PHYSICAL INTERNET ENABLED
HYPERCONNECTED CITY LOGISTICS

PROF. BENOIT MONTREUIL

P H Y S I C A L I N T E R N E T C E N T E R
G E O R G I A I N S T I T U T E O F T E C H N O L O G Y
Building a Physical Internet dealing with physical objects
Learning from the Digital Internet dealing with informational objects

Serving humanity’s demand for physical object services

The information highway gets physical
The Physical Internet would move goods the way its namesake moves data

Science Magazine
June 6, 2014

Rethinking the Global Supply Chain

Worldwide Next-Generation Logistics System: The Physical Internet

Hyperconnected global logistics system aiming to serve efficiently and sustainably humanity’s demand for physical object services by enabling seamless open resource sharing and flow consolidation through standardized encapsulation, modularization, protocols and interfaces.

Hyperconnected: Components and actors intensely interconnected on multiple layers, ultimately anytime, anywhere.

Interconnectivity layers: digital, physical, operational, business, legal and personal.
**Physical Internet Building Blocks**

**Transport Containers (π-Pods)**
- Modular fit in π-certified vehicles
- 12; 6; 4,8; 3,6; 2,4; 1,2 meters

**Handling Containers (π-Boxes)**
- Modular fit in π-Pods
- 1,2; 0,8; 0,6; 0,4; 0,3; 0,2; 0,1 – ε meters

**Packaging Containers (π-Packs)**
- Modular fit in π-Boxes
- 1,2; 0,8; 0,6; 0,4; 0,3; 0,2; 0,1 – ε - δ meters

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**Easy to Handle, Store & Transport**
- Robust & reliable
- Snap and interlock
- Load and unload
- Seal and unseal
- Compose & decompose
- Conditioning capable
- Cleanable
- Panel (pub + info)

**Smart & Connected**
- Uniquely identifiable
- Communications capable
- State memory
- Reasoning capabilities

**Eco-friendly**
- Light & thin
- Reusable and/or recyclable
- Minimal off-service footprint
- Distinct structural grades

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**Unified Set of Standard Modular Logistics Containers**

Unified Set of Standard Modular Logistics Containers

Certified Open Logistics Facilities and Ways

Containerized Logistics Equipment and Technology

Physical Internet Building Blocks
Enabling Seamless, Trustworthy, Ubiquitous Monitoring, Traceability and Transactions

Simple Links
- Open Logistics Decisional & Transactional Platforms
- Certified Open Logistics Facilities and Ways

Internet-of-Things
- Standard Logistics Protocols
- Containerized Logistics Equipment and Technology

BlockChain
- Unified Set of Standard Modular Logistics Containers

We here adapt to hyperconnected parcel logistics the Simple Links concept recently introduced by the Consumer Goods Forum to illustrate the basic concepts of Simple Links: www.theconsumergoodsforum.com
Physical Internet Building Blocks

- Smart Data-Driven Analytics, Optimization & Simulation
- Open Logistics Decisional & Transactional Platforms
- Global Logistics Monitoring System
- Certified Open Logistics Facilities and Ways
- Standard Logistics Protocols
- Containerized Logistics Equipment and Technology
- Unified Set of Standard Modular Logistics Containers
Physical Internet Building Blocks

- Certified Open Logistics Service Providers
- Smart Data-Driven Analytics, Optimization & Simulation
- Open Logistics Decisional & Transactional Platforms
- Global Logistics Monitoring System
- Certified Open Logistics Facilities and Ways
- Standard Logistics Protocols
- Containerized Logistics Equipment and Technology
- Unified Set of Standard Modular Logistics Containers

Enabling Efficient, Sustainable, Smart, Agile, Adaptable, Scalable, Resilient, Hyperconnected Supply Chains

Logistics Infrastructure: Shared assets enabling logistics to support supply chains
Hyperconnected Transportation: A Simple Case

Current Conceptual Networks

Dedicated Transportation

Hyperconnected Transportation

Adapted from: Hakimi D., B. Montreuil & E. Ballot (2012), Simulating a Physical Internet Enabled Logistics Web: the Case of Mass Distribution in France, ISIC 2012, 2012/5/19-23
Hyperconnected Distribution: A Simple Case

Transposing Cloud Storage & Computing Concepts, Practices & Business Models from IT to Logistics and Supply Chains

Dedicated distribution

Hyperconnected distribution

- 4.2%; - 4.4%

- 19%; - 27%

- 29%; - 23%

+16%; +15%

[Average; Max]

Delivery-Time-to-Store

- 82%; - 74%

- 79%; - 71%

Adapted from: Hakimi D., B. Montreuil & E. Ballot (2012), Simulating a Physical Internet Enabled Logistics Web: the Case of Mass Distribution in France, ISPEC 2012, 2012/5/19-21

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Hyperconnected Transportation: Large Scale Experiment in France
Simulation Experiment with Top Retailers Carrefour & Casino and their top 100 suppliers

Modular Container; Open Crossdocking Hubs; Multimodal, Multi-Party, Inter-Hub Routing

Current flows
Hyperconnected flows
Current: Trucks
Hyperconnected: Trucks & Rail

Economical: Up to 32% overall cost saving
Environmental: About 60% reduction of greenhouse gas emissions
Truckers return home every day: Helping reduce trucker turnover and shortage

Project lead by E. Ballot, B. Montreuil & R. Glardon: PREDIT Best International Project
Hyperconnected Distribution & Fulfillment: Current Large-Scale Models

Dynamically deploying products for rapid on-demand fulfillment
Exploiting Physical Internet principles, Beyond client dedicated facilities and services

The ES3 Model
Openly shared automated DC
Multi-manufacturer: full load inbound
Multi-retailer full load outbound
Enables Direct-to-store
Medium-to-Long Term Commitment

The ES3 Model
On-Demand Warehousing
Asset-free platform
Multi-warehouse, Multi-User
AirBnB-like shared economy model
Pay-per-Use

The Fulfillment-By-Amazon Model
First Open Large-Scale Asset-Based Storage and Fulfillment Service Provider
Asset-Intensive: US fulfillment center network
Open to any vendor, selling or not on Amazon
Inspired by Amazon’s huge success in cloud storage

Adapted from Brenda Montreuil, ES3 case study book: Customer Final Supply Network

FLEXE connects you to warehouse capacity when, where, and how you need it.

Warehouse space fragmentation drivers
Demographic Product promotions
Bulk buying
Lead time variability
Towards Smart Hyperconnected Omnichannel Logistics and Supply

Hundred of thousands of suppliers, distributors & (e-)retailers

Millions of facilities and vehicles, billions of customers

Blurred Facility Roles

A Web of Hyperconnected Facilities, Modes and Actors

Expected Delivery or Pickup with Minutes, Hours, maybe a few Days

With Minimal Stock Smartly Flowed and Deployed Between Suppliers and Customers


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City Logistics: Its Main Goals

To reduce the negative impact of freight-vehicle movements on city-living conditions, particularly in terms of congestion/mobility and environmental impact, while not penalizing its social and economic activities and fostering an efficient and sustainable transportation system (e.g., Taniguchi et al. 2003, 2013)

• To reduce and control the urban presence and motorization of freight vehicles
• To improve the efficiency of freight movements & their environmental footprint
• To reduce the number of empty vehicles getting in, through and out of the city (e.g. Benjelloun et al., 2010, Dablanc, 2007)
City Logistics Concepts

Access and Parking Regulations

Zoning Access Regulations

Access Forbidden to Heavy Trucks
Highly Restrictive Access & Parking
Regulated parking

City Distribution Center

Last-Mile Delivery Service Providers

Mostly smaller, green, active or electrical vehicles

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Interconnect Cities as Nodes of the World’s Logistics Web

• Do not focus only on the city by itself
• Inter-City Flows: inbound and outbound
Each city thinks it is unique and requires custom logistics solutions, yet the last thing large retailers, e-tailers, manufacturers and the likes want is for each city to have distinct interfaces and protocols.
Exploiting smartphone-based apps; Pickup packs at hub near departure
Deliver them at hub near arrival, making money; Others carry them in relay mode to destination
Exploiting most zone-appropriate \( \pi \)-container transport, handling & storage modes, vehicles, means & facilities

Building on synergies between freight logistics and people mobility

Aiming for gains in economic, environmental and societal efficiency, sustainability and service capability

Exploiting existing infrastructures (subway, tramway) and gradually developing innovative interconnected infrastructures

Numerous Stakeholders: At the Core, Citizens (Quality of Life, Jobs, ...), Businesses (Ease to Do Business, ...), Logistics Hubs (Near & Far, Ease to Connect)
Hyperconnected City Logistics: Multi-Plane Urban Logistics Web
Interconnected Meshed Hub Networks for Fast, Precise, Efficient, Reliable Delivery

The meshed networks of adjacent planes are connected by inter-hub links.
Innovation Driven Journey
Grasp Vision, Aim for Early Quick Wins, Act along Roadmap, Adapt to Evolving Landscape

Adapted from www.etp-logistics.eu
Thanks!

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