The Physical Internet
Towards Hyperconnected Automotive Supply Chain Logistics

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While the Digital Internet deals with bytes, 
The Physical Internet deals with physical objects
Grand Challenge Tackled Through the Physical Internet

To improve by an order of magnitude the economical, environmental and societal efficiency and sustainability of the way physical objects are moved, deployed, realized, supplied, designed and used

Induced cost reduction
  Price reduction
  Business opportunity
Economic development opportunity

Reduction of
  Greenhouse gas emissions
  Energy consumption
  Waste
  Pollution
  Traffic & Congestion

Improved
  Quality of life
  Goods accessibility
  Faster more precise delivery
  Novel service capabilities
The Physical Internet

Hyperconnected global logistics system enabling seamless open asset sharing and flow consolidation through standardized encapsulation, modularization, protocols and interfaces

A system is said to be hyperconnected when its components (agents, things, etc.) are intensely interconnected on multiple layers, ultimately anytime, anywhere

Interconnectivity layers notably include digital, physical, operational, business, legal and interpersonal

Hyperconnected system definition by B. Montreuil, July 2015
PI definition adapted by Montreuil B., R.D. Meller & E. Ballot, June 2015
Physical Internet at a Glance

- Open market for goods transportation, storage, realization, supply and usage
- Encapsulates goods in “black box” standard modular containers for transport, handling and packaging purposes
- New generation of handling, transportation and storage technologies and facilities for seamless, fast flow & exchange of loads
- Standard protocols and interfaces for seamless open asset sharing & consolidation across interconnected networks and modes
- Critical mass: vast community of users
- Service provider certification and ratings-by-users to drive performance
- Continuous tracking & monitoring
- Smart, fact-based, proactive, distributed routing, deployment, production decisions

Seamless modular container consolidation in the Physical Internet
B. Montreuil & C. Thivierge, 2011
Pillars of Economy and Society in the Emerging Hyperconnected Era

World Wide Web (WWW)
- Digital Internet
- Digital Information Packets

Connecting Physical Objects through WWW
- Internet of Things
- Smart Networked Objects

Logistics Web
- Physical Internet
- Smart Physical Packets

Smart Grid
- Energy Internet
- Energy Packets

Read also: Rifkin J. (2014), Zero Marginal Cost Society.
**PI Enabler: Encapsulating goods in \( \pi \)-containers**

- **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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**Protect the encapsulated objects**

- **Standard Modular**
- **Factories**
- **Clients** (Retail shelves, Homes)
- **Products ever better designed for encapsulation**

Original drawing by Benoit Montreuil & Eric Ballot 2014-09-13
PI Enabler: Evolve towards $\pi$-containers at all scales
Beyond current containers, pallets, totes, cases and boxes

Transport Containers
Modular fit in $\pi$-certified vehicles

Handling Containers
$\pi$-Boxes
Modular fit in transport containers

Packaging Containers
$\pi$-Packs
Modular fit in handling containers

The Modulushca project has prototyped the two first generation of $\pi$-Boxes, TU Graz has engineered and prototyped the first generation

PI-Enabler: $\pi$-container handling & storage technologies

New generation of technologies and logistics facilities enabling seamless, fast, cheap, safe, reliable, distributed, multimodal transport and deployment of modular containers across the Physical Internet

$\pi$-movers

$\pi$-conveyors

$\pi$-stores

Hyperconnecting transportation and delivery

Illustrated through a small Three-Supplier Three-Brand case


Simple case: single-mode, In general: multimodal
Hyperconnecting Distribution

Current Distribution
Dedicated assets
Static structure

Hyperconnected Distribution
Deploy stock in openly shared DCs as demand fluctuates
Hyperconnected Transportation

Results from a simulation experiment with top retailers Carrefour and Casino in France and their 100 top suppliers

Economical: Up to 32% overall cost saving
Environmental: About 60% reduction of greenhouse gas emissions

Hyperconnected Distribution

Hyperconnected distribution is by far the best alternative, even better as consumer delivery has to be faster.

Case of ten illustrative companies serving Canada-USA markets: Optimization of distribution networks.

Hyperconnecting Product Realization
Manufacturing, Production, Assembly, Personalization, Recycling, etc.

Much easier and much less expensive to move and store info rather than matter

Exploit extensively knowledge-based dematerialization of products and their on-demand materialization in physical objects near point of use by certified open fabs

3D Printing is an enabling upcoming technology
Hyperconnected Manufacturing
Beyond current outsourcing, subcontracting, offshoring, reshoring compromises

Dedicated realization

Hyperconnected realization

Enabling Efficient & Agile on-Demand Near Point-of-Use Product Realization

Current snapshot

Currently exploited certified open manufacturer
Currently unexploited certified open manufacturer
Currently exploited certified open assembler
Currently unexploited certified open assembler

Producer
Assembler
Integrated producer+assembler
Client
Hyperconnected Supply Chains

Each supplier may for example sign a guaranteed X-time accessibility contract with each client, keeping responsibility for product delivery, deployment, and realization.

Hyperconnected Realization

Hyperconnected Distribution

Hyperconnected Transport

Each client has minimal stock of a global pool of \( \pi \)-certified suppliers and vice-versa.
Evolution of Logistics, Transportation, Production & Supply Chains

**Hyperconnected**
- Physical Internet, Logistics Web
- Open hubs, DCs & fabs, Co-operation Platforms
- Efficiency, Sustainability, Resilience, Agility

**Collaborative**
- Horizontal & Vertical
- Collaboration with SC partners
- Economies of Scale/Scope, Green
- Long to Deal
- Tough to Adapt
- Hard to Scale

**Integrated**
- EDI, Just-In-Time, ECR, Lean
- Dedicated & Centralized DCs & Factories
- End-to-End Supply Chain

**Atomistic**
- Fragmentation, Solo Operations
- Long leadtime, big lots, large inventory

Timeline

Original concept by Benoit Montreuil & Jean-Claude Dufour
Physical Internet Induced Innovation
Thread 1 for the Automotive Industry:
Hyperconnected Vehicles and Transportation Systems

Mercedes-Benz has just announced the Physical Internet as Key to Its Vision of the Future

Physical Internet Induced Innovation
Thread 2 for the Automotive Industry:
Hyperconnecting the Worldwide Automotive Supply Chain

The North American Automotive Industry has a huge footprint yet it is mostly disconnected.

Reference: Center for Automotive Research 2014 (supplier locations from ELM Analytics and MarkLines)
Illustrative Focus on Hyperconnecting Southeast Automakers

63% of plants are within 100 miles east or west of I-65

Georgia
5000 dealers
300 suppliers
15000 service facilities

Brunswick and Savannah Ports: Largest Importers

Florida Ports: Largest Exporters

Significance of Existing Infrastructure and Ports

Automotive Logistics Supply Chain Conference, Professor Benoit Montreuil, 2016/05/18, 20/26
Away from OEM-Supplier Specific Totes, Cages and Pallets To Pan-Industry Standard Modular Containers

Illustrating the current state

Illustrating the future state

Hitching a ride through the physical internet
Hyperconnected Supplier-OEM-Dealer Transportation
Multimodal, Multi-Party, Inter-Hub, Relay Transportation
Massively Open Transportation Asset Sharing and Flow Consolidation

Specific links and hub locations are illustrative, not engineered yet!
Hyperconnected Automotive Parts & Vehicle Distribution
Dynamic Deployment in Near Point-of-Use Open Multi-Party Distribution Centers

Instead of each OEM, 3PL and supplier having dedicated storage and fulfillment capabilities: massively open distribution asset sharing
Hyperconnecting Automotive Supply
U.S. Continental, International Imports/Exports

Hyperconnected International Supply: Germany and USA Example

Current
Each Car Brand Operates Independently

Hyperconnected Consolidation from the origin
Shorter Lead Time
Less inventory
Cheaper

Enabling same-day shipping of German parts production to US OEMs through multi-supplier consolidation
Hyperconnected Automotive Manufacturing
Use of Shared Vehicle Assembly and Parts Production Facilities

Hyperconnectivity:
Use of Open Hubs and Open DCs

250 miles
Open Hub

250 miles
Open DC

Shared Facility
Physical Internet Induced
Automotive Supply Chain & Logistics Innovation

- Process Innovation
- Technological Innovation
- Infrastructural Innovation
- Cultural Innovation
- Business Model Innovation
- Legislative Innovation
Four Concurrent Research and Innovation Axes
Toward Physical Internet Enabled
Hyperconnected Automotive Supply Chains

Axis 1: Conceptual and Functional Design
Vision, Roadmap, PI constituents, Hyperconnected Supply Chains ...

Axis 2: Assessment of Efficiency, Sustainability & Capability Improvements Through Analytics, Optimization, Simulation

Axis 3: Engineering Solutions
Containers, MH systems, Facility design, Business Models, Decision models, Digital platforms ...

Axis 4: Validation
Case studies, Field pilots, Virtual pilots, Living labs
Questions, comments and ideas are most welcome

www.pi.events

We are shaping a research & innovation initiative on hyperconnected automotive supply chains & logistics
We welcome your feedback, support & engagement!

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