Possibilities for the joining mechanism of a modular PI handling container

Stefan Roth BSc, Dipl.-Ing. Florian Ehrentraut

Institut für Technische Logistik

TU Graz

Introduction

One of the core elements for the realization of the Physical Internet (PI) are the PI-containers. These PI-containers should offer standardized sizes to fit perfectly together with common handling systems e.g. EUR-pallets, shipment containers etc. without any lost space and are e.g. used for FMCG´s to ease their handling during the transportation process. They are described to be reusable, able to interconnect and built out of modular panels to fulfill all the requirements mentioned by Montreuil (cf. [1]).
First concepts for the interconnecting mechanism have been developed in an earlier research within the project MODULUSHCA by a team of the Institute of Logistics Engineering of Graz University of Technology (cf. [2]).

Objectives

Based on the concept developed in MODULUSHCA, the focus of the presented research work was set on finding methods to join the reusable panels together, to further realize the idea of building PI handling containers out of modular panels instead of building a rigid box as done in MODULUSHCA. Another objective for this research was that the joining can be built with available parts and knowledge.
This poster shows the methods, results and concepts of the development step mentioned before acquired within the research by Roth.

Methodology

To create as many solutions as possible the research was done with the help of methodological design guidelines VDI 2221 and VDI 2222.
The main steps of the research are described as followed:
First all requirements of the PI container were evaluated and defined. Afterwards all functions could be derived out of them. This was done as abstract as possible to get a big range of solutions with no focus set on feasibility in this early stage of design.
In the next step solutions were generated with the help of effect catalogues in which for example all effects for generating a force are listed. The use of such catalogues ensures not to run in danger to forget a possible effect.
Next a set of possible concepts was created by combining the effects for joining the panels and possibilities for the interface. A table with the found concepts can be seen in Fig. 1 below.
Later all these concepts have been proved for their feasibility. After this check only selected concepts were pursued and the best two are described in the boxes beneath.

Results

Version	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Design		Splint					1.2 a c b vgl. [ROT96], S.82	
Description	Adhesive connection with angular splice (adhesive has to be renewed every time)	Splint pin joining with rectangular splice	Flange connection with rectangular splice	Dovetailing with security pins (pins are removable)	Rivet joining with rectangular splice (everytime new rivets needed)	Bolt joining with rectangular splice	Plug connection with rectangular splice	Pressed in pins with rectangular splice
Version	1.9	1.10	1.11	1.12	1.13			
Design	e st st vgl. [ROT96], S.159	st vgl. [ROT96], S.159		3.4 vgl. [ROT96], S.21				
Description	Lever buckle with angular splice	Hook with eyelet and rectangular splice	Clamp joining with rectangular splice	Snap joining with rectangular splice	Clamped connection with rectangular splice			

Fig. 1: Table of possible concepts

Concept 1:

The first concept found in the research is shown in Fig. 2 below. This solution uses an interlocking mechanism which is integrated in the bottom/top panels. The mechanism was developed in an earlier research within the project MODULUSHCA by a team of the Institute of Logistics Engineering of Graz University of Technology (cf. [2]).
To build a box depending on this system, first all side panels have to get connected together. This is done very fast and easy by just pressing the button Nr. 4 of Fig. 3. By doing this, the energy of spring Nr. 1 is used to move bolt Nr. 2 down and connect the panels together with it. After assembling the whole side wall the bottom/top panels must be fixed. This is done with the help of special turning connectors which are also integrated into the side panels and can be seen in Fig. 4.

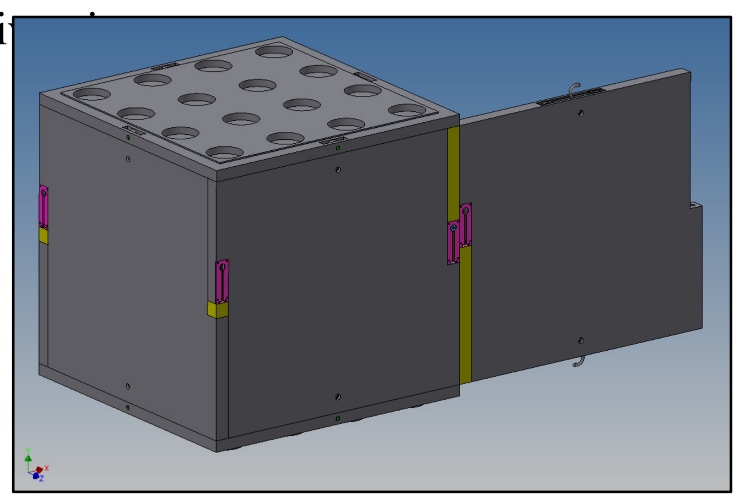

Fig. 2: Concept 1

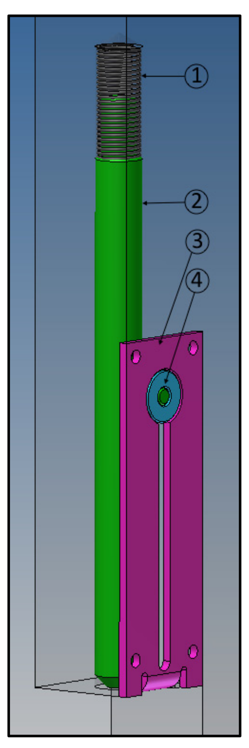

Fig. 3: Detail 1

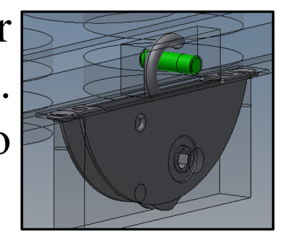

Fig. 4: Detail 2

Concept 2:

The second concept (see Fig. 5) also uses an idea which was found in an earlier research by a team of the Institute of Logistics Engineering of Graz University of Technology (cf. [2]) and was further developed by the research of Roth.
This concept uses the same type of side panels for each wall of the box. Due to its special geometry it´s possible to access the box from ever side, which makes the system much more flexible for loading and unloading bulky goods.
Building a box based on this system is very simple. It is done by fixing a special formed connecting rail on each side edge of the panel and fix them with two butterfly-locks Nr. 1 in Fig. 6. There are two types of rails, one for creating the corners of the box (see Nr. 2 in Fig. 6) and another type for connecting two panel together in one plane (see Fig. 7).

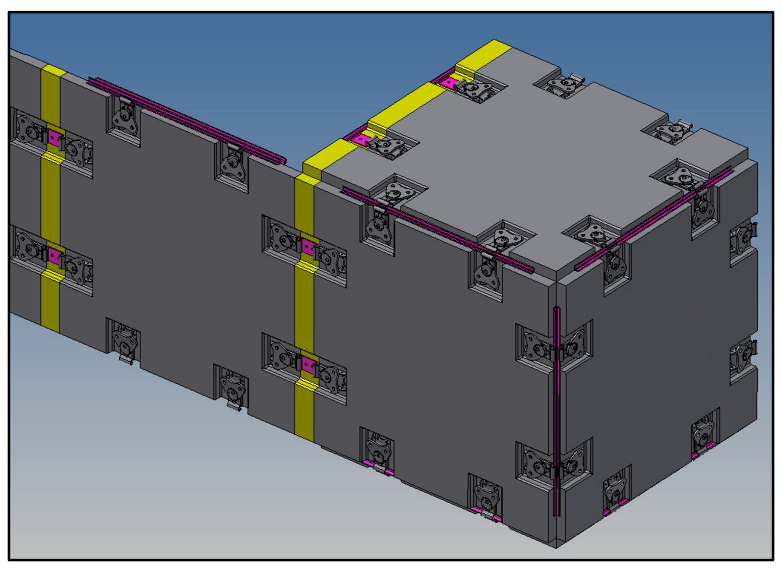

Fig. 5: Concept 2

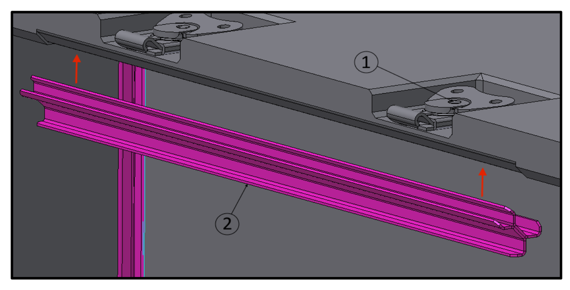

Fig. 6: Rail 2 for creating corners

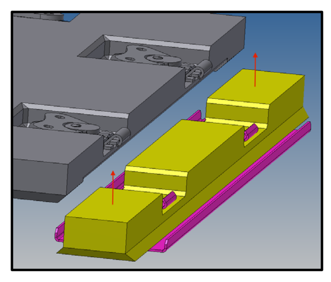

Fig. 7: Rail 1

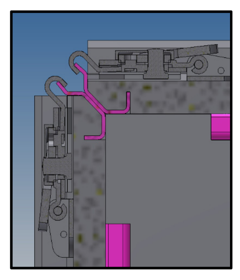

Fig. 8: Joined corner of Concept 2

Conclusion and Further Work

Advantages and Disadvantages of Concept 1:

+ Boxes are able to interconnect	- No access to goods from every side
+ Fast assembling	- Different panels for side and top walls
+ Simple connecting mechanism	- Two different connectors needed

Advantages and Disadvantages of Concept 2:

+ Easy access to goods from every side	- Boxes are not able to interconnect
+ Only one panel type	- Long assembly time
+ Only one connector type	- Can´t get assembled automatically

Both concepts shown on this poster have advantages and disadvantages described above. Concept 1 has the big advantage using the already existing and tested interconnecting mechanism of an earlier research. In a further research it is necessary to modify this mechanism in a way, that it can be activated by other actuators than done in the concept found by a team of the Institute of Logistics Engineering of Graz University of Technology (cf. [2]). Another development step is to find a better, faster and smaller connector for joining the side panels with the bottom/top panels.

The biggest drawback of the existing Concept 2 is that the assembling process is quite slow, because of the used butterfly-locks. In a further research it is necessary to find a lock which can be opened and closed with just one push or similar solutions. Furthermore the existing Concept 2 is not able to interconnect. For this problem also solutions have to be found.

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Protection of goods inside PI-handling container

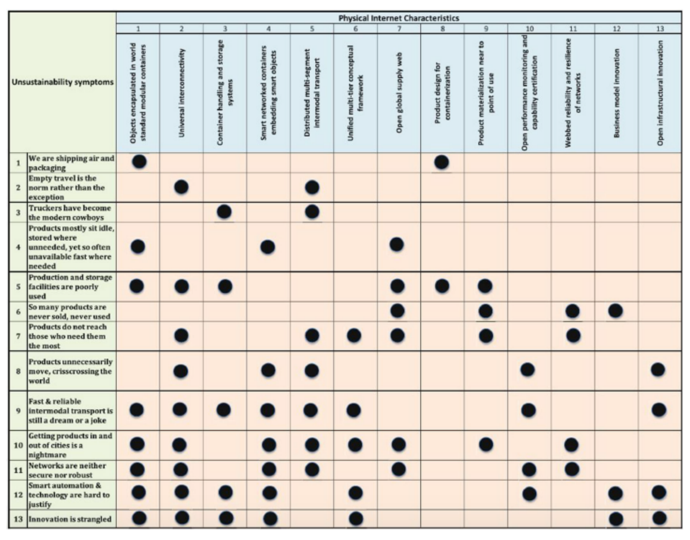
Konstantin Reinmüller, Florian Ehrentraut

Graz University of Technology

Introduction and objectives

According to Montreuil, today's logistic is not economically, ecologically or socially sustainable. The physical internet, however, provides necessary requirements for the development of methods for sustainability [1]. Montreuil presents 13 constitutional unsustainable symptoms which are confronted with 13 PI features with which a perceptive change can be made [2].
In the presented bachelor thesis the focus is on the development and evaluation of a protection of goods concept in order to create a sustainable property from the first unsustainable symptom and focuses on "Product design for containerization" (see table 1). The presented poster shows detailed methods and first results.

Table 1: Physical Internet addressing unsustainability symptoms [1]



Methods

With the systematic approach of VDI 2221 and VDI 2222 which deals with the development and design of technical systems and products [3], a new kind of product protection is developed, which shows how a protection of goods for a future PI can look like (see figure 1).
In order to get a first result, three steps of the development methodology were carried out: developing a requirement list, finding solutions and their principles, and evaluate the findings.

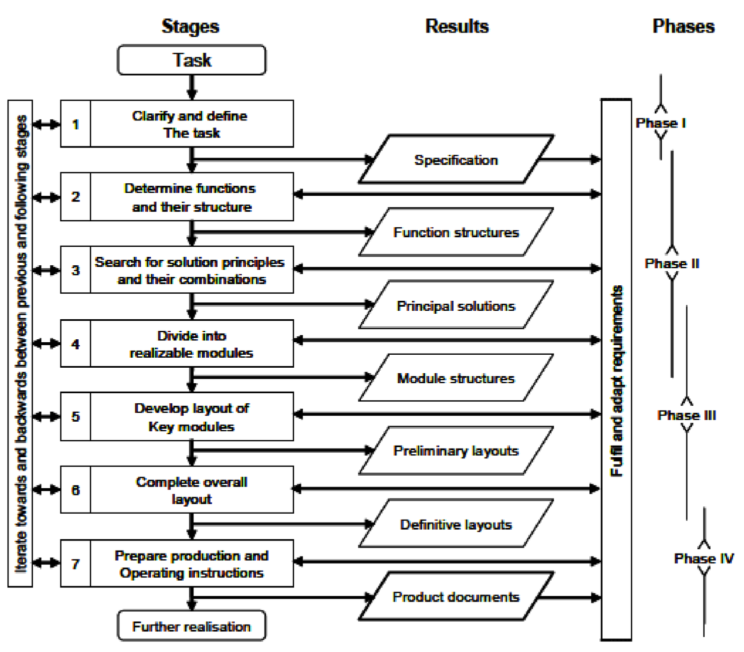


Figure 1: Different phases of the VDI 2221 [3]

Development of a requirement list:
In general, it is necessary to clarify which regulations of the protection of goods must be imposed by the government. The requirements can be derived from the regulations, which are then compared with the vision of the PI. This leads to a list of requirements that future protection of goods must meet.

Finding solutions and their principles:
Design catalogs offer a variety of solutions, some of which are selected to meet the requirements. The next step is the combination of solutions through morphological boxes. This method makes meaningful solution principles visible.

Evaluate the findings:
From step 2, there are also a large number of solution principles which, from the outset, presuppose a certain plausibility and feasibility. The possible solution principles are evaluated by the selection list of Pahl/Beitz (see figure 2) and reduced to the most promising solutions [4]. The remaining solutions are further reduced to a remaining solution by means of a value analysis with which the product development can be completed.

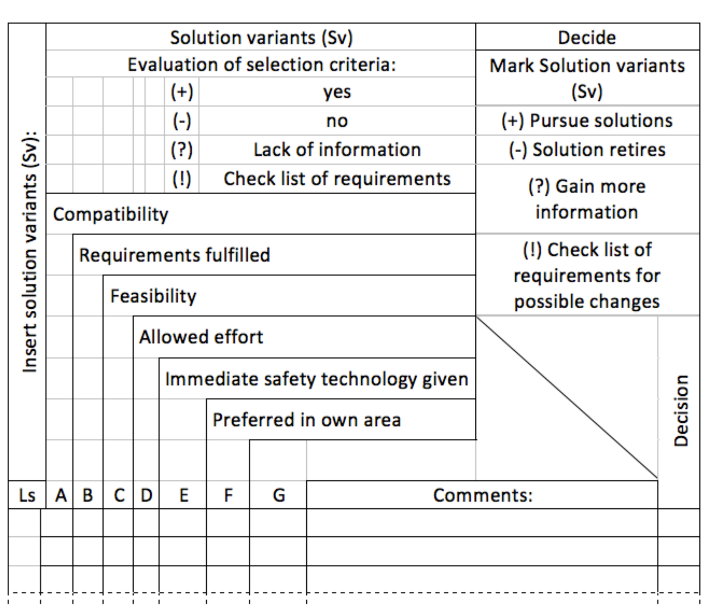


Figure 2: Selection list of Pahl/Beitz [4]

Results

Development of a requirement list:
From international packaging regulations, eight requirements have been worked out, which correspond to the vision of the PI. A protection of goods that meets the following eight requirements can contribute to sustainable logistics:

- Reusability
- High protection
- Low weight
- Possibility of automation
- Recyclable
- Cheap
- Renewable raw materials
- Easy handling

Finding solutions and their principles:
One possible concept is splitting into an integrated and moving part. The solutions are shown in the morphological boxes in Figures 3 and 4. The differently colored paths combine solutions for partial functions into a total solution.

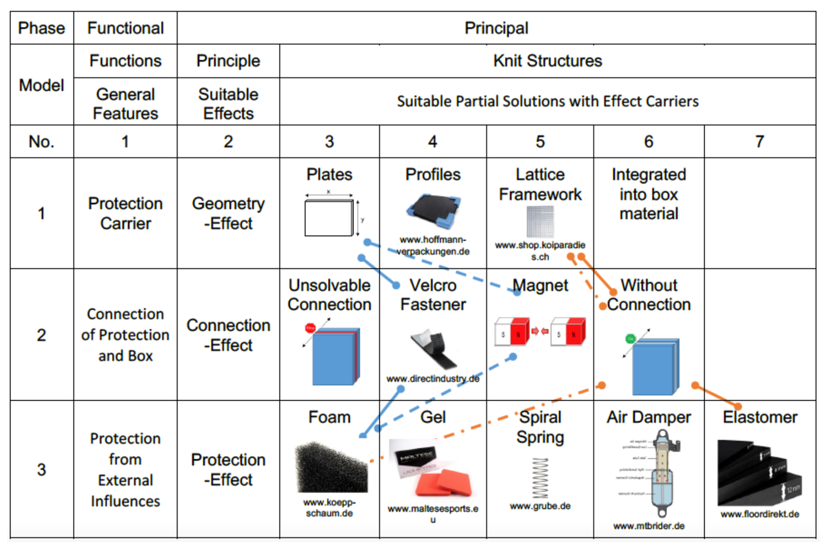


Figure 3: Morphological box with the integrated Solution

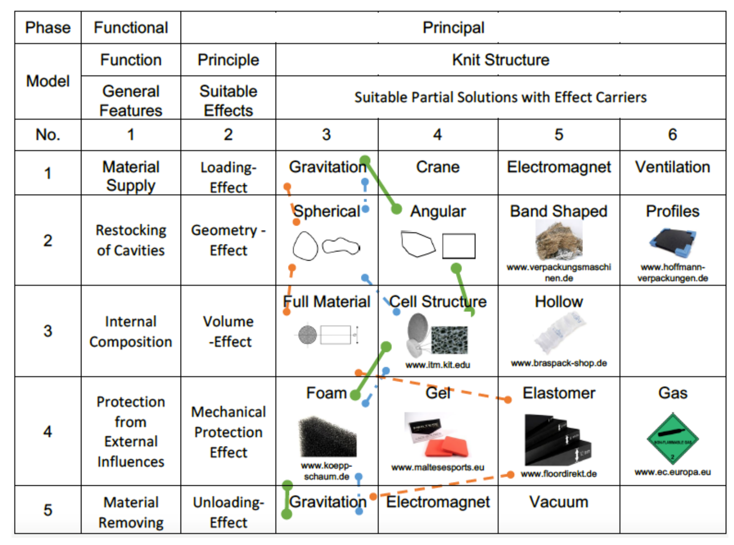


Figure 4: Morphological box with the movable solution

Evaluate the findings:
The most promising concept, which should be followed after the evaluation with the selection list and value-in-use analysis, consists of a carrier plate, which can be integrated into the modular box with a Velcro fastener and protects the goods against external influences with foam. In addition, the cavities are filled with a flexible protection of goods, which is made of foam material and has round geometries.

Conclusion and Outlook

The concept developed corresponds to the requirements list for the PI Vision. By splitting into an integrated and moving part, the reusability is increased and the empty space in the modular boxes is reduced. The movable part is based on already existing processes, which allow the concept to be automated. The integrable part had to be introduced in order to achieve the desired goals for sustainability. This part, however, still requires some research.
Further steps should be:

- Selection of materials for integrated and movable protection of goods, which correspond to the requirements list.
- Determination of the necessary material protection thickness for integrated protection of goods.
- Development of a prototype and execution of tests

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Atropine – Fast Track to the Physical Internet

P. Brandtner, L. Simmer, M. Plasch, A. Haller, M. Kalt and M. Neubauer

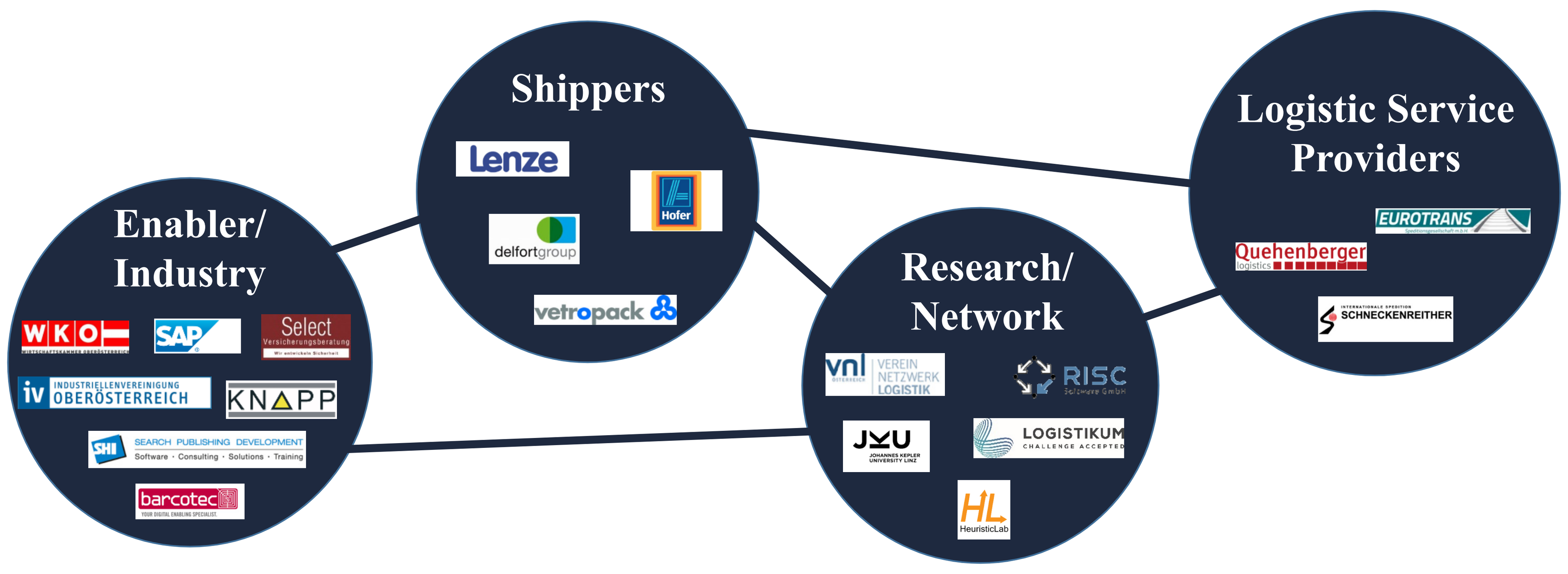
Introduction

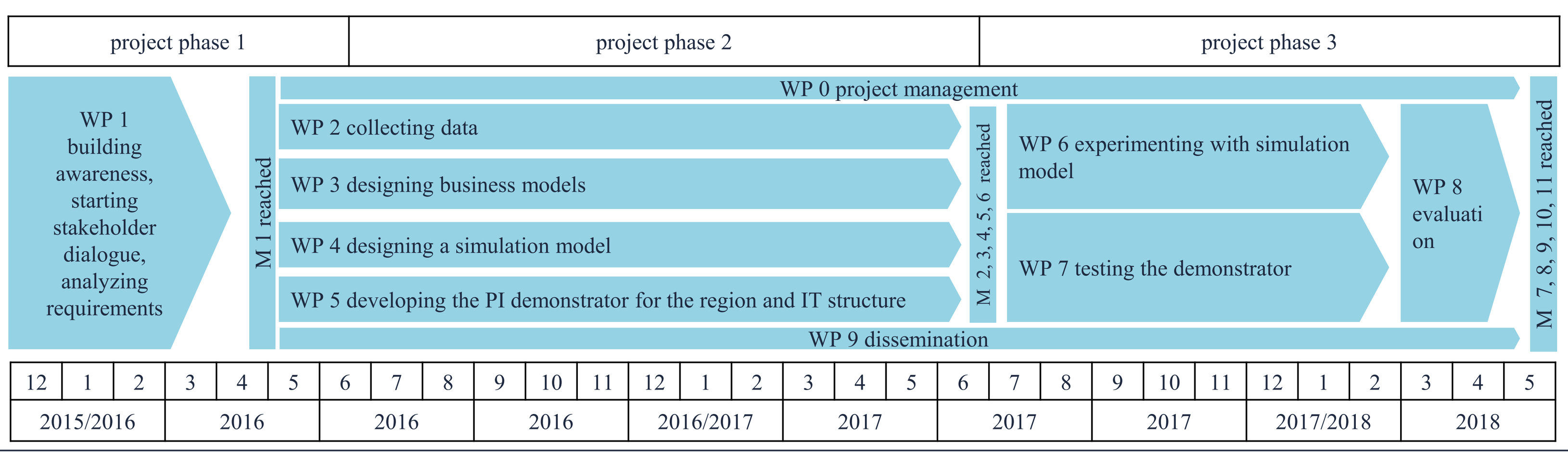
Making the Physical Internet (PI) a reality will require radical changes with respect to the roles and responsibilities of many stakeholders. It takes levels of industrial co-operation, asset sharing and supply chain transparency well above those prevailing today. “Atropine - Fast Track to the Physical Internet” is a multi-disciplinary cross-industry project, which aims to raise the awareness and the willingness to cooperate in the participating companies. The project team seeks to

(1) analyse partner companies’ flow of goods by simulation
(2) derive potentials for optimizing existing network structures
(3) conduct a demonstration-based proof-of-concept within the partner companies
(4) identify framework conditions for new business models in PI settings
(5) communicate findings to project partners and transfer knowledge to other domains
(6) increase existing research capabilities and generate new ones
(7) create and maintain an international network in the PI community.

Atropine is the first project to combine logistic service providers, shippers, research partners and technology enabling companies. The common vision of the project is to support the realization of the Physical Internet in the test region of Upper Austria in order to provide insights for decision makers from industry, research and policy making.

Project Team and Approach

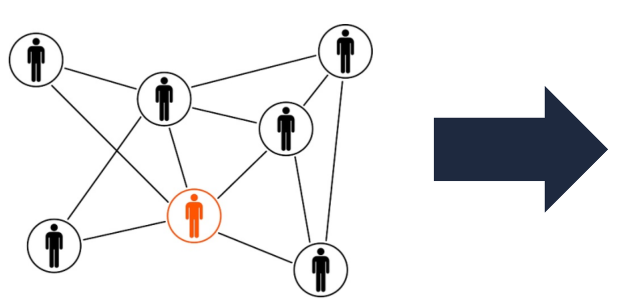




Results

(1) best practice analysis

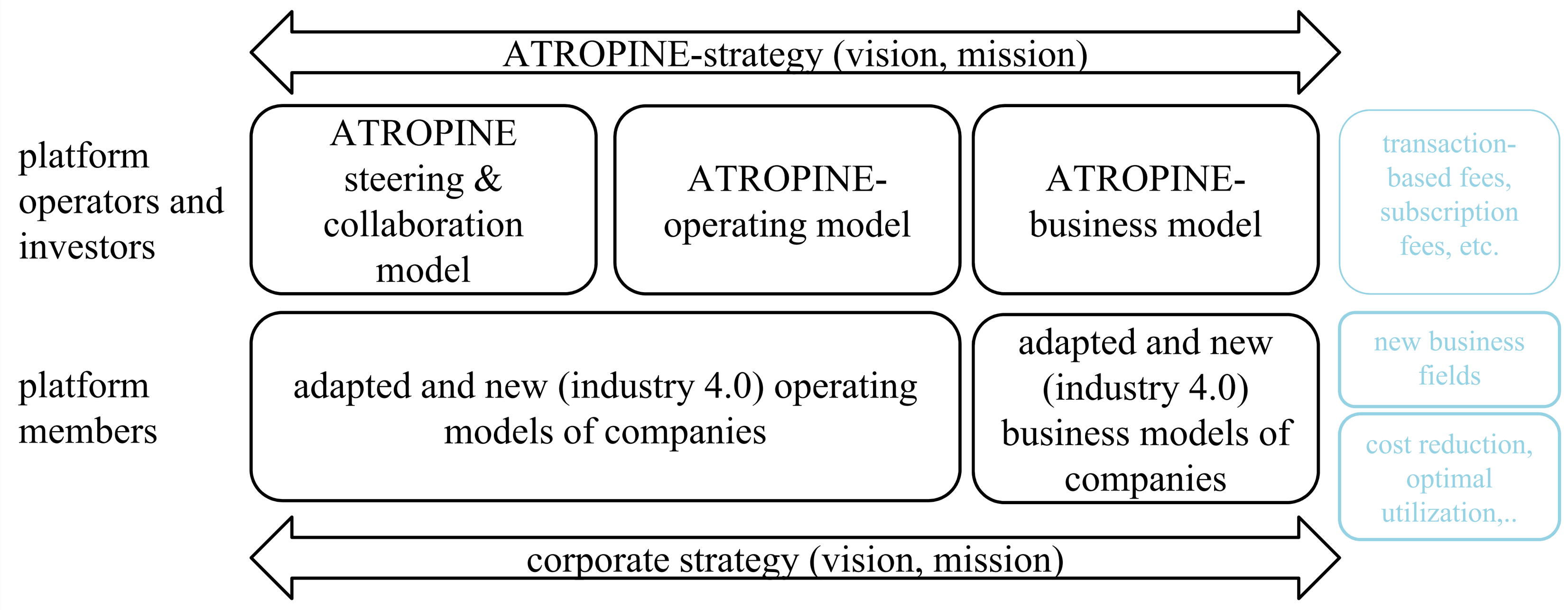
(2) stakeholder dialogues and requirement analysis



four task fields

- legal framework
- business model
- modelling, interaction, simulation und optimization
- device2cloud

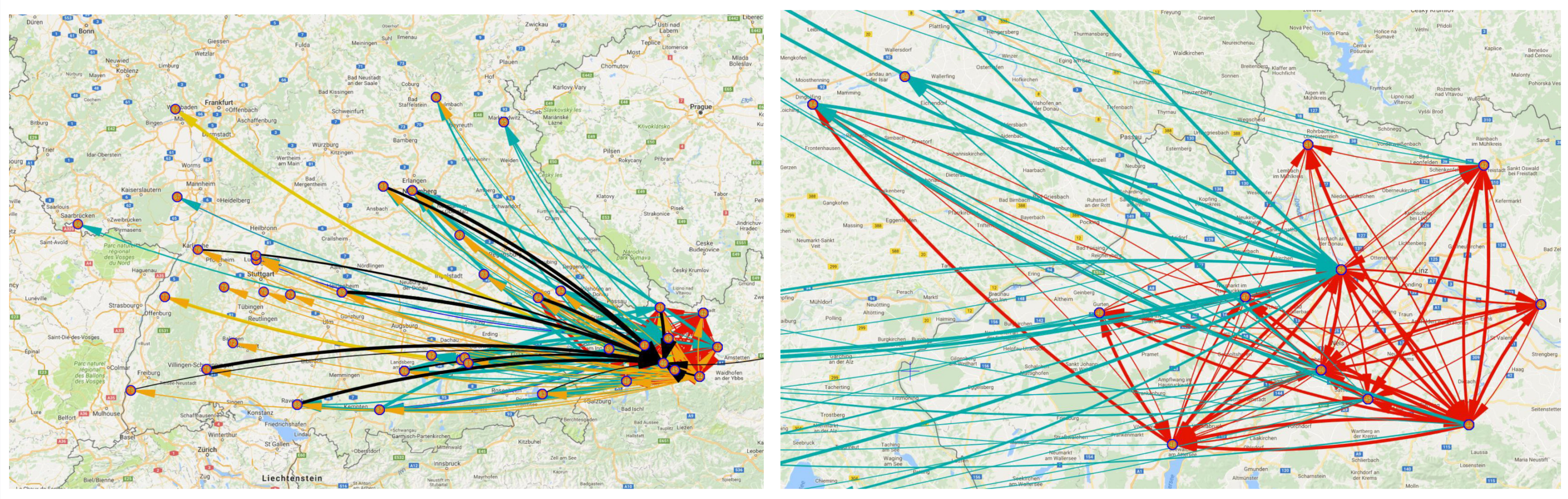
(3) business model



(4) legal framework

platform operation with model platform conditions and value added services	**transport and warehouse services** in a synchromodal logistic network with transport and warehouse conditions and model contracts for the D-A-CH-region

(5) modelling, interaction, simulation und optimization



(6) device2cloud

Conclusion and Future Work

The project makes the Physical Internet a more prominent agenda item in Upper Austria and will show the participating project partners benefits, challenges and solutions of co-operation and asset sharing. Atropine shall pave the way for a full-scale development of the PI vision in the next few decades and provide the basis for pushing the industry toward a new level of co-operation with more shared resources and increased standardization.

In a long-term the project should help to

(1) boost the use of inland waterway and rail in freight transport through bundling
(2) harmonize transportation relevant regulations in the EU
(3) simplify the handling and storage of goods
(4) make Upper Austria a nationally and internationally recognized pioneering Physical Internet model region
(5) and reach a significant reduction of greenhouse-gas emissions and of energy and resource consumption.

Nevertheless this project will just provide the first major step into the implementation of a Physical Internet. It will be necessary to scale up the effort with the addition of a wider range of players. Awareness in the companies should be raised, the benefits of co-operation demonstrated and the companies supported in cooperation, because collaboration between actors will have to be further intensified in order to develop consistent and impactful solutions towards a Physical Internet.

Acknowledgements

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Research on the Physical Internet – Status quo

Lena Krammer – SCM master student at WU Wien

Introduction

The poster discusses the status quo of the concept of Physical Internet (PI) by collecting benefits as well as challenges stated in existing literature. As outcome of a structured literature review (SLR), a framework of discussed topics and a citation analysis are provided.

Benefits of PI

Compared to a private supply network, companies in a global open supply web, enabled by the PI, can benefit from various aspects. Benefits discussed in literature can be categorized in 9 areas as shown in the following:

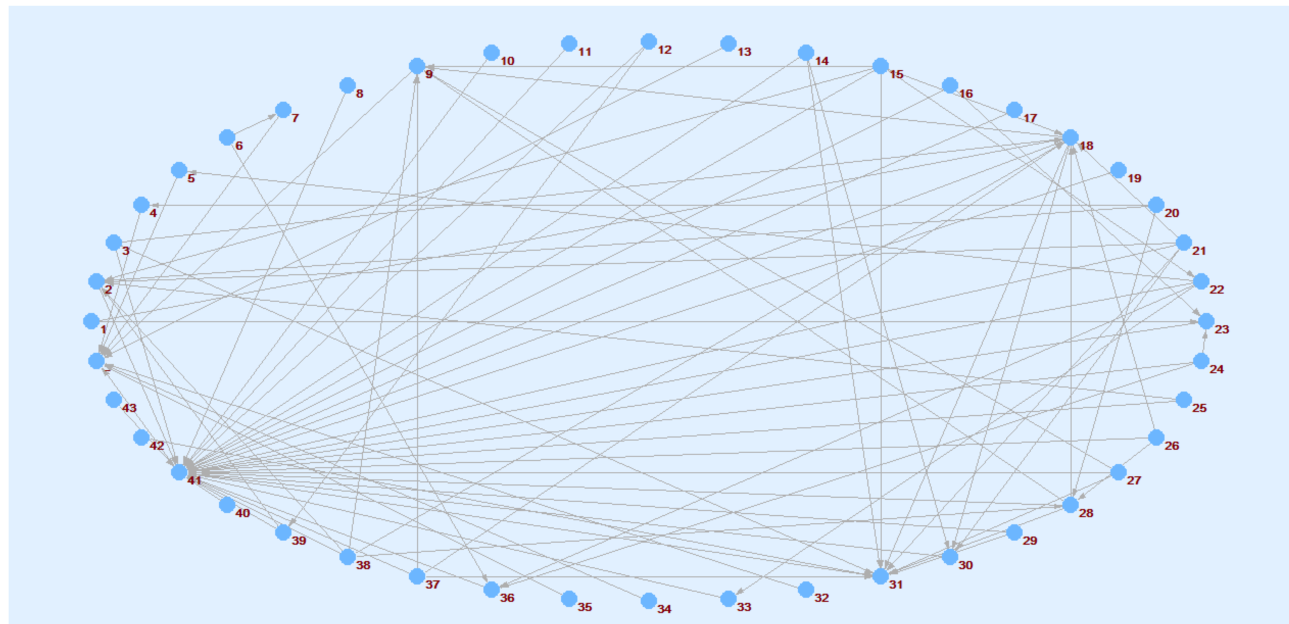
- General aspects
  - Increased supply productivity [1]
  - More responsive, adaptive and resilient logistics systems [1]
  - Enhanced efficiency and sustainability of logistics on a global scale [2]
- PI containers
  - Lower effort, variety and costs in purchasing containers [3]
  - Usage of recyclable green smart boxes leads to lower total cost, fewer resources needed and reduced CO_2 emissions [4]
  - Less labor-intensive and erroneous packaging of goods due to support by RFID [4]
  - Cost effective reading of massive data flow due to activeness of PI containers [5]
  - Active role of PI containers in grouping several transportation containers to one composite transportation container in PI hubs [5]
- Distribution and transportation
  - Higher economies of scale the more parties are involved and the larger the size of the distribution network is [6]
  - Higher density of points in a PI system allows reducing the length of different tours at the same service level and improving usage of transport means [7]
- Cloud usage and sharing
  - PI is a supporter of cloud manufacturing and storage [8]
  - Goods and facility lending and sharing or support from virtually present specialists [8]
  - Pooling of resource utilization, saving time and costs, reducing risk and fostering of just-in-time interaction [8]
  - Economical, ecological and social sustainability achieved by offering idle capacity to other participators in an open logistics network [9]
  - Reduced storage and transportation costs via storage in PI hubs closer to final customers [9]
- Inventory
  - Lower average total costs, reduced average inventory levels and remaining service levels by using a PI-inventory control model [10]
  - Option of repositioning and replenishment between hubs [11]
  - Option of multi-sourcing [11]
  - Option of dynamically changing inventory locations (e.g. in case of demand variations) [11]
- Visibility and traceability
  - Real-time visibility by Radio Frequency Identification leading to improved decision making, enhanced efficiency and effectiveness of processes by information sharing and sophisticated models [12]
  - Closed-loop visibility and traceability of production status, processes, progresses and costs [12]
- Shipment consolidation and vehicle utilization
  - Faster and less costly cross docking at PI hubs [13]
  - Faster, easier and more efficient load consolidation of goods from different parties [13]
- City logistics
  - PI as enabler of hyperconnected transportation in cities [14]
  - All existing (public and private) logistics and transport facilities of urban areas can be used [14]
  - Reduced transports, fuel consumption and CO_2 emissions in cities [14]
  - Less utilization of infrastructure and less traffic jams [14]
- PI manufacturing system
  - Interconnected manufacturing resources [15]
  - Better control, focus on processes, "quick response, balanced production, highly effective throughput, low consumption, and scientific decision-making in a manufacturing system" [15]

Challenges of PI

The following challenges are described in literature:

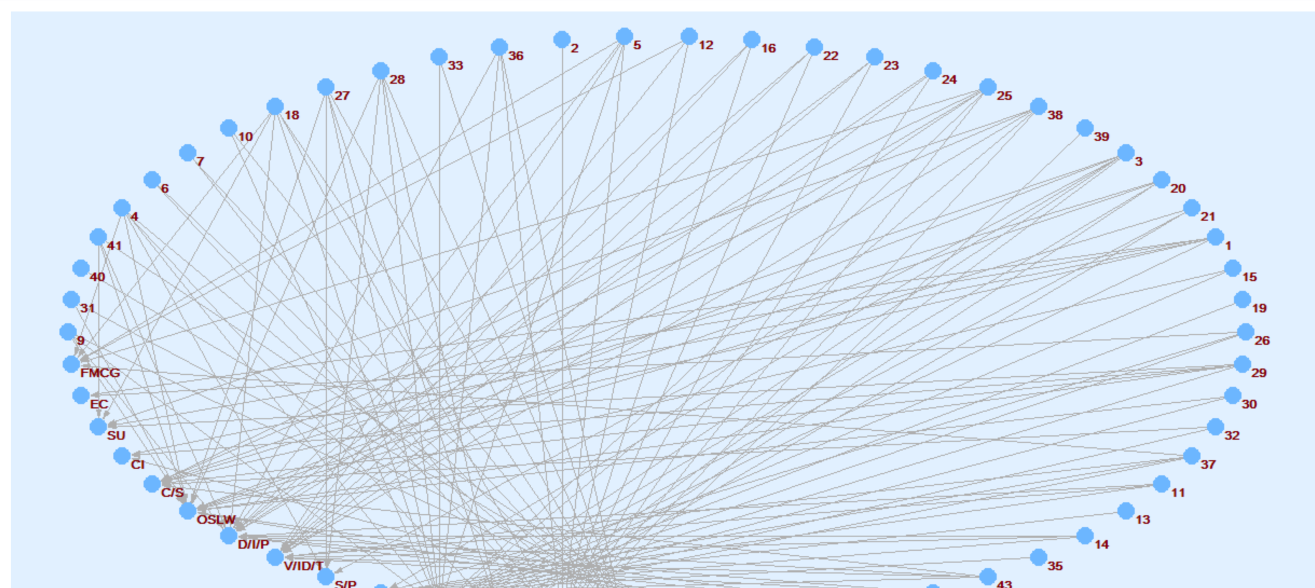
- Development of efficient PI hubs due to high variability and uncertainty (e.g. in container size, quantity, time) [16]
- Efficient tracing and management of PI containers [17]
- Data management and interoperability of logistics in PI [18]
- Lack of appropriate IT systems in SMEs [18]
- Fear of negative effects coming with information sharing [18]
- Increased price competition between carriers [19]
- Optimization of scheduling [20]
- Different parties in the PI might need training and new equipment [20]
- Intelligence of, communication and interaction between PI containers [5]
- Development of specifications and compatibility of PI-related smart devices [21]
- Short-sighted decision making of smart devices and PI containers leading to system nervousness [22]
- Decisions on size of PI containers and platforms [23]

Citation analysis



Citation analysis of 43 papers received from the SLR regarding PI is performed with the application Pajek. The result shows that the majority of papers have no citation relation, while a few having strong relations.

Framework of topics



A framework of topics has been created from the relevant pieces of literature found in the SLR. These are assigned to15 topics that have been detected to be the main ones discussed in literature. Results show that the topics transport/distribution, data/information/protocols, containers, open supply/logistics web and visibility/identification/traceability are the ones most often described.

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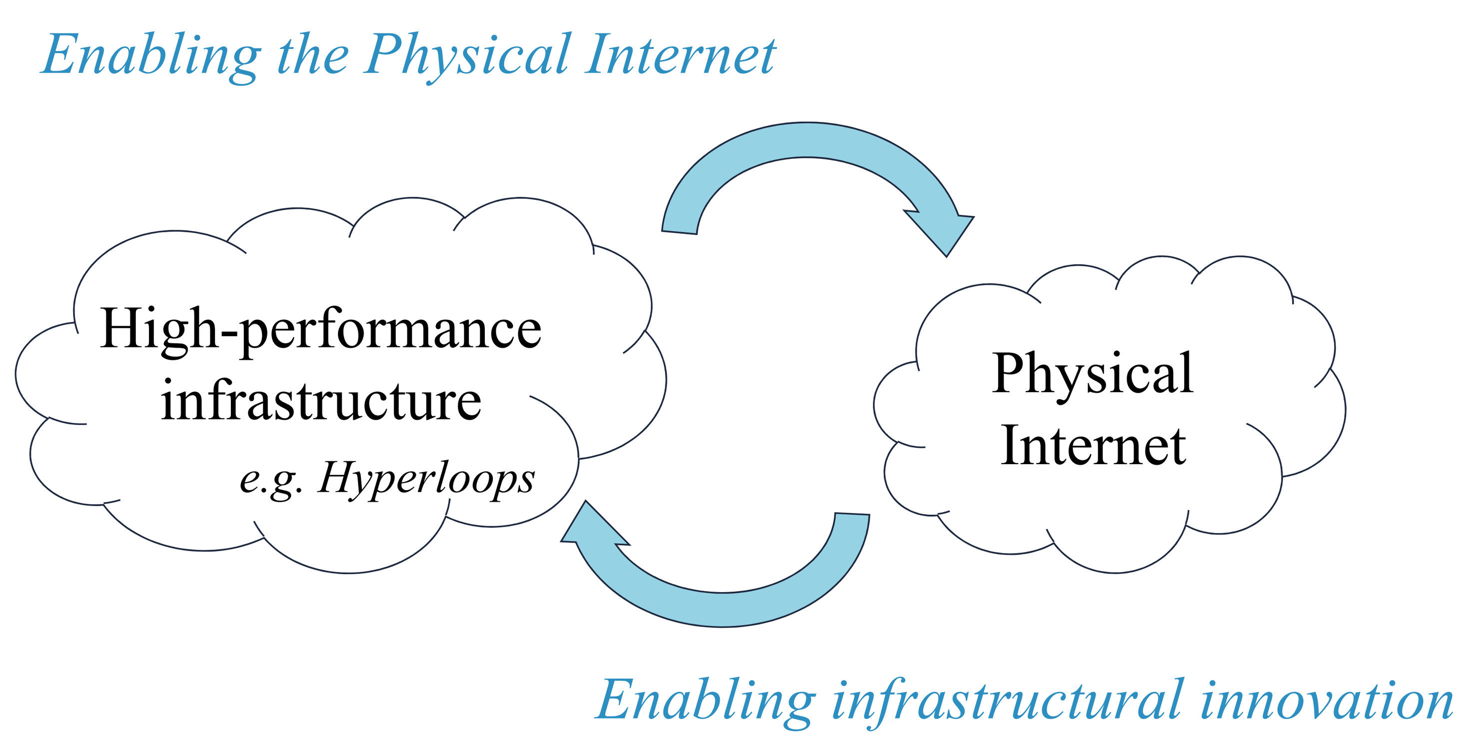
Hyperloops: New transport mode enabled by the Physical Internet?

S. Pfoser, T. Berger, L.M. Putz, O. Schauer, G. Hauger, M. Wanjek, C. Berkowitsch, R. Schodl, S. Eitler, K. Markvica, M. Prandtstetter

Motivation

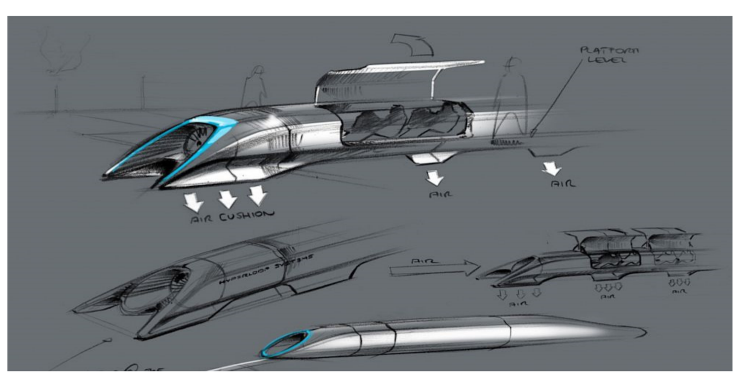
- 25 % of carbon emissions caused by transport sector in Austria → overall aim is to reduce carbon footprint
- EU-target: to shift 50 % of transports with a distance of more than 300 km to environmentally friendly alternative modes of transport until 2050
- To be able to cope with the expected increase of demand, investments of € 1.5 trillion in existing infrastructure at the period from 2010 – 2030 are necessary
- Current situation of unsustainable and inefficient transports in terms of economical, environmental and social aspects



Innovative transport solutions and alternatives are crucial to meet the targets of economical, environmental and social sustainable logistics
→ Hyperloops represent such a solution (?)

Hyperloops: State of the art

- Fully autonomous high-speed transportation of freight and passengers with special capsules through near-atmosphere pressure tubes
- Transportation at top speeds of up to 1220 kilometers per hour
- Capsule departure every 30 seconds possible at peak demands
- Capsules for freight and individual traffic are planned



Interrelations to PI

Characteristics Hyperloop

- Independent departures based on transportation demand are possible
- Transport capability of 12 tons per capsule in order to split and optimize transport frequencies and arrivals at different destinations
- Self-powering by solar panels at the roof of the tubes

Targets Physical Internet

Hyperloop \ Physical Internet	Physical Interconnectivity	Digital Interconnectivity	Operational Interconnectivity	Sustainability	Profitability
High-speed	X				
Time-flexibility	X				
Interoperability	X	X	X		
Eco-friendliness				X	X
Autonomy		X			X
Low operational costs					X

Conclusion

- *Symbiosis Hyperloops – Physical Internet*: Currently unreachable innovations such as hyperloops can be achieved through PI (cf. Montreuil, 2012)
- Mutual benefits existing in implementing hyperloops together with PI
- However, high investment costs required. Potential especially for high value freight transports.

Contact details: Sarah Pfoser
University of Applied Sciences Upper Austria
sarah.pfoser@fh-steyr.at
Tel.: +43 5 0804 33261

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protoPI – an Austrian project to create a Prototype of a regional Physical Internet web platform

Andreas Gasperlmair, Hans-Christian Graf,
Sophie-Therese Hörtenhuber, Christian Landschützer

Introduction

The regional material flow between the federal states Upper Austria and Styria are quite well connected by the existing transport industry. However, because of the fragmented nature of individual deliveries from many different medium-sized companies as well as the special geographical and topological effects in European comparison, there is further potential in bundling of goods. Innovations of the PI Initiative connect dislocated production sights to regional production clusters thus enabling high-quality planning and control. However, interfaces to connect logistics and their integration to the integral value networks with variable capacities are widely missing.

The following frame conditions to this project have been analyzed during the survey phase by interviewing the main forwarders on the focused transport relation Upper Austria – Styria:

Business in the logistics sector is still mainly done the **old-fashioned** way:

- E-Mail and telephone are more important to most companies than standardized interfaces
- Even fax is still widely used

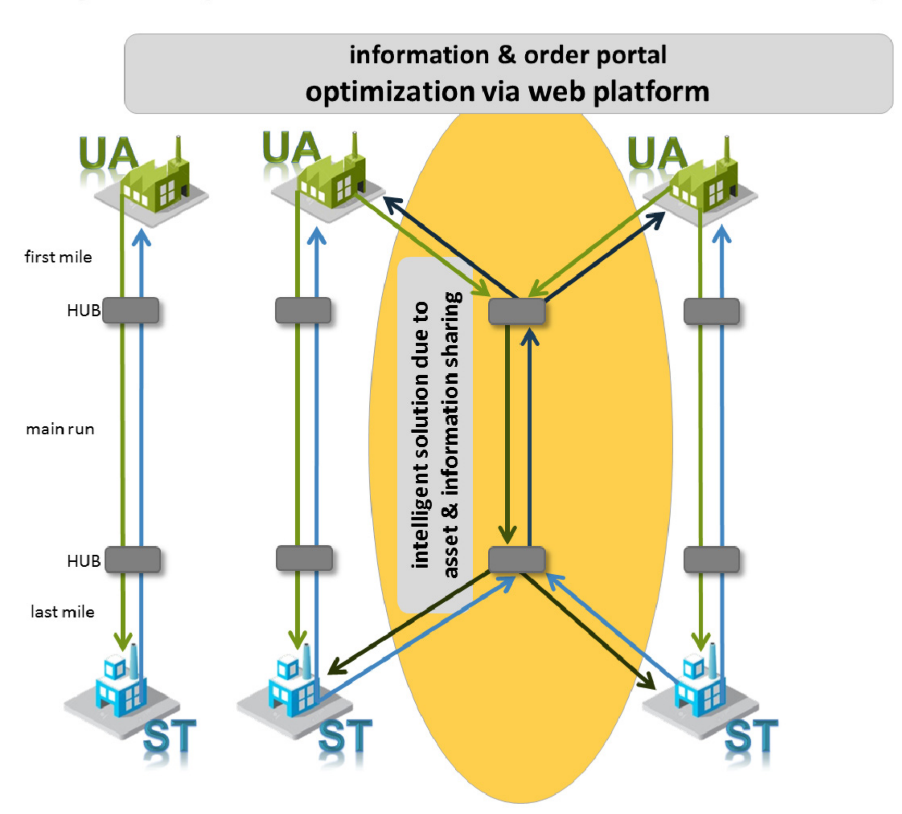
Freight exchange platforms are **widely-used** by logistics service providers but account for comparably **little turnovers**.

- More than 90 % of the interviewed Austrian transport companies use freight exchange platforms
- 76 % of the interviewed companies stated, that freight exchanges contribute less than 20 % to their turnovers.

Nevertheless, the Austrian transport industry considers **digitalization as a big challenge.**

Methodology

Project „protoPI“ collaboration concept



The main objective of the project is the design of a pioneering cooperation model for cargo management, which plans, consolidates and controls the single unit loads of all partners cross-company-wide via a designed Internet platform.

Objectives

The superior project goals are:

- Reducing the traffic by implementing an intelligent cross-company ("smart") logistics system
- Creating more transport efficiency
- Standardization of currently incomplete information flows and transport data between shippers, receivers and logistics companies.
- Flexible transport pricing

The scientific objective of the project protoPI is to identify inefficient part loads and single unit loads between Styria and Upper Austria within the existing supply chains and creating more transport efficiency as well as reducing the traffic through an intelligent cross-company ("smart") logistics-system.

The research approach includes:

- Creating a data model which is necessary for the consolidation and bundling of transport orders cross-company-wide
- Identifying relevant system components and the necessary ICT-functionalities
- Enable pooling of standardized reusable handling units (PI-Container)
- Design of a suitable business model
- Design of a web-platform prototype
- Verification of concept validity and calculation of potential savings via a field study

Project Status and Outlook

- relevant existing businesses analyzed on the basis of the main forwarders on the focused transport relations
- necessary ICT functionalities defined
- potential business models in design phase
- potential analysis for PI-based collaborations in progress
- setting up field study to validate the usability of the concept

ProKapa: Dynamic Capacity Management to Support the Development of Physical Internet's Framework Conditions

Georg Brunnthaler, Sandra Stein, Wilfried Sihn

Introduction

"The way physical objects are moved, stored, realized, supplied and used throughout the world is economically, environmentally and socially inefficient and unsustainable." Montreuil stated in 2012 [1]. As he implies, there are several ecological and economical problem dimensions:

- The transport sector has the highest objective discrepancies regarding Kyoto-objectives in the last evaluation period for Austria [2].
- Greenhouse-gas (GHG) emissions are growing disproportionally compared to gross domestic product [3].
- Logistics service providers have a high share of fix costs and are in danger to slide into the reds easily in case of fluctuations in capacity utilization [4], [5].

The European Union presented ambitious objectives to GHG-emissions, which are directly related to modal split and capacity utilization [3].

- In road transport, only 50-70% of potential capacity is utilized [6].
- Between 1995 and 2013, overall transport performance in tkm was reduced within the European Union. Road transport has grown in the same period [7].

From a logistics service provider's perspective, logistics planning is conducted hierarchically. Continuous preplanning of transport demand is not implemented, even though there are several areas for optimization:

- Provision of necessary means of transportation [5],[8] in required quantity and derivation of capacity management strategies (e.g. "available to promise") [9].
- Overcoming lack of planning competencies with regard to personnel planning [10],[11].
- Implementation of advanced business models, which can reduce demand fluctuations (e.g. "Peak-Load-Pricing", "Yield-Management") [5], [12].

To cope with economic and ecological challenges, freight transport has to overcome lack of capacity utilization and use of unsustainable means and modes of transport. Continuous preplanning of transport demand holds potential to overcome these challenges.

Objecitves

The upcoming research project ProKapa aims at enabling logistics service providers to react flexibly and adaptably to dynamic market changes and to challenges of the „Physical Internet". By developing a **cybernetic planning approach** from the perspective of logistic service providers, the following objectives are addressed:

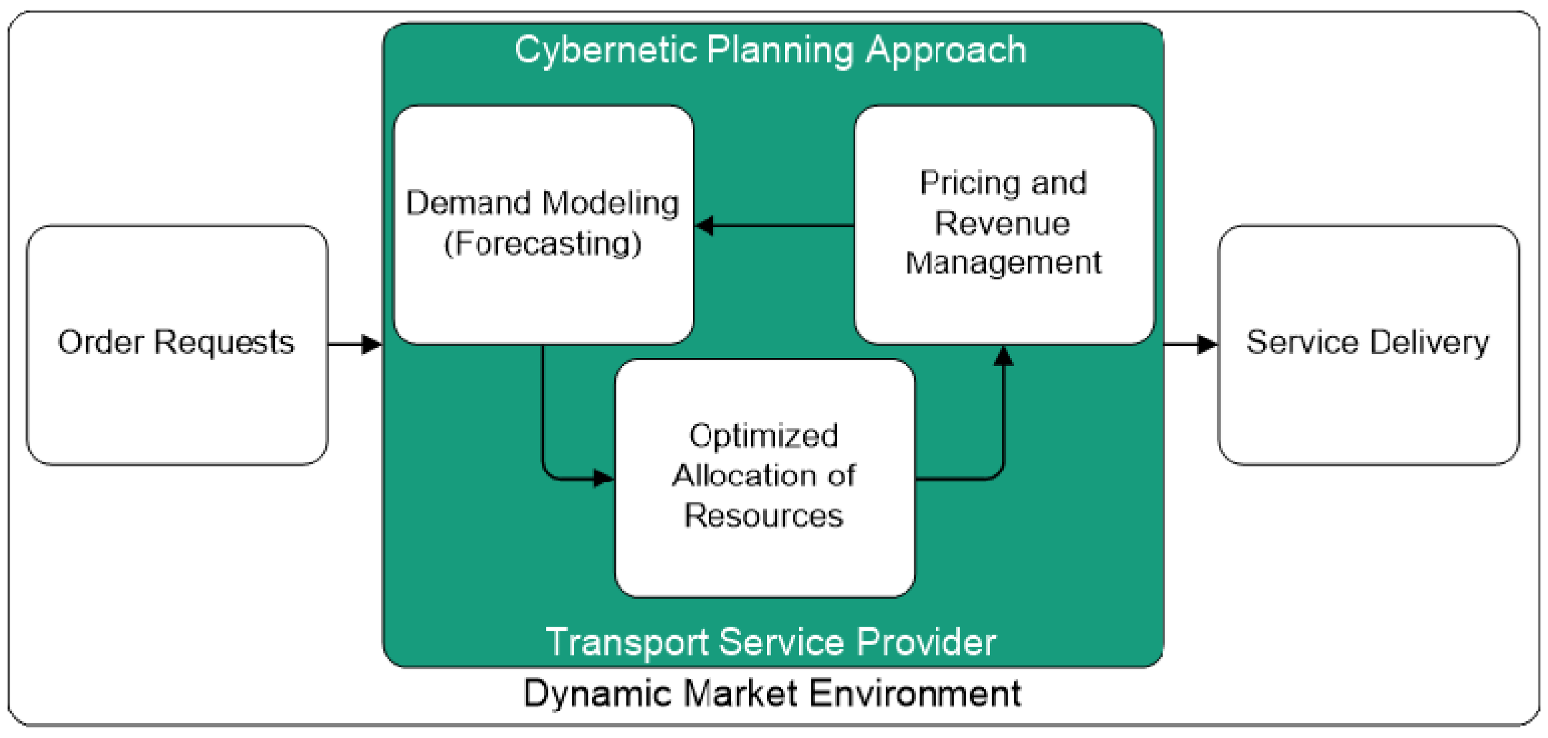
- **Accelerate planning duration and enhance planning frequency (close to real-time) in fleet and personnel planning.**
- **Increase resource utilization, planning and reduce empty mileage.**
- **Smoothen transport demand through capacity management, cooperation and pricing strategies.**

Methodology

The cybernetic planning approach contains the following work steps:

- Transport demand within an abstract transport network is continuously modeled in an abstract network by extensive use of data.
- According to the transport demand, capacities of transport means and staff are planned close to real time and resource allocation is optimized within the network.
- Resulting from remaining capacity constraints, transport demand is smoothed by measures such as pricing strategies, horizontal and vertical cooperation activities.

By applying that method, conditions for incoming order requests and resulting service delivery are optimized:



To realize the cybernetic planning approach, several interdependent research activities are necessary:

- Comparative analysis of transport requirements in different industries and definition of a common target system.
- Development of a hybrid forecasting approach by extensive use of internal and external data.
- Development of a multi-step planning approach for fleet and personnel planning.
- Development of an optimization model for the derivation of pricing strategies regarding transport demand and capacity constraints.
- Integrate forecasting, capacity planning and pricing strategies into a cybernetic planning approach.
- Evaluation of effects on flexibility and ability to transformation in a dynamic market environment as well as on the ecological and economical impact.

Results

Expected results are suitable methods and tools for the preliminary planning for transports, a stronger interconnection between data sources and constant recommendations of actions concerning the adjustment of capacity, the allocation of resources and action in pricing.

In this respect, necessary flexibility is created in order to face future challenges in a highly dynamic environment.

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NOLI, A Proposal for an Open Logistics Interconnection Reference Model for a Physical Internet

Jean-Yves Colin, Hervé Mathieu, Moustafa Nakechbandi
Le Havre Normandie University, FRANCE

A New Open Logistics Interconnection Model: NOLI

This poster presents a New Open Logistics Interconnection (NOLI) reference model for a Physical Internet, inspired by the Open Systems Interconnection (OSI) Reference Model for Data Networks. This NOLI model is compared to the standard OSI model, and to the Transmission Control Protocol/Internet Protocol (TCP/IP) model of Internet. It is also compared to the OLI model for a Physical Internet proposed by Montreuil.

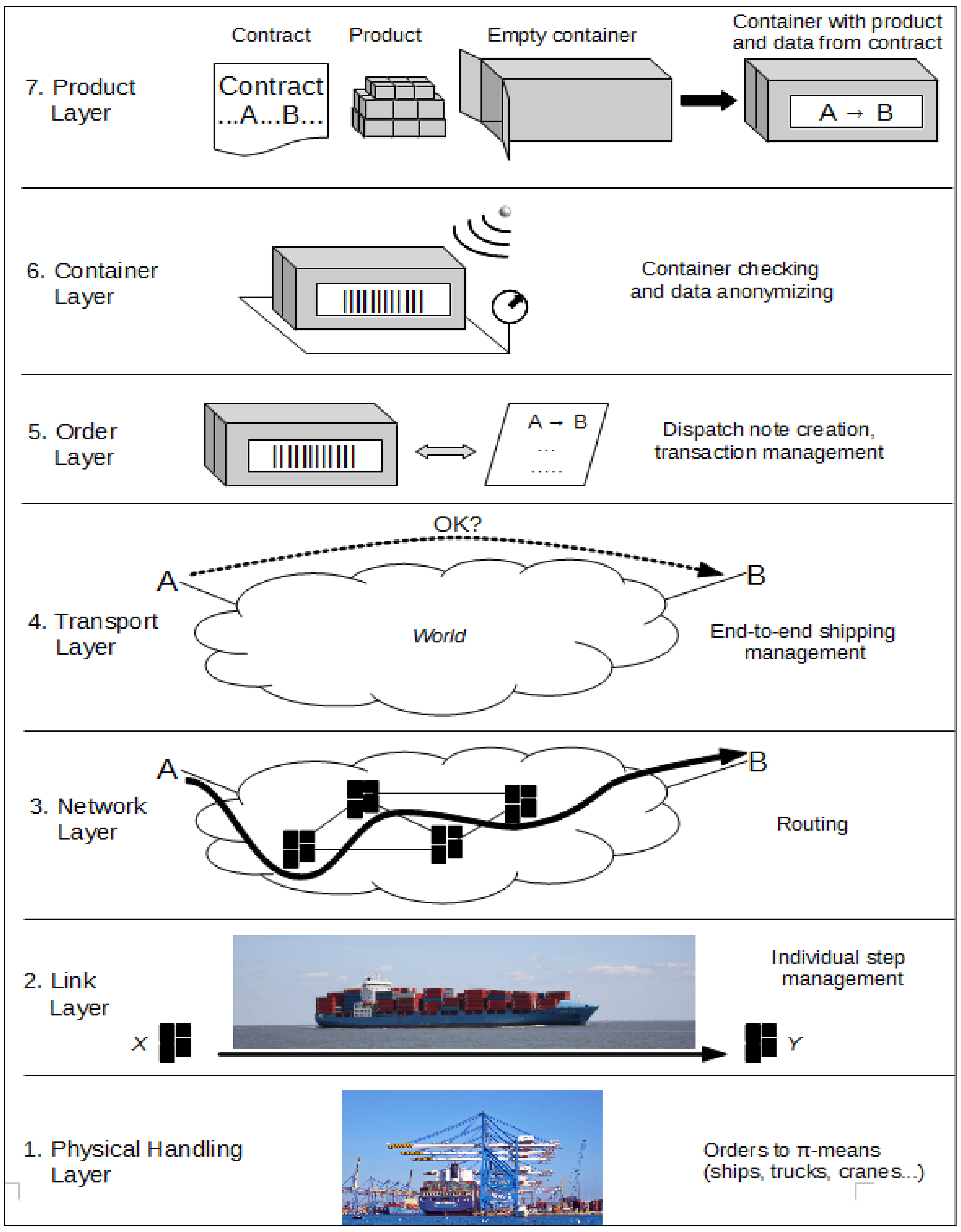
The seven layers of the NOLI reference model

Position in the NOLI model	Layer Name	Role of the Layer
7	Product Layer	Defines the possible products or goods that can be transported inside π-containers. It fills the π-containers with the products and establishes the related contracts.
6	Container Layer	Defines the physical characteristics of the π-containers allowed on the Logistics Network. It will check the physical integrity of the π-containers and combine them into "sets" according to their characteristics.
5	Order Layer	Receives sets of π-containers from the Container Layer. It will create the orders according to the specified constraints (deadlines, client whishes, starting and destination point, etc.), and assigns the π-containers to the orders.
4	Transport Layer	Receives orders made of π-containers from the Order Layer. The transport Layer creates "loads" from the received orders, and manages the end-to-end trip for each load.
3	Network Layer	Receives loads of π-containers from the Transport Layer and creates "blocks" from the loads. The Network Layer defines a path across the network for each block.
2	Link Layer	Manages the individual steps (point-to-point movement) of π-containers on π-means.
1	Physical Handling Layer	Physical characteristics description of the π-means used to move the containers.

Comparison between the layers of the TCP/IP, OSI, OLI and NOLI models

TCP/IP Layer Name (Internet)	OSI reference Model Layer Name	OLI Layer Name (Montreuil et al.)	NOLI Layer Name (Colin et al.)
Application	7. Application	7. Logistics Web	7. Product
	6. Presentation	6. Encapsulation	6. Container
	5. Session	5. Shipping	5. Order
Transport	4. Transport		4. Transport
Network	3. Network	4. Routing	3. Network
		3. Network	
Network Access	2. Data Link	2. Link	2. Link
Physical	1. Physical	1. Physical	1.Physical Handling

Example of NOLI layers functionalities



Lean tools to help to transform the traditional logistic into the Physical Internet

López-Molina, L; Cervera Paz, A; Popa, A.C.; Rodríguez Cornejo, V.M.; García, R; Pérez, V; Buiza, G.

Universidad de Cádiz

INTRODUCTION AND OBJECTIVES

1.-Introduction

Today's "Hiperconnected world" ➔ improved connectivity in the future (people, countries, institutions and enterprises); who isolates himself will NOT move forward.

The hiperconnectivity encourages to reflect upon the interaction between VIRTUAL WORLD (PI) AND LEAN MANAGEMENT.

"Virtual world" ➔ PI is moving to the logistics field: involves stakeholders throughout a more sustainable supply chain.

Lean Management: Techniques to improve the manufacturing, management, etc. ➔ removal of everything that is unproductive, useless and that doesn't provide benefits to the value chain.

2.-Objetives

Analyse the existence of interconnections between PI and Lean. Illustrate with Lean tools the relation with PI.

PHYSICAL INTERNET

Inefficiency And unsustainability symptoms	Economical	Environmental	Societal
1. We are shipping air and packaging	•	•	
2. Empty travel is the norm rather than the exception	•	•	
3. Truckers have become the modern cowboys	•		•
4. Products mostly sit idle, stored where unneeded, yet so often unavailable fast where needed	•		•
5. Production and storage facilities are poorly used	•	•	•
6. So many products are never sold, never used	•	•	•
7. Products do not reach those who need them the most	•		
8. Products unnecessarily move, crisscrossing the world	•	•	•
9. Fast & reliable multimodal transport is a dream	•	•	•
10. Getting products in and out of cities is a nightmare	•	•	•
11. Logistics networks & supply chains are neither secure nor robust	•		•
12. Smart automation & technology are hard to justify	•		•
13. Innovation is strangled	•	•	•

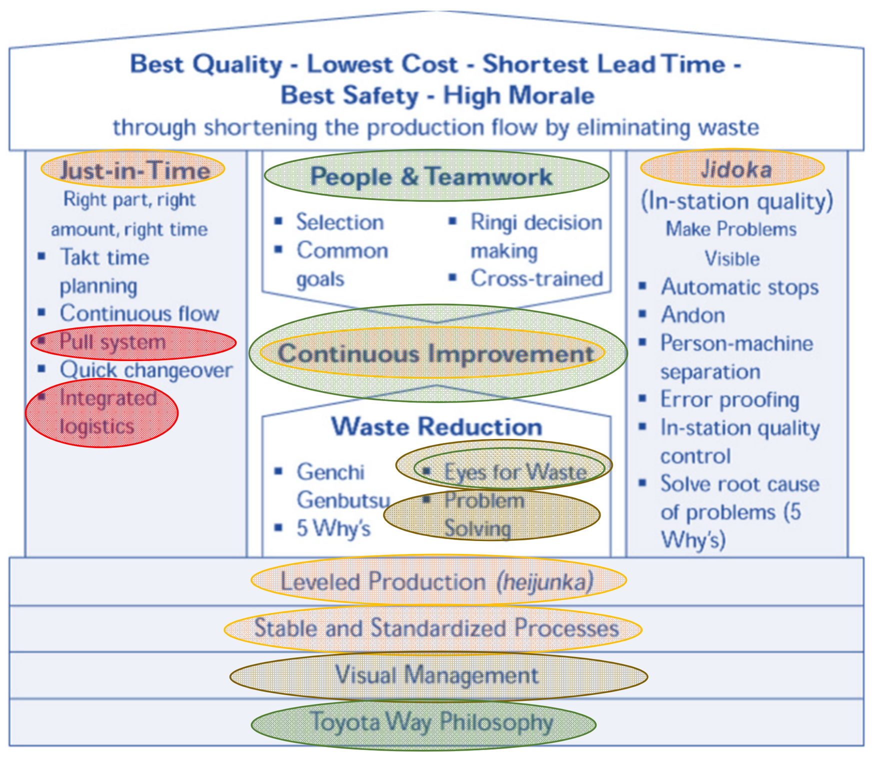
Source: Montreuil, B. (2009 and 2011a)

The Physical Internet is an open global logistics system founded on physical, digital, and operational interconnectivity, through encapsulation, interfaces and protocols (Montreuil, B. Physical Internet Manifesto, 2012)

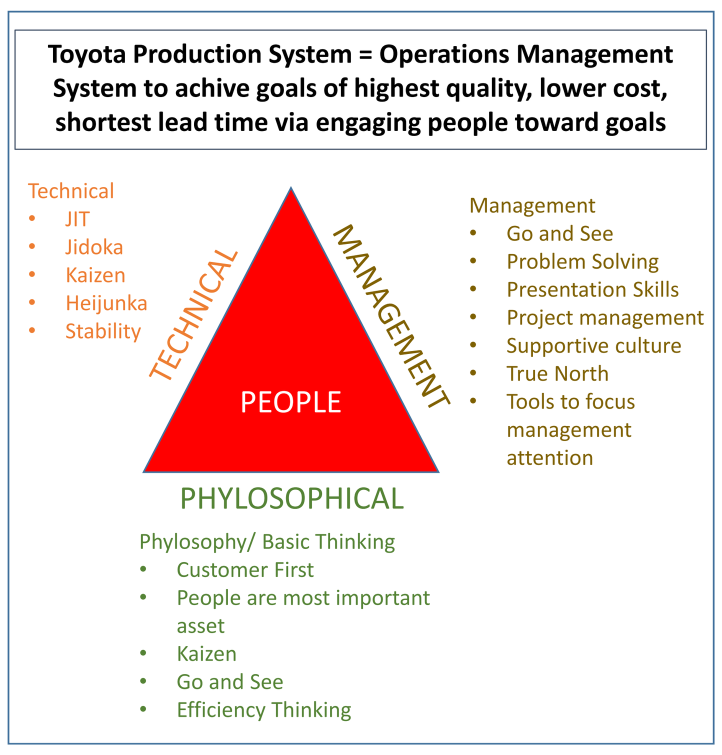
LEAN THINKING

What goals does Lean Logistics philosophy seek?

1. Supply the necessary products, when necessary, in the appropriate quantity and conveniently presented looking back into the supply chain.
2. Seek for the effectiveness in the distribution of products looking forward to the supply chain.
3. Eliminate waste in each tier of the value chain to improve the effectiveness of operations.
4. Shorten delivery times at each tier through the value chain to reach sooner the customers.



The Toyota Production System (TPS) (Liker, 2004)

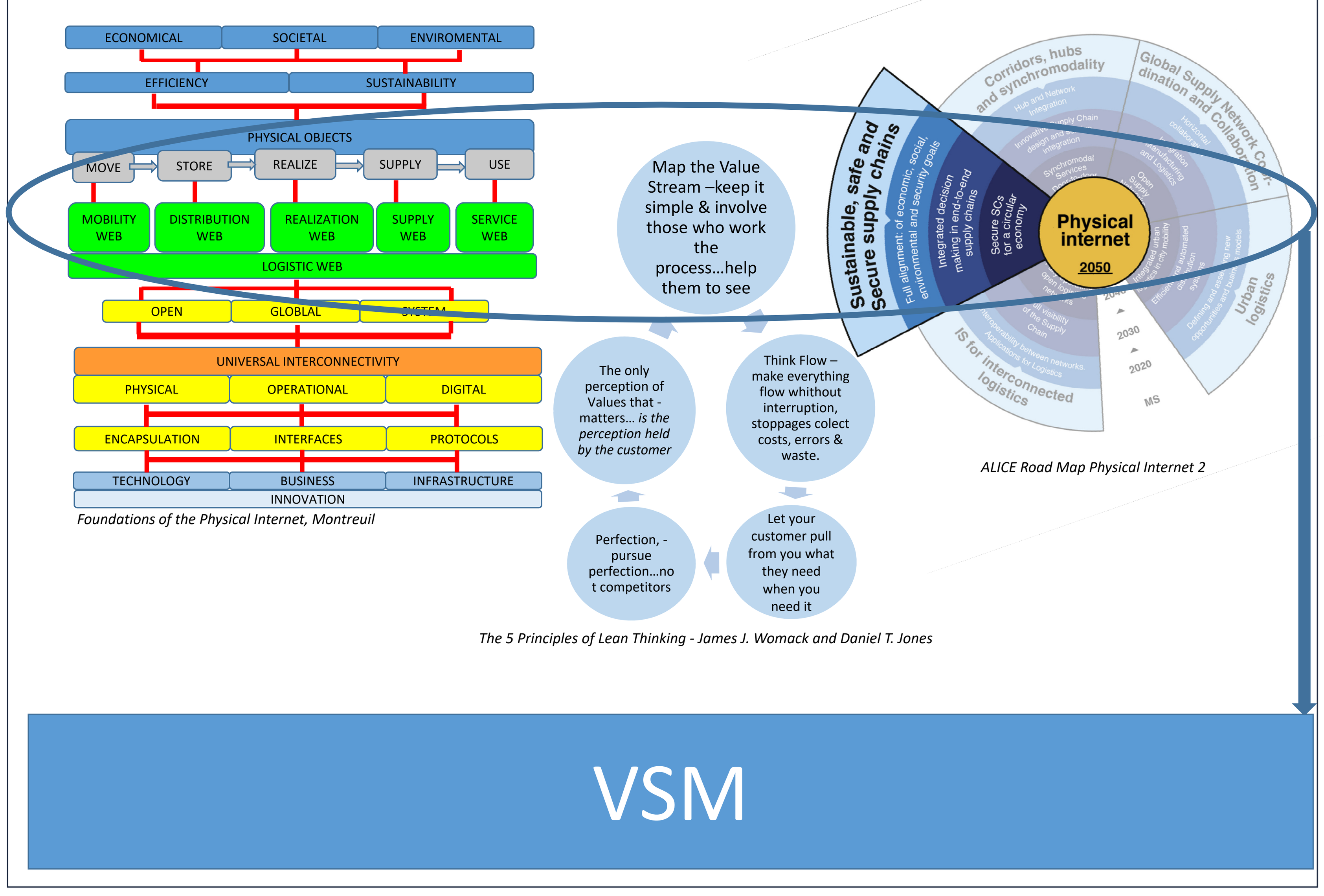


A Toyota leader's view of Toyota Production System (TPS) (Liker, 2004)

As we observe from the Lean Manufacturing or TPS principles, what really interests is the philosophy and the management.

INTERACTION PI-LEAN

In order to identify the possible interactions that PI&Lean concepts could share, have been included in a single sheet the figure that ilustrates the PI foundations, the ALICE Road Map and the 5 principles of Lean Thinking.
After reviewing the interactions, we obtain as a result that exists a logical connection between the different parts covered by the blue circle, with a result drown from LEAN tools.

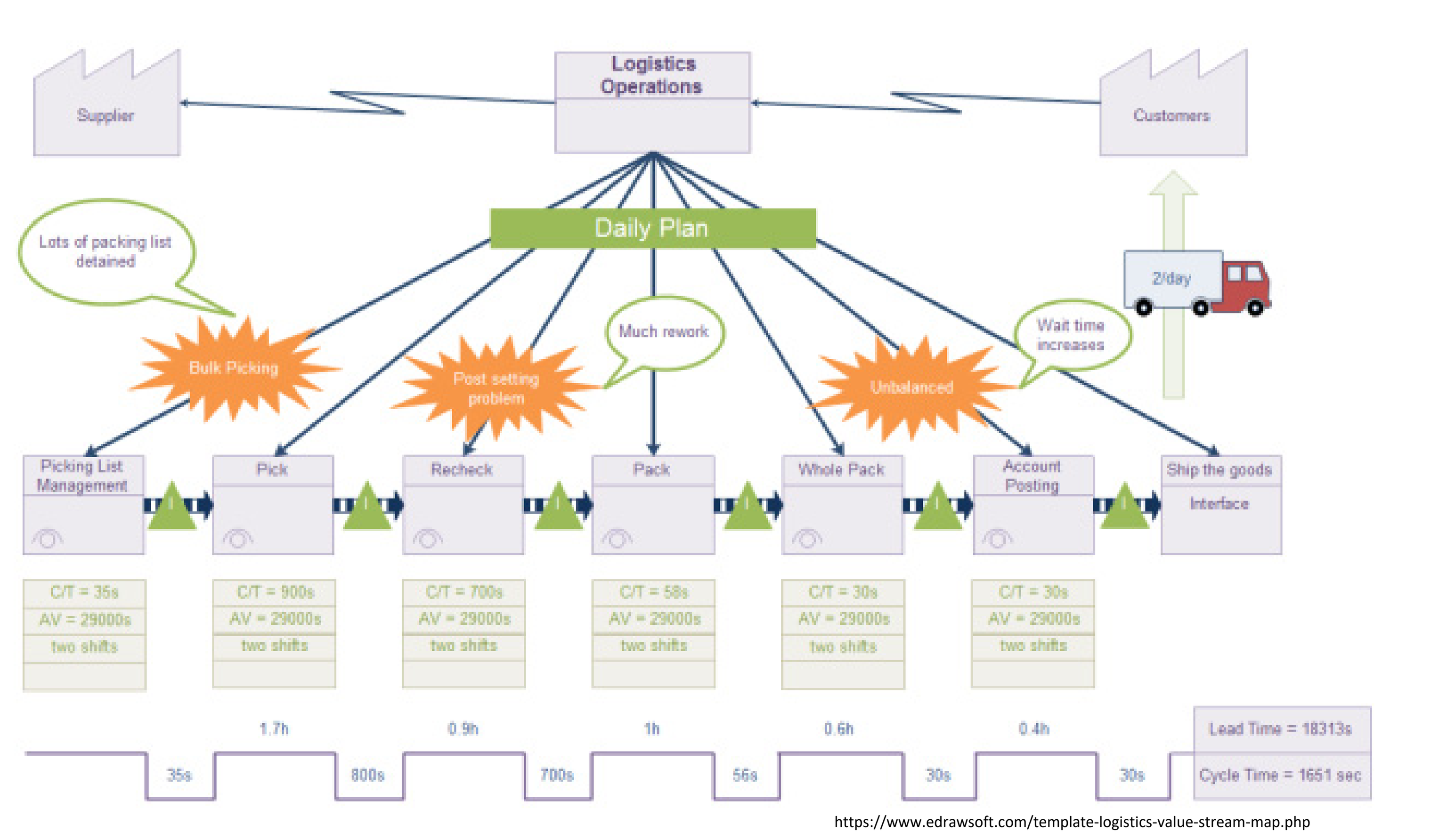


VALUE STREAM MAPPING

Value Stream Mapping (VSM): A paper-and-pencil tool that helps you to see and understand the flow of material and information as a product or service makes its way through the value stream. Value Stream Mapping is typically used in Lean, and it differs from typical process mapping in Six Sigma in three ways:

1. It gathers and displays a far broader range of information than a typical process map.
2. It tends to be used at a broader level, i.e., from receiving of raw material to delivery of finished gods.
3. It tends to be used to identify where to focus future projects, subprojects, and/or Kaizen events.

Mapping the Total Value Stream Mark A. et al (2008)



CONCLUSIONS

After the interactions we can observe connections between both concepts entailing that the PI philosophy could be applied to support the implementation of PI.

VSM (as Lean tool) helps to detect activities that don't add value. Some of these activities are: excessive warehousing, overproduction, excessive and unnecessary waiting times, defects, rejections and reprocessing, and, finally, unnecessary transport and movements.

VSM could help to reduce the activities that does NOT add value such as warehousing, waiting times, transports and unnecessary movements that lead to the PI core. Some other wastes that could be included and searched using the VSM are: empty transport, unnecessary CO2 emissions.

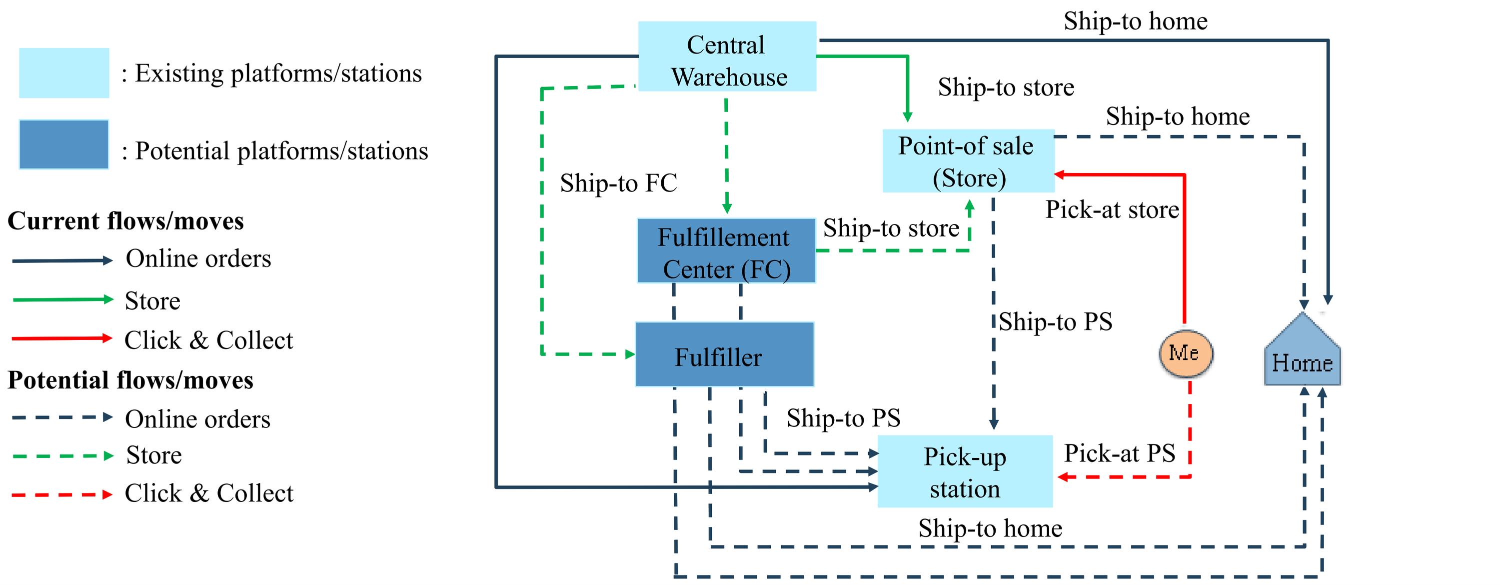
Towards Hyperconnected Distribution: the Retail Supply Chain Reengineering

Yesmine Rouis, Walid Klibi and Benoit Montreuil

KEDGE Business School – Supply Chain Center of Excellence
Georgia Tech – Physical Internet Center – Stewart School of Industrial & Systems Engineering

Introduction

In urban areas, the issue of goods transportation has been the subject of a great deal of economic, social and sustainable development studies. Despite its potential value, several evidence-based researches showed distribution inefficiency and unsustainability.
On the other hand, transportation strategies drastically impact customer service, one of the key components of an effective Business-to-Consumer logistics. Indeed, customers are mobile and ultra-connected, they are at the origin of the changes affecting the distribution networks.
In the context of an industrial case study, alternative facility options are designed in order to conceptualize and exploit the hyperconnectivity potential of distribution networks.

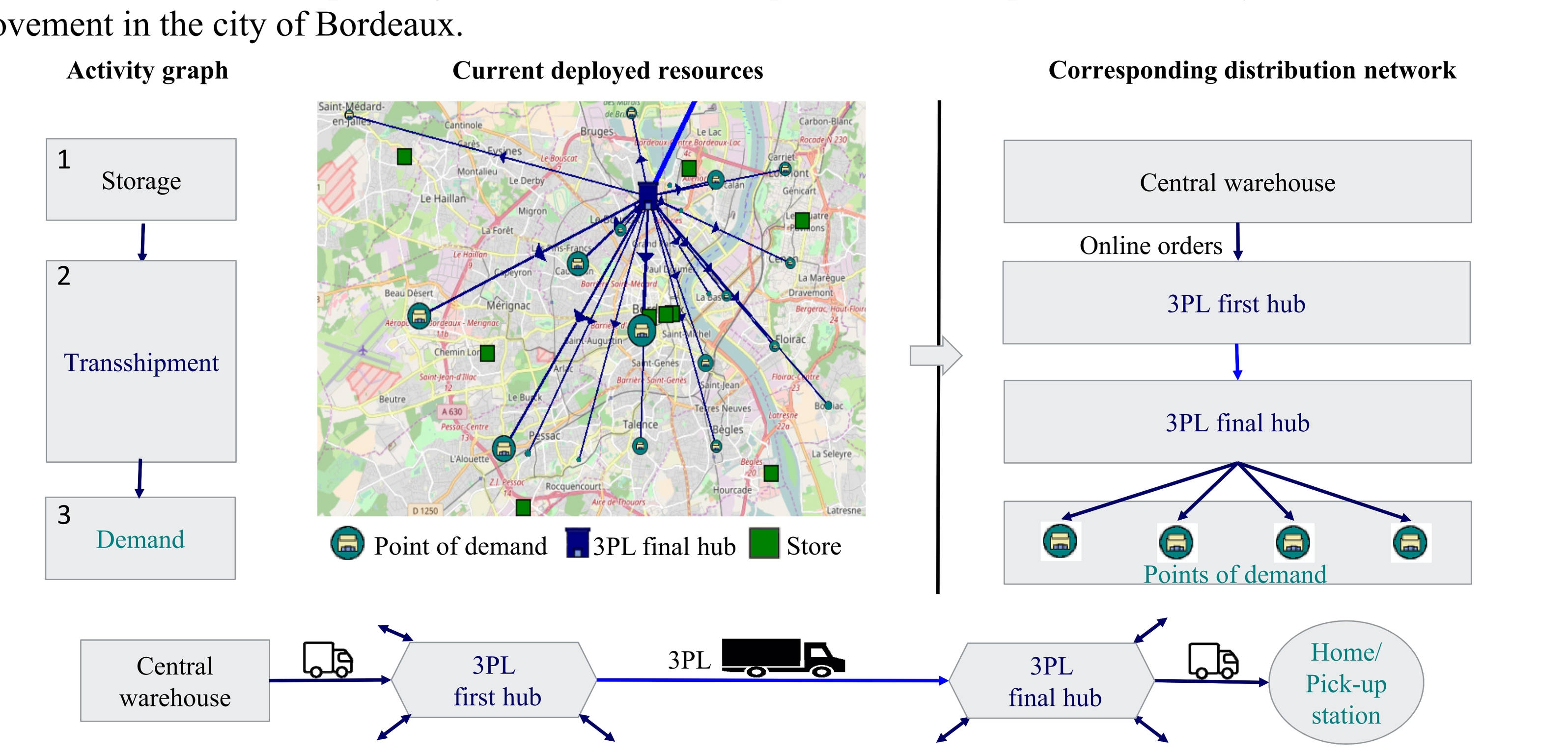


Objectives

The objective of an open hyperconnected distribution network is to:
1) Improve online orders fulfillment process.
2) Increase profitability.
3) Minimize ecological footprint.

Methodology

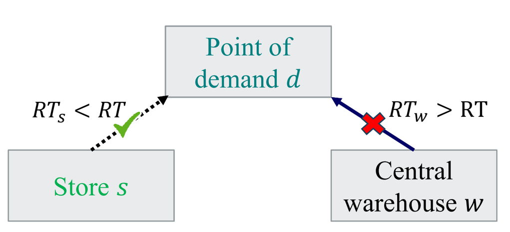
The focus of our research is mainly set on last-mile delivery management and pre-positioning deployment of online orders. We emphasize for the current situation, a distribution network, where online orders are delivered from a central warehouse far from points of demand. The shipment of these orders is carried out by a Third-Party Logistics (3PL), relying on its own internal hubs. The activity graph, the current deployed resources, and the corresponding distribution network provide a description of monthly online orders flows movement in the city of Bordeaux.



In order to highlight the performance of a hyperconnected distribution network and to reengineer the baseline scenario, three simulated scenarios are hereby depicted.

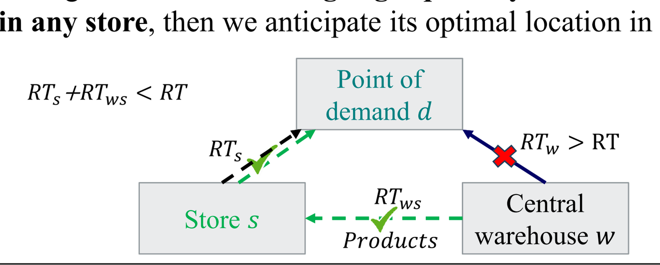
Scenario 1: Ship from store using existing inventory

If the online order **could be met** from multiple stores, then it is shipped from the most convenient one.



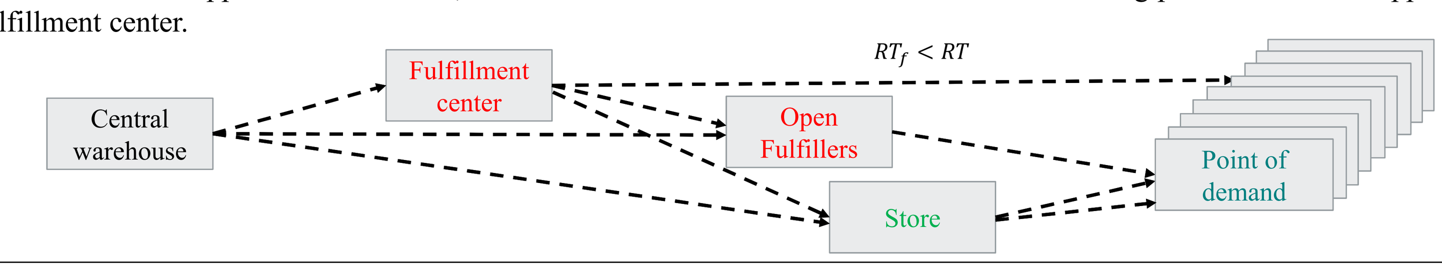
Scenario 2: Ship from store using existing and advanced inventory

In addition to the first scenario option, if the online order belongs to the **fast moving high-quantity** and **doesn't exist in any store**, then we anticipate its optimal location in stores.

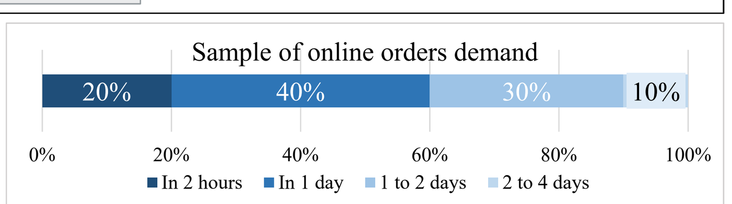


Scenario 3: Hyperconnected distribution network using existing and advanced inventory

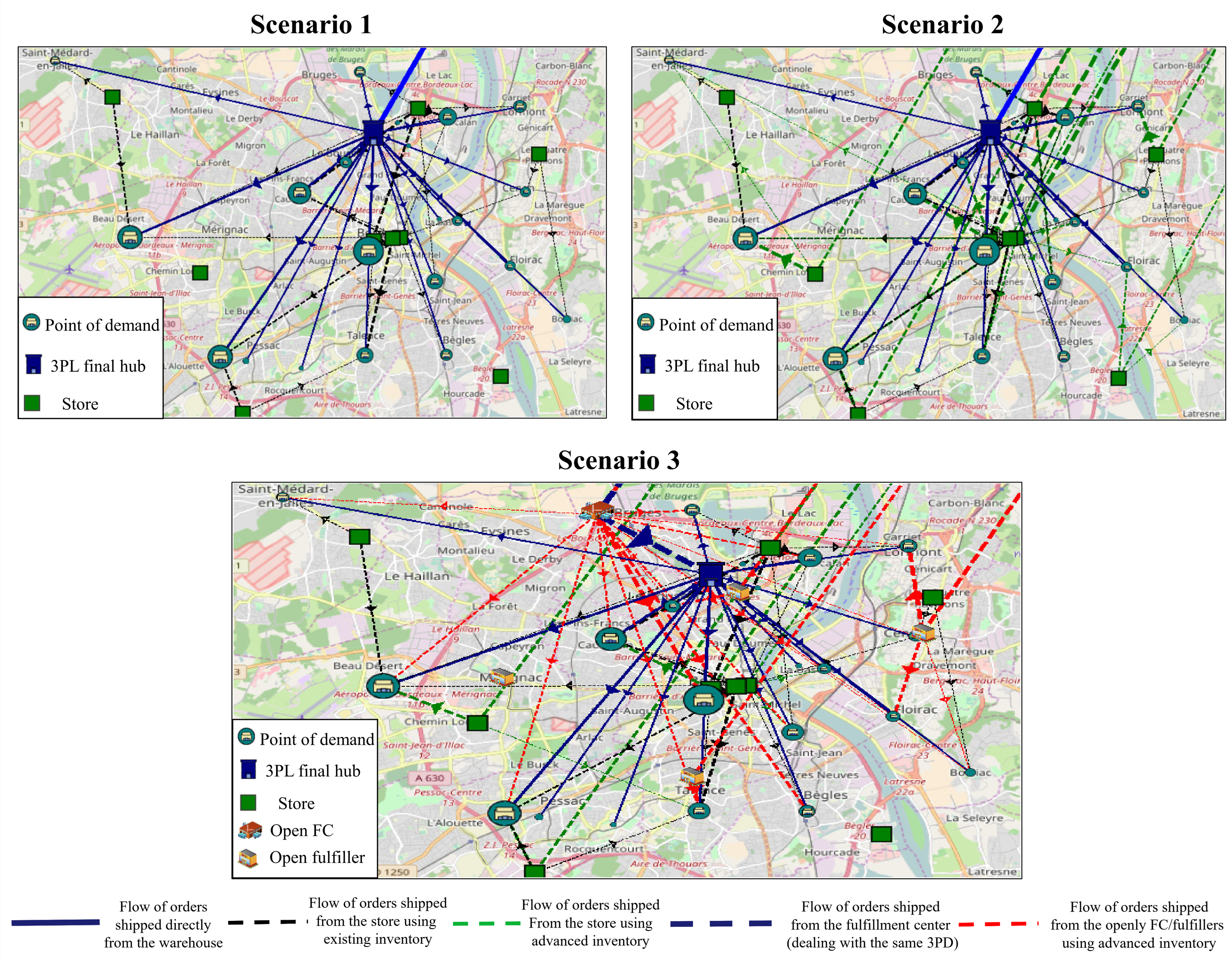
To illustrate the interconnection options for a hyperconnected distribution system, we firstly introduce a new set of **open Hubs** in strategic areas. The new hyperconnected network includes one **open fulfillment center** and **4 open fulfillers**. The fulfillers and the stores are fed from the fulfillment center, which in turn is being fed from the central warehouse. The fast moving high-quantity products can be shipped from the stores, the fulfiller and the fulfillment center. The slow moving products can be shipped from the fulfillment center.

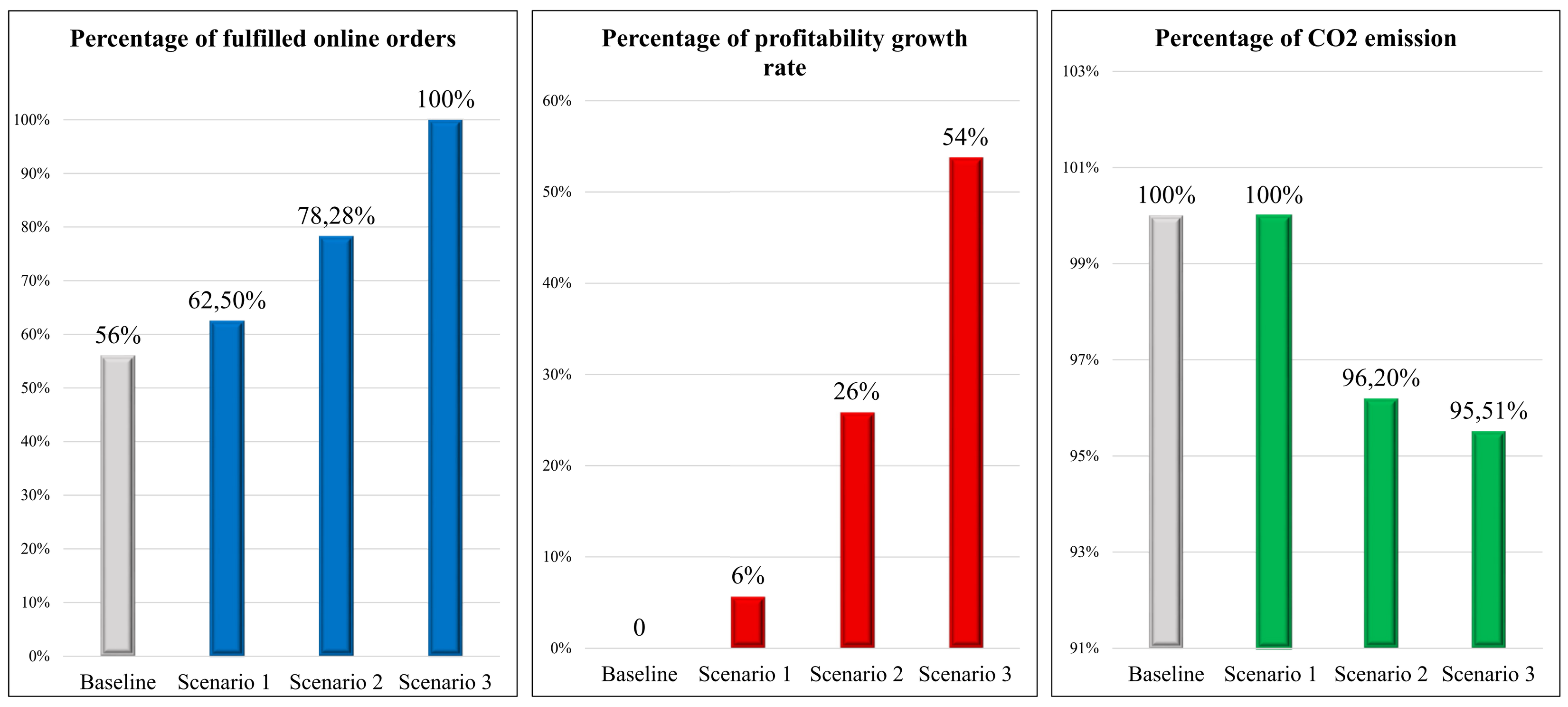


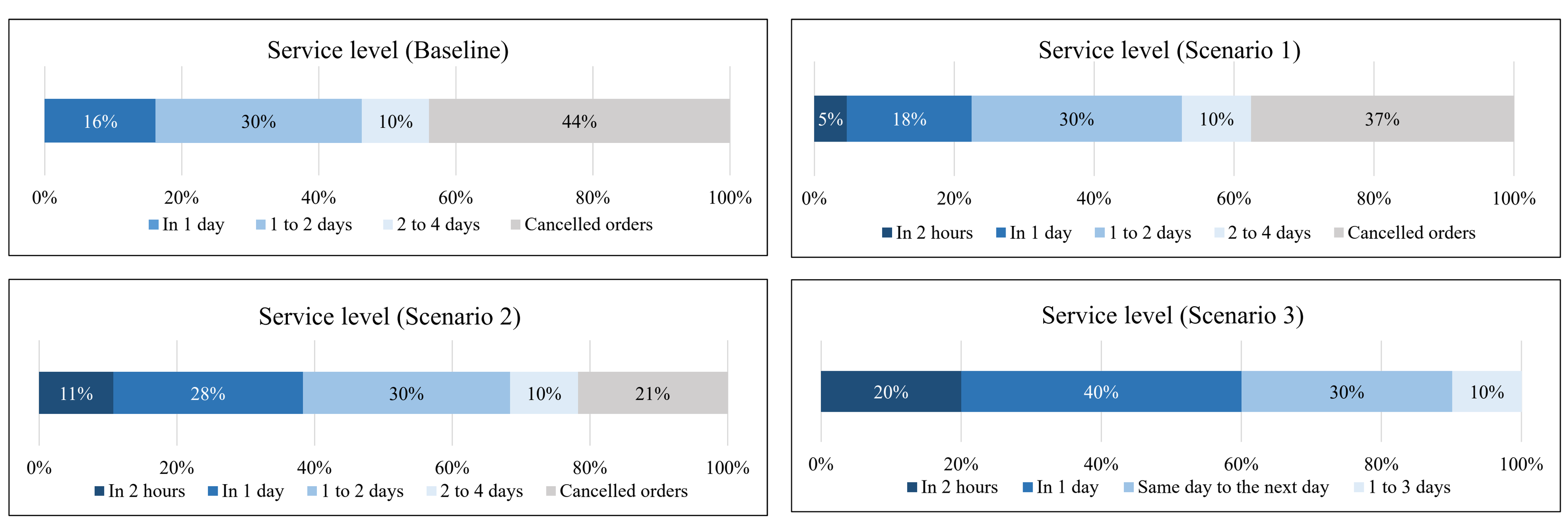
RT: Response Time required by the customer.
RT_s, RT_w: Response Time respectively provided by the store and the warehouse.
RT_{ws}: Response Time of products delivery from the warehouse w to the store s.
RT_f: Response Time of each facility defined in the hyperconnected distribution network.



Results







Conclusion

The aim of this work was to investigate the potential for operational, economic and environmental gain from exploiting a hyperconnected distribution system in the retail sector.
In order to measure the effectiveness of such strategy, three key performance indicators, including the percentage of fulfilled orders, the profitability and the CO2 gas emission, were considered.

The results reveal that these indicators are improved in the hyperconnected distribution system:
- The percentage of fulfilled online orders increased by 22.2% when the retailer stores were exploited; and by 44% in a hyperconnected distribution network.
- The enhancement of online orders fulfillment process resulted in increasing monthly profitability by 26% and 54%, respectively in the second and the third scenario.
- The CO2 gas emission of total hyperconnected network flows decreased by 220 Kg in one month due to improvement of trucks fill rate.

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Transport and packaging optimization using a three-tier modular encapsulation

Sihem Ben Jouida, Anicia Jaegler, Walid Klibi and Benoit Montreuil

KEDGE BUSINESS SCHOOL — SUPPLY CHAIN CENTER OF EXCELLENCE

Georgia Tech — Physical Internet Center — Stewart School of Industrial & Systems Engineering

Introduction

In this work, we propose a new characterization of products into modular packaging containers. The problem addresses the business case of a company that is trying to look for an optimal packaging configuration of its sourced products. The aim of the company is to optimize its ordering plans, reduce its transportation costs, and improve its sustainability performance. This is done by taking into consideration a set of suppliers with various packaging options, a set of customer zones with various demand levels, and the replenishment/inventory policies at the company's warehouse. The proposed optimization-based packaging approach is summarized hereafter based on three encapsulation tiers and starting from the suppliers' level.

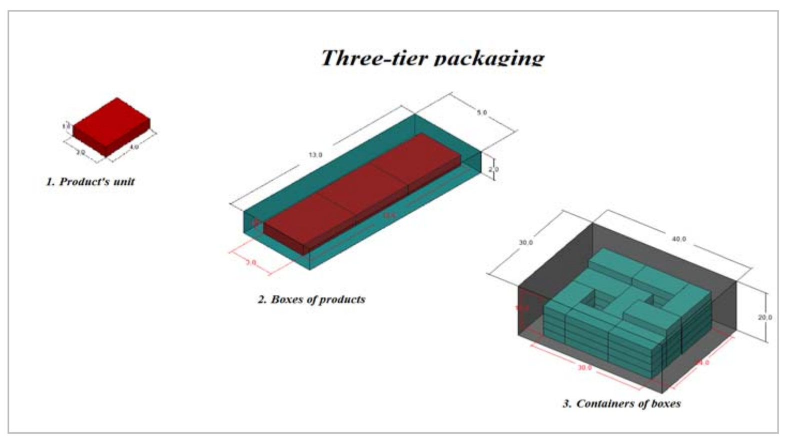
Motivation

As-Is packaging

Contexte

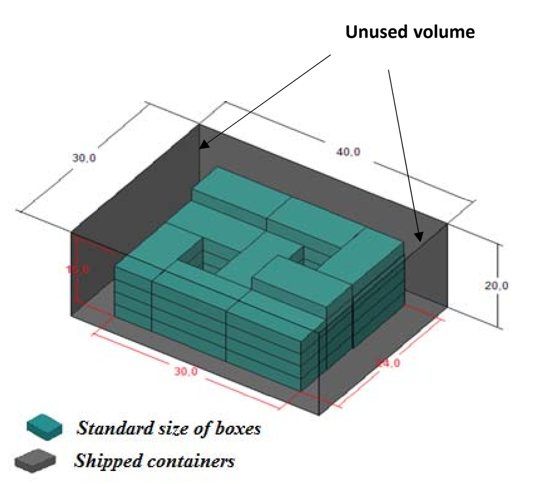
Capacities' exploitation

- Products' quantities are not optimized regarding containers capacities
- Boxes' sizes are not optimized regarding customers' demand



Operational costs

The way products are packed and supplied at the supplier level is not economically, environmentally and socially sustainable for the company



GOAL

Improve the packaging, handling, and transportation of products from the supply sources to the company warehouses in terms of economic and ecological performance

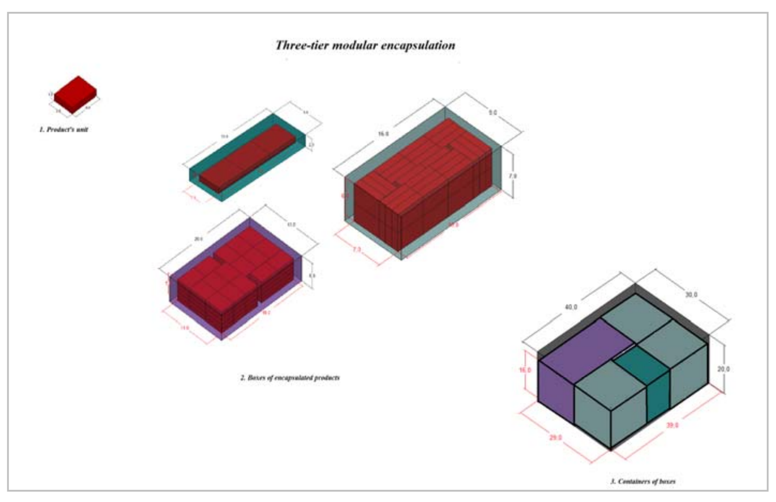
Products' encapsulation-based packaging

VISION

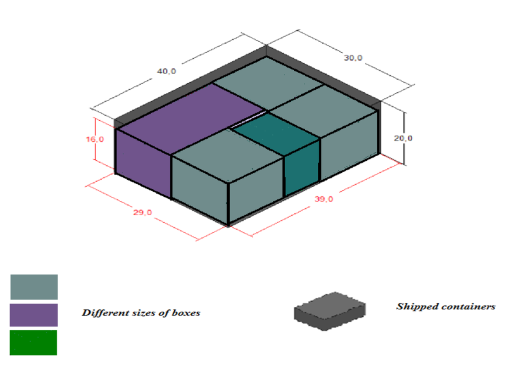
Packaging with encapsulation

Optimize sequentially for each product:

1. the number of units to fix
2. the sizes of boxes (tier 2) to synchronize with the demand level
3. the choice of the best size of containers (tier 3) to handle



- ✓ **Minimize the number of boxes**
- ✓ **Match shipped boxes' sizes with customers' demands**
- ✓ **Minimize operational costs**
- ✓ **Optimize the size of handled containers**



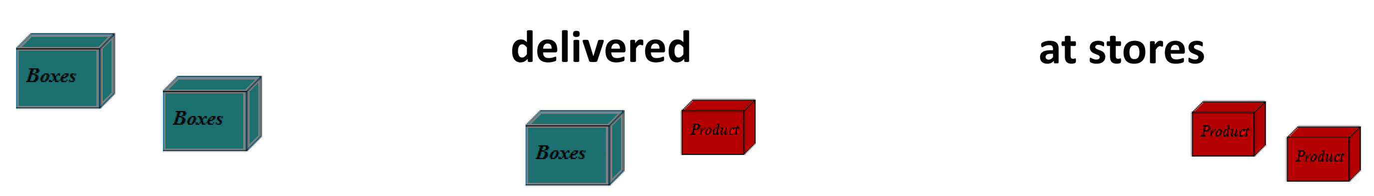
Methodology

Products' encapsulation-based packaging

➢ Optimize the size of the boxes with the demand level

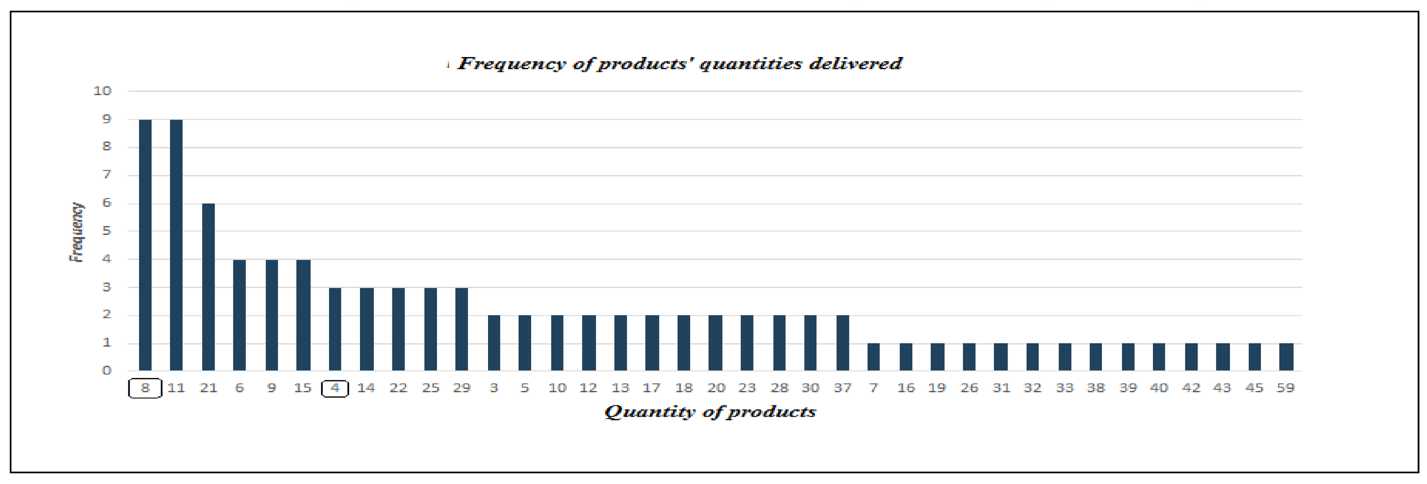
The company can improve its customers' satisfaction regarding:

1. **Demand-boxes matching**
2. **Number of entire boxes delivered**
3. **Quantity of unused products at stores**

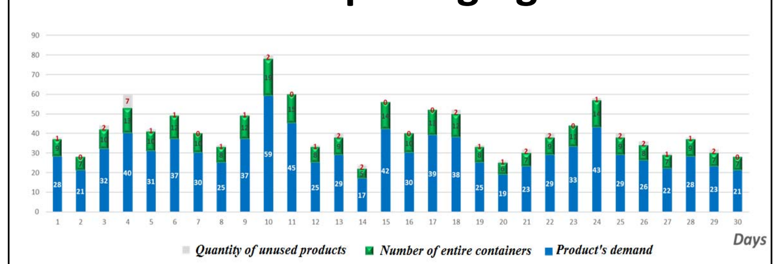
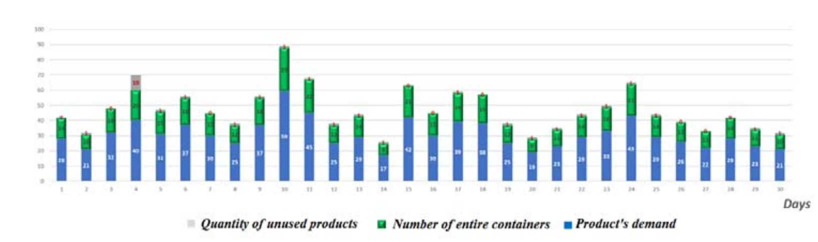


Results: The case of a Retailer

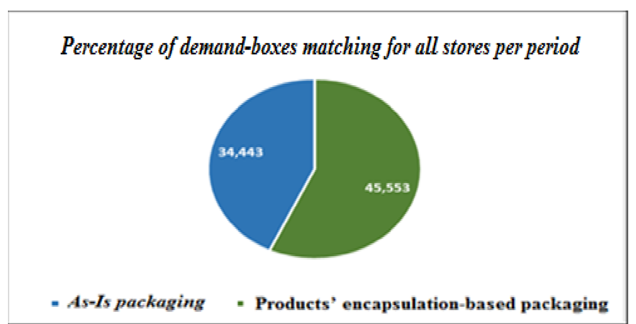
Boxes' size optimization with ordered quantities for one product

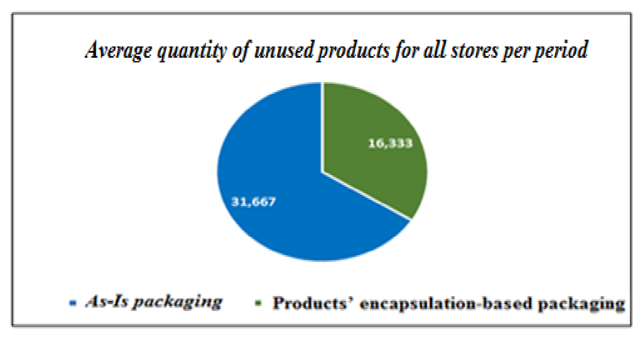


Packaging improvement for one product at one store

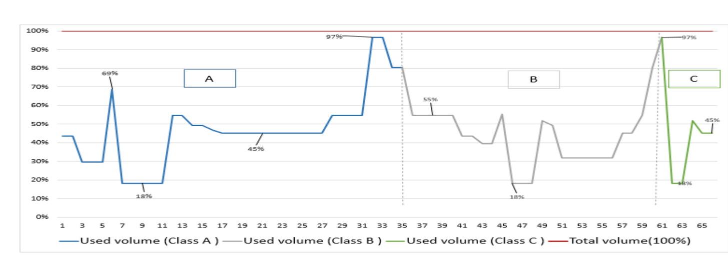
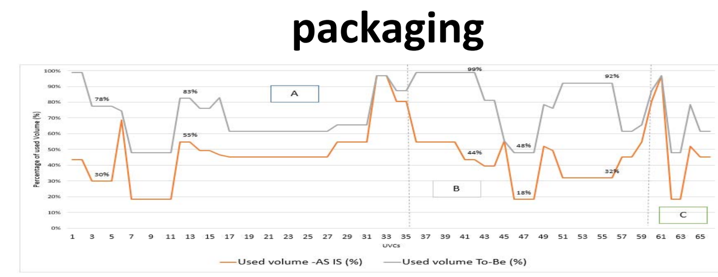
As-is packaging	Products' encapsulation-based packaging
	
1. Demand-boxes matching = 26,67 %	1. Demand-boxes matching = 30 % ✓
2. Number of entire boxes = 309	2. Number of entire boxes = 463 ✗
3. Quantity of unused products = 1	3. Quantity of unused products = 0 ✓

Packaging improvement for one product and all stores





Shipped containers' volume percentage per product

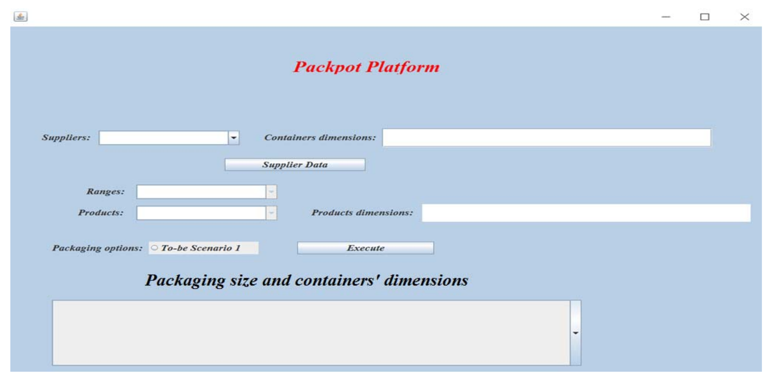
As-is packaging	Products' encapsulation-based packaging
	
55% of transportation volume is unused	**26%** of containers' volume is unused

Conclusions

- ✓ A packaging problem considering the positioning of products at particular boxes and containers is studied.
- ✓ Encapsulation as a potential concept that aims to optimize sequentially for each product, the number of units to fix, the sizes of boxes to synchronize with the demand level and the choice of the best size of containers to handle.
- ✓ Promising results were obtained regarding the decrease of the number of boxes and unused products
- ✓ Also in terms of capacity performance, a significant diminution of the unused containers' volume was observed when comparing the as-is and packaging with encapsulation scenarii.

Futur works

- ***Developing a*** Decision Support System for the packaging



- **Studying the impact of the encapsulation on transportation costs and decisions**

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Legal framework conditions and guidelines for the implementation of the Physical Internet in the D-A-CH region (Germany, Austria, Switzerland)

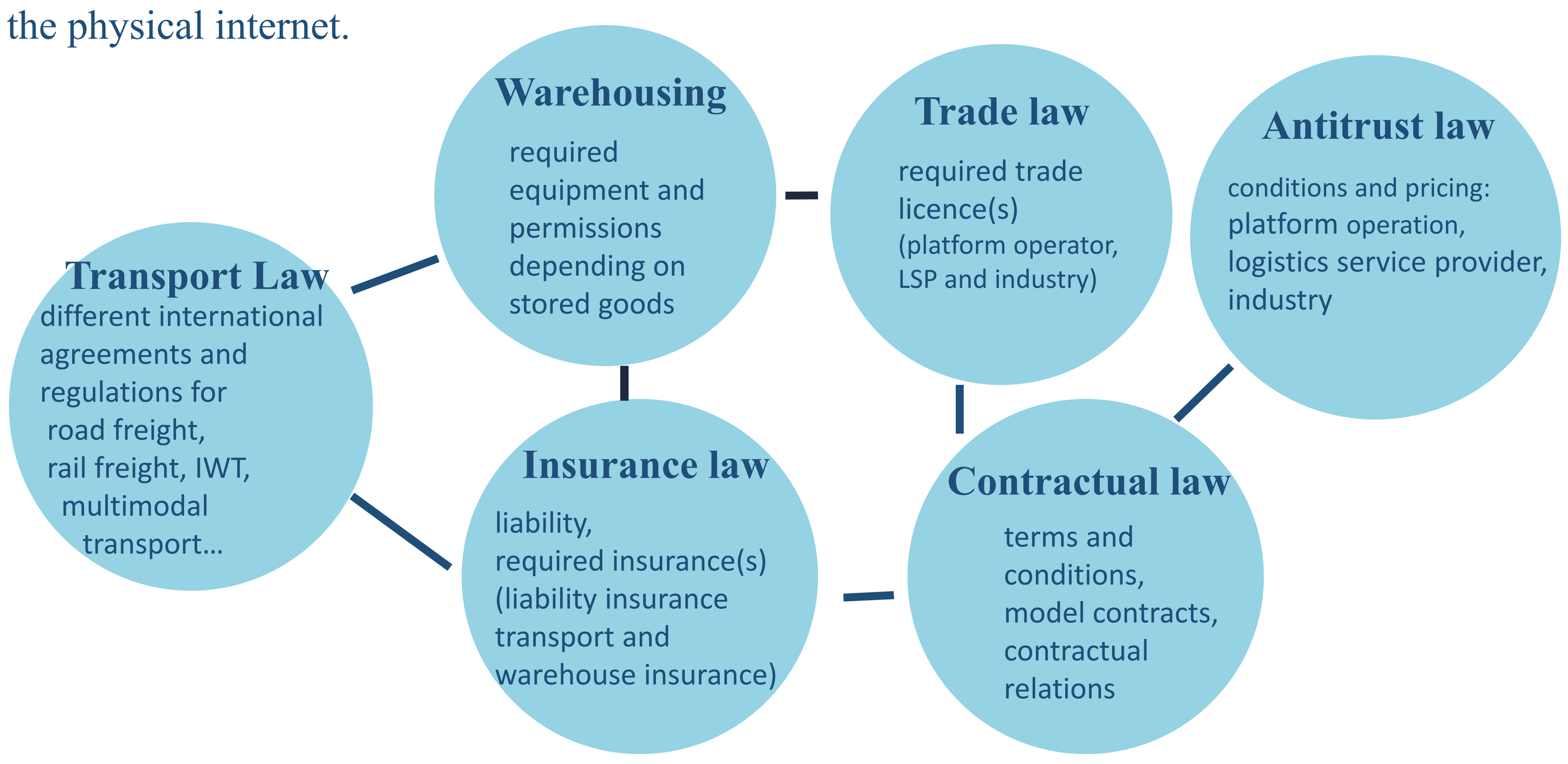
A. Haller, O. Schauer

ATROPINE – Fast Track to the Physical Internet

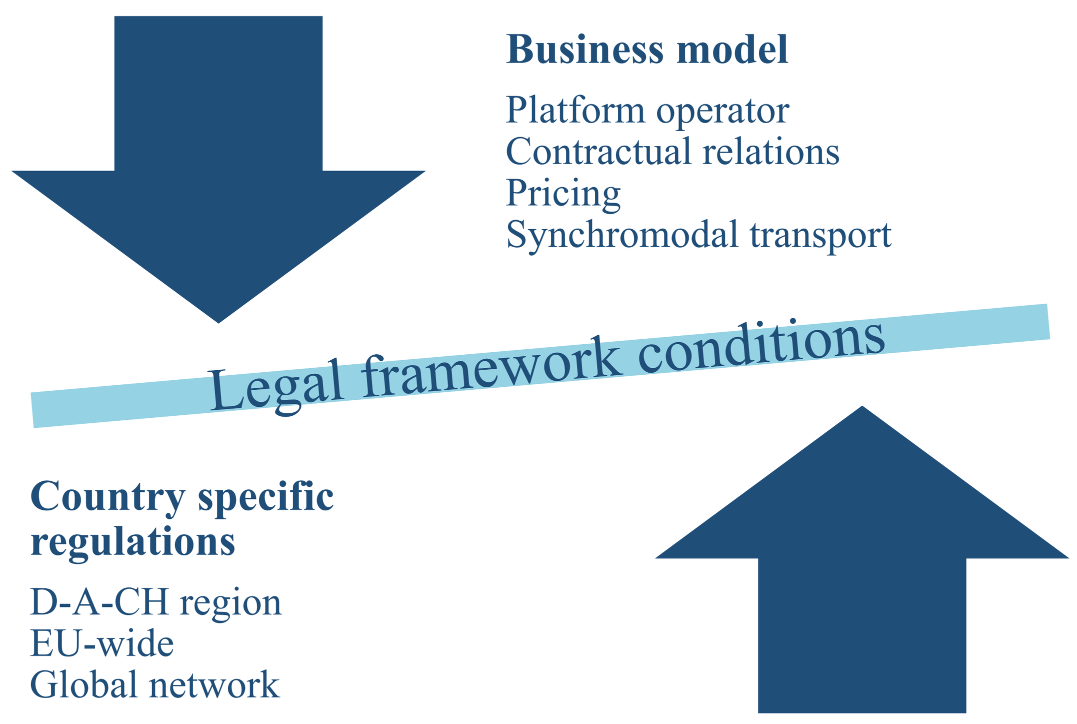
LOGISTIKUM – CHALLENGE ACCEPTED

Introduction

Making the Physical Internet (PI) reality will require extensive legal scrutiny. A variety of legal framework conditions have to be examined to enable legally viable implementation of the physical internet.



Depending on the respective business model, legal framework conditions and legal feasibility vary considerably.



Country specific policy and regulations represent additional obstacles for an EU-wide or even global implementation of the PI.

Approach

One goal (=task force "legal framework") of the multi-disciplinary cross-industry project "Atropine - Fast Track to the Physical Internet" funded under the Strategic Economic and Research Program "Innovative Upper Austria 2020" is to evaluate legal framework conditions and guidelines for the implementation of the Physical Internet in the D-A-CH region (Germany, Austria, Switzerland). To examine legal framework conditions for the implementation of the Physical Internet, key aspects have been defined and three main pillars elaborated:

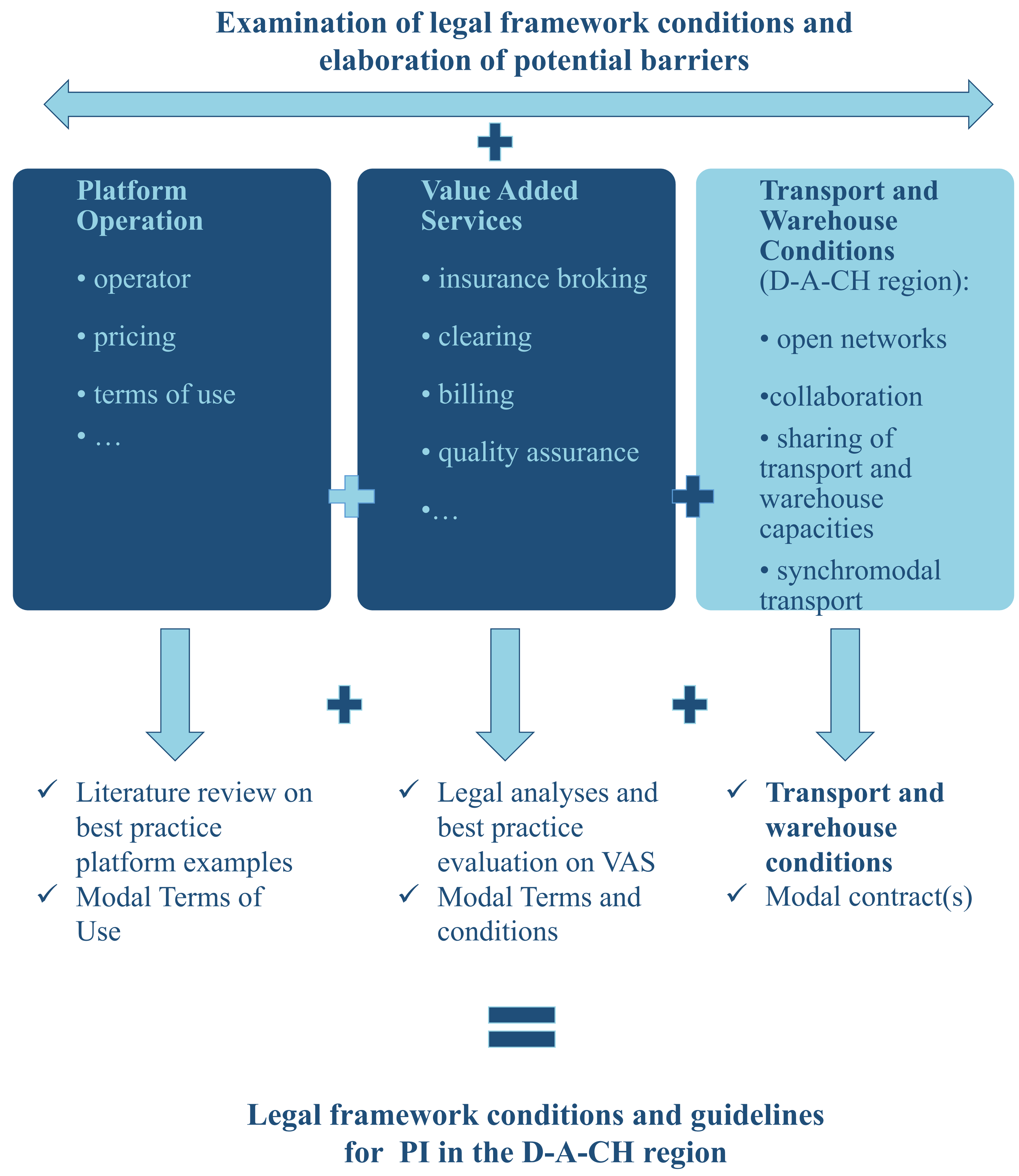

Platform operation


Value added services (insurance, clearing, etc.)


Transport and warehousing

Within the three pillars concerned parties (platform operator, logistics service providers, industry, third parties) and relevant areas of law vary considerably. Within the three pillars legally viable implementation approaches will be investigated, legal barriers defined and model terms and conditions elaborated.

Results



Conclusion and Future Work

The evaluation of the legal framework conditions in the D-A-CH region will show possible business model approaches as well as barriers/challenges for the future implementation of the Physical Internet. The developed modal terms and conditions might serve as first basis for the future implementation of the Physical Internet.

Goal of the task force "legal framework" is to illustrate and examine major parts of the future vision of the Physical internet from a legal perspective. In this context a variety of legal issues will arise - from the present point of view not all are solvable.
In this context legal regulations will be examined and critically reviewed. The developed transport and warehouse conditions might serve as basis for a potential reorganization of actual legal framework conditions (for the D-A-CH region) required for the successful future implementation of the Physical Internet.

Since legal framework conditions vary considerably depending on the business model, estimations and assumptions have to be made, to develop legally feasible solution approaches. Thus, the scientific work of the task force "legal framework" can only give an overview of legal framework conditions and guidelines in the D-A-CH region. Depending on the actual business model for the implantation of the Physical Internet legal aspects have to be examined in detail.

Acknowledgements

This work has been funded by the programme 'Innovative Upper Austria 2020'.

INNOVATIVES OBERÖSTERREICH 2020

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Vehicle Routing Problem for the Physical Internet

Yannis Ancele*, Trung Thanh Nguyen*, Ben Matellini

Y.Ancele@2016.ljmu.ac.uk, T.T.Nguyen@ljmu.ac.uk, D.B.Matellini@ljmu.ac.uk

LIVERPOOL JOHN MOORES UNIVERSITY

Liverpool Logistics Offshore and Marine (LOOM) Research Institute

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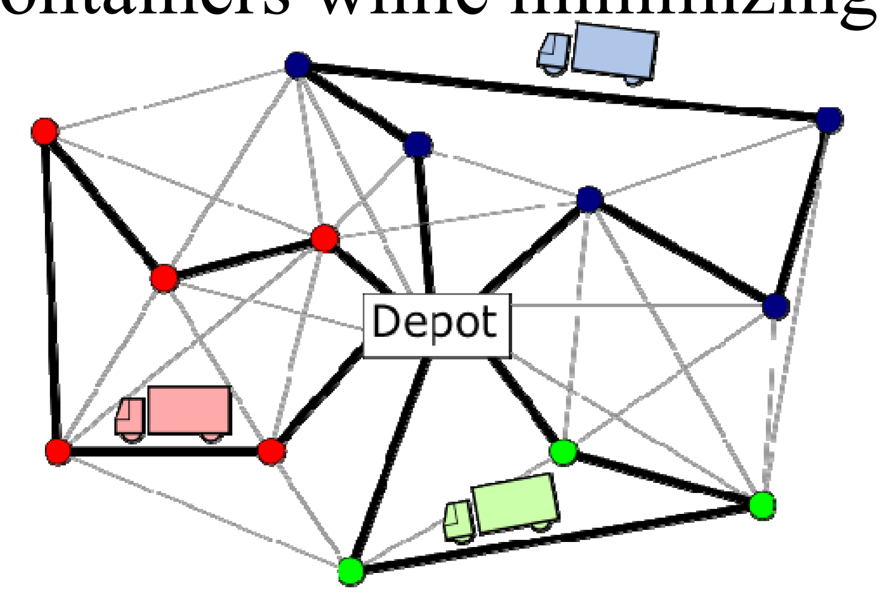
Project Description/Chalenges

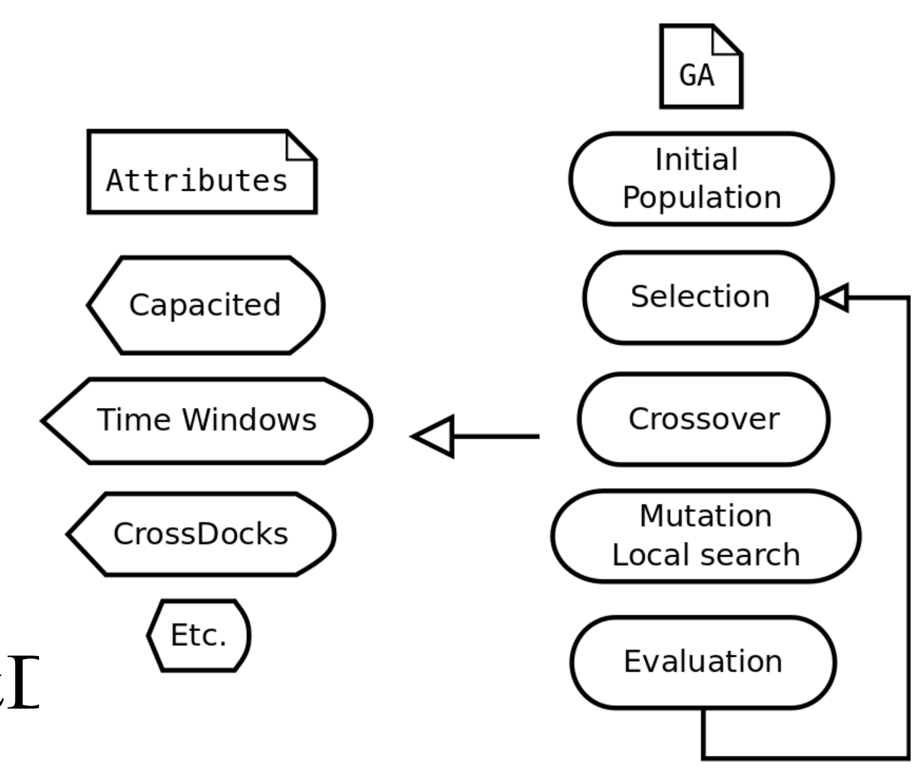
As a central problem in SCM and Operations Research, the VRP is the subject of this research. The objective is to design a set of routes for the vehicles to carry PI containers while minimizing the total cost.



Methodologies

VRP attributes:

- Capacited
- Heterogeneous
- Crossdocks
- Open
- Time Windows
- Simultaneous P&D



Cplex: Mixed integer programming model.
Genetic Algorithm: VRP attributes handled via components.

Experiments

Since there is no or few real PI applications, all the datasets are generated randomly.

|K| = 4 |R| = 4	Q = 500 |R| = 5	|O| = 2 |R| = 6
10	54	2487
5	261	52
20	33	1628
74	155	13473
17	83	74

This table emphasize the need of metaheuristics to solve real-world size instances. Especially when the instance difficulty vary.

Contributions

Several contributions will be made in this research:

- A Cplex model and a new GA algorithm which consider the PI environment – sustainability, scalability, collaboration.
- A VRP solver which works alongside with a Bin Packing solver
- A visualization module which displays the vehicles routes and the consolidation solutions in the vehicles
- An open source modular framework which is composed of the above modules

Conclusion/Future work

This research tackles one of the most important challenge in the PI – routing algorithm which will lead to novel soltions.
Moreover, this work aims to consider the use of actual technologies such as IoT which would allows a dynamic and stochasticity perspective.
Finally, in addition to the VRP, container routing protocols will also be studied.

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- Benoit Montreuil. Physical internet manifesto. In Transforming the way physical objects are moved, stored, realized, supplied and used, aiming towards greater eciency and sustainability, 2012.

- Thibaut Vidal, Teodor Gabriel Crainic, Michel Gendreau, and Christian Prins. A unied solution framework for multi-attribute vehicle routing problems. European Journal of Operational Research, May 2014.

- Yousef Maknoon and Gilbert Laporte. Vehicle routing with cross-dock selection. Computers & Operations Research, 2017.

*co-first authors

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Bin-packing arising from the Physical Internet Hub

Igor Deplano
Trung Thanh Nguyen

Igor.Deplano@gmail.com
T.T.Nguyen@ljmu.ac.uk

LIVERPOOL JOHN MOORES UNIVERSITY
Liverpool Logistics Offshore and Marine (LOOM) Research Institute

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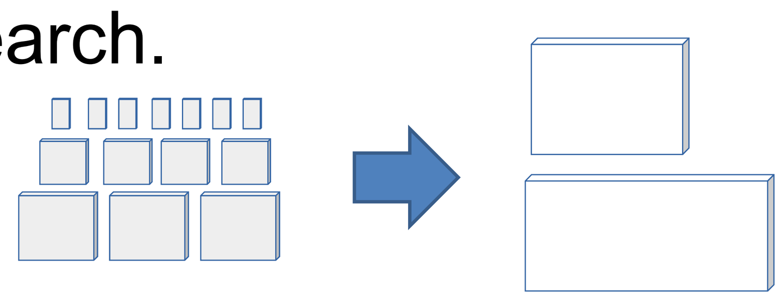
Project Description/Challenges

The π-hub is a cross-docking hub where π-containers are marshalled and delivered to the next destination. One of the most critical operations is attaching π-containers. The configuration can be modelled as a Multiple Heterogeneus Knapsack Problem (MHKP) with container loading constraints. Solving large scale instances in reasonable time is the final aim of this research.



Methodologies

The MHKP objective is to minimize the wasted space and the bins used, considering items priorities and destinations.

MHKP constraints:

- geometrical constraints in 3D space
  - Absolute positioning, not-overlapping, orthogonal rotations, stability
- Load bearing
- Weight limits
- Weight distribution

Experiments

The testing datasets are generated randomly picking from 24 different type of bins and 450 different type of items. The following table shows some preliminary results for the MIP model.

bins	items	Solving time	Instance hardness
4	30	18 min	hard
3	50	8 min	normal
8	100	8 hours	normal

Contributions

Several contributions will be made in this research:

- A MIP model and an heuristic algorithm applicable in the context of Physical Internet Hub and ready to use also for the nowadays Container Loading Problem.

- An open source testing framework that binds generator, solvers and result visualisation.

Conclusion/Future work

This research tackles one of the most broad applicable problems that arise from the challenges in the Physical Internet Hubs, the MHKP problem. This solution is ready to use into the nowadays containers, because they can be seen as a special case of the Physical Internet case.
Moreover, to meet real logistics needs, the solution schema will be designed to be scalable in order to solve large scale instances.

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- Bortfeldt, A., Wäscher, G.: Constraints in container loading–a state-of-the-art review. European Journal of Operational Research 229(1) (2013) 1–20

- Zhao, X., Bennell, J.A., Bektaş, T., Dowsland, K.: A comparative review of 3d container loading algorithms. International Transactions in Operational Research 23(1-2) (2016) 287–320

EAGLE

Innovative technical solution for automated parcel unloading

Assoc.Prof. DI Dr.techn. Christian Landschützer,
DI Dr.techn. Andreas Wolfschluckner,
DI Dr.techn. Matthias Fritz.

Problem statement

Challenges in CEP-industry:

- increasing number of shipments
- short delivery times
- no changes to existing layouts

→ **bottleneck: manual unloading**

- Poor throughput performance (800-1000 #/h per employee)
- Discontinuous material flow
- Physical demanding process
- Max. three employees per unloading station possible

Figure 1:Manual unloading [*Source: Hermes*]

→ **For further increase of capacity only through increase of number of unloading areas/ bays**

New technology necessary to raise capacity without rising number of unloading areas

Function principle

Mobile part

The mobile part consist of a belt (1) and a return mechanism. It can be easily retrofitted in already existing containerand swap bodies. Through to the simple design and the fact that no power supply is neccesary in the mobile part, the design needs very little space in the load area which has a positive effect on the overall capacity and further on the throughput.

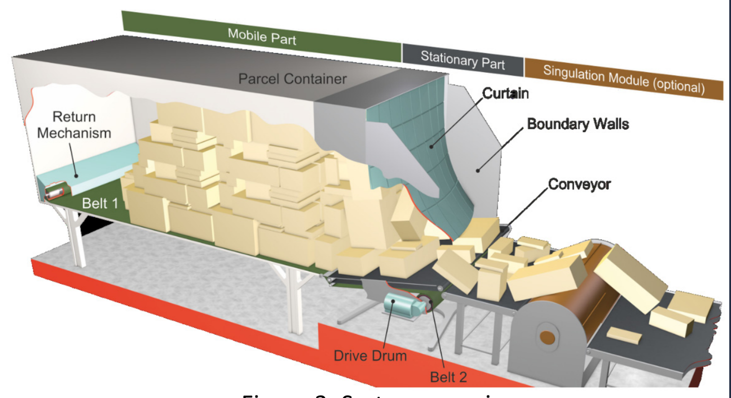

Figure 3: System overview

Stationary part

The stationary part consists of a fully automated docking unit and all the neccesary drives to run Belt 1 of the mobile unit and addtional conveyors for further transportation of the parcels. It docks fully automated to the container/ swap body and compensates offsets automatically.

Singulation module (optional)

An important point within the mechanism ist the pre-seperation and singulation of the parcel bulk after the unloading process on a very small area. Within the project special simulation techniques were developed to simulate the singulation of the parcels*.

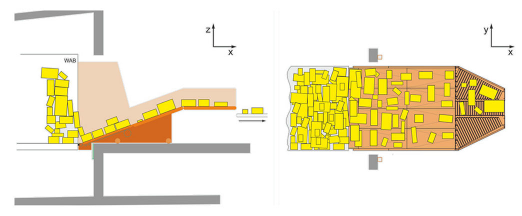

Figure 4:Excerpt simulation of unloading process

* [Dissertation DI Matthias Fritz :"Beitrag zur Simulation des Bewegungsverhaltens von Stückgütern im Pulk im Kontext der Vereinzelung"; Graz, November 2016)]

Key facts

Fast

- Reduction of unloading duration of one container/ swap body by min. 70%
- High throughput (≈ 4500 $^{\#}/_{h}$)
- Continuous material flow

Economic

- Easy retrofittable into containers/ swap bodies
- Reduction of staff expenses
- Shorter idle times of bays

→ Higher car pool utilization

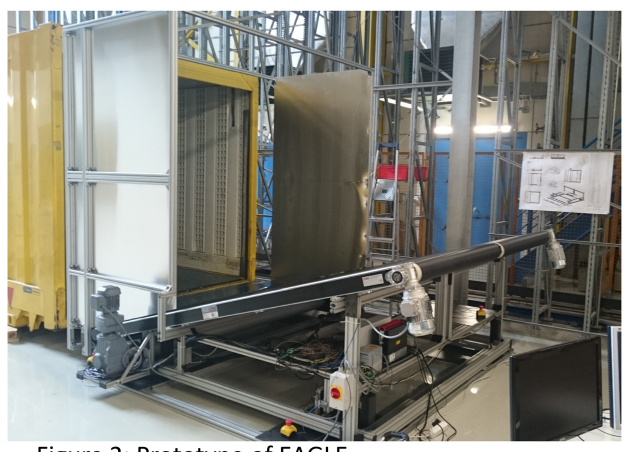

Figure 2: Prototype of EAGLE

Fully automated

- Gentle unloading / singulation process
- Pre-seperation and singulation before entering further logistic processes

➢ **Key success factor for unloading device is knowledge of physical bulk parcel movement**

➢ **Physical parcel bulk behavior investigated scientifically and prototype tested successfully in the institutes labs**
(both see singulation module)

Unloading process

Positioning
- Positioning container/ swap body in front of stationary Part at unloading bay
- Angular and distance deviation get compensated automatically by the stationary part

Connecting
- Connecting transportation belt [1] (Fig. 3) with fastener [2] and the traction belt [3] (Fig.8)

Activation
- Throug activation of drive belt [1] gets pulled out of the container/ swap body
- Simultanously the belt [1] gets unrolled from pulley in the mobile part [5]

Unloading/ Singulation
- During the unloading process the return [5] gets tesioned
- The parcels are then running over on an additontal conveyor [6]
- At this point special pre-seperation and singulation units are possible to implement

Dis-connecting
- Drive changes direction of rotation → return pulls belt [1] back into the container/ swap body
- Fastener gets loosend → system free for next unloading process

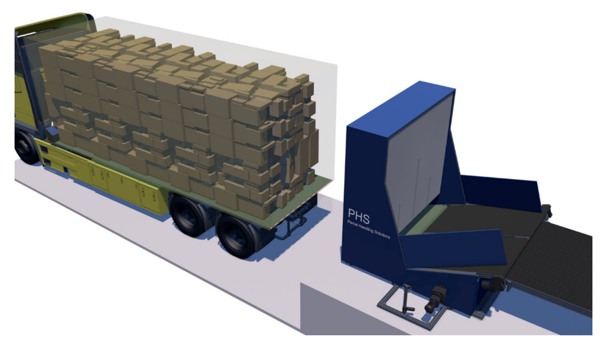

Figure 6: Positioning of Truck/ Container

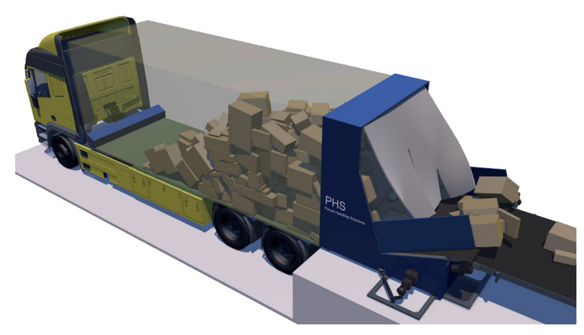

Figure 7: Unloading Process

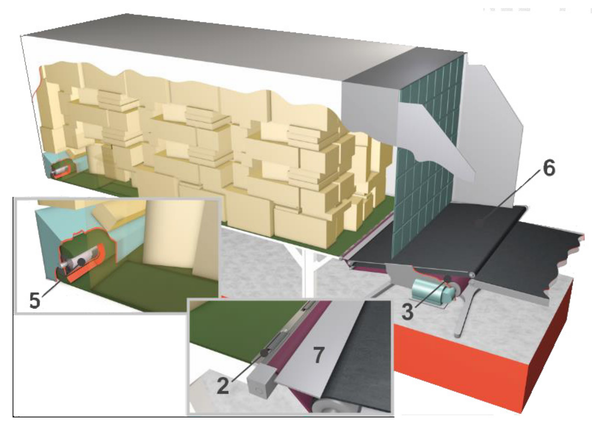

Figure 8: Principle Sketch

Press echo

- **MMLogistik; „*Truck and carpet*"; 11.04.2017**
- **bmvit: „*unloading reinvented*"; 15.05.2017**
- **Österreich Journal: „Technology from Graz fastens unloading" 31.05.2017**
- **LOGISTRA: „*parcel logisctics: belt-systems fastens truck unloading* "; 19.04.2017**

Future use/ scope

- Automated loading of container/ swap body
- Redesigning intralogistics for bulk parcels (loading, handling,…)

Automated loading and unloading processes

CEP | Airport logistics | Distribution of goods

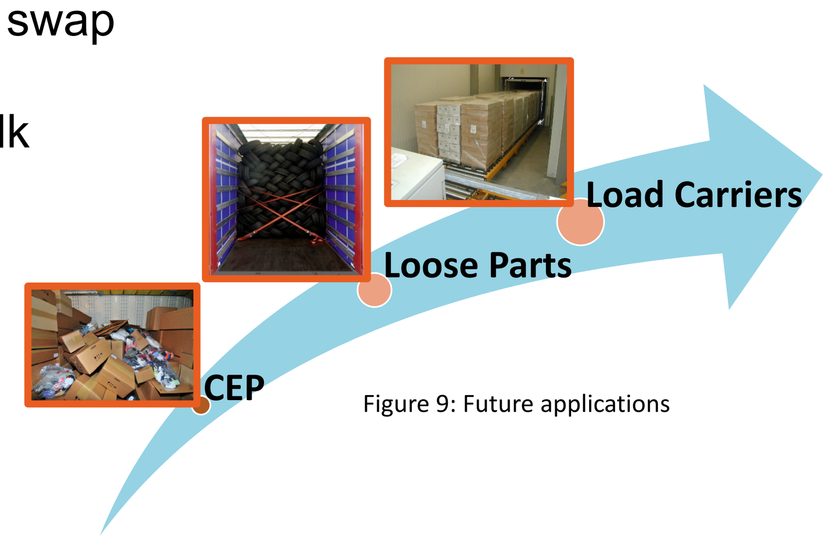

Figure 9: Future applications

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