# Pi and Ports (PI&P):
# A Conceptual Framework and Future Development Paths

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**2017-07-05**

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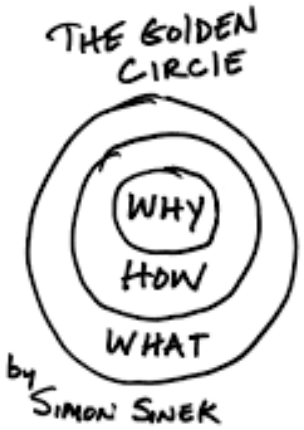
# Outline

- Objective: Introducing PhD topic area
- Why? Relevance of PI for ports…
- How? Research questions…
- What? Activities…
- Summary

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# Project context

***Towards virtual ports in a Physical Internet (PI)***

## Overall goal

Conceptualize the roles of maritime ports in the PI

## Stakeholders

NWO

TKI DINALOG
Dutch Institute for Advanced Logistics

rijksuniversiteit groningen

TU Delft

MINES ParisTech

Georgia Tech

Port of Rotterdam

GRONINGEN SEAPORTS

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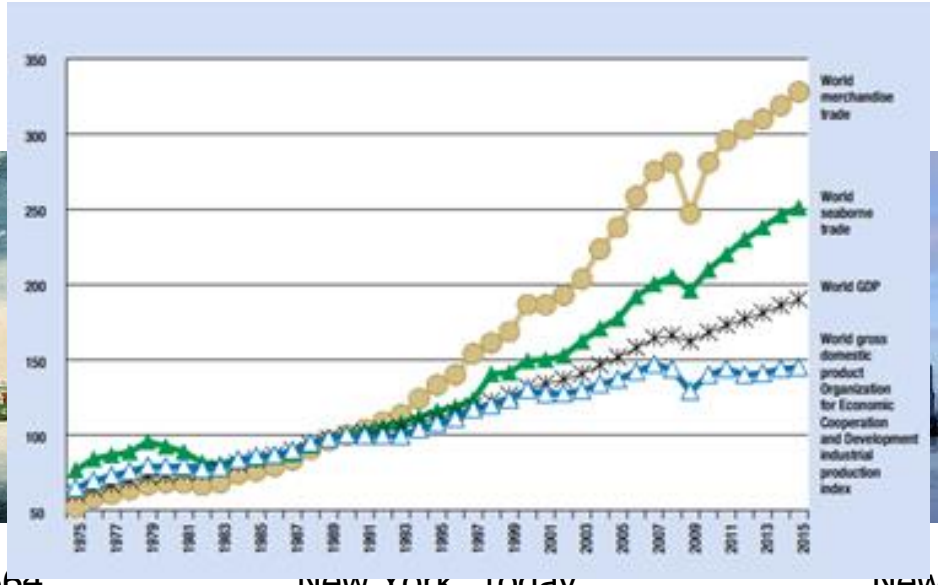
# Why? – Relevance

Why investigating the future roles of ports in PI is of crucial importance?

# Ports & PI Issues (opportunities & threats)

- Crucial importance in supply chain (management)
- Huge asset investments
- Global trade enabler
- Crucial for local and regional development
- Times are changing…!

New Amsterdam - 1664




*GDP, Seaborne trade and total trade (UNCTAD, 2016)*

New Shanghai – 2264?

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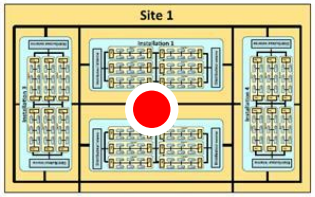
# The Physical Internet: the same conceptual framework at any scale

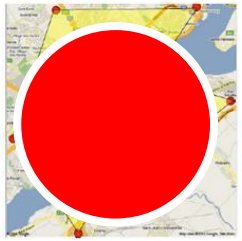
Intra-center Inter-processor Network

Intra-Faciilty Inter-Center Network

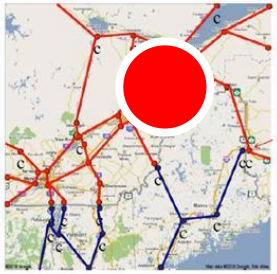

Intra-Site Inter-Facilities Network




Intra-City inter-Site Network



Intra-Continental Inter-City, Inter-State/Province Network



Inter-Continental Worldwide Network

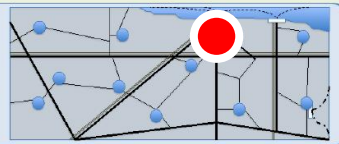
Physical Internet
Efficient Sustainable Logistics

Physical Internet Manifesto, version 1.11.1
Professor Benoit Montreuil, CIRRELT, Université Laval
Québec, 2012-11-28, 44/76

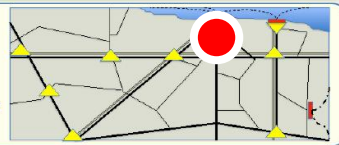
# Logistics Web

Set of openly interconnected physical, digital, human, organizational and social agents and networks
aiming to serve efficiently and sustainably
the logistics needs of people, organizations, territories and society

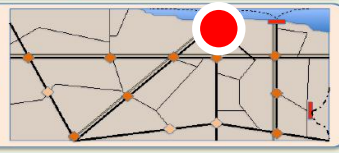
**Realization Web**
**Realizing products**
*Interconnected open production, personalising & retrofit centers*



**Distribution Web**
**Deploying, storing products**
*Interconnected open warehouses & distribution centers*



**Mobility Web**
**Moving goods & people**
*Interconnected open unimodal & multimodal infrastructures, movers, hubs and transits*



**Supply Web**
**Supplying goods**
*Interconnected open suppliers and subcontractors*

**Service Web**
**Enabling and sharing access and usage of services rendered by goods & people**
*Interconnected open users and service providers*

Port · Maritime route · Air route · Road · Railroad · Highway · Open m-Port · Open m-factory zone · Open m-store & m-distributor zone · Open multimodal m-hub & m-transit zone · Open unimodal m-hub & m-transit zone

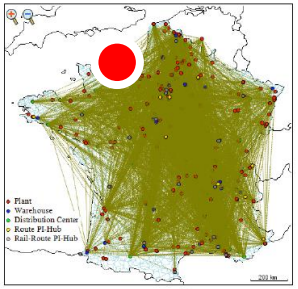
Physical Internet
Efficient Sustainable Logistics

Physical Internet Manifesto, version 1.11.1
Professor Benoit Montreuil, CIRRELT, Université Laval

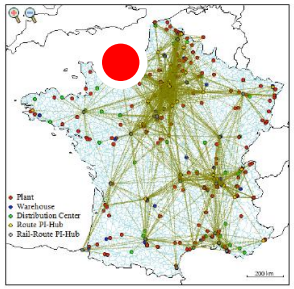
# Exploiting a Physical Internet Enabled Bimodal Mobility Web for the Consumer Goods Industry in France

**Road and rail transport seamlessly integrated into the PI backbone network**

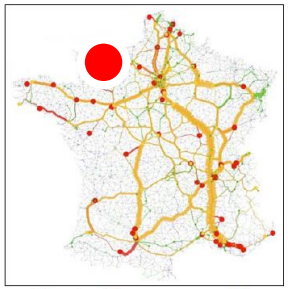
Simulation based on product distribution flow to two top retailers in France, from their 100 top suppliers




Current flows




Physical Internet flows



Physical Internet traffic

**Preliminary results using existing infrastructures, facilities, demand patterns and service levels**

**Economical: From 4% to 26% overall cost saving**

**Environmental: About 2 times better in terms of greenhouse gas emissions**

Source: Montreuil (2012): Physical Internet Manifesto

Physical Internet
Efficient Sustainable Logistics

Physical Internet Manifesto, version 1.11.1
Professor Benoit Montreuil, CIRRELT, Université Laval

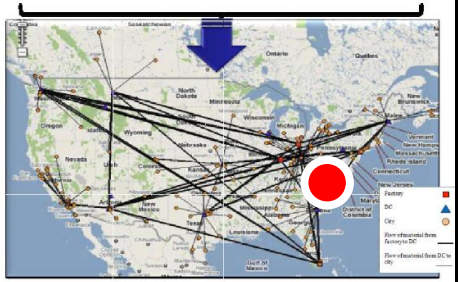
# Activate and exploit an Open Global Distribution Web

**Most companies design, run and optimize independently their private distribution networks, investing in DCs or engaging in long-term leases or contracts**

There are 535 000 distribution centers in the U.S.A. only

Most of them are used by a single company
Most companies use often a single DC
and generally less than 20 DCs

Imagine the potential
if each company could deploy
its products through a open web
including 535 000 open DCs in the USA

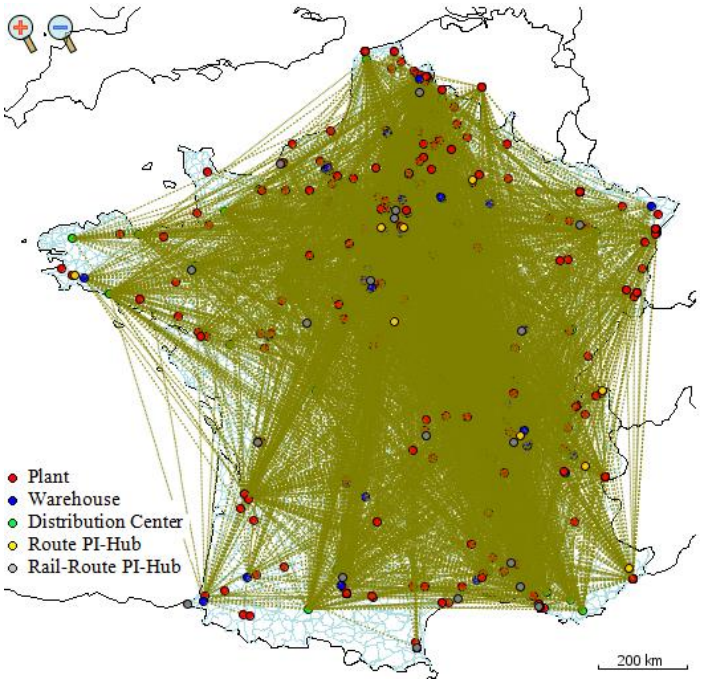


Montreuil and Sohrabi, From Private Supply Networks to Open Supply Webs, IERC 2010

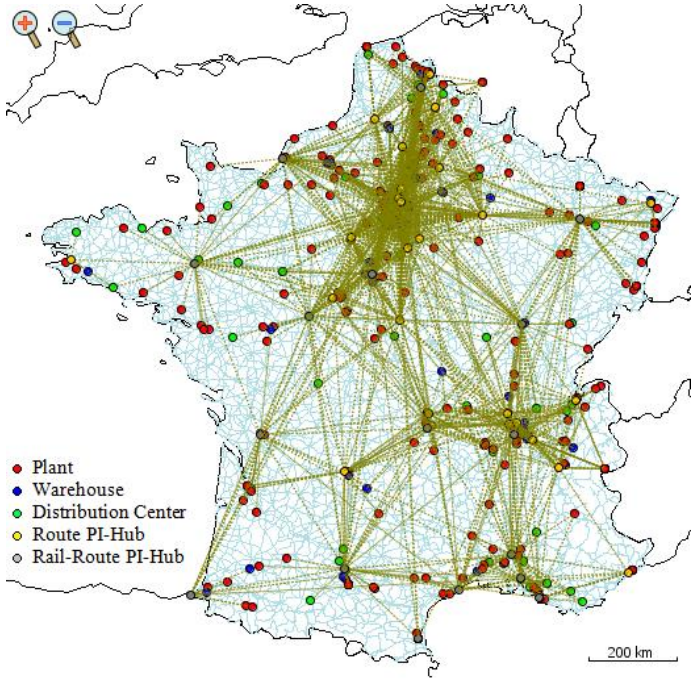
Physical Internet
Efficient Sustainable Logistics

Physical Internet Manifesto, version 1.11.1
Professor Benoit Montreuil, CIRRELT, Université Laval

# Example: France retail, image for ports?




Current flows




PI flows

*Flows of 2 retailers with 100 suppliers (Ballot et al., 2012)*

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# Example: US distribution

## Activate and exploit an Open Global Distribution Web

Most companies design, run and optimize independently
their private distribution networks,
investing in DCs
or engaging in long-term leases or contracts

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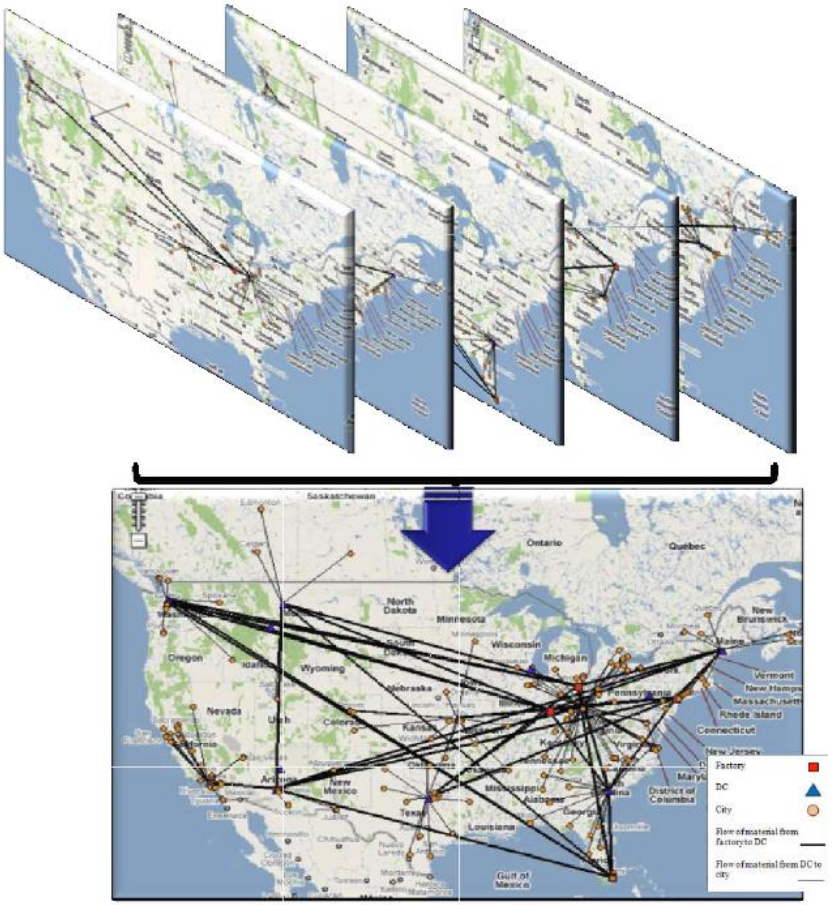
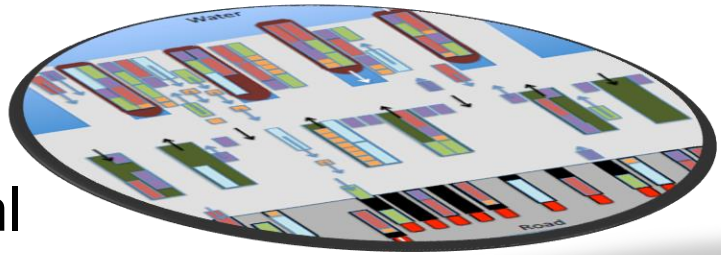


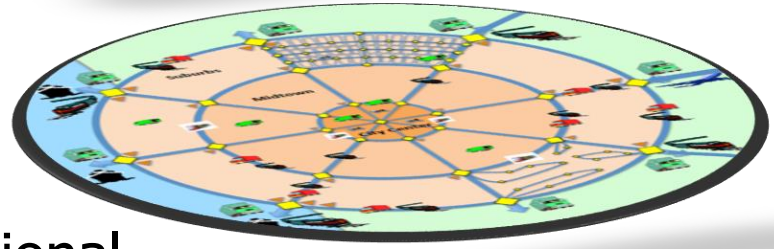

Montreuil and Sohrabi. From Private Supply Networks to Open Supply Webs. IERC 2010

Montreuil and Sohrabi, 2010

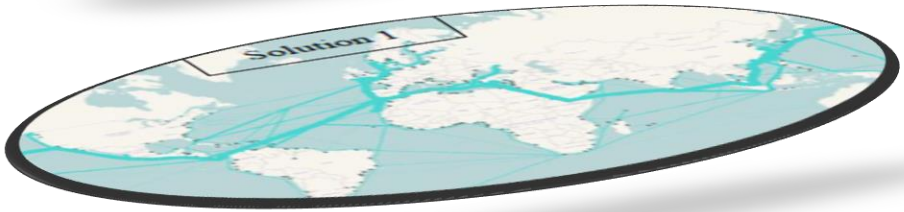
# Impact on ports: scoping




Local




Regional




Global

*focus*

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# How? – Research questions

1. PI essential elements: linkages to ports?
2. Impact of PI on ports: physical, economic?
3. Development paths, co-evolution?
4. What are sustainable port policies?

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# What? – Activities

- Conceptual modelling
- Freight modelling
- Scenario modelling
- Policy design


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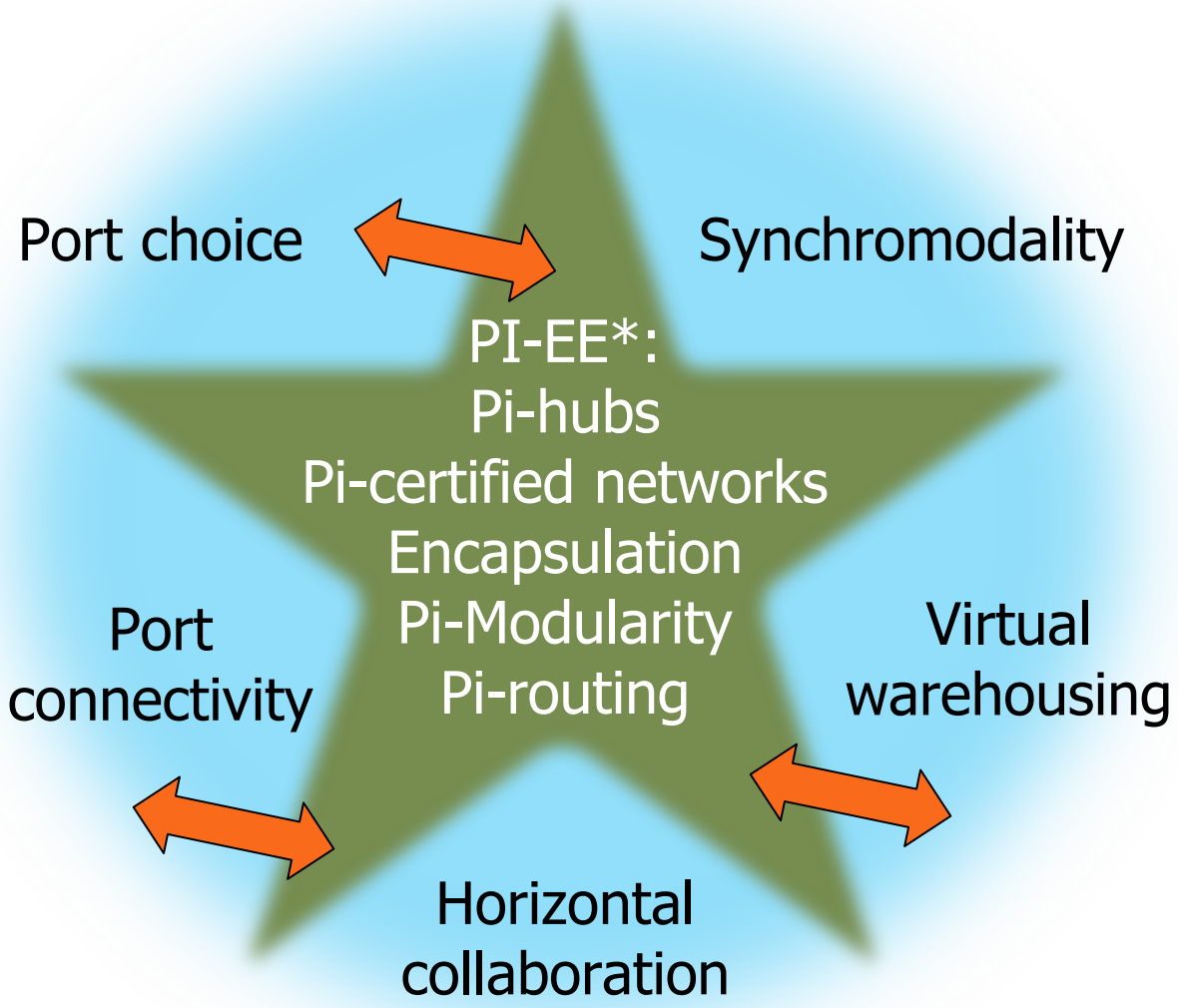
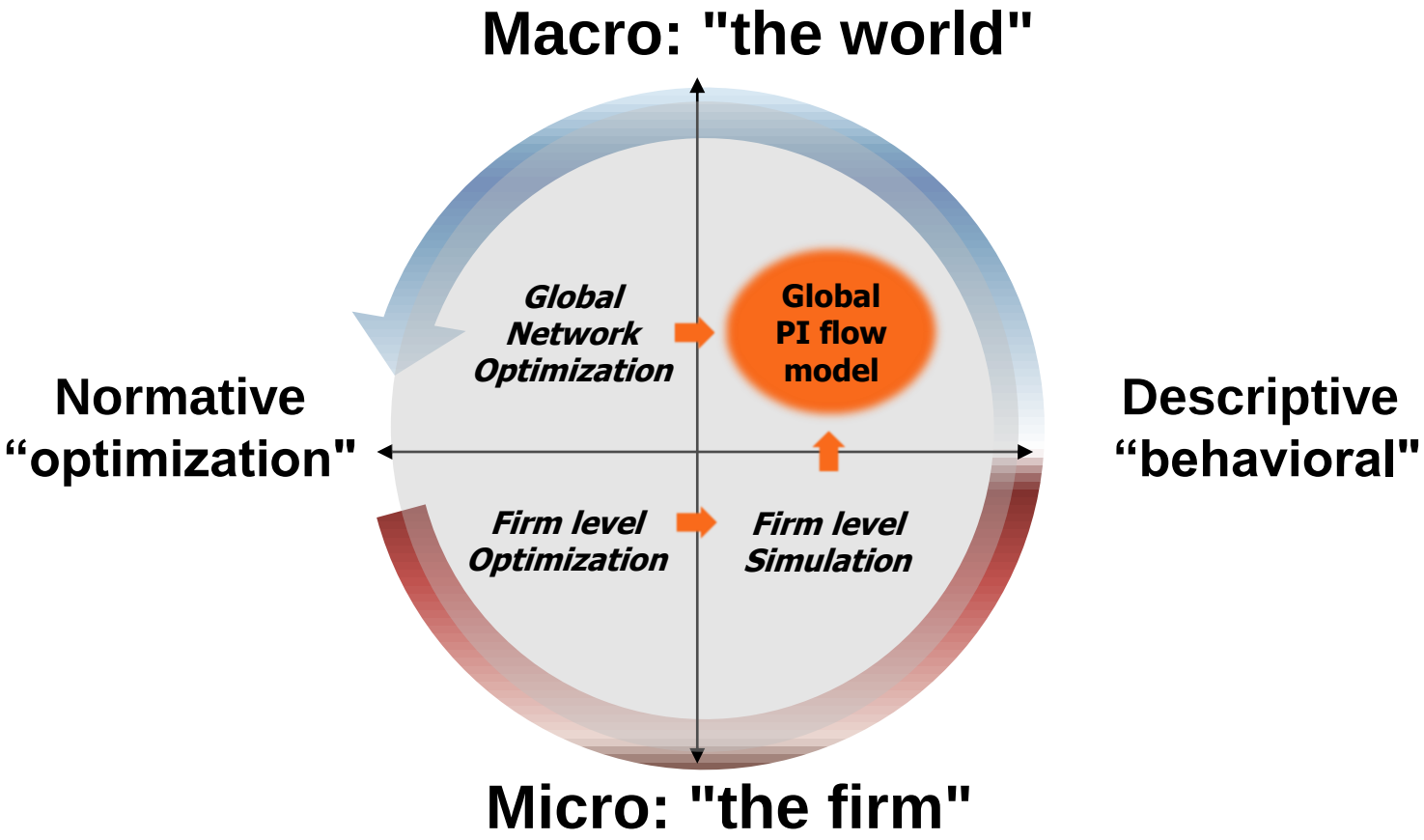
# PI&P Conceptualization




*PI Essential Elements

# Impact-modelling framework

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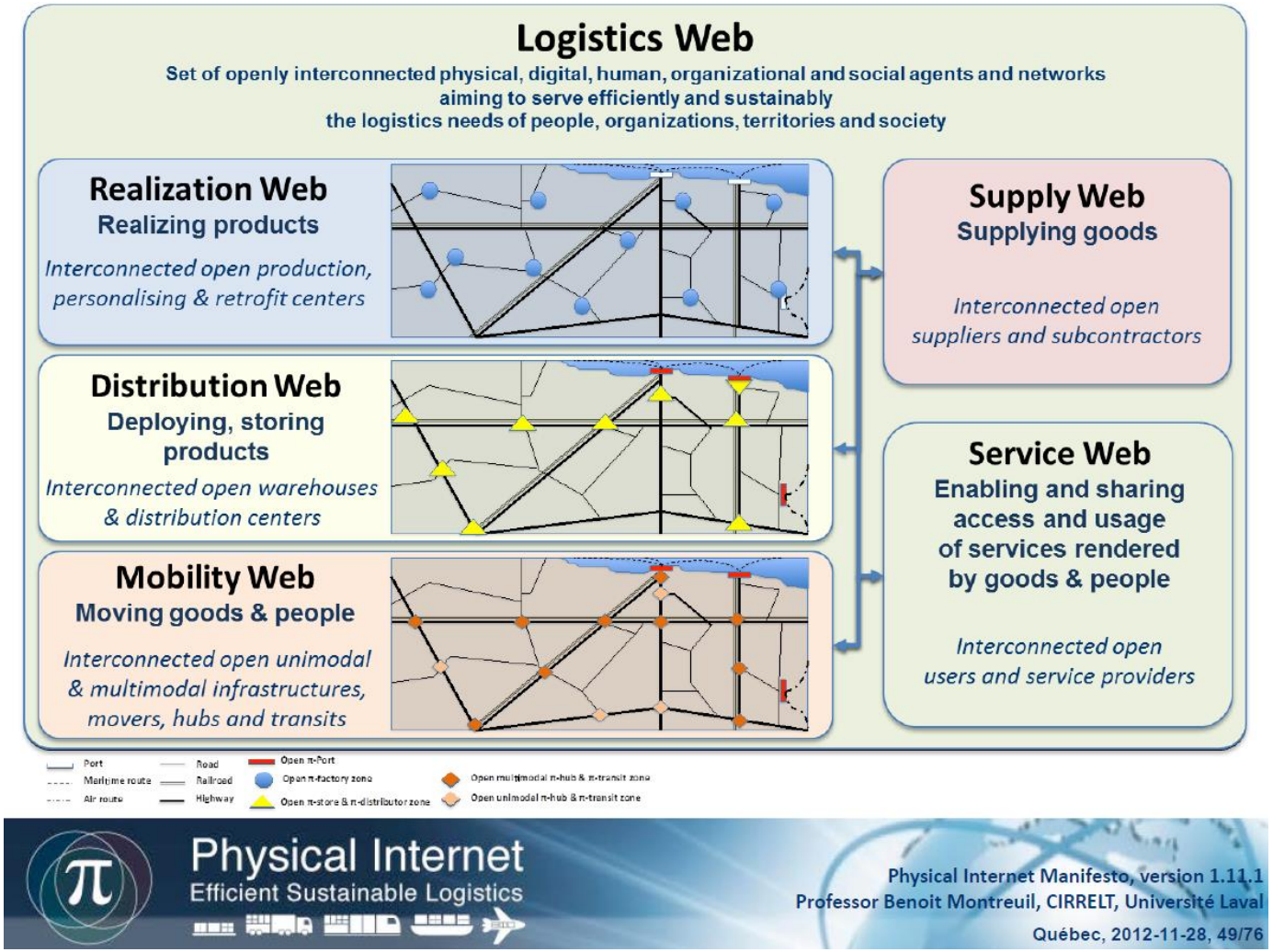
# Ports will function at all levels of PI




Source: Montreuil (2012): Physical Internet Manifesto

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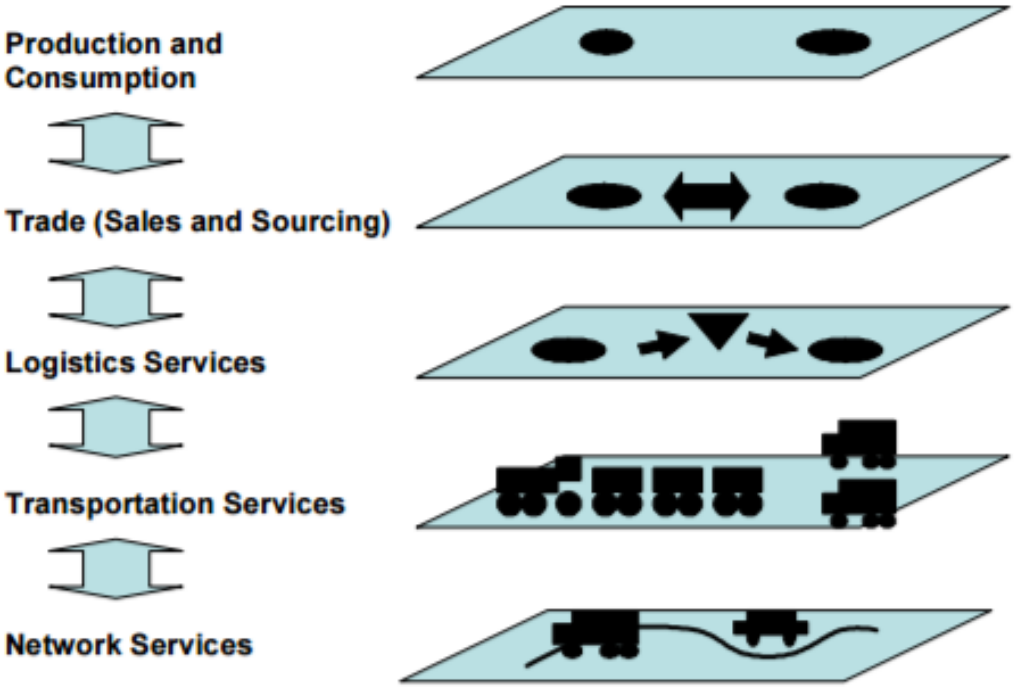
# Freight modelling framework




**Typical decisions and models used**

- **Production and consumption: I/O, multi-sectoral equilibrium**
- **Trade: gravity, spatial equilibrium models**
- **Logistics and transport decisions (shipment size, inventory, mode choice, port choice, routing): random utility discrete choice models based on normative models (facility location, EOQ, VRP etc.)**

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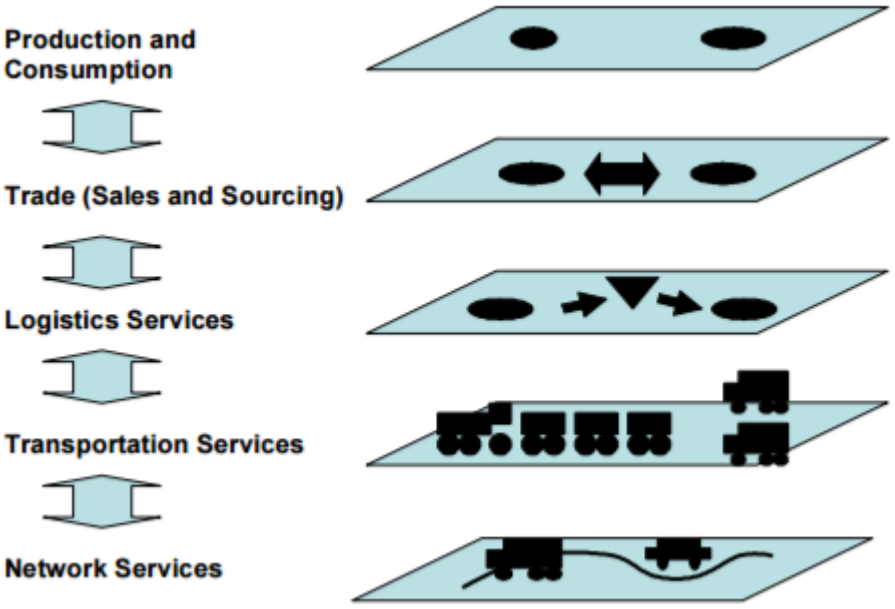
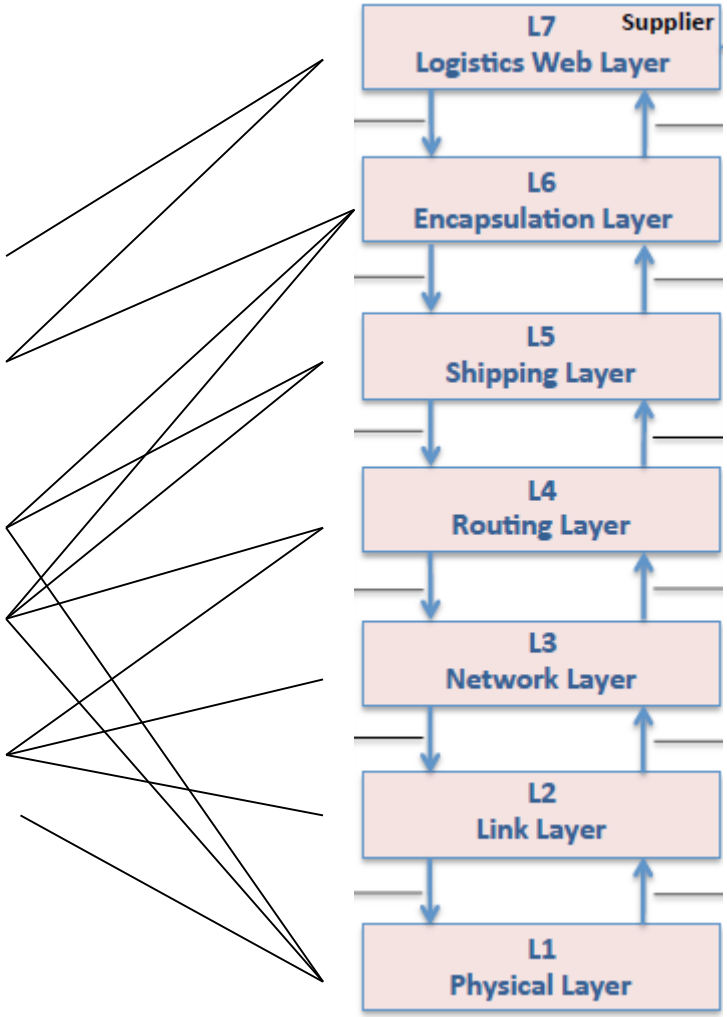
# Parallels with OLI




*Freight modelling conceptual Framework (Tavasszy, 2006)*




*Conceptual OLI model (Montreuil, 2012)*

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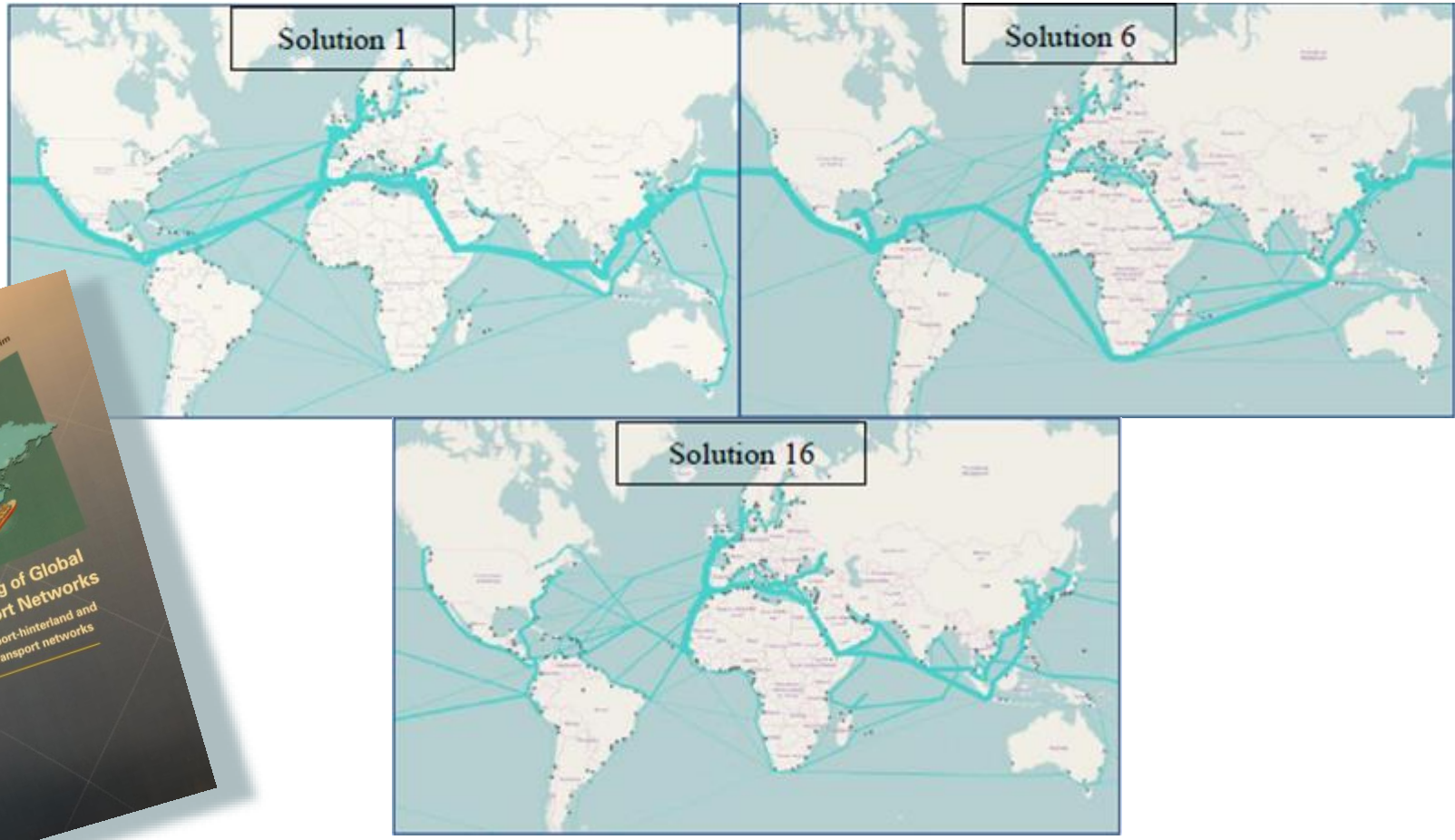
# Global Freight Flow Modelling





*Global freight flows (Halim, 2015)*

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# Co-evolution of PI&P

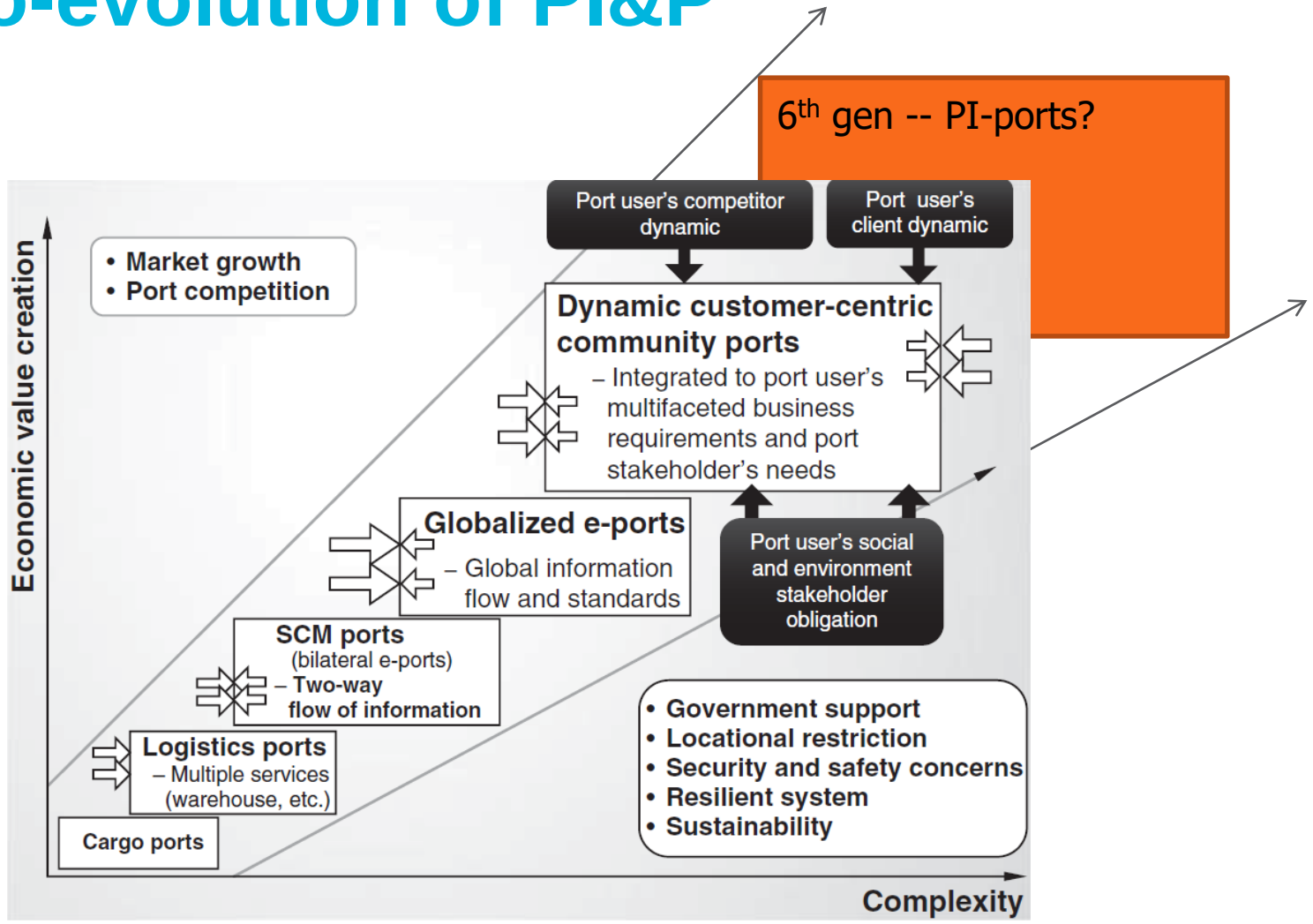


*Figure 8.1* Evolution path to the fifth generation as "Dynamic Customer-Cen
Community Ports"

*Source*: Flynn and Lee (2010); modified by Lee (2014).

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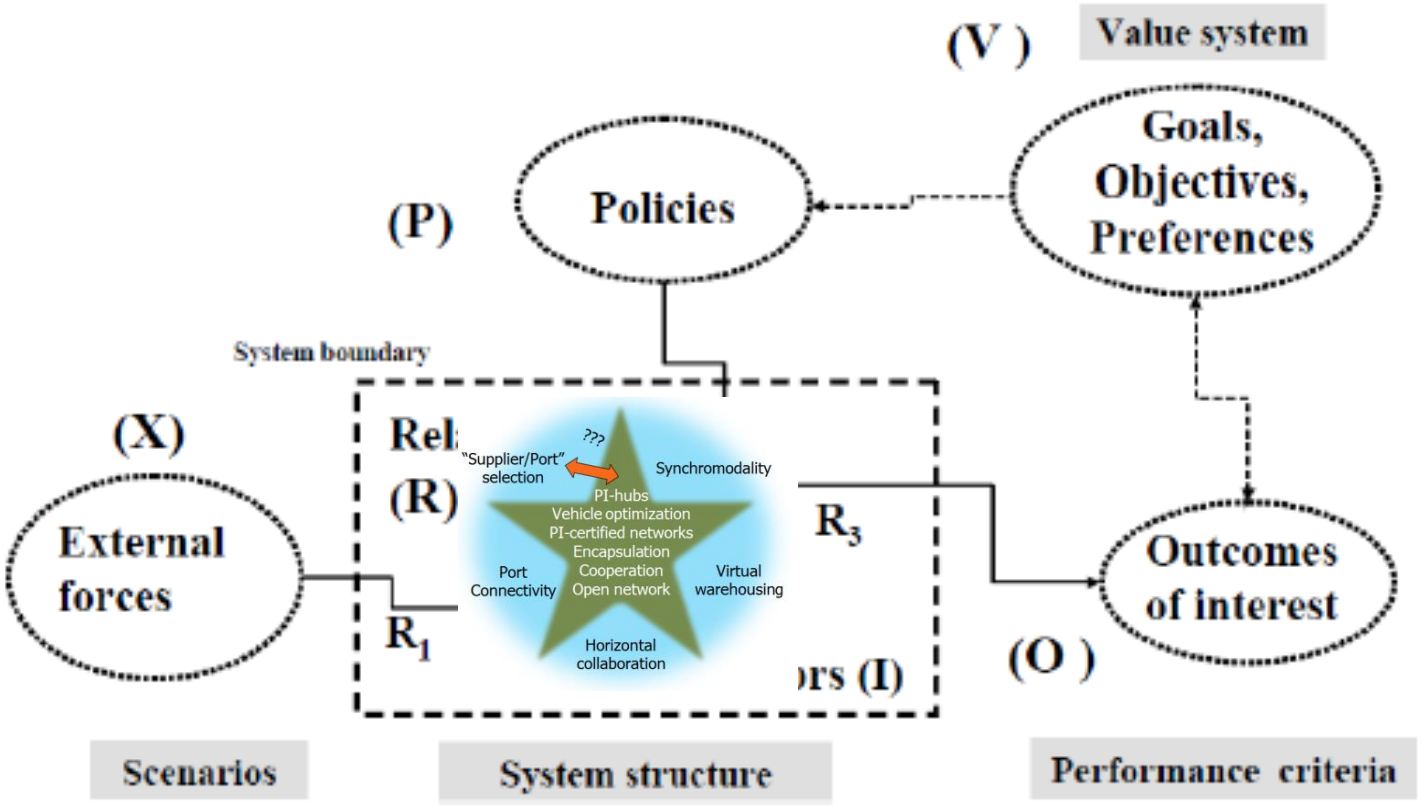
# Policy design




*XPIROV-framework (Agusdinata, 2008)*

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# Summary

- Ports
- Physical Internet Conceptualization
- Impact of PI on Ports
  - PI essential elements: linkages to ports?
  - Impact of PI on ports: physical, economic?
  - Development paths, co-evolution?
  - What are sustainable port policies?
- Activities
  - Conceptual modelling
  - Freight modelling
  - Scenario modelling
  - Policy design

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# A Multi Simulation approach to develop Physical Internet.

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Spain

CENTRO DEMOSTRADOR TIC | LOGÍSTICA

# ITAINNOVA

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ICT4LLOG
Technological and Logistic for Companies.

National knowledge center in the application of ICT technologies to solve logistics problems recognized by Spanish Ministry of Industry

Events - Organization and participation of ICT4LOG, Gartner SC Ex conf, ECITL, SIL

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-Smart warehouse
-Smart transport
-Point of sale

ETP – Alice, Logistop, ALIA

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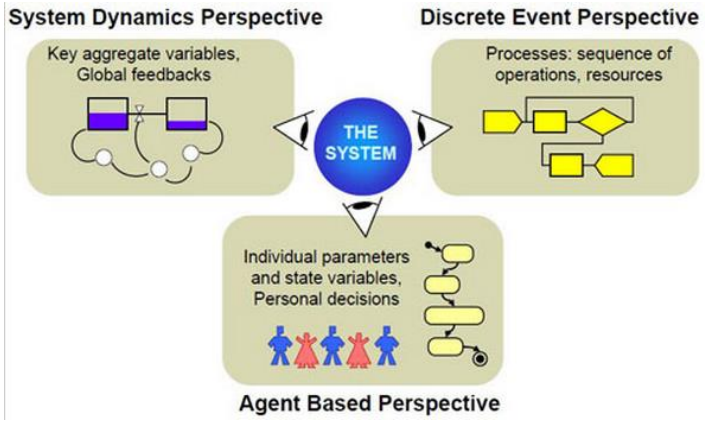
# Introduction

- The Physical Internet (PI) concept has many different connotations at various levels of business
- **Complexity** reduces the sense of control in the logistics operation.
- This paper describes how the use of different types of analytical models and simulation tools could help to **create trust and confidence around the PI concept**.
- The simulations help to :
  - analyse business models
  - evaluate the relationship between the main variables
  - visualize the flows
  - understand the dynamics of the processes and to
  - evaluate numerically the impact

# Introduction

## Simulation techniques

- **System dynamics (SD)** is an approach to understand the nonlinear behaviour of complex systems over time using stocks, flows, internal feedback loops, time functions and time delay.
- **Discrete event simulation (DES)** works by modelling system state changes occurring at specific points in time, which are probabilistically determined by historical data.
- **Multi-agent simulation (MAS)** or Multi-agent-based modeling (MABS) is a branch of computer simulation where multiple intelligent agents, capable of independent action and interact within environments that are typically dynamic and unpredictable.



# Framework description

Two levels to deal with the high complexity:

Strategic level
- Global scope
- Reduced detail

Operational level
- Specific scope
- High detail

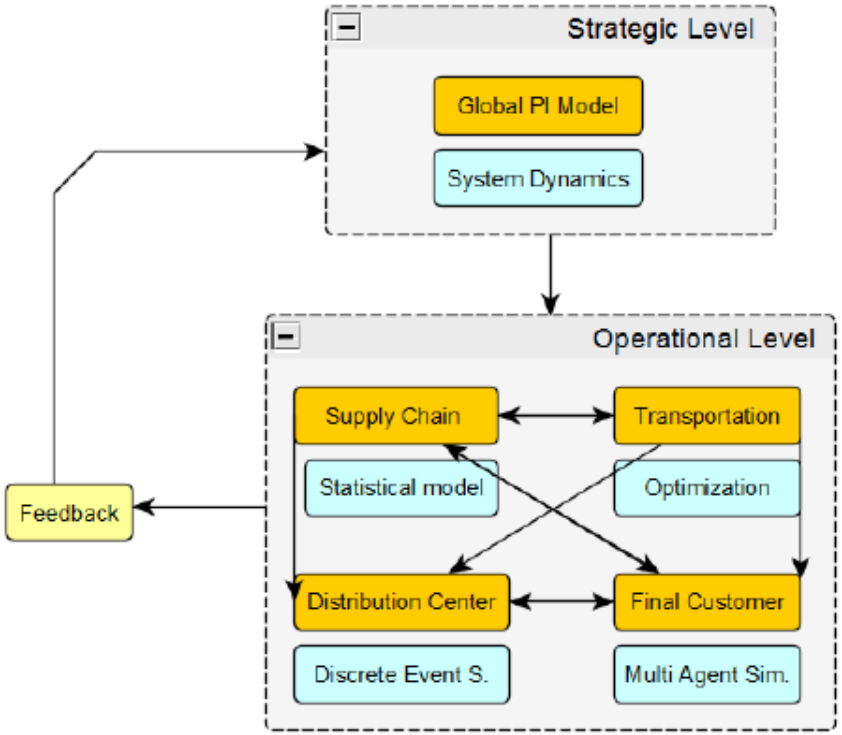
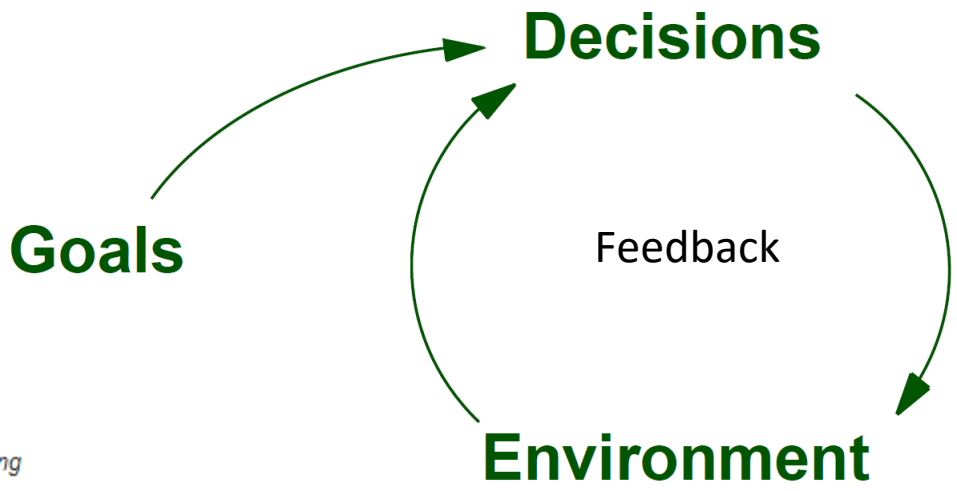



*Figure 1: Multi-Model Physical Internet Framework*

# Global System Dynamics

- The **System Dynamics (SD)** method has proved to be particularly good at supporting a strategic point of view, in the sense of matching very closely the concerns of top-level decision-makers.
- Feedback mechanism

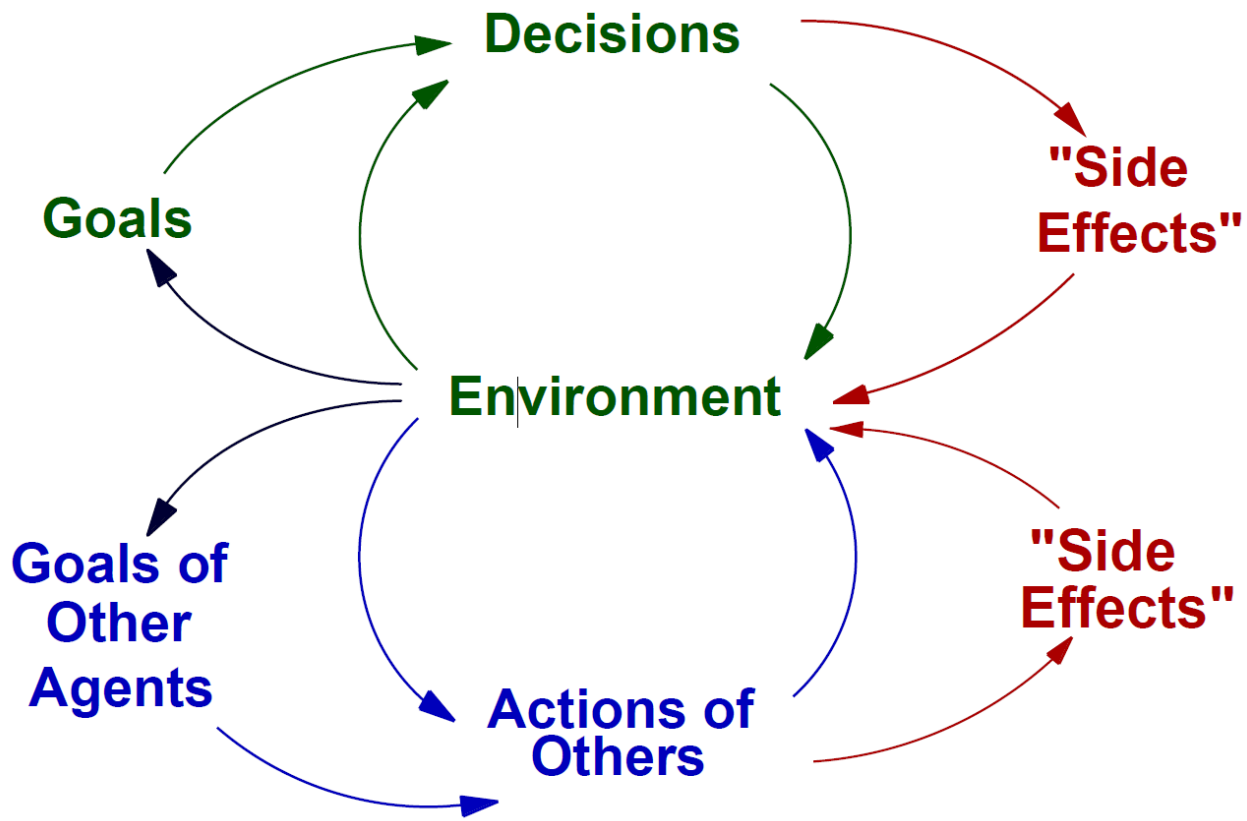

Open Loop Thinking




Sterman, J. D. J. D. (2000). *Business dynamics: systems thinking and modeling for a complex world* (No. HD30. 2 S7835 2000).

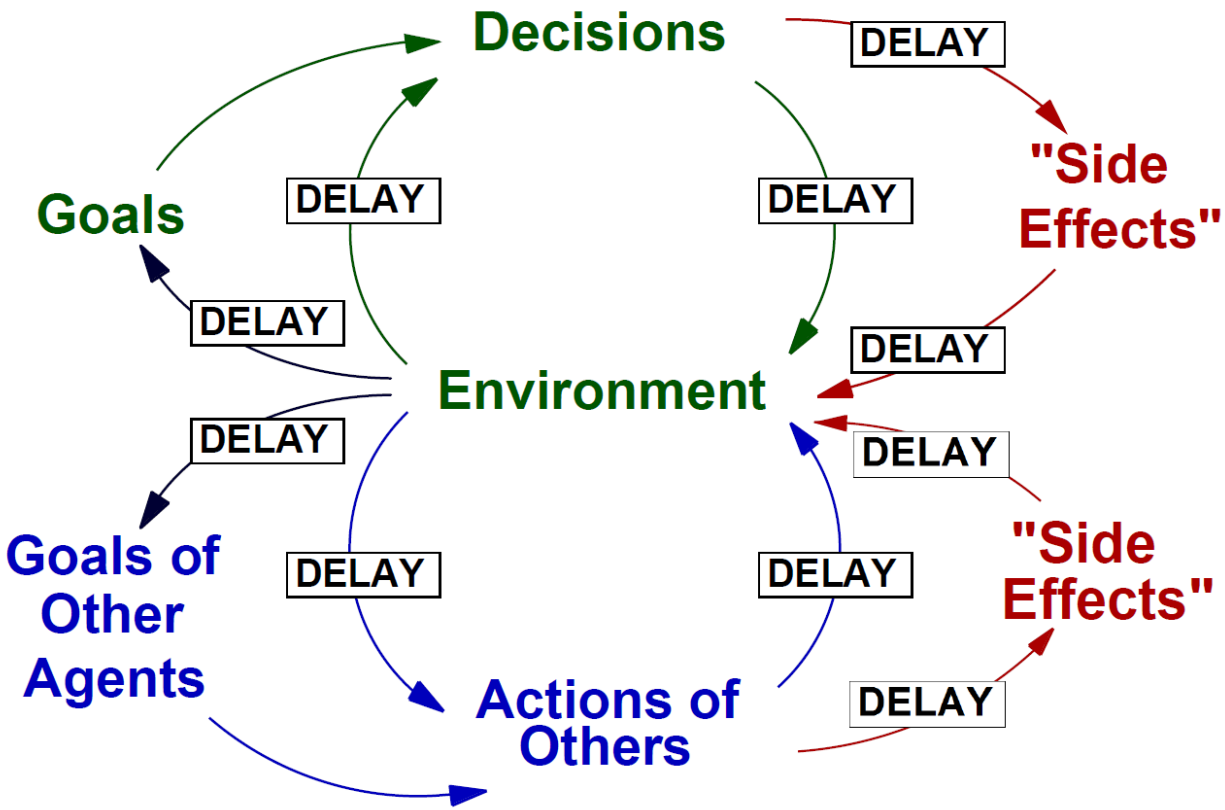
# Global System Dynamics

- Larger System, complex effects



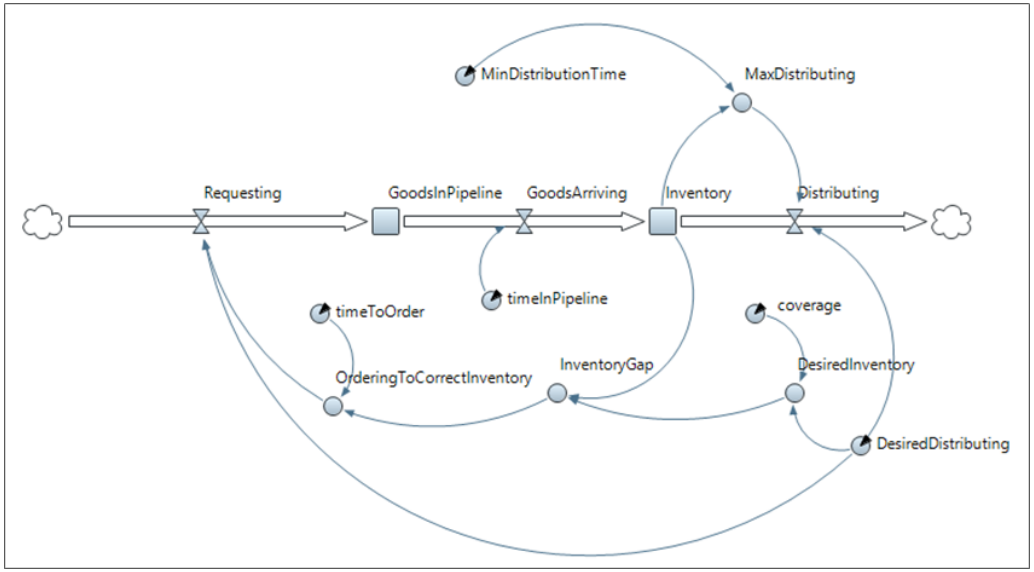
# Global System Dynamics

- Critical point, Delays : Separate causes and consequences



# Global System Dynamics

- Dynamic systems can represent complex models
- Accurate parameters to represent the relationship between flows properties.
- Examples of parameters: Impact of price variations in the number of customers, influence of advertising, forecast accuracy…
- Impact in Flow Dynamics:
  - Increment, Decrement, Oscillation...




System Dynamics : Stock and flow diagram

# Framework description

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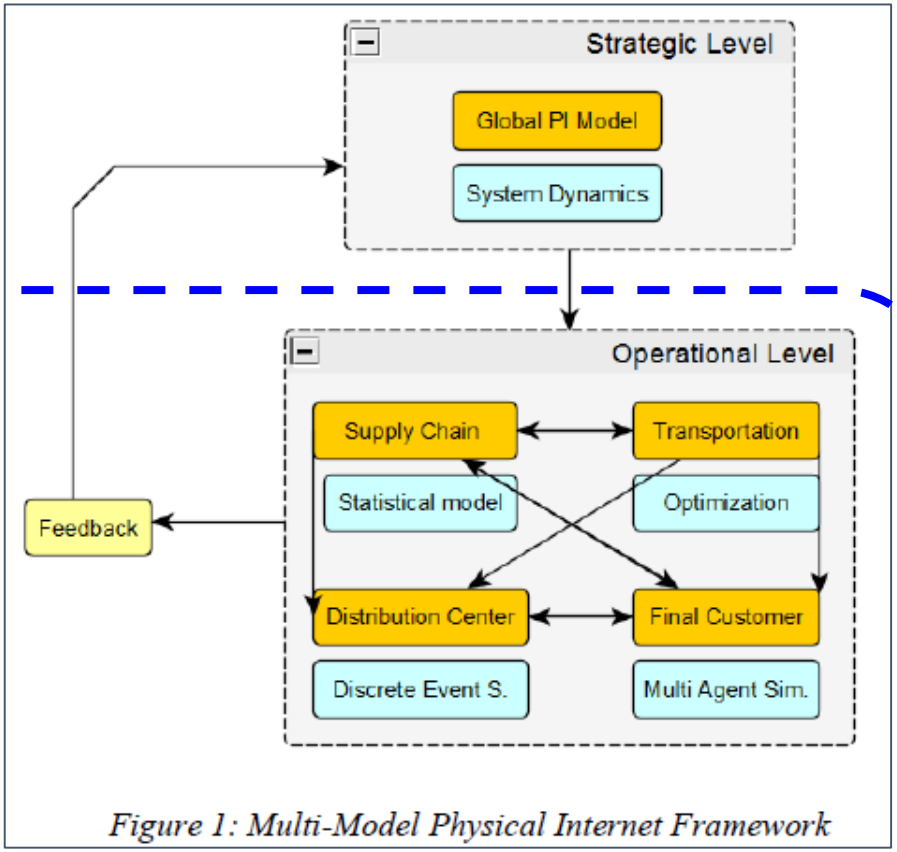



*Figure 1: Multi-Model Physical Internet Framework*

# Supply Chain

**Simulation and statistical models** are often used to get a better distribution network design with parameters like lead time, lot sizing, forecast accuracy...

With a simulation model we compare the performance of MTO, MTS and VMI strategies in the two-echelon serial supply chain with finite production capacity.

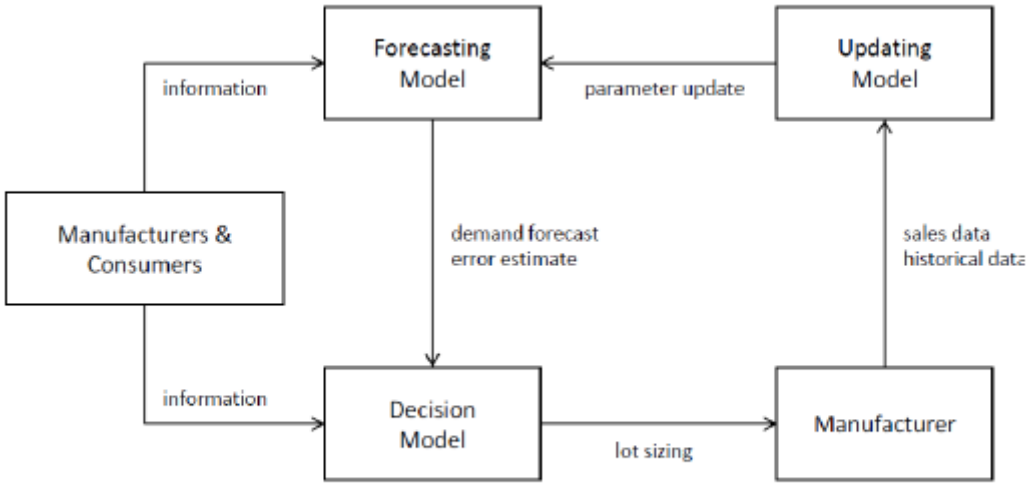



*Figure 3: Information flow in a supply chain model*

# Transport

- Optimal transport plan is a key point in the Physical Internet framework
- Example: Freight transport network similar to the carriage of passengers (one order is like one passenger).
- Between two nodes, there is a set of connections, each one with a mode of transport (bus, train, car), and certain capacity (volume, number of seats, etc) and a set of frequencies.

- PI network should not only be fed by the network layout but also for other transport status.
- Optimization problem integrated with a simulation model to evaluate alternatives.

- Result: Best route for each order

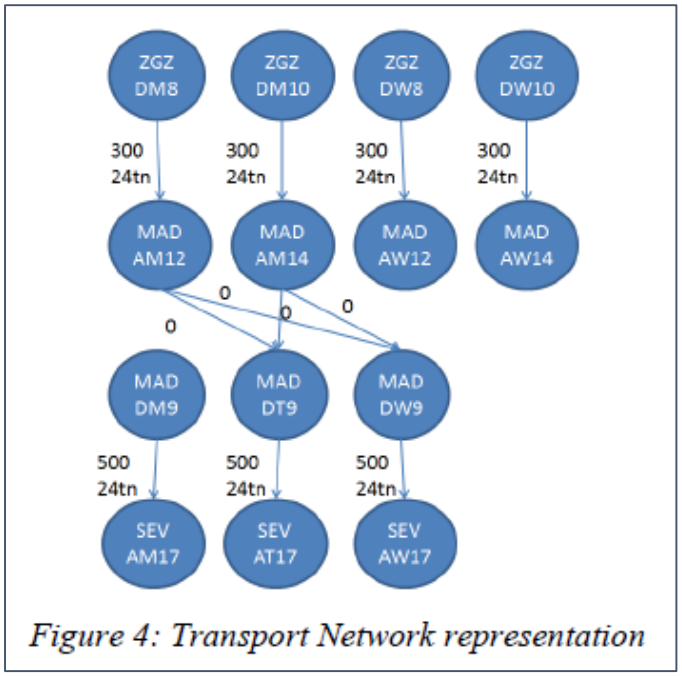
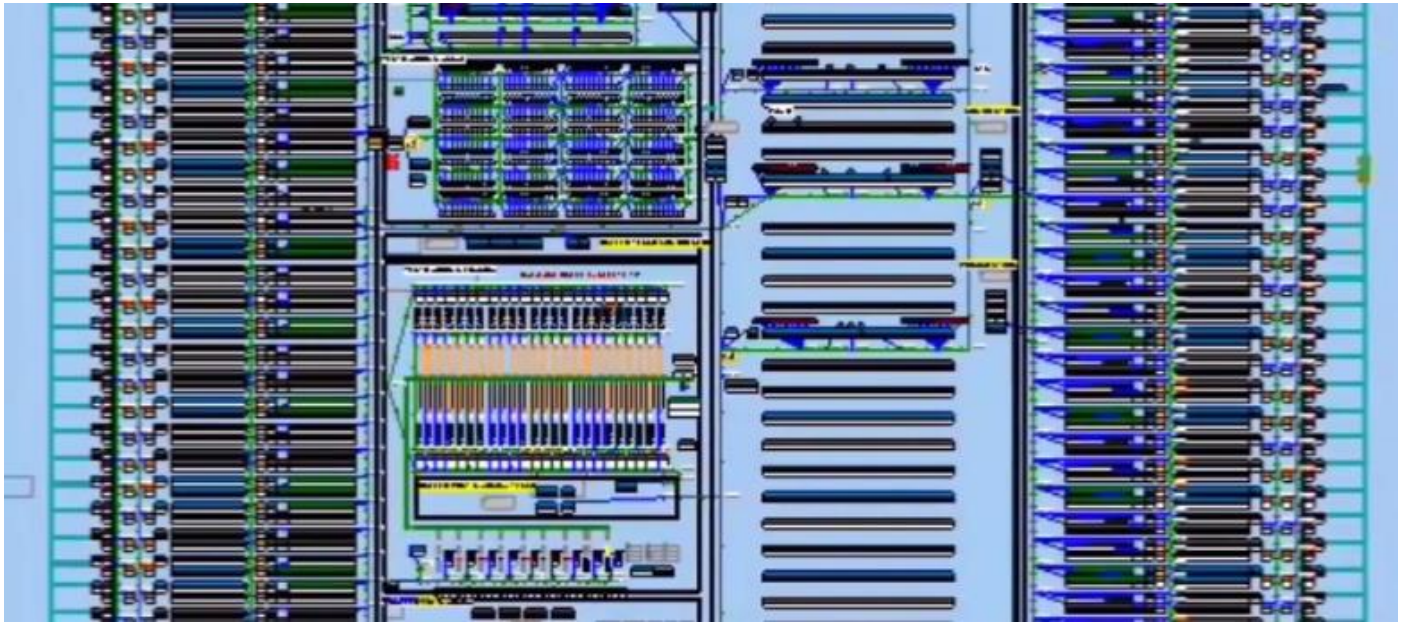


*Figure 4: Transport Network representation*

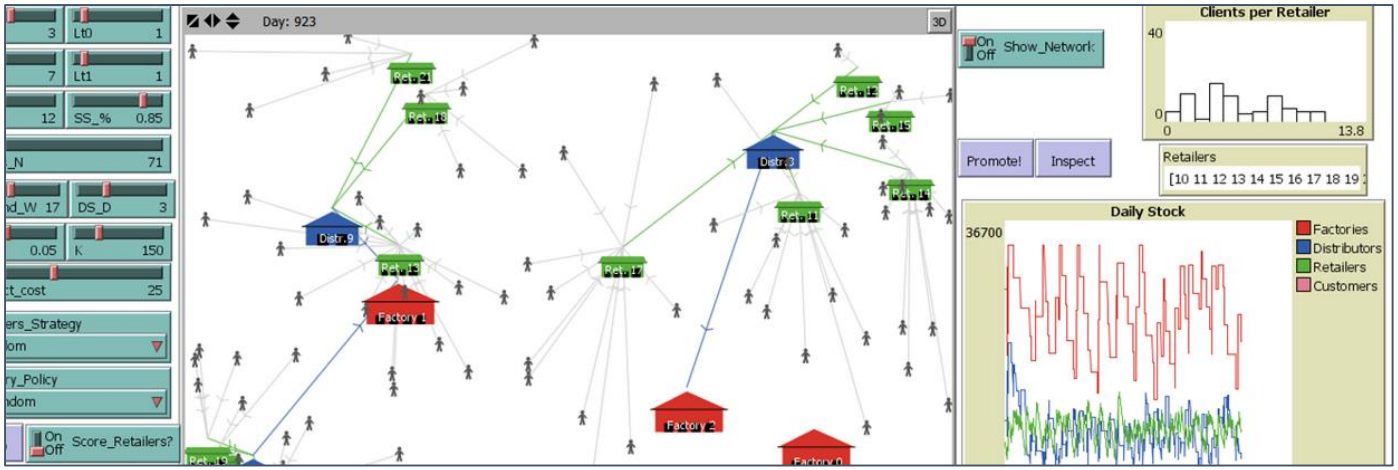
# Distribution Center

- Distribution centers (hubs) are the “heart” of Physical Internet flows. They pump the goods.
- New operations appear with PI flows: Cross Docking, PI-Containers, multi-client picking strategies…
- Discrete Event Simulation for new processes
- Design of Experiments to measure the influence of main variables



# Customer behavior

- The behaviour of humans differs notably among people and therefore the heterogeneous and diverse nature of the actors needs to be taken into account during the service design and the processes to provide de services.
- Multiagent simulation systems play a key role to evaluate new behaviors
- Example: Ecommerce represent a revolution in terms of
  - Range of products
  - Time order fulfillment
  - Delivery points
  - Time windows restrictions
  - Returns processing



# Conclusions

- This paper describes a **framework** to evaluate different aspects of the Physical Internet framework to build trust among stakeholders
- The **strategic** level, deals with socio-economics aspects from the PI initiative.
- The **operational** level evaluates the process with a higher level detail.
- The combination of all this powerful **simulation** tools gives a complete vision from the **complexity** of PI flows.
- As final remark is important to mention the **importance** of involving different **people**, which are related to the decisions about Physical Internet flow: validate models, create confidence, integration risk evaluation.

# Thank you!


**A Multi Simulation approach to develop Physical Internet.**

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