of IT landscapes at terminals. To allow an extensive overview, not only SMEs were considered, but also larger terminals and more comprehensive systems like TOS. SME and branch-specific challenges are derived from this step (see Section 4.2). Moreover, suitable visualization approaches for IT and business landscapes are identified.

4 State of Research and Practice

Trends in the technological as well as market environment regarding TOS were highlighted by Lee and Meng (2015), further pointing out that evaluation and testing of TOS requires high costs and time. Therefore, TOS are often not an option for SMEs due to the large range of functions, the high adaptation effort (especially during ongoing operations) and the associated costs for acquisition, adaptation, maintenance and further development. Smaller handling terminals tend to use a variety of different IT solutions, some of which may be developed in-house. Moreover, some processes may even be carried out solely paper-based or without suitable IT support and therefore causing inefficient and error-prone media breaks. Data consistency and transferability between the different systems are not always given. For example, terminals maintain medium or long-term business relationships with many companies, such as haulage or rail companies, but also with personnel service providers or operating companies. The communication between the terminals and the business partners is often still carried out by e-mail or telephone or via systems of business partners. This leads to a high expenditure of time and to a degree of complexity in use, since these systems often differ in their requirements and operation. Furthermore, the use of different systems leads to a lack of flexibility in the event of changes in operational processes and an increase in data redundancy and inconsistencies. Ruile (2018) shows, based on a multi-case study, that efficiency of multi-modal inland terminals, as part of a highly fragmented network with diverse actors, strongly depends on collaboration regarding the information flow within the order and execution system as well as standards in services and procedures.

Although the number of business processes and IT systems of SMEs is significantly lower than in large companies, their heterogeneous application landscape and the variety of technical interfaces result in a high degree of complexity (Aarabi, et al., 2011). This is particularly problematic because the documentation of the application landscape is often inadequate (for instance due to time or budget constraints or a lack of knowledge of methods and tools). Furthermore, the lack of employees trained for this purpose makes it difficult for companies to adapt complex management processes or software tools adequately on their own (Bernaert, et al., 2014; 2016).
Interviews with representatives of the sector and terminals emphasize that there is currently a need for improvement regarding the business and IT landscape at SME terminals. The challenges are varied, starting with the systematic identification of existing processes, the creation of interfaces to external systems that are often still missing or insufficient, the adaptation of systems to the required flexibility and services and the investment costs for the respective systems.

4.1 Enterprise Architecture and Visualization Tools

Buckl, et al. (2007) outline the importance of visual models of the EA to make the information more perceivable. They further identify issues in utilization, based on an extensive survey of existing modeling tools for EAM. Further, Ernst, et al. (2006a) describe strengths and weaknesses of EAM tools. In the following, the visualization of EA is dealt with based on a literature review focusing on EA modeling approaches that can be used to support the documentation, planning as well as evaluating of the application landscapes.

For example, software cartography aims to systematically represent complex application landscapes in companies by using the knowledge and methods of cartography and thus to facilitate the description, evaluation and designing of application landscapes. Fundamental principles of software cartography, an approach for EA modeling, can be found in Lankes, Matthes and Wittenburg (2005). So-called software maps are based on a layering principle. The lowest level (base map) visualizes (several) instances of different object types (such as process steps, functional areas etc.) depending on the map type and is built up according to the application purpose (Ernst, et al., 2006b). Lankes, Matthes and Wittenburg (2005) have derived different types of software map types. These differ in the underlying structure of the map base, the objective pursued with them and the editing process (automatic vs. semi-automatic vs. manual). Based on this, Wittenburg (2007) derives a visualization model for software maps, which among other things consists of design tools and rules and defines relevant characteristics of application landscapes. For example, a process support map can express the assignment of IT systems to business processes and can be enriched with the interconnections between the IT systems and other key figures and metrics, such as planned usage time or downtime of the IT systems. Figure 2 shows this layered principle. Layers can be used to adjust the information density and together they form an overall map.

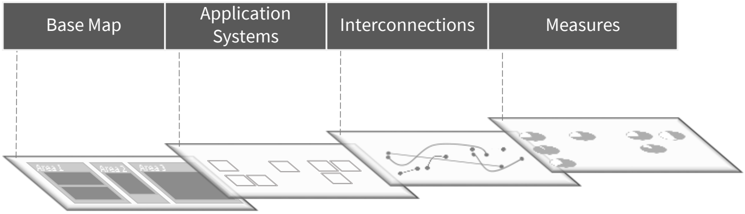

Figure 2: Layering principle of a software map (based on Lankes, Matthes and Wittenburg, 2005)

Several different visualization tools use a cartography metaphor to illustrate information. For example, software visualizations in reverse engineering can be found using elements of cartography (Loretan, 2011). Jeffery (2019) presents a number of tools using the city metaphor to visualize program code. These code cities feature three-dimensional views, several tools offer a virtual reality approach. The visualization of software in reverse engineering comprehends huge amounts of data and is driven by size and complexity (Lanza and Ducasse, 2003). EAM follows a different approach. EAM tools aim to support IT managers to align business and IT (Matthes, et al., 2005). EAM tool surveys (e.g. Matthes, Hauder and Katinszky, 2014; Matthes, et al., 2008; Matthes, et al., 2005) create an overview of various tools in a still growing market, which were investigated with a scenario based approach. The surveys consider the specific functionality (such as creating visualizations of the application landscape or usability) as well as specific EAM support, e.g. landscape or application architecture management. Whether the tools support the creation of certain types of software maps, such as cluster maps, process support maps or time interval maps, is answered. The following Table 1 lists a few tools, classified regarding their capabilities to create visualizations concerning different types of software maps (see

Matthes, Hauder and Katinszky, 2014; Matthes, et al., 2008; Matthes, et al., 2005).

Table 1: Visualization tools regarding the support of software map types

	Type of map		
	Cluster	Process support	Interval
Description	Uses logical units such as organizational units, functional areas or geographic locations; groups application systems into these units.	Shows which business processes (linearly ordered sequence of processes) are supported by which applications.	Representing the time spans (as bars) of e.g. projects or lifecycle phases of applications.
Exemplary tools (and Vendor)	Architect (BiZZdesign); LeanIX (LeanIX GmbH); MEGA Modeling Suite (MEGA International SA); Iteraplan (iteratec)	Architect (BiZZdesign); MEGA Modeling Suite (MEGA International SA); PowerDesigner (SAP Sybase)	LeanIX (LeanIX GmbH); MEGA Modeling Suite (MEGA International SA)

It should be noted that this list is not exhaustive, due to the large number of existing tools. Table rather indicates the variety of tools with multiple approaches of creating visualizations. Most of the tools mentioned provide the possibilities to create software maps with an easy handling, though some visualizations require manual effort or need to be adapted by the user, e.g. by using scripting capabilities. For further information, please refer to Matthes, Hauder and Katinszky (2014).

4.2 SME- and Branch-specific Requirements

The documentation of the application landscape, e.g. with the help of software maps, is a common procedure in EAM for the analysis, coordination and planning of the development of those landscapes. However, EAM is generally used in larger companies. Hanschke (2016), for example, only recommends EAM above a certain size (for medium-sized companies with a very large number of diverse IT applications). Often these EAM approaches are not feasible for SMEs, e.g. because they do not have the necessary financial and human resources and experience for these approaches. New, extensive projects for adjustments and strategic alignment of the system during operation and the development of new knowledge are usually not manageable (Lange, et al., 2014). In order to support SMEs and their integration of individual IT sub-systems into a coordinated overall system, a simple and low-cost procedure model is required, which the SMEs can use as a guideline. In Section 2 it is shown that terminals are characterized by a wide range of customer relationships, services and organizational interfaces, which may lead to heterogeneous IT structures. IT and business process landscapes therefore should be developed in the sense of future-oriented digitalization and thus to establish agility with regard to changing framework conditions and requirements for digital interfaces to partners in the maritime transport chain. Professional IT management is a challenge or not possible due to financial and human resources. In order to further develop the IT and business process landscapes, methods and models for the description and design of application landscapes of handling terminals are relevant. Therefore, an overview of visualization approaches and tools was given in Section 4.1. For the application case of an IT reference model for inland intermodal terminals, it is advisable to refer to functional areas (e.g. as shown in Section 2.1) as a base map. This allows an adjustable representation of the individual functional areas, but also the simple selection and deselection of certain additional services or processes by means of appropriate filters. The positive emphasis on cluster maps was confirmed by feedback from the industry in a discussion round. A visualization based on layers which map relevant aspects like interconnections and measures (that can be shown or hidden as required) would moreover be beneficial. The selection of a suitable software for the creation of software map is necessary. Ease of use and availability as well as comparatively low costs are of particular importance.

5 Conclusion and Future Research

Especially small- and medium-sized inland intermodal terminals still use a variety of different small, sometimes even self-developed IT solutions. Findings show a lack of means of communications and IT equipment as well as the interlinking of systems, which lead to media breaks and inefficient information flow. The paper therefore highlights the potential of comprehensive IT systems. It becomes apparent, that larger terminals widely use comprehensive TOS for managing their IT landscapes. Due to the efforts and costs which are required to adapt TOS to operational conditions, TOS are often not an option for small and medium-sized terminals. Therefore, potential for improvement and approaches to visualize relevant processes and their application landscapes are presented. In the course of this paper, branch-specific requirements and suitable visualization approaches for the demands of the user domain were highlighted. This paper provides a basic approach for SMEs to systematically visualize and improve their IT as well as business process landscape using multi-layered software maps.

The aim of the next project steps is to coordinate with relevant partners in practice in order to ensure the suitability and practicability of the software map types and software for mapping their business and IT processes. It is necessary to develop and define design rules based on the current state of science for creating clear and quickly comprehensible models for this particular application case. In order to make the model as universally valid as possible, it is essential to consider different inland intermodal terminals.

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