Simulating Physical Internet Enabled Distribution Webs

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Plan

• Introducing the Physical Internet concept
• Research objective
• Describing the existing simulator supporting the mobility webs
• Upgrading the simulation model to support distribution webs
• Conclusion
The Physical Internet Initiative

Using the Digital Internet as a Metaphor for the Physical World

The Physical Internet (PI, π) initiative aims to exploit the Internet metaphor so as to propose a vision for a sustainable and progressively deployable breakthrough solution to global problems associated with the way we move, handle, store, realize, supply and use physical objects all around the world.

Enabling a Logistics Web

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

Supporting $\pi$-Containers

**$\pi$-movers**
A fork-less lift exploiting the snapping and interlocking functionalities of the $\pi$-container

**$\pi$-conveyors**
A highly flexible plug-and-play $\pi$-conveyor exploiting the standard modular dimensions and interfaces of the $\pi$-containers

**$\pi$-stores**
In $\pi$-stores, modular $\pi$-containers can be stacked as in container port terminals.

In $\pi$-stores, contemporary racking can be used, however innovations in storage technologies exploiting the functional characteristics of modular $\pi$-containers are bound to be exploited.

A $\pi$-container equipped with wheels snapped through its standard modular interfaces

Modular and standardized worldwide in terms of dimensions, functions and fixtures

Research Objective

• General objective
  – Provide holistic simulation to study the economic, environmental, and social implications for evolving toward a \( \pi \)-enabled Logistics Web in France
    • Mobility Web simulations are already supported

• Objective of the current step
  – Integrate the simulation of Distribution Webs
    • A multi-agent conceptual model
Simulating Mobility Webs

Existing Transportation System

- origin 1
- origin 2
- origin 3
- origin 4

- dest 1
- dest 2
- dest 3
- dest 4

Open Mobility System

- origin 1
- origin 2
- origin 3
- origin 4

- rail-road π-router
- road π-router

-One company full truck load or less Shipments
-Multi-company train Shipments
-Multi-company full truck load or less Shipments
-Inventories

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The Existing Mobility Web Simulator

The flow of goods in the existing mobility web

- Preliminary results:
  - Truck Fill rate: +15%; CO2 Emission: -12%--55% (modal shift to electric train); Logistics cost: -4%--30%
  - Integrating distribution web is expected to result in even greater results

A screenshot of the main simulation view
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 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.

Reference: Montreuil and Sohrabi, From Private Supply Networks to Open Supply Webs, IERC 2010
Illustrating a Distribution Web
Dynamically Deploying Stock Across the Distribution Web
for Efficient, Fast & Agile Customer Response

Existing Distribution System

Manufacturer A
PA1
DA
D1
S1a
Retailer 1

Manufacturer B
PA2
PL
D2a
Retailer 2
D2b
S2a
S2b
S2c

Open Distribution System
Exploiting a Distribution Web

Manufacturer A
PA1
PA1

Manufacturer B
PL

Retailer 2

S1a
S1b
S2a
S2b
S2c

S1a
S1b
S2a
S2b
S2c

O1
O2
O3
O4
O5
O6

client order
physical flow
P#: plant; D#: distribution center; S#: store; O#: open facility
The Simulation Solution Architecture

Real Logistics Web

Aggregated events

Data Adapter

Logistics Web Decision Support Tools

Simulation Analysis Tools (KPIs)

Structural data

Scenario Generator

Environmental & Functional Module

Logistics Web Infrastructure Generator

Logistics Web Simulation Solution

Daily events

Logistics Web Simulation Database

Environmental & Functional Data

Structural Data

Events

Virtual Logistics Web

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Integrating the Distribution Web Capability into the Simulation Model

Supply Chain Manager 0..* Production Agent 1..* Distribution Agent 0..*

Transport Agent 0..* Site 1..* Inventory 1..* MBOL 1..*

Company

Distibutor

Manufacturer

Routing Company

Distributing Company

Rail-Route PI-Hub

Route PI-Hub

Transporter

Transit Company

Retailer

Department

Store

Distribution Center

Warehouse

Plant

Transport Segment 1..*

Travel Segment 1..*

Travel 1..*

Transport Mean 1..*

MBOL 1..*

Shipment 1..*

Order 0..1

Order line 1..*

Product 0..*

Product Category 0..*

Pallet 0..*

PI-Container 0..1

Truck 1..*

Train 1..*

PI-Container 0..1

Distributor

Retailer

Transporter

Transit Company

Product

Order

Order line

Product Category

Shipment

Travel

Travel Segment

Transport Mean

Abstract Class

Logistics Web class

Product management and transportation class

Agent class

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The Agents’ Interactions

Sale
Orders

Supply Chain Manager
Feedback
Query
Notifications

Distribution Agent
Feedback
Query

Routing Agent
Feedback
Query

Transport Agent

Place Orders, and Plan and manage shipments
Supply Web Functions

Find a \( \pi \)-node where to store, deploy, or ship a \( \pi \)-container
Distribution Web Functions

Find the entire path for a \( \pi \)-container’s travel from an origin to a final destination
Mobility Web Functions

Transport a \( \pi \)-container on a certain segment of the travel

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Supply Chain Managers

**Existing Logistics System**
- Placing orders to suppliers
- Managing the inventory of their sites
- Handling customer orders

**Logistics Web System**

**As customer**
- Placing orders to plants
- Managing the inventory of their sites

**As suppliers**
- Designing the distribution network for their products
- Managing the inventories in each open zone of the distribution network
- Placing orders to control the inventories in each open zone
- Monitoring the order handling

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Introducing Physical Internet

Research Objective

Simulating Mobility Webs

Integrating Distribution Webs

Conclusion

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Distribution Agents

Existing Logistics System

- Not applicable

Logistics Web System

- Put orders in \( \pi \)-containers
- Determine the origins of shipments
- Determine the exact destination site for each \( \pi \)-container if it’s not already defined by the supply chain manager
- Manage the excess of storage space in sites belonging to their company.

Notifications

Query

Feedback

Distribution Agent

Supply Chain Manager

Routing Agent

Transport Agent

Plant

Client site

Open facility zone

Product flow

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Routing Agents

Existing Logistics System
- Not applicable

Logistics Web System
- Determining the path segments, the π-hubs, and, depending on the scenario, the transport means, of the containers travels
  - Estimations requested by distribution agents
  - Static vs. dynamic routing
- Making reservations
Transportation Agents

Existing Logistics System

- Associating master bills of lading with transport means
- Loading transportation means and authorizing their departures
- Monitoring travels
- Delivering and unloading products at destinations

Logistics Web System

- Associating π-containers with transportation means
- Managing transportation means’ schedules
  - Maximizing loads
- Loading and authorizing departures
- Monitoring travels
- Delivering and unloading products at destinations
Conclusion

• **Holistic** simulation of Logistics Web
  – **Mobility** Webs (advanced versions)
  – **Supply** Webs (partially)
  – **Distribution** Webs (conceptual model)
  – **Realization** Webs (not yet)

• Study and quantify the impact in terms of **economical**, **environmental**, and **social** efficiency and performance of evolving from the current system of freight transportation **toward open logistics webs**
  – The simulation of mobility webs promises important gains
  – That of distribution webs will lead to **much higher level improvements**
Thank you for your attention!

Welcome to your questions and comments.

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www.PhysicalInternetInitiative.org