Agent Based Simulation Enabling Assessment of Customer Centric Hyperconnected Demand and Supply Chain Transformations

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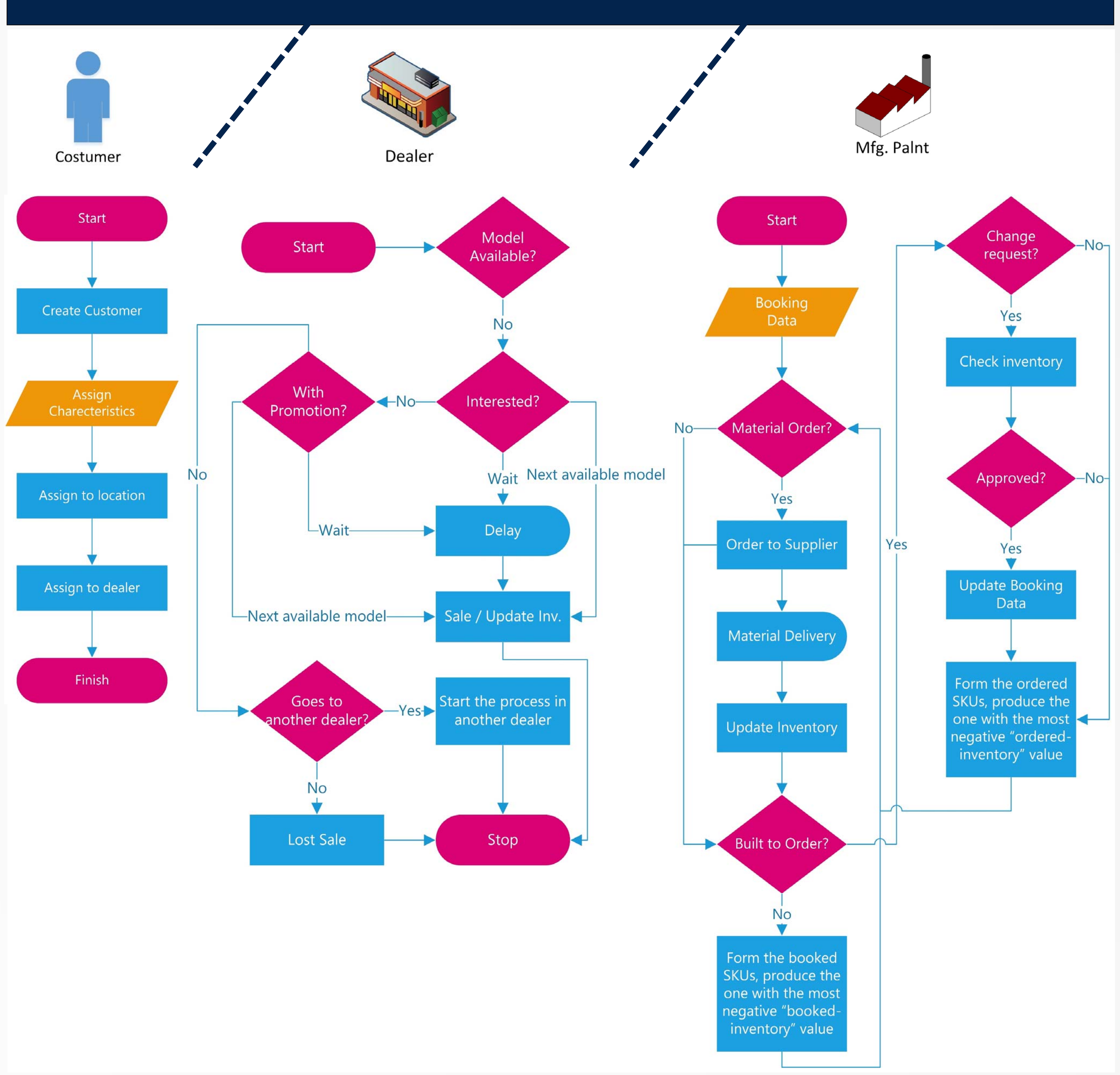
Research Challenge

- Create an agent based discrete event simulation model enabling to simulate a complex large scale demand and supply chain for high value consumer products such as vehicles
- Interconnect the simulation with the company's supply chain cockpit, automatically computing and displaying key performance indices
- Model explicitly:
  - Behavior of each customer interacting with a dealer in his purchasing process in a potential substitution context
  - Ordering behavior of each dealer in the network,
  - Product delivery, assembly and manufacturing planning and control process
  - Parts supply planning, ordering and delivery processes
- Enable simulation based experimentations assessing tactical and strategic transformations of the demand and supply chain, including exploitation of the Physical Internet

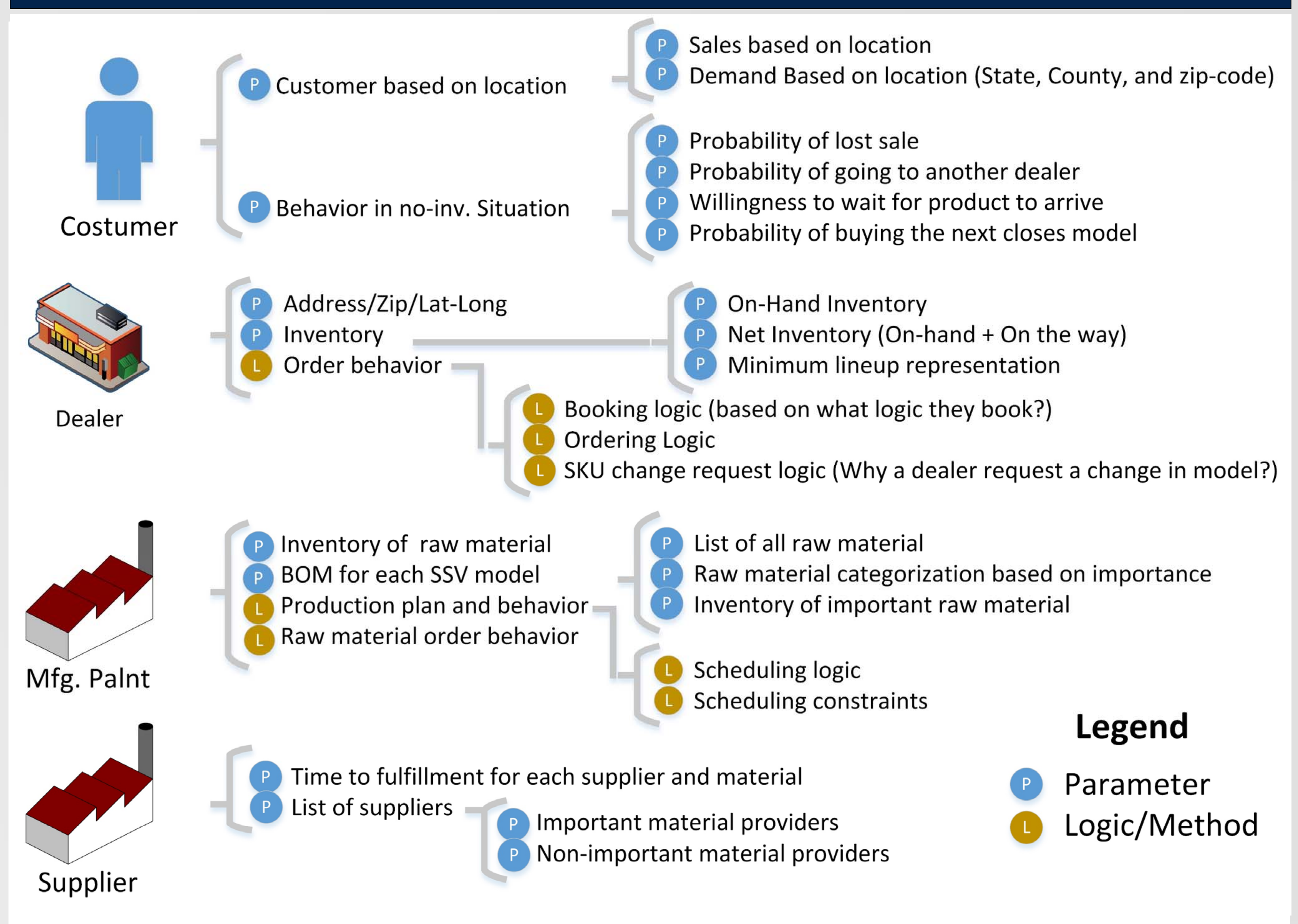
Demand & Supply Chain Map

*Supply Chain map is highly simplified for presentation purposes

Illustrative Agent Flowcharts



Illustrative Inputs



Illustrative Outputs

Continual
- # of successful sales
- # of lost sales
- Total $ of promotions
- Total $ of sales
- Product availability ratio (PAR)
- On-hand inventory (Unit/Day/$)

Daily

All Continues +
- % of successful sales
- # sold of each SKU
- % of successful sales
- # sold of each SKU

Weekly

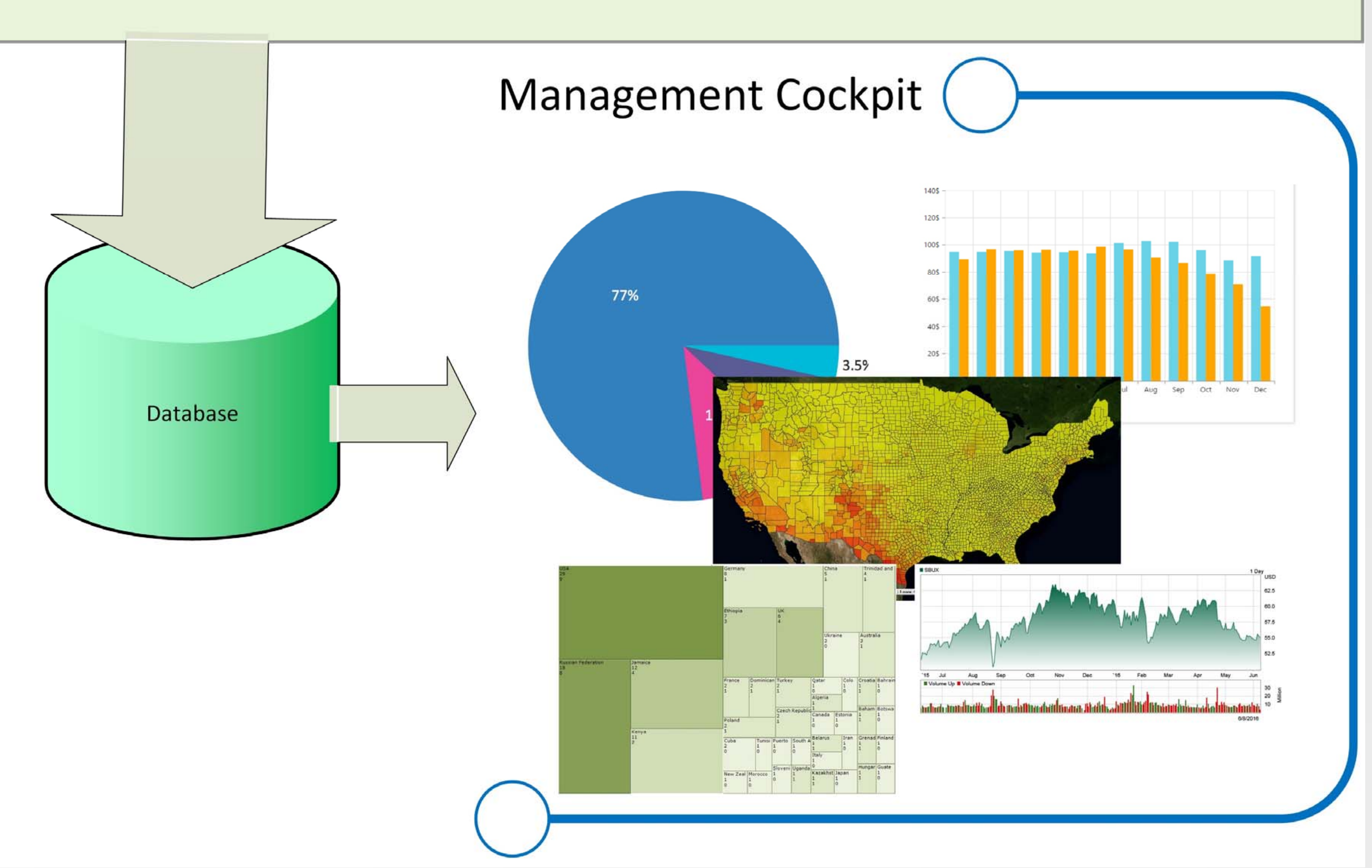
All Daily +
- Trends of all daily outputs

Monthly

All Weekly +
- Trends of all daily outputs
- Trends of all weekly outputs

Quarterly

All Monthly +
- Trends of all daily outputs
- Trends of all weekly outputs
- Trends of all monthly outputs



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3rd International Physical Internet Conference

Modeling and simulation of goods transportation to estimate the benefits of a Physical Internet

Simon GORECKI, Beñat ACHIGAR, Jean-François STREBY, Asma BEN ARBIA, Olivier LABARTHE, Walid KLIBI, Jean-Christophe DESCHAMPS

Goals

Modeling and simulation of physical/informational flows : orders and goods.

2 simulations with different context, locations, and data sources :
- Bordeaux-city, Aquitaine, France : with data from a freight survey.
- Aquitaine, France : with exportation data from customs.

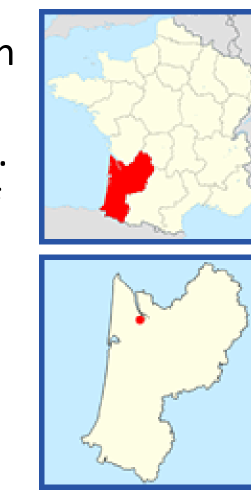
The main objective of this project is to towards to a simulation environment witch is able to simulate the goods mobility in 2 mods :
- status quo : the actual organization mod for good transport
- Physical Internet : new logistic organization based on open distribution centers. This mod is actually in development.

The simulation will evaluate different indicators :
Economics (cost travel, employee cost, delivery time, travel distance by vehicle)
Environmental (emission pollutants), and social (Time travel).

Context

Estimate the performances of a Physical Internet on several context : urban and regional areas.
Evaluate those performances with three different indicators : economic, environmental and social.

Data sources :
- Data from Bordeaux's customs : Actors list and flow information who are concerned by exportation of wine and agri-food from Aquitaine to 186 countries around the world, for 2014 and 2015. That represent 1.700.000 tons of food, and 550.000.000 liters of wine.
- Freight survey in Bordeaux-city and his surrounding : all the flows information transiting into and around the city : 300.000 flows for 72.000 actors in 1 week.



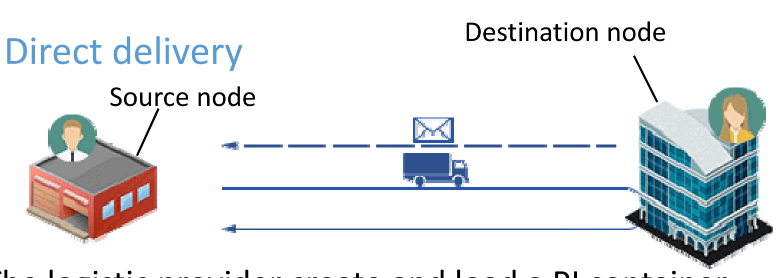
Area : Bordeaux | population : 760.000 hab / density : 1.300 hab/km² / 28 communes

Scenario

Several scenarios with different actors :

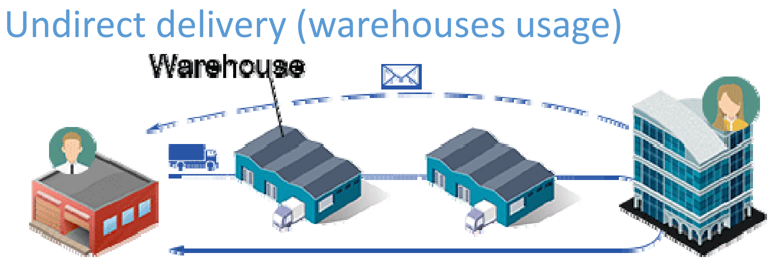
The simulation plays both examples below :

- Direct delivery

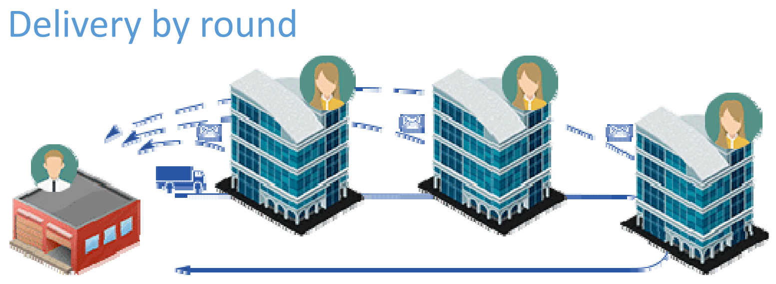


The logistic provider create and load a PI container into a truck who drive to the customer.

- Undirect delivery (warehouses usage)



- Delivery by round

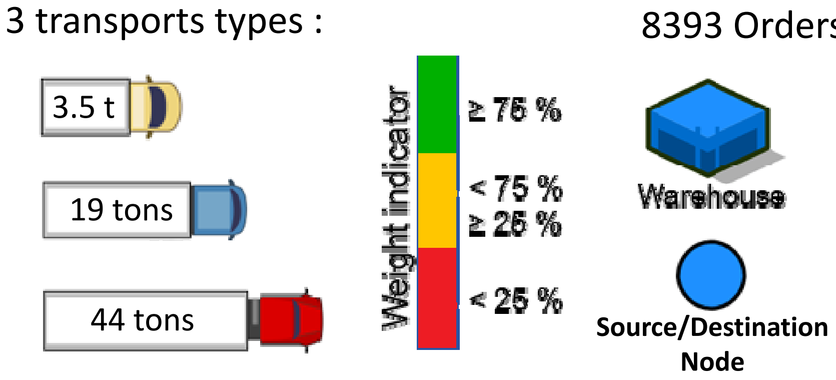


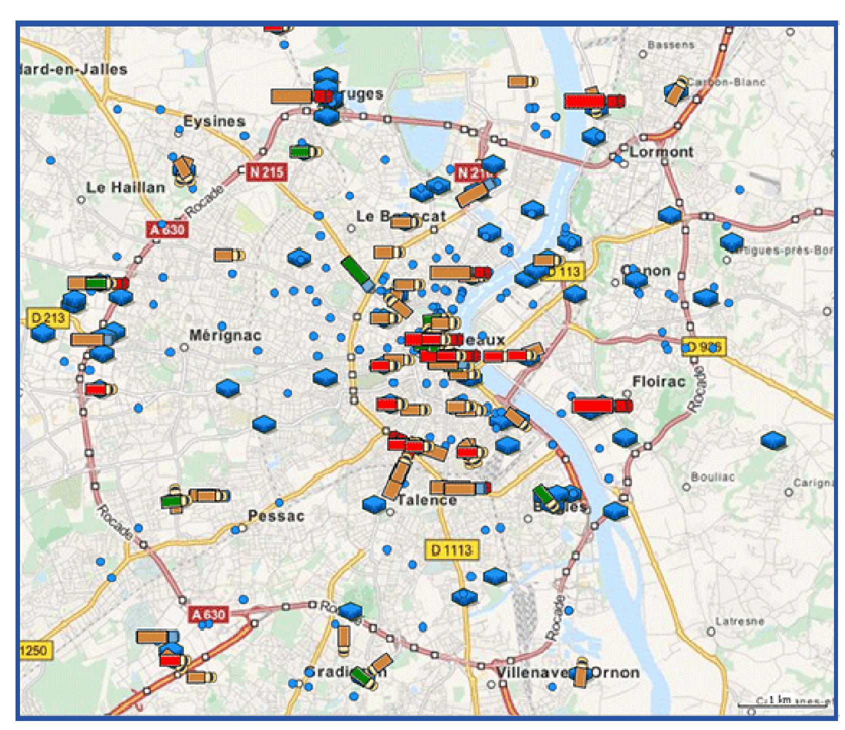
Simulation

Simulation running with : anylogic

Simulation in discrete time
Time simulation : 6 days
3 transports types :

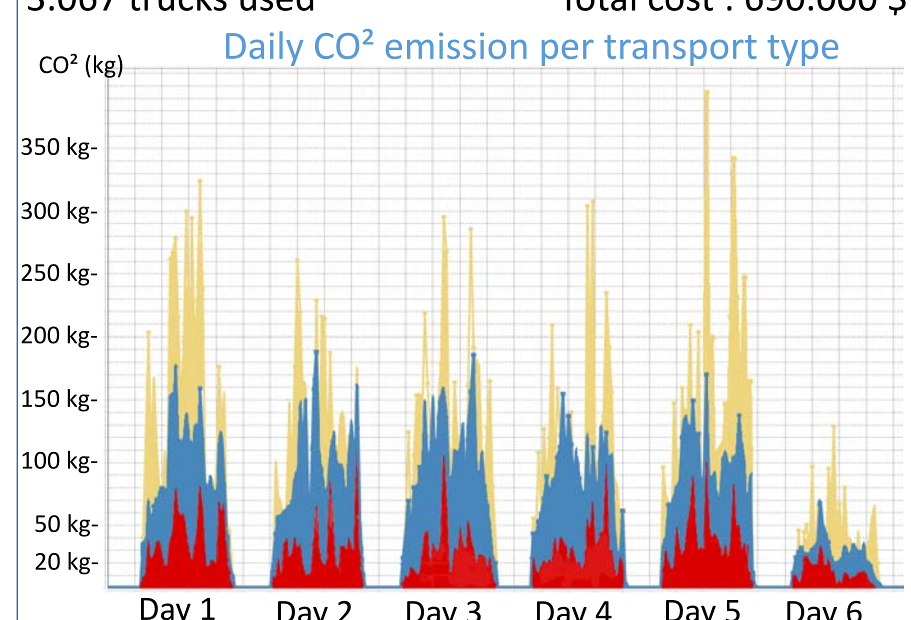
262 Establishments
106 Warehouses
8393 Orders

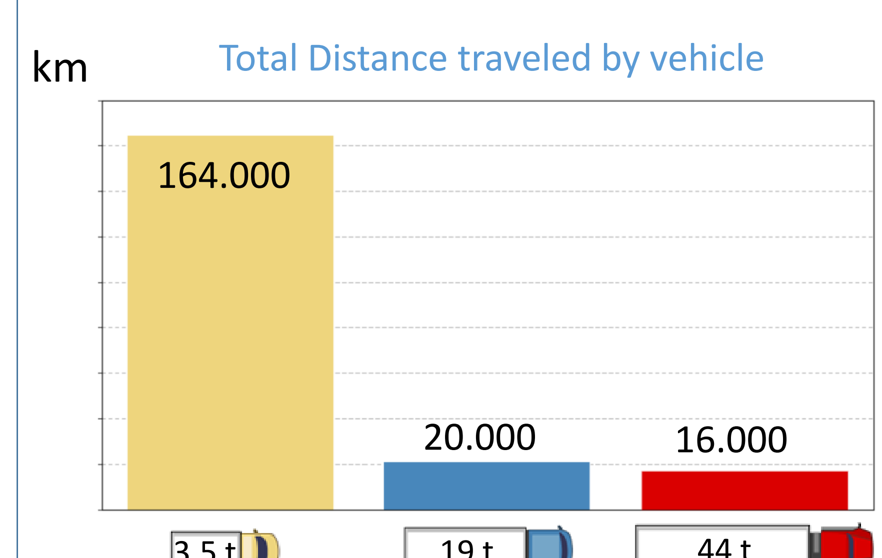




Results

200.000 km traveled
3.067 trucks used
Average delivery time : 6 hours
Total cost : 690.000 $

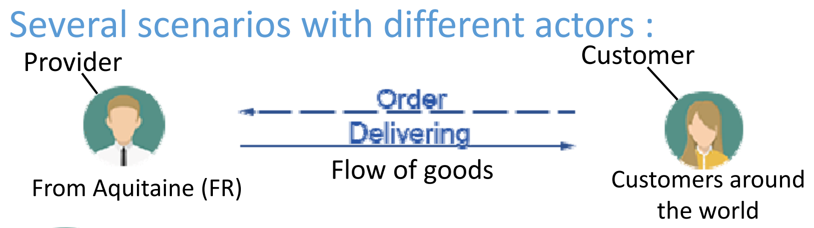




Area : Aquitaine | population : 3.300.000 hab / density : 80 hab/km²

Scenario

Several scenarios with different actors :



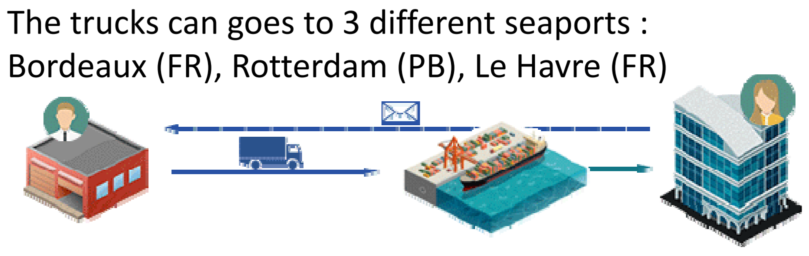
The flow starting point is an establishment from Aquitaine (FR). He will received orders from the customer and then, launch trucks.

The flow destination is a country around the world. In the simulation, we will represent a country by a point at its center. There are several country types :

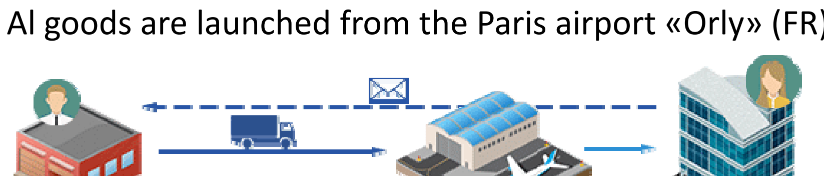
- European country : delivering by trucks

- Countries with coastline : delivering by boat

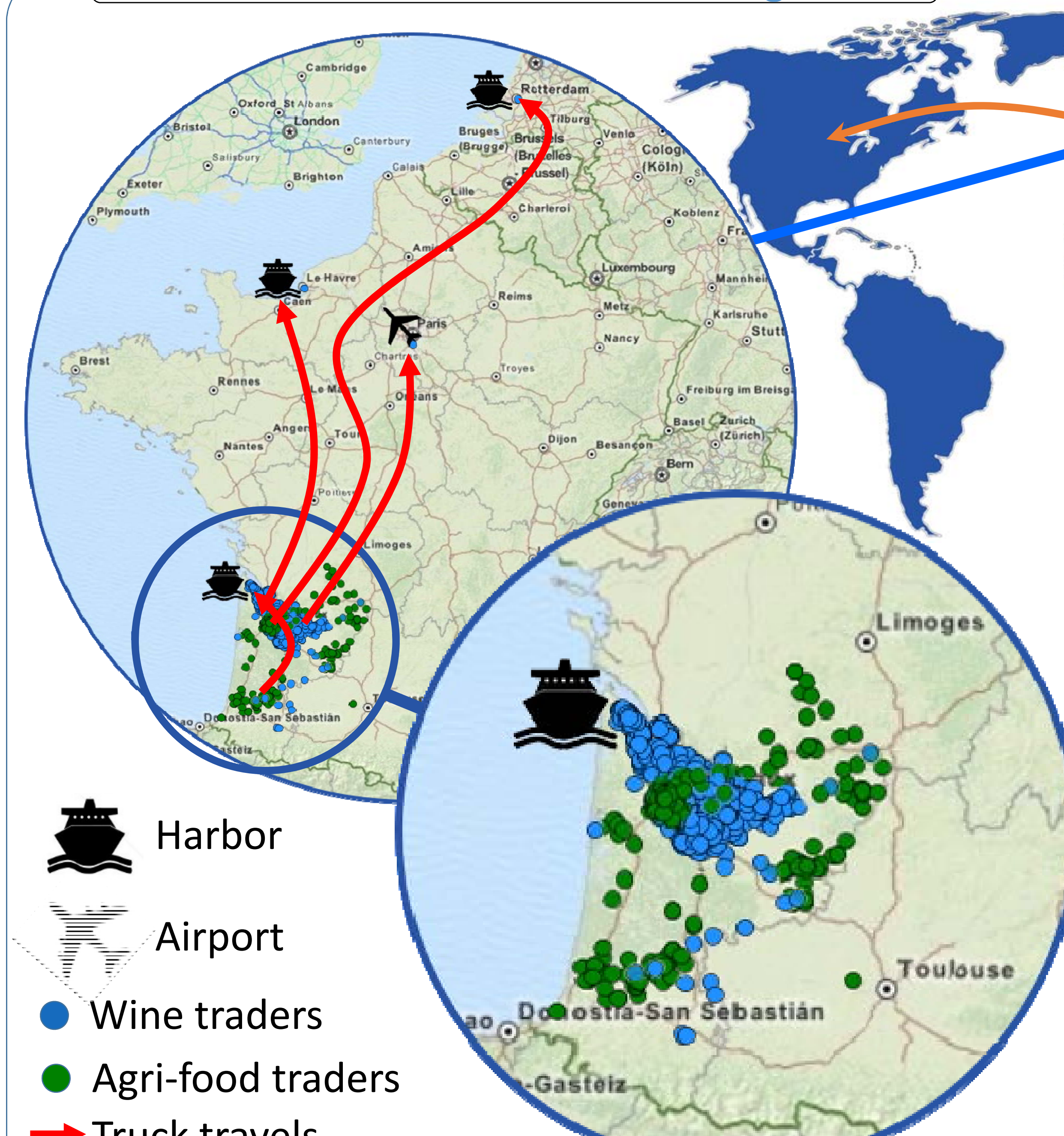
The trucks can goes to 3 different seaports : Bordeaux (FR), Rotterdam (PB), Le Havre (FR)



Al goods are launched from the Paris airport «Orly» (FR)



Actual distribution of wine and agri-food



	Wine	Agri-food
America	12 %	0,8 %
Europe	45 %	94 %
Africa	04 %	2,2 %
Asia	38 %	2,6 %
Oceania	01 %	0,4 %

Source : French customs 2014/2015

Modeling of urban mobility web enabled by Physical Internet

Asma BEN ARBIA, Walid KLIBI, Olivier LABARTHE, Jean-Christophe DESCHAMPS, Benoit MONTREUIL

Objectives

- Propose an **urban mobility web** enabled by **Physical Internet**.
- Map the current mobility network in the city.
- Define three scenarios : From the existing mobility network to consolidated and interconnected networks.
- Evaluate each scenario by calculating economic and environmental indicators.

Context : the City of Bordeaux

The analysis of data from the survey of freight transport in Bordeaux allows us to determine detailed flows between firms established in Bordeaux and grouped flows between regions.

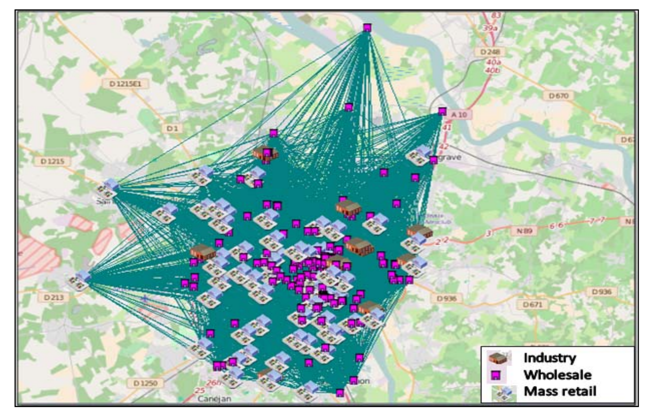


Fig 1 : Inter-firms Flows

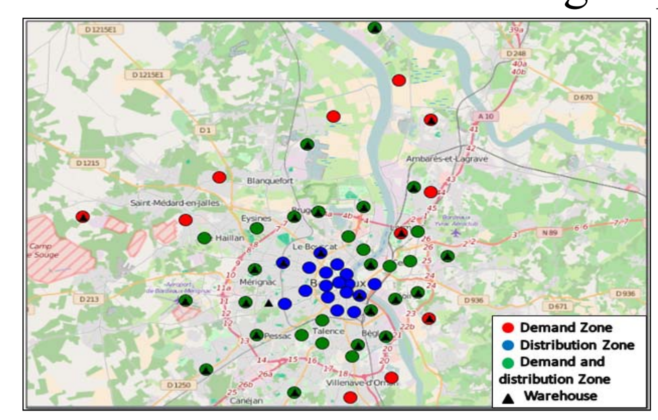


Fig 2 : Different types of Zones

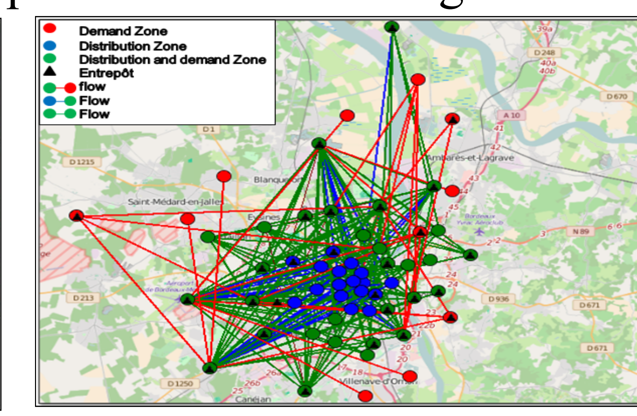


Fig 3 : Flows between Regions

BORDEAUX MÉTROPOLE

Number of municipalities : 28
Population : 749 595 inhabitants (2013)
Density : 1294 inhabitant/Km^2
Area : 579,27 m^2

Methodology

Existing mobility network

We represent actual flows between **warehouses** using **articulated vehicle** (semi-trailer). As Bordeaux is not an industrial city, we expand the network by adding flows from other French regions through three main highways A62, A89 and A10.

Consolidated flows

Consolidated network

The optimization of the existing mobility network is based on **minimizing the transportation costs** using a mutualization approach that proposes to share distribution lanes between each origin and destination node using an average delivery cost.

Augmented network of hubs

Interconnected network

The transition to an interconnected network consists first in locating a new set of **Hubs** in **strategic areas** in order to connect sources to destination nodes through these Hubs and avoid that external flows cross the city with trailers.

Scenario 1

- The map shows the existing mobility network in the city.

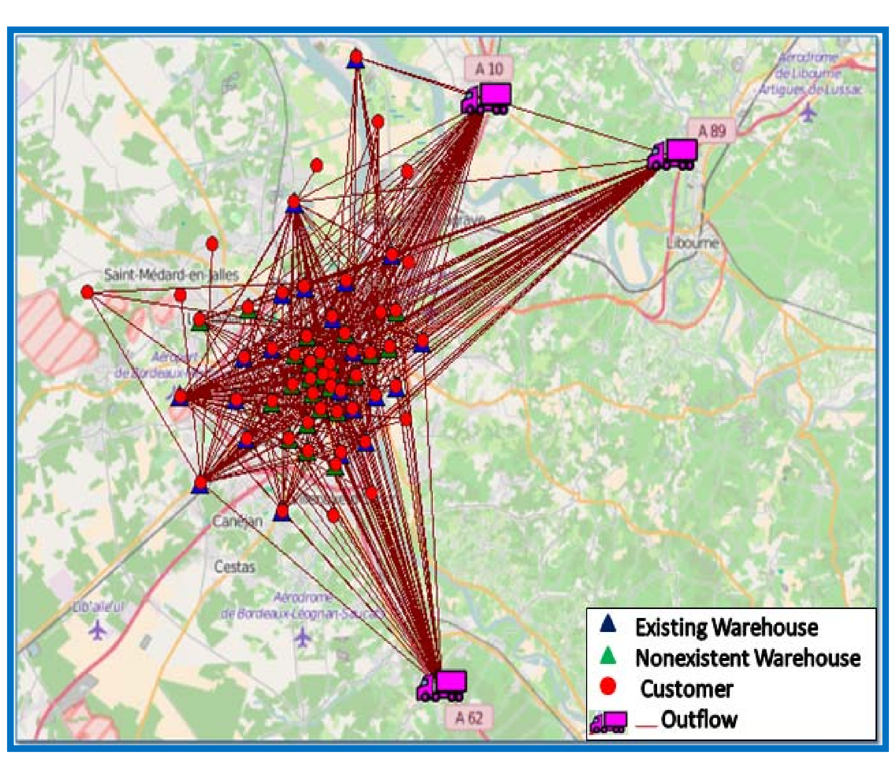


Figure 4 : Existing mobility network

Scenario 2

- The consolidated network optimization represents consolidation of flows while respecting the demand for each zone.

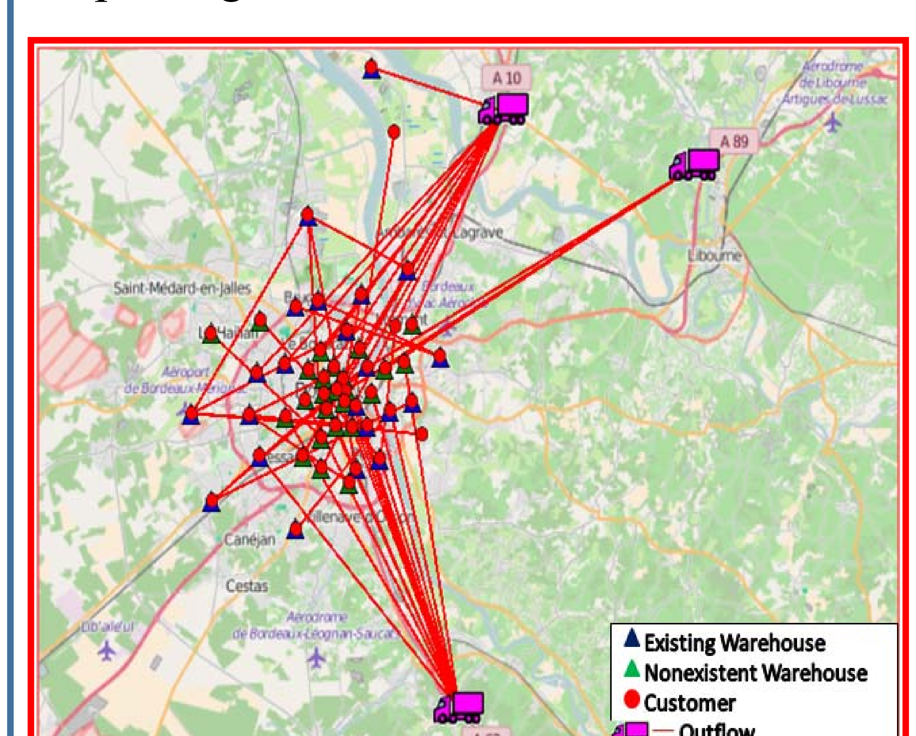


Figure 5 : Consolidated network

Scenario 3

- The interconnected network reveals the structuring impact of consolidating travels from 1st tier to 2nd tier π-hubs in an open mobility web.

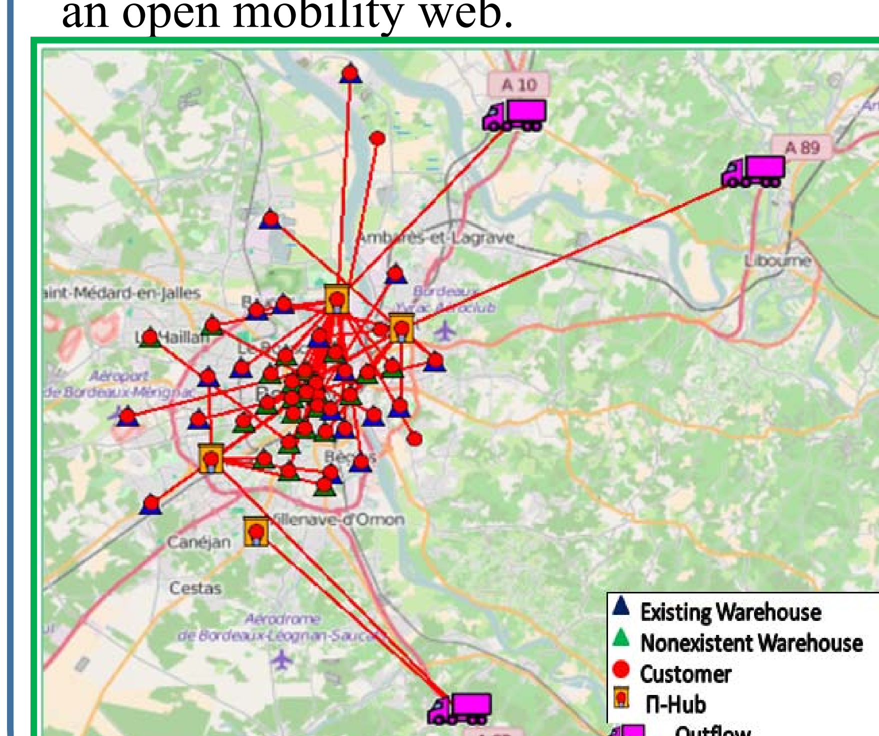


Figure 6 : Interconnected network

Results

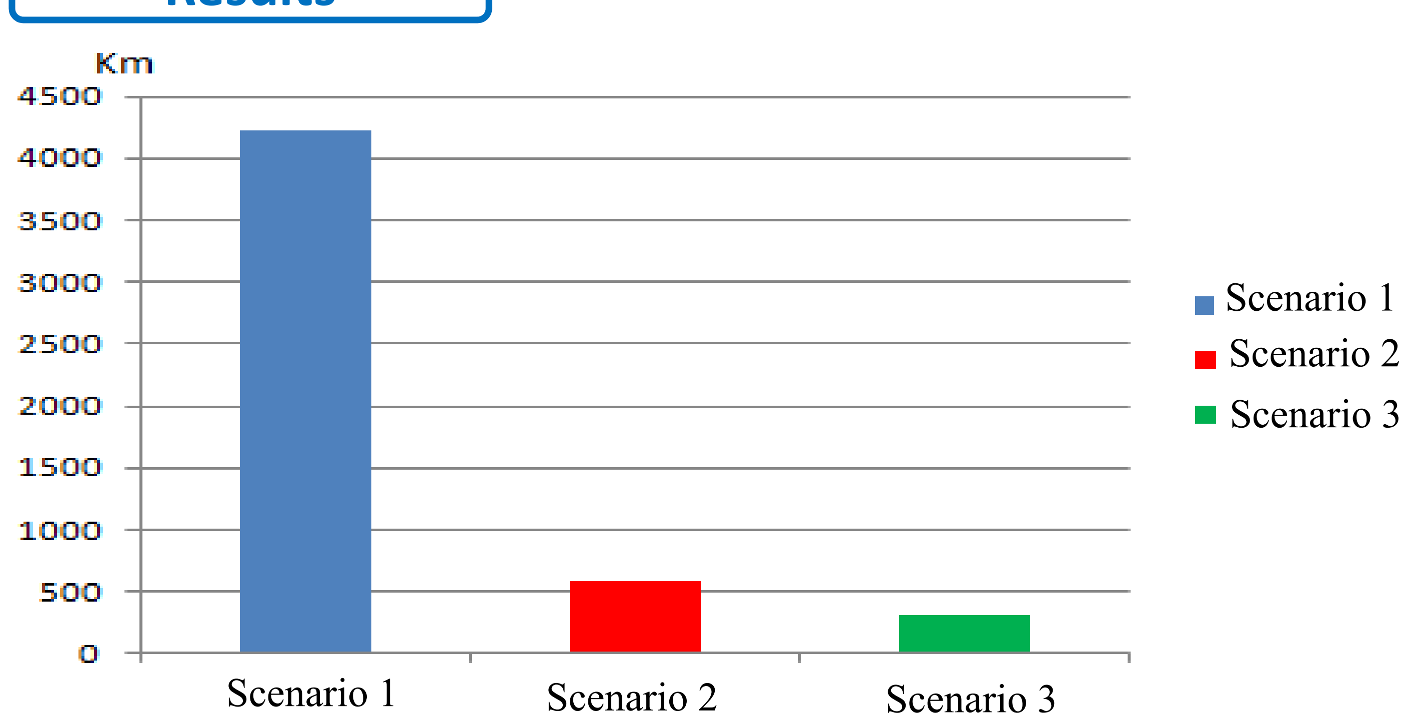


Figure 7 : Cumulative Traveled distance

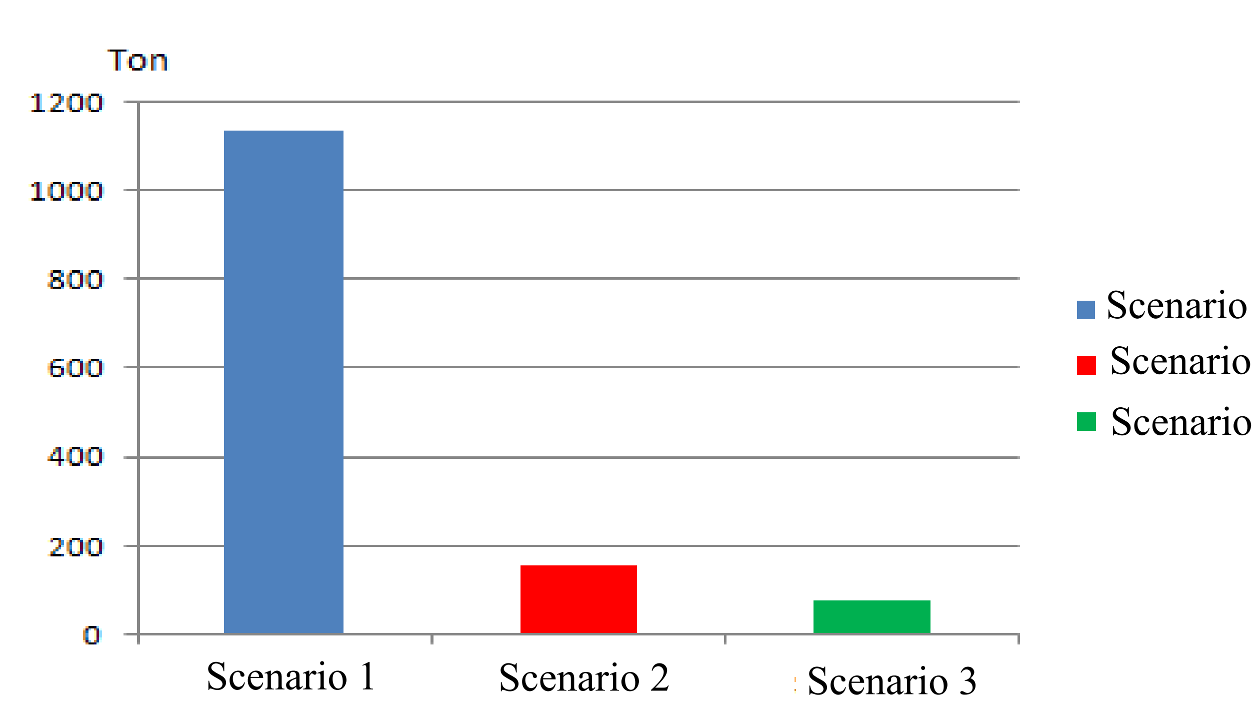


Figure 8 : Total CO2 emissions

Modeling of urban mobility web enabled by Physical Internet

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Coopetition as an Enabler for the Physical Internet

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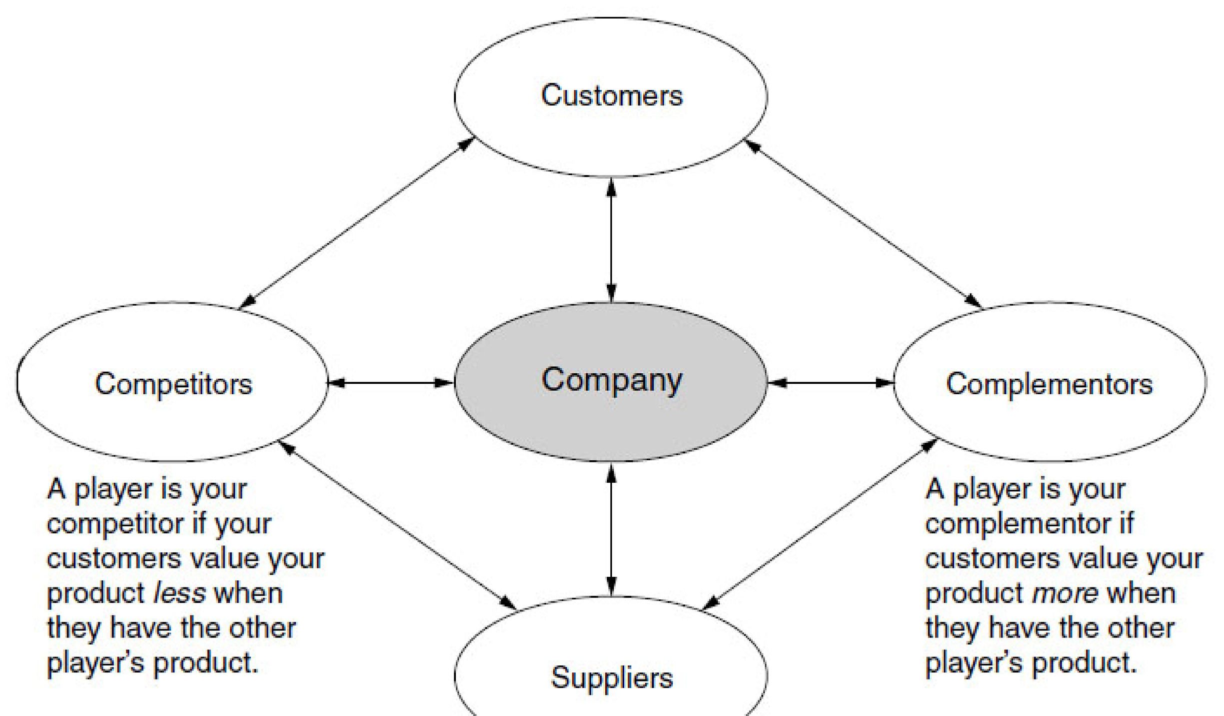
Background & Motivation

Coopetition – a Portmanteau Word with Potential

Unifying **Coop**eration and Com**petition** means:
A reduction of boundaries for network partners – a modified perception in approaching dependencies between companies or organizations.



Source: „The inventory software blog", KCSI Blogger, http://www.simmssoftware.com/wordpress/?p=4472

Understanding the Nature of Coopetition

- Achievement of coopetitive value through integration of supplementary and complementary resources
- Enhancement and application of innovation and product development, market expansion and internationalization (→ explorative motives)
- Gain access to resources, realize cost reductions and generate competitive advantage (→exploitative motives)

(Bengtsson/Kock, 2000; Das/Teng, 2000; Möller/Rajala, 2007)

Methodology

The underlying research stream "Cooperation & Competition":

Literature Review	Word Origins & Definitions Coopetitive Relationships & Models Framework: Conditions & Drivers Coopetition Management
Twofold Field Research	**Logistics Service Providers'** (LSPs) points of view Coopetition in **Commercial and Industrial Enterprises**
Coopetition Framework	• Structuring the applied context of coopetition by means of antecedents, moderators, mediators and outcomes • Identifying indicators in an intra- and inter-firm context (German-speaking area perspective)
Survey	Quantitative survey among companies in German-speaking area

Contribution to existing research in terms of linking coopetition strategies with boundary spanning and value creation from an intra-firm perspective.

Initial Insights

- **Gathering of the state-of-the-art and defining the term coopetition as a new strategic management paradigm**
- **Definition of a conceptual framework for proficiencies that describes antecedents, mediators and outcomes within an applied coopetition context**
- **Description of a coopetitive background, entrepreneurial strategic thinking and identification of different kinds of coopetition strategies**

Insights (LSP's points of view)

- A **neutral platform** as a basic requirement for the interconnection of "all" transport companies/logistics service providers
- Intention to "complete each other" → a goal which requires to work with competitors and make them to complementors
- **Cooperation** with competitors **not imaginable** for those surveyed! Differences between companies are pertaining to core markets, geographical areas, special services, …
- Obligation to data sharing and information security **agreements and guidelines**
- Implementation of a **standardized system** as a necessity for shared operations

Perspectives

Opportunities connected to the **strategic use** of the coopetition approach or changes in existing mindsets shall be explored.

Results are expected to further develop the understanding of coopetition **and its strategic importance in terms of mindsets and cooperation conducts** on the revolutionary path toward an applied Physical Internet.

Outlook

Results to be discussed with potential first mover businesses or coopetition pioneers.

Research question: How can a coopetitive strategy support the vision of the Physical Internet?

International project proposal on coopetition planned.

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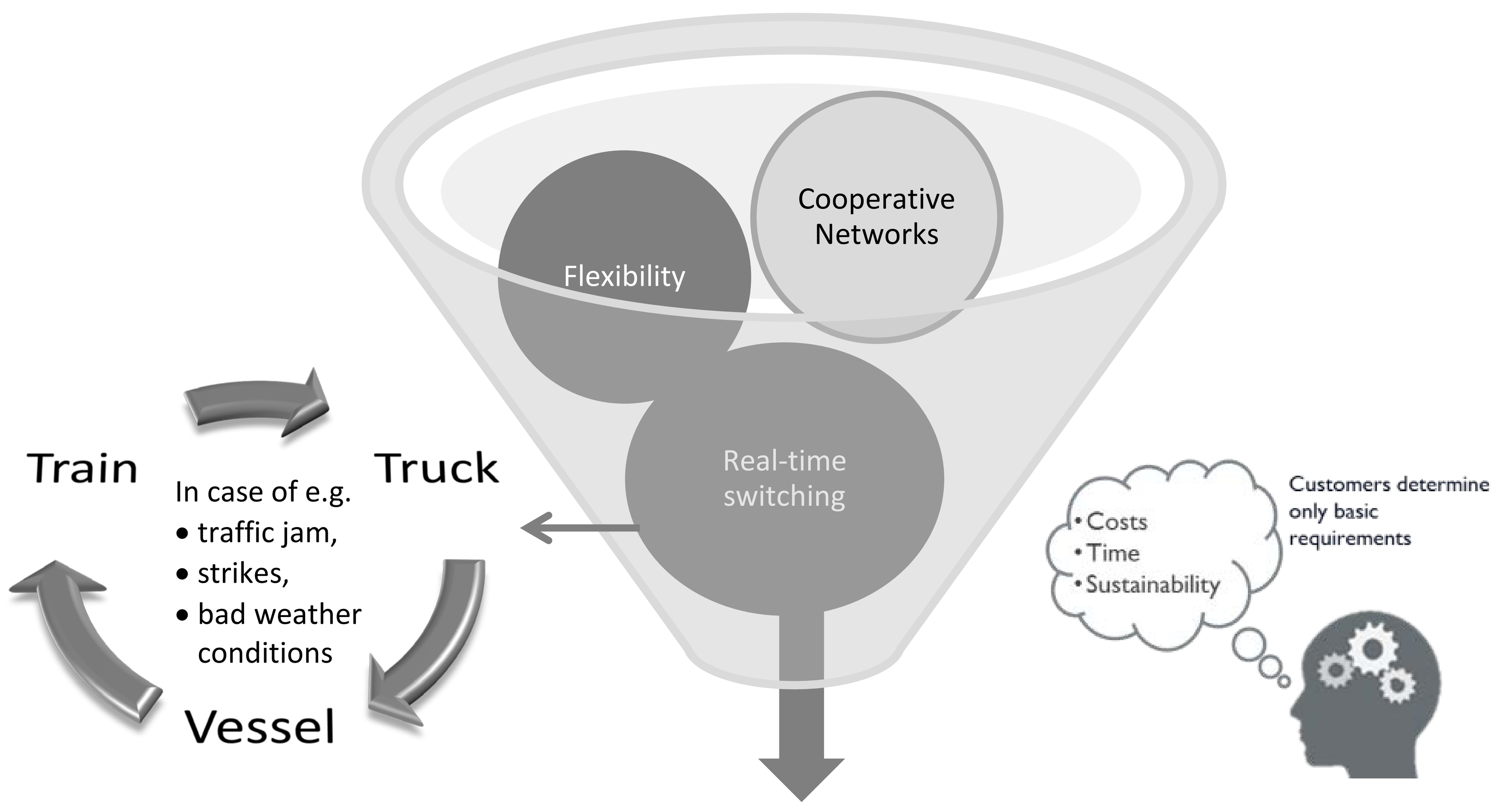
An Assessment of Stakeholders' Attitude towards Synchromodality

S. Pfoser / O. Schauer / L.-M. Putz /
M. Prandtstetter / A. Haller

SYNCHROMODALITY AS A NEW CONCEPT FOR FREIGHT TRANSPORT

- Can be seen as evolutionary stage subsequent to the transport concepts multimodality, intermodality and comodality
- Mode-free booking of transport services allows flexible use of resources



Aim: Bundling of transports, optimized and sustainable use of resources to support the vision of Physical Internet

- Virtually unknown in Europe except for the Benelux countries
- Potential to promote modal shift has been demonstrated in a pilot along the corridor from the ECT Terminal in Rotterdam to the Dutch hinterland:

	2010	2033 target	Synchro pilot
	57%	35%	19%
	33%	45%	46%
	10%	20%	35%

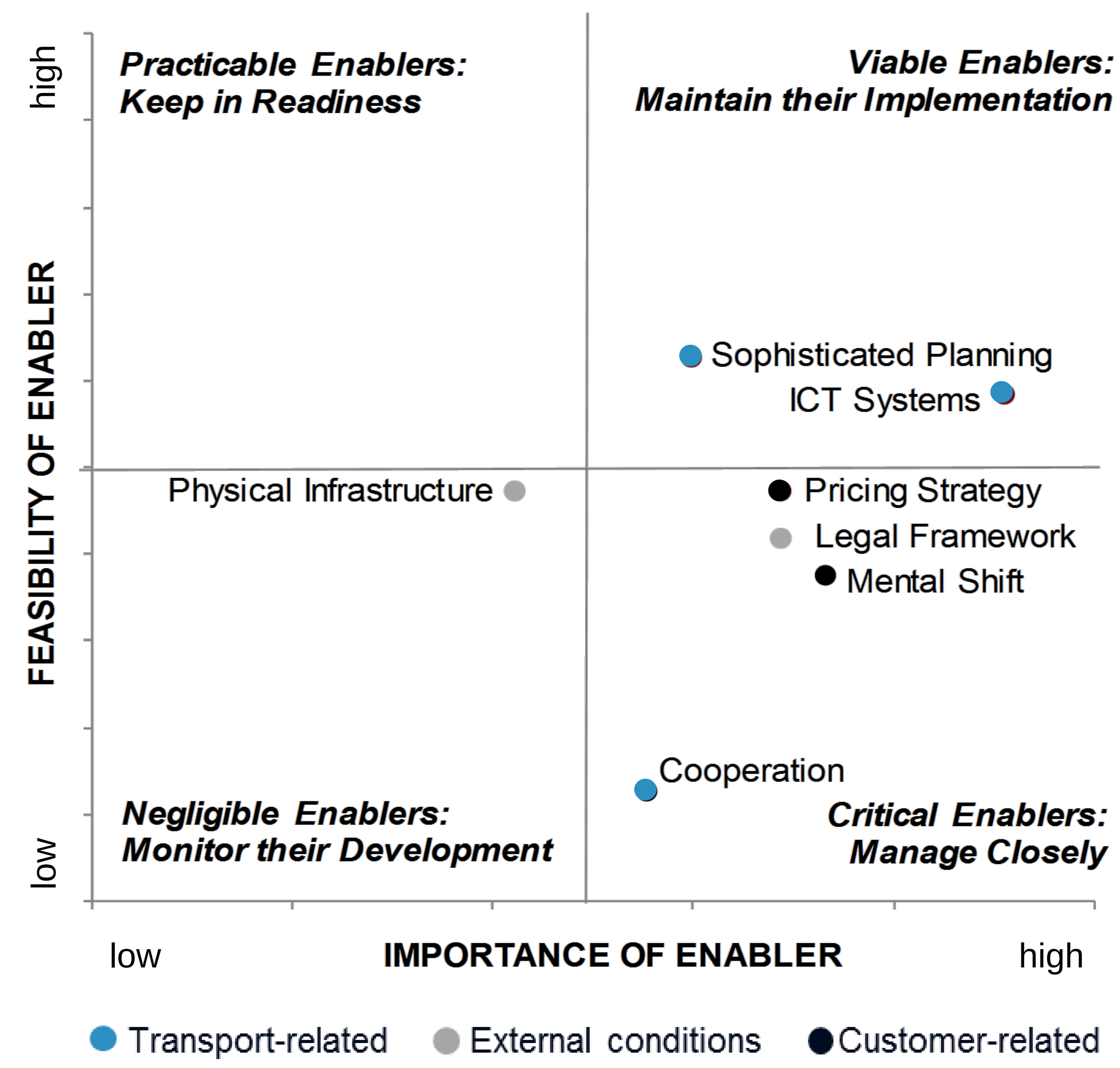
Source: Lucassen/Dogger, 2012

SYNCHROMODALITY IN AUSTRIA

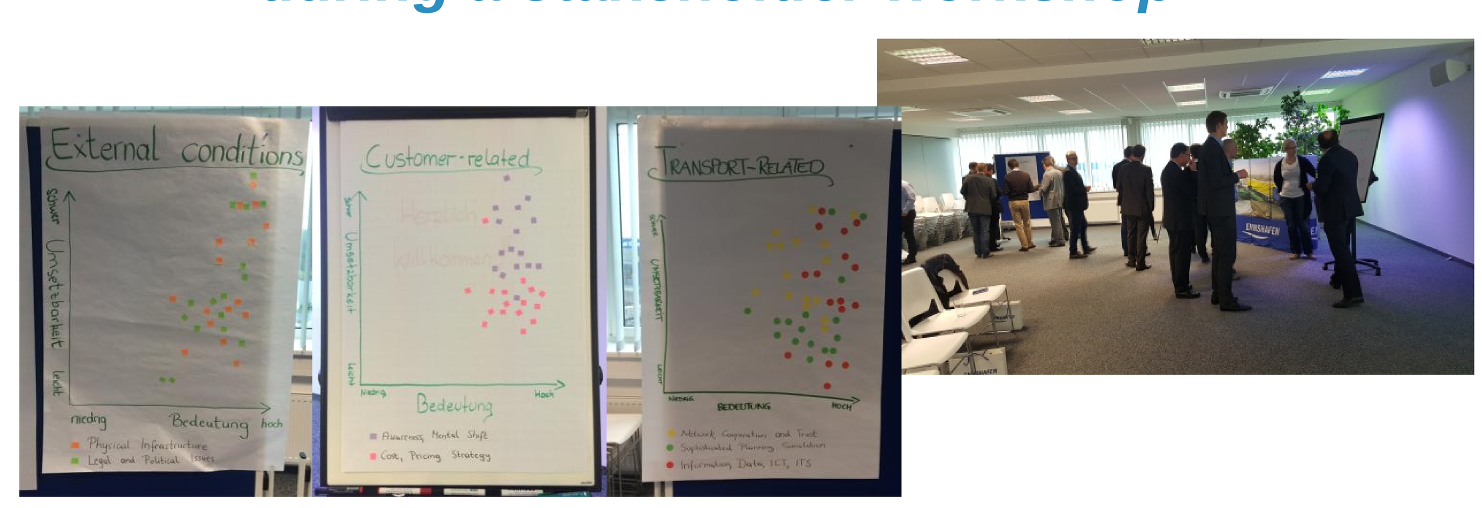
- Austrian Project "SynChain" to understand the concept and raise awareness
- Initial knowledge building through dedicated desktop research and study visit in the Netherlands (leading country for synchromodality)
- Stakeholder workshop in October 2015 to promote synchromodality and evaluate Austrian stakeholder's attitude
- Twenty representatives from industry as well as logistics discussed usefulness and feasibility of introducing synchromodality in Austria. To facilitate open communication, the World Café Method has been used

ASSESSMENT OF SYNCHROMODALTIY

Evaluation of critical success factors by Dutch experts



Assessment within Austrian context during a stakeholder workshop



- Interactive evaluation of previous research results on flip charts and in group discussions within World Café
- Assessing the presence of critical success factors of synchromodality in Austria and detecting conditions to be fulfilled
- Results comparable with estimations from Dutch experts: Establishing close cooperation between actors in the transport chain is the main concern, providing appropriate technical infrastructure (ICT- and ITS-systems) is considered less problematic. Sufficient freight volumes are needed to ensure that real time switching and bundling of goods
- Synchromodal pilot corridor might be implemented or simulated in a follow-up project

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Requirements for a Physical Internet handling container

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Vorstand: Univ.-Prof. Dr.-Ing. Dirk Jodin

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Graz University of Technology

Introduction and objectives

Funded on physical, digital and operational interconnectivity the Physical Internet (PI) has been introduced to achieve an open, global and interconnected logistics network. Next to standardized interfaces and protocols, the encapsulation of goods is one of the key pillars to realize the PI and therefore enables an order-of-magnitude improvement in the efficiency and sustainability of logistics systems ([1] and [2]).

In order to generalize and standardize the unit load design, Montreuil, Ballot and Tremblay proposed a three-tier characterisation of transport-, handling- and packaging containers depicted in figure 1. Current packages will be transformed to packaging containers, basic handling unit loads and pallets will be replaced by handling containers and the current shipping containers will be evolved to transport containers [2].

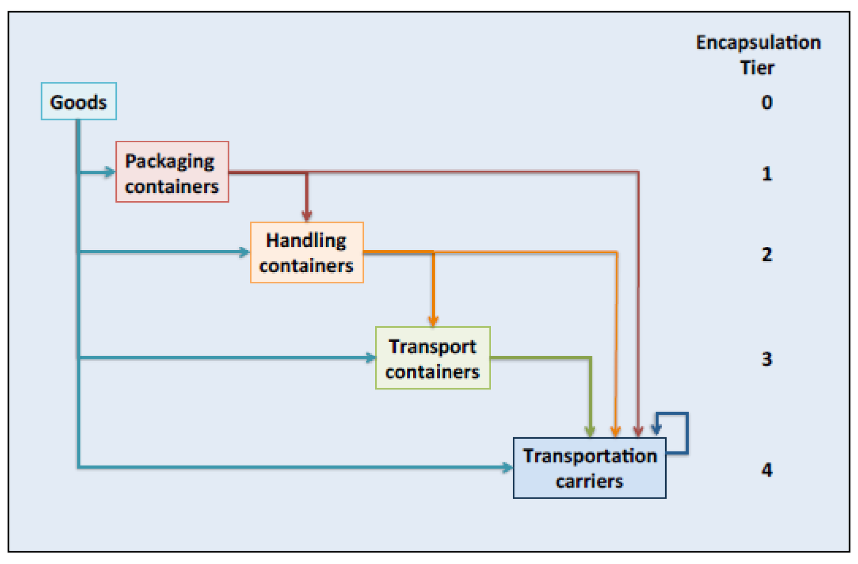

Figure 1: Proposed PI encapsulation characterization [2]

Building on this work, the particular focus of this poster is on the requirements and functions which a future PI-handling container has to fulfil. The findings from the European MODULUDHCA project and the Austrian Go2PI projects are merged with ongoing research work in order to prioritize and show the impact of box functionality.

Methods

In Europe, one of the first projects aiming to realize the PI was the MODULUSHCA project (Modular logistics units in shared co-modal networks) 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 [3]. Within the scope of the project one of the integrated working fields was to develop and prototype a set of exchangeable (IOS) modular logistics units providing building blocks for larger units – the PI-handling containers for FMCG: the MODULUSHCA box (M-box) [4].

Following the systematic approach of VDI 2221 and VDI 2222 which deals with the universal and non sector-specific principles of the methodological engineering design the MODULUSHCA box was developed in defined process steps after a common logic and practicality (see figure 2).

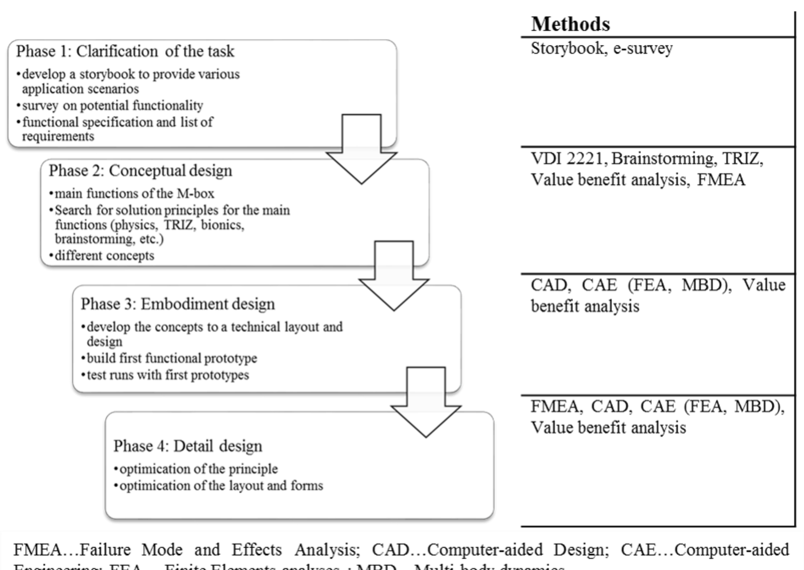

Figure 2: Different phases of the VDI 2222 applied on the development process for the container design [5]

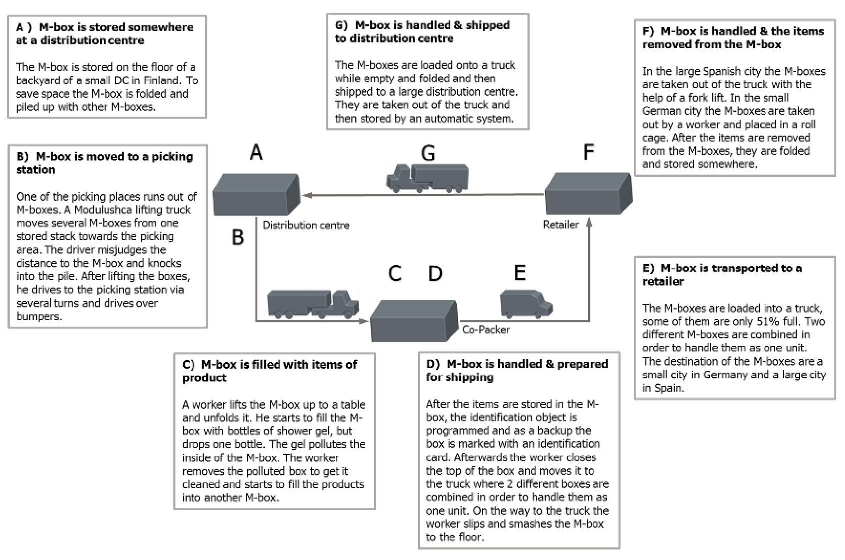

Figure 3: Storybook to sketch Supply Chain interactions [6]

A key enabler of this work was to develop a functional specification for the modular units. Therefore a pragmatic way by using a storybook approach was chosen (an example is outlined in figure 3). The storybook created a map of "typical" Supply Chain (SC) interactions between manufacturing sites, distribution centers, co-packing sites and retail outlets and was used to derive future requirements and functions for the PI-container as a basis for the conceptual design.

In addition to the MODULUSHCA project, further requirements and functions concerning the PI-handling container are derived in the Austrian research project Go2PI. The project is funded by the Austrian government and raised the question on how to lead a small and medium sized enterprise (SME) in the automotive sector towards the PI. Based on a case study, 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 following the PI vision. A proposed standard process for B-to-B (see figure 4) was developed as a basis for the storybook method and to derive further requirements and functions.

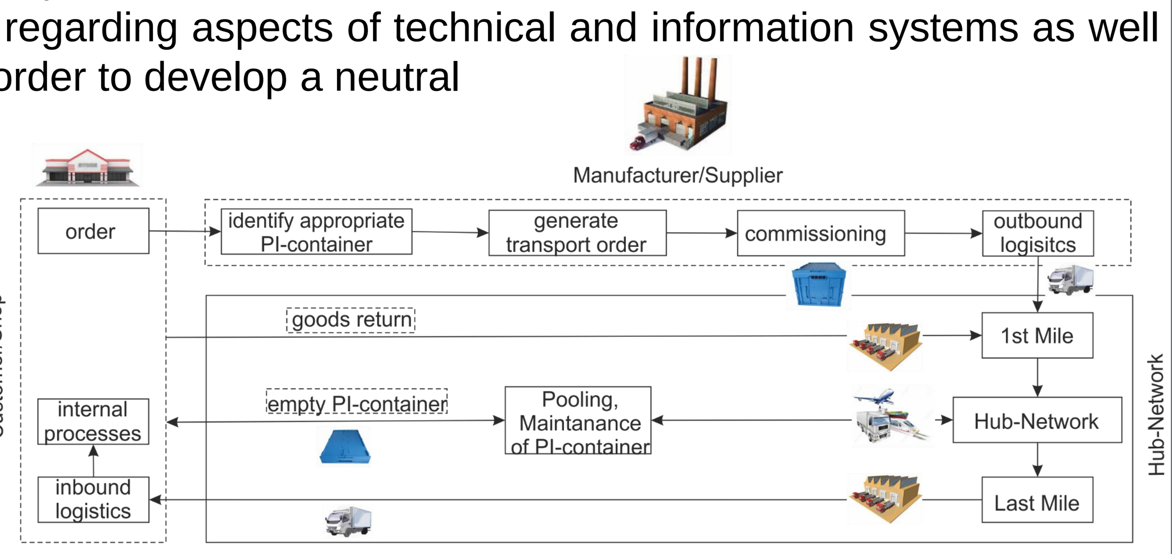

Figure 4: proposed standard process for B-to-B in a future PI [7]

Results

Within the MODULUSHCA project it was possible to derive multiple requirements for a future PI-handling container in FMCG logistics. Taking this requirements to a survey and capture stakeholder inputs for a better understanding of cross-industry and sector views, resulted in a list of main functions and also requirements for the design presented in figure 5. Based on the main functions a prototype was designed and manufactured with 3D printing (see figure 6). More detailed information and further results of the MODULUSHCA project are presented on the MODULUSHCA webpage [3] and in the work of Landschuetzer, Ehrentraut and Jodin (2015) [4].

Supplementary to the requirements for the FMCG logistics the Go2PI project derived further requirements and functions in the field of an SME in the automotive sector. Additional requirements are in particular the interaction with handling assets used in production, environmental conditions in production sites and the interaction with regular high-rack storage. Additional information is presented by the work of Gasperlmair et al (2016) [9].

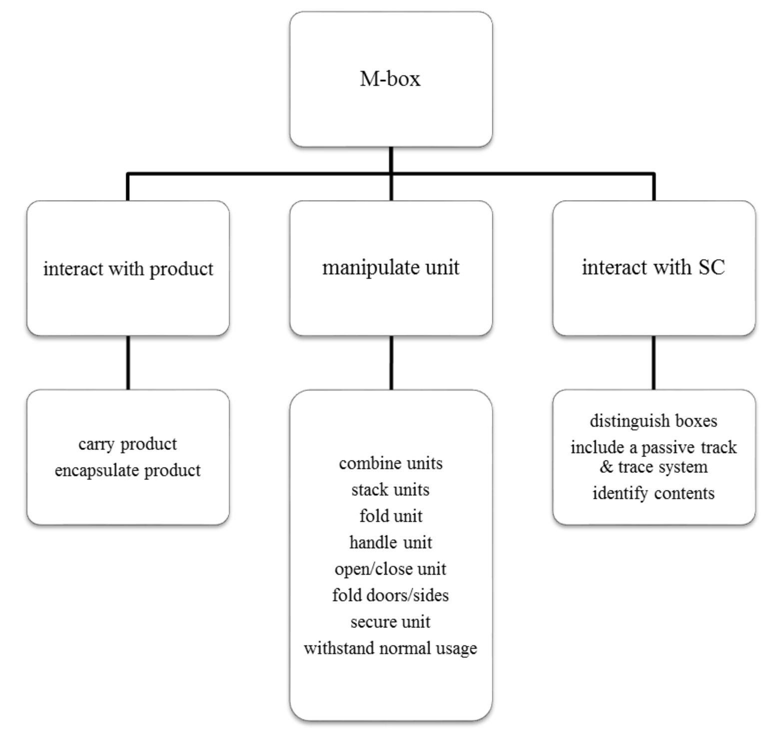

Figure 5: Key functions of the PI-handling container [8]

Figure 6: Interlocked part of a unit load comprising small and large M-box prototypes [4]

Conclusion and outlook

The PI aims to introduce many beneficial aspects to today´s SCs and the PI-containers are one of the main elements to realize the PI-vision. The presented methods and findings show main requirements and functions of a future PI-handling container derived from two different research projects.

Next steps to carry on and elaborate the research and the development of PI-handling container are:

- Investigate in reusable packaging material
- Further develop the idea of building PI- containers out of modular panels (see Fig. 7).
- Derive further requirements and functions for the PI-handling containers by investigating other industrial sectors (by the Austrian research project "ProtoPI")
- Develop physical assets and processes to automatically handle and build unit loads

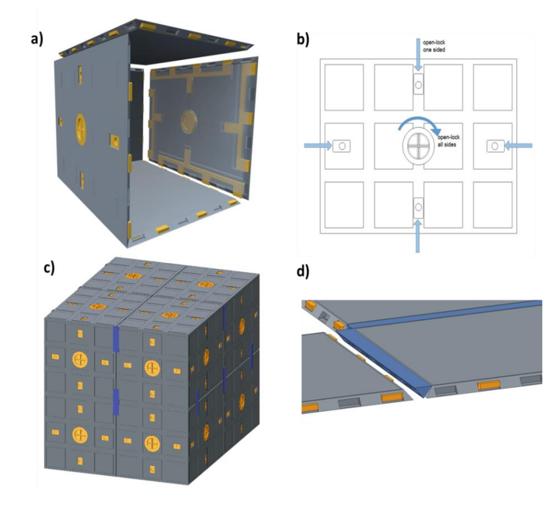

Figure 7: PI-container built out of modular panels [10]

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Multi-agent simulation study of the Physical Internet in a network of e-commerce businesses in the area of Louisville

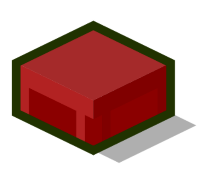
Pieter Beem, Sipke Hoekstra, Benoit Montreuil, Kevin Gue

Introduction

This study provides an example of the Physical Internet (PI) implemented in a realistic scenario. It demonstrates a multi-agent simulation model of the logistics in Louisville, Kentucky. The model handles large flows of goods, encapsulated in containers, using hubs and gateways. Of special interest are the outbound flows of e-commerce businesses, for which statistics are collected. This poster presents the model and its assumptions, goals and expected results.

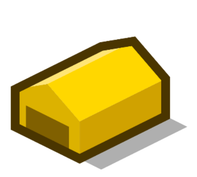
Model Layout

The PI network is constructed with three types of locations:

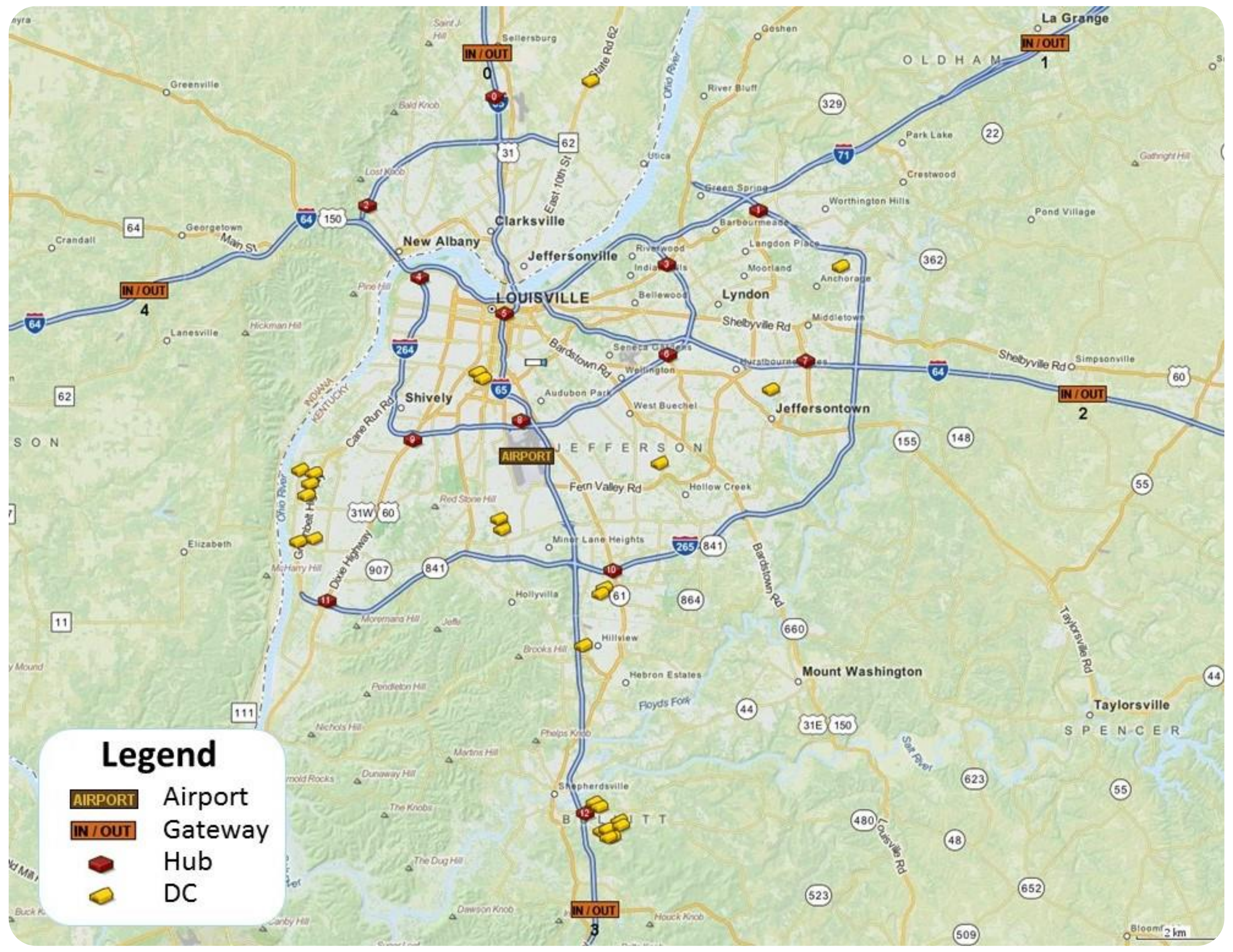


Hubs are placed throughout the city on intersections of major highways. Hubs are the nodes of the network. Containers travel from hub to hub.

Gateways are put on the city's incoming interstates. They are the entrances and exits of the system. Gateways generate goods coming into the city and sink goods that exit the city



Distribution centers are positioned on actual locations of e-commerce businesses. There are 26 e-commerce companies in the model. They all generate an outbound flow of goods.



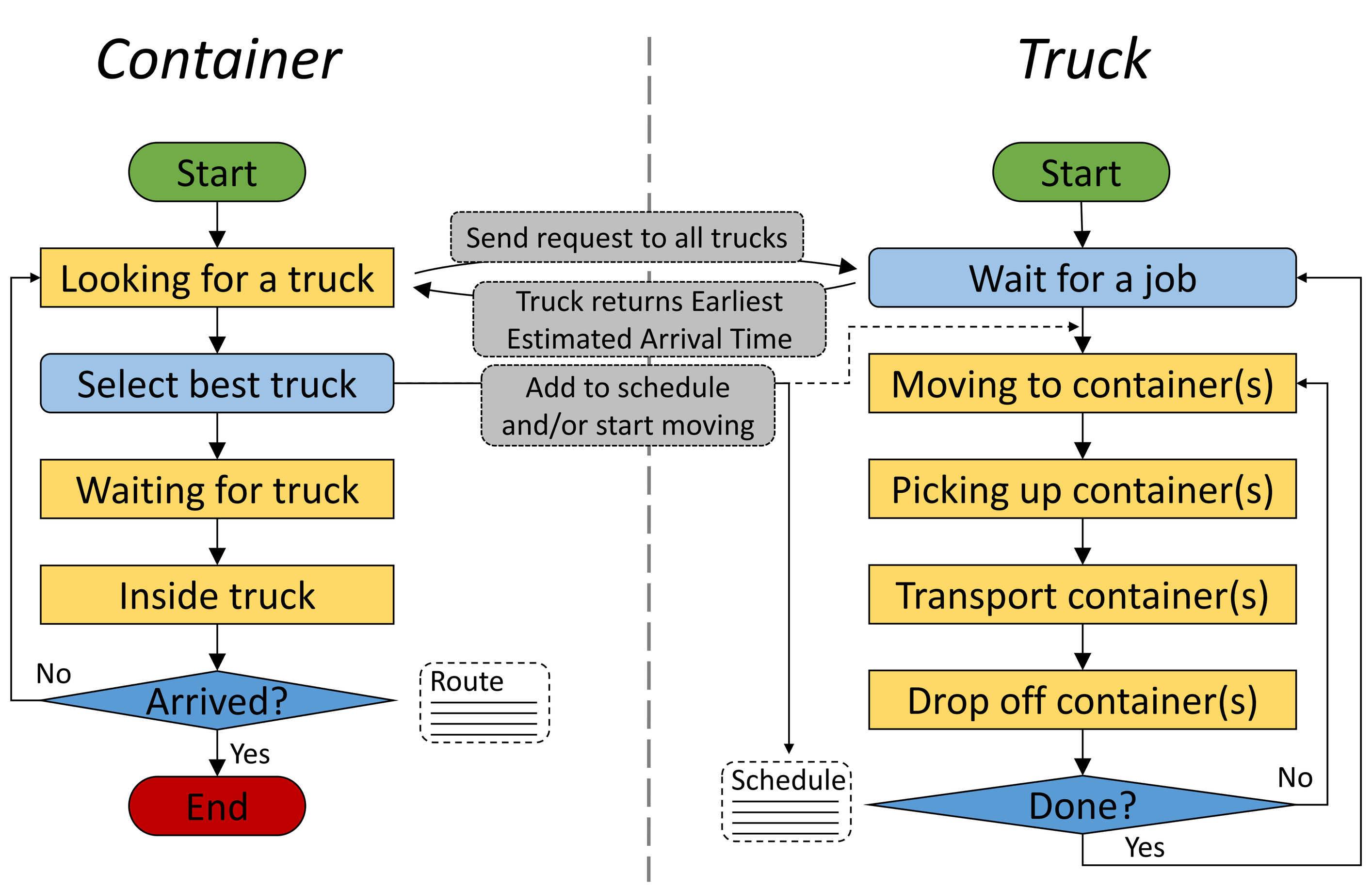
The model's GIS environment with hubs, gateways and DC's

Agents

There are two types of agents that control themselves:

Containers are requesting transportation. When entering the system, the shortest route is generated, which passes by hubs. At every stop, a container asks every truck what the earliest arrival time is that they can make, it then selects the earliest.

Trucks transport containers. They have a schedule with pick ups and drop offs. As long as they have capacity on an already scheduled ride, containers can reserve a spot. If not, a new job can be created at the end of the list.



Flowcharts of the logic of the container and truck agent

Assumptions

This model serves as a proof of concept. Therefore, many simplifications and assumptions have been done.

In the model, all goods are assumed to be:

- Encapsulated in containers when entering the system.
- Fitted in the same container size.
- Bound for the airport, when sent by e-commerce DC's.
- Arriving according to assumed probability distributions and arrival rates.

Goals

The main goals for this study are to:

- Understand the behavior of PI system in a city and learn what parameters are critical to its performance.
- Benchmark the system with current operations. In these operations, fully loaded trucks serve the airport directly from the DC's.
- Quantify the performance of the PI system under high load levels. This is benchmarked against current operations as well.

Expected Results

It is expected that the PI system:

- Performs well with basic agents. Advanced agents may enhance performance.
- Lowers average lead times and increases vehicle utilization.
- Deals better with peak loads.

Further Research

In addition to delivery time it is interesting to consider costs. Trucks have costs per time unit and per distance travelled. Based on these costs, trucks can quote prices for which they can take containers. Containers can then setup an auction in which they select the lowest bid.

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