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A case study derived methodology to create a roadmap to realize the Physical Internet for SME

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Abstract: *Sending goods like an e-mail – only by one click. What sounds quite easy gets rather complex and uncertain when taking a closer look on the details. The groundbreaking change intended by the Physical Internet (PI) enables many beneficial aspects but rises a lot of questions, uncertainness and concerns. To change today´s supply chain processes, to change the assets which are needed to handle, store and transport goods, to introduce new information and communication technology and new business models will mean a fundamental change. Current logistic systems and the stakeholders involved in today´s logistics are deeply affected and influenced. To dispel concerns and to allow the PI-vison to become an operating system this paper proposes a methodology to create a roadmap to realize the PI for SME based on a real industry case study.*

Keywords: *Physical Internet; Go2PI; Realization of the Physical Internet; Realization Methodology, Physical Internet for SME*

1 Introduction

To reach the goal of limiting climate change below 2°C the European Union (EU) needs to reduce the greenhouse gas (GHG) emissions until 2050 by 80-95% below the levels of 1990. In the whitepaper "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" published by the EU in 2011, analysist of the European Commission (EC) point out that for the transport sector a reduction of at least 60% of GHGs is required in order to achieve that goal (EC 2011). Considering the substantial increase in emissions in the transport sector over the past decades and the given megatrends like urbanization and individualization, logistic distributors are forced to organize and shape their business more and more efficient. They are forced to minimize GHG emissions and the logistic costs while facing an increasing volume of one item delivery (Meller 2012).

Focusing on those challenges, the vision of the Physical Internet (PI) was born in 2006. The PI tries to evolve logistics around the world to be societal, environmental and economically more sustainable compared to today's logistics (Montreuil 2011). Following the application of the digital internet, in PI goods will be sent over an open and global logistics system founded on physical, digital and operational interconnectivity through encapsulation, interfaces and protocols. The aim of the PI is to enable an efficient and sustainable logistics web at the logistics hubs as well as at the end consumer, where current systems are not efficient enough to address the outlined challenges (Montreuil 2011; Ballot et al. 2014).

In order to realize the groundbreaking idea of the PI, initiatives and research projects around the world are proposing and implementing first steps to change the current logistics systems. In Europe, the Technology Platform ALICE was set-up to develop a comprehensive strategy for research, innovation and market deployment of logistics and supply chain management innovation to reach the PI by 2050 (Alice 2016). Inspired by the ALICE strategy the Austrian research project "Go2PI" was set up in 2015 and this paper will deal with the proposed methodology derived in this project to create a roadmap toward the PI with focus on Small and Medium Sized Enterprises (SME).

The first part of this paper will give information on background, related work and will highlight the scope of the Go2PI project. In the second part the authors describe a real use case of an SME in the automotive sector and a future PI-scenario developed for this use case based on 4 different levels: the physical level, the information level, the business model level and the process level. The derived proposal for a methodology to develop a roadmap towards the implementation of PI for SMEs will be the focus in the third part. In the forth and last part of the paper an outlook will be given and considered next steps will be highlighted.

2 Background and related work

Next to the promising attributes of the PI the different stakeholders along the supply chain (SC) are facing groundbreaking changes which raise a lot of uncertainness, various risks and many questions and concerns. Extending the work of Cimon (2014) who described several roadblocks the following can be named: Using modular and smart containers instead of carton boxes and pallets, transparency of the system regarding pricing, management, coordination and decision making, security issues regarding data, damage and theft, modes of contracts for full vertical and horizontal cooperation between competitive and non-competitive companies, sharing intellectual property in open source software, the need of flexibility versus the need for relationships between partners, standards for data, information and physical interfaces, physical border crossing and awareness of geography in culture.

One of the first projects in Europe to tackle those roadblocks was the MODULUSHCA (Modular logistics units in shared co-modal networks) project which was funded by the 7th Framework Program of the European commission. Focusing on the FMCG domain 15 partners from research, logistics business, postal business and FMCG industry participated in this research project in close coordination with North American Partners and the international PI-Initiative. The goal of the project was to enable operations with newly developed ISO-modular logistics units of sizes adequate for real modal and co-modal flows of FMCGs, providing a basis for an interconnected logistics system seeking a significant two-digit improvement in operations' efficiency (Modulushca 2016). Within the scope of the project a first physical prototype of a PI-container for FMCGs (Landschützer et al. 2015), a High Level Information and Communication Technology (ICT) Architecture for Modular Logistics (Tretola and Verdinio 2015), a common data model for PI (Tretola et al. 2015) and possible business models (Modulushca 2015) were presented.

Next to the Modulushca project which was focusing on FMCGs other research project have considered other branches or fields in the logistics industry:

Abdoulkadre et al. (2014) explore the perspectives of PI in the context of how the humanitarian are conducted. Focusing on a global level, already involved or potential actors are harmoniously and efficiently connected, addressing humanitarian needs and in particular crisis emergencies.

Roodbergen et al. (2014) are adopting the PI concept for libraries in order to meet social, economic and environmental goals. They discuss a fist set of ideas which together form the base for smoothly operating library system which are able to meet today's standards.

One major aspect of the PI, the traceability, is regarded by Mtibaa et al. (2014) in the context of the Canadian forest sector. An ICT framework is proposed to track the origin of wood, control information of raw material utilization, trace production progress in order to increase collaboration between the different SC actors.

A production-logistic synchronization is proposed by Lou et al. (2015) in a case study of the make-to-order (MTO) industry. Some core concepts of the PI are illustrated by addressing a real life industrial project in the chemical industry by investigation cross docking (CD) synchronization.

In a Quadruple Case Study by Hambleton and Mannix (2015) they explore the possibility of a small company to rapidly expand the reach of its products without any capital investment. Using the ES3 hub facilities (ES3 2015), which represent the principles of the PI-hubs, allowed a Mozambican start-up to move their goods efficiently, with high speed and low costs through the ES3 networks and as a consequence allowed the start-up to develop their business.

The freight building software MixMoveMatch was originally developed in the iCargo project (iCargo 2016) and enables a future PI-scenario. It represents a cloud based, multi-hub, cross docking tool that enables significant reduced shipping cost by postponed palletisation, consistent processes across hubs and providers, consistent visibility of the entire supply chain, fast and cost-effective supply chain partner integration and reduced locking for service providers through custom developed electronic data interchange (EDI) interfaces (MixMoveMatch 2016).

Concentrating on future scenarios, Ballot et al. (2014) give an illustration on the target operations of the PI in 2030. Possibilities for individuals and effects of the PI network are highlighted out of the point of few of a random consumer, a service operator and different producing companies in diverse industrial braches.

In addition to these projects, implementations and scenarios described above the Austrian research project Go2PI, which is funded by the Austrian government, has raised the question on how to lead a small and medium sized enterprise (SME) in the automotive sector towards the PI. Based on the case study of the Austrian SME company "Aspöck Systems GmbH", criteria and guidelines regarding aspects of technical and information systems as well as processes are evolved in order to develop a neutral and open business model in the area of distribution logistics following the PI vision. Thereby, the use of future loading and transport devices of the PI in combinations with future PI-ICT are postulated and further a roadmap to the PI-services is designed. Go2PI investigates in detail possible impacts, changes, prospects and risks in a future distribution logistics according to the PI-vision in order to optimize the volume and weight usage and the common usage of resources.

For operationalization purposes of the Go2PI project the broadly diversified aims of the PI are reduced to three main core areas: Optimization of the volume and weight usage, common usage of resources and the therefore required data and business models. The approach focuses thereby on four different levels: the information level, the physical level, the process level and the business model level (see Figure 1). The research partners University of Applied Sciences Upper Austria - Logistikum Steyr, the Graz University of Technology - Institute of Logistics Engineering and the corporate partner SATIAMO GmbH analyze the characteristics, periodicities, capacities and basic conditions of the second corporate partner Aspöck System GmbHs current distributions logistics. The project is also taking specific characteristics of the Austrian distribution logistics into account like the special geographical and topological effects caused by the Alps and the fragmented nature of individual deliveries from many diverse SMEs. Based on this analysis, general process models, functionalities, logistic services and cost structures for a future PI-realizations are derived. Furthermore, the Go2PI project is particularly focusing on identifying practicable gaps between the PI-scenario and the current situation, defining short- and long term measures to adopt the current distribution logistics to the PI and assessing prospects and risks. The project is moreover identifying further unsettled research questions. Specific results are given by Gasperlmair et al. (2016).

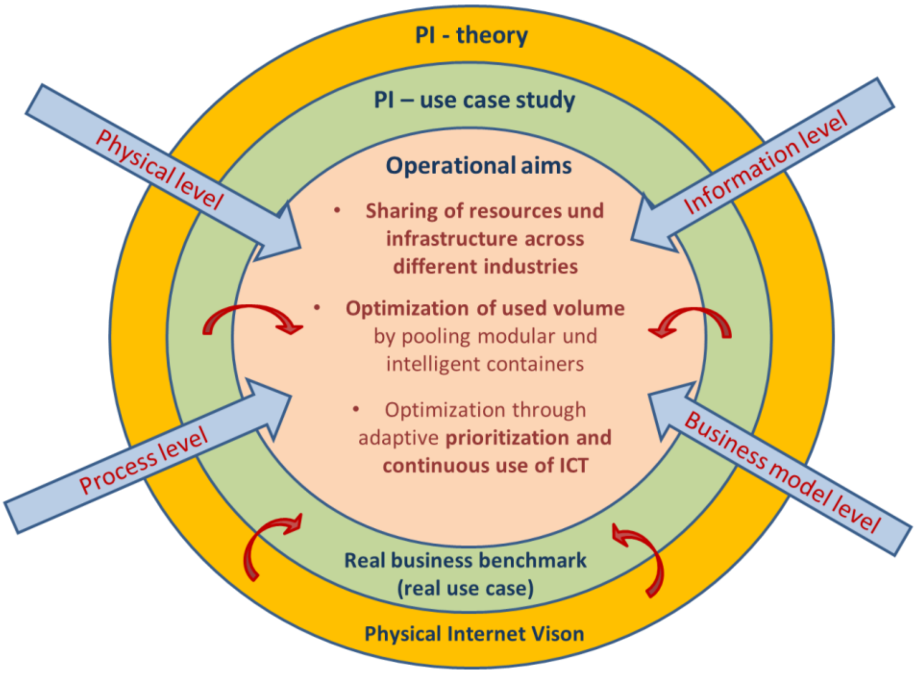

Figure 1: Scope of the Go2PI project

This paper is furthermore focusing on a proposed methodology to create a roadmap towards the PI. The presented methodology is based on a future PI-scenario and a derived PI-process for distribution logistics. The scenario and the process were developed in the Go2PI project and are based on the use case of the Aspöck Systems GmbH.

3 Description of the use cases and the future PI-scenario

Aspöck System GmbH has 35 years of experience in the planning, development, and manufacturing of pioneering lighting for a wide variety of vehicles. They are Europe´s market leader in all types of trailer lighting and one of the leading partners for the European automotive industry. They offer a comprehensive range of solutions and complete lighting systems, which also include a wide range of cables, and are focused on developing custom-tailored solutions for each individual customer (Aspöck 2016). The headquarter of Aspöck System GmbH is located in Peuerbach, Austria but production sites are located worldwide in four different countries: Brazil, Portugal, Poland and Austria. At the headquarter around three hundred employees deal with final production of the lighting systems and the global purchase, logistics, quality management and development.

Aspöck´s products are produced on stock or on order depending on the sales volume. The products are consolidated almost entirely in the central storage in Austria before being picked to orders and shipped to the customers in small load carriers (SLC) or in various sized carton boxes piled on pallets. Customers are either original equipment manufacturer (OEM) or suppliers of spare parts and their orders range from a small amount of SLCs to several pallets. Shipments in the outbound logistics are mostly performed by three different shipping companies, with Aspöck System GmbH owned trucks or some customers are even collecting their orders with their own trucks. Orders are consolidated and shipped to over 200 different customers in shipments which range from one pallet up to full truck loads. In addition to the outbound logistics the Aspöck System GmbH receives also inbound shipments form over 100 different suppliers.

The described manifoldness in distribution logistics and the type diversity and flexibility in the design, manufacturing and production of the lighting systems entails a high flexibility in the intra- and distribution logistics of Aspöck System GmbH.

Based on the PI-theory pictured in the work of Montreuil (2011, 2013), Ballot et al. (2014), MODULUSHCA (2016), Landschützer et al. (2015), Meller et al. (2012) and on the above described structure of the distribution logistics in the use case a suggestion for a standardizes Business to Business (B-to-B) process for the distribution logistics along the PI vision was created in the Go2PI project. It is depicted in Figure 2 and can be described as following:

The placement of a customer order initiates the standardizes PI-process for B-to-B at a supplier. Based on master dates of the ordered products, customer specific requests and specific requirements for the destination the need of PI-containers is automatically identified and compared to the actual stock of stored empty containers. If necessary, the required lack of containers is communicated with the responsible pooling provider. In addition to arranging the PI-container the scheduling of the order is determined based on prioritization of the order and occupation of the PI and a preliminary transport order is placed in the PI. According to the transport order the starting time for the order picking is scheduled to arrange internal logistics at the supplier. The order picking is performed into the determined PI-containers and arranged after a given packing pattern. After finalizing the order picking, the PI-containers are provided to the goods-out of the supplier and are consolidated with other orders for shipment. The first mile logistics is performed by a PI-carrier and arranged after the milk run principle. After goods for the inbound logistics of the supplier are unloaded the provided shipment is automatically loaded on a PI-carrier and shipped to the proposed PI-hub. Even before arriving at the fist hub a new transport order is generated for the shipment to enable efficient logistic processes at the hub.

Arriving at the first hub the logistic processes affecting the shipment are organized in the same way as in the last hub before the destination or at any hub in-between. Shipments can be left on the first mean of transport and only a change of operator is performed, they can be cross docked at the hub to another means of transport, the shipments can be separated and consolidated according to the destination or the shipments can be temporary stored at the hub. Furthermore, it is also possible for the supplier and the customer to change delivery date, destination and priority of an order or even for the different PI-containers. If PI-containers or the transported goods are damaged by any incident the supplier is automatically informed and the relevant processes can be initiated. At the last hub the declaration of goods is performed and the order is shipped to the customer according to the milk run principle. In the customer’s goods-in, the standardizes PI-process for B-to-B is concluded and internal logistics processes are performed.

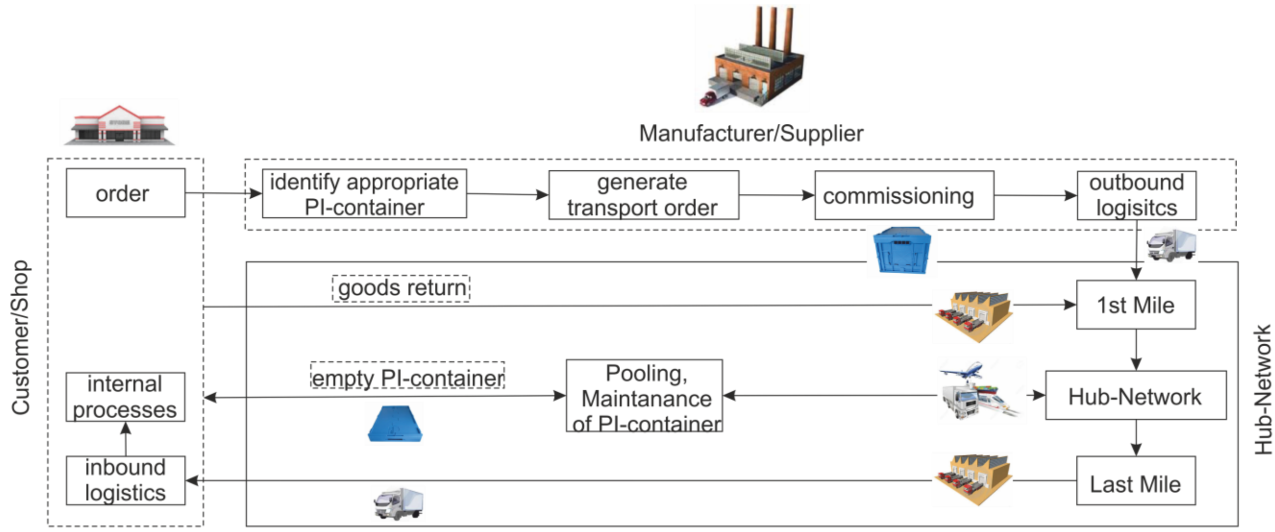

Figure 2: proposed standard process for B-to-B in a future PI

Based on the suggested standardized PI-process for the distribution logistics and the earlier described boundary conditions within the Aspöck System GmbH, different future scenarios have been created in the Go2PI project by the use of the storybook method. The scenarios are thereby described in short stories and range from order picking, consolidating of shipments, generation of transport orders, inbound logistics, loading of PI-carriers, changing of delivery dates, unauthorized opening of PI-containers, high priority shipments, handling of damaged PI-containers, processes at PI-hubs, up to value adding processes at hubs. Based on this future scenarios for the Aspöck System GmbH, requirements for a future PI have been derived on the four different layers already mentioned in chapter 2: the information level, the physical level, the process level and the business model level. Taking those requirements and comparing them to today's boundary conditions in the above described use case leads to guidelines developed within the Go2PI project. They can be summarized and generalized to following three main implementation steps, which become part of the developed roadmap towards the PI and are explained in detail in the work of Gasperlmair et al. (2016).

- Setting the vision for coopetition
- Standardization of logistics operation
- Standardization of financial clearing models

Based on the chosen approach in the Go2PI project the proposed methodology to create a roadmap towards the PI for SME was derived and will be explained in the following chapter.

4 Methodology to create a roadmap towards the PI

The proposed methodology is characterised through a combination between insights of theoretical research and given facts of a real use case investigated in the Go2PI project and can be seen as a guidance with a practical orientation. Note that the proposed methodology is taking the boundary condition described in chapter 3 and the current understanding of the PI in the Go2PI project into account. The methodology is divided in three different phases (see table 1): Starting with an analysation phase the current situation in the distribution logistics including derived boundary conditions, the used loading equipment, current PI-processes and used business models are monitored with the use of methods given in table 1. In the second phase, the proposed methodology deals with the development of requirements. In detail for PI optimized loading equipment, for collaborative transports, for business models and future PI-processes defined in the PI-research. Those requirements are derived from short stories which describe the future PI-processes and in detail the differences to the currents situation. Depending on the field of investigation different methods are suggested. To derive requirements e.g. for future handling equipment or loading equipment it is suggested to use the VDI 2221. Other methods to derive requirements can be seen in table 1. In the third phase of the proposed methodology potential and feasibility of the developed scenarios for the SME are evaluated. This evaluation creates a solid basis to determine first implementation steps towards the PI and monitors affects, benefits and roadblocks for the chosen steps. Furthermore, promising research gaps can be derived to determine research project in order to evolve physical assets, logistics processes, ICT and business models towards a future PI.

Table 1: Different phases of the proposed methodology

Phases	Methods	Sources
Phase 1: Analyzation ▪ Defining the fields of action ▪ Analyzation of the current distribution logistics ▪ Monitoring of the current processes and boundary conditions ▪ Monitoring the state of the art in the PI-research	material flow analysis, EPC, FAST, ABC analysis, desk research, Value Stream Mapping, Process- Information analysis, VDI 2225	VDI (1998), Schenk and Wirth (2004), Montreuil (2011, 2013), Ballot et al. (2014), MODULUSHCA (2016), Landschützer (2015), Meller et al. (2012),
Phase 2: Developing requirements ▪ Comparison of the current situation to the standardized future PI-process ▪ Design of scenarios in the future PI ▪ Deriving requirements and criteria for PI optimized loading equipment, for collaborative transports, for future PI-processes and business models	Benchmarking, Storybook method, VDI 2221, Brainstorming, Process- reengineering, Blueprint method, Scenario planning, Cross-Impact analysis	VDI (1993), Orloff (2007), Pahl (2007), VDI (1998), Seidelmeier (2010), Koch (2011), Hammer and James (1999), Herrmann (2012)
Phase 3: Feasibility and next steps ▪ Definition of prospects and roadblocks for the developed scenarios ▪ Assessment of the feasibility and potential for the developed scenarios ▪ Divining the next implementation steps and promising research gaps	FMEA, Value benefit analysis Cross-Impact analysis, SWOT-analysis, Gap-analysis, Total Cost of Ownership, VDI 2225	Pahl (2007), VDI (1998), Schönsleben (2007), Koch (2011)

EPC…Event-driven process chain
FAST…Function Analysis System Technique
FMEA…Failure Mode and Effects Analysis
SWOT…Strength, Weaknesses, Opportunities and Threats
TRIZ…Theory of Inventive Problem Solving

5 Conclusion and Outlook

The PI will introduce many beneficial aspects to today's SCs and aims to bring maximum interconnectivity and flexibility to the different SC-stakeholders. However, the groundbreaking and fundamental changes intended by the PI rise a lot of questions, uncertainness and concerns. In the presented work a proposed methodology to create a roadmap for SME was presented. Methods applied in the Go2PI project were suggested for each phases of the methodology and a detailed overview of problem related work within the PI-research community was given. Based on boundary conditions derived from a use case in the automotive sector, and a proposed future standard PI-process, this proposed methodology can be seen as a guidance with a practical orientation to map first promising implementation steps towards a future PI.

Beyond this paper, future research will need to further generalize the presented methodology and standardized PI-process. Furthermore, additoinal industrial sectors, companies with varying strategies and higher shipping volumes have to be taken into account to broaden the presented approach. Promising research areas identified by the authors include further development of the PI-containers and standardization of ICT in order to consolidate shipping volume.

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