The Physical Internet: Shaping a Global Hyperconnected Logistics Infrastructure

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Hyperconnected global logistics system enabling seamless open asset sharing and flow consolidation through standardized encapsulation, modularization, protocols and interfaces to improve the capability, efficiency and sustainability of serving humanity’s demand for physical objects.

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

Interconnectivity layers: digital, physical, operational, business, legal and personal.
Hyperconnected Supply Chain Infrastructure

Hyperconnected Logistics Infrastructure

Energy Infrastructure
- Smart Grid, Fuel & Charging Distribution

Transportation Infrastructure
- Roads, Ports, Railways, ...

Information & Communications Infrastructure
- Digital Internet, Internet-of-Things
Hyperconnected Logistics Infrastructure

Ubiquitous Modular Containerization

- Private nest in an open space
- Used throughout the Physical Internet
- Owned by producer, pooler, logistic service provider, or user
- Transacted on the spot as pertinent
- No need to return to source
- Reused numerous times
- Drastically eases handling activities
## Hyperconnected Logistics Infrastructure

**Open-Access, Shared, Fast-Response, Agile Facilities**

<table>
<thead>
<tr>
<th>Production Fabs</th>
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<tbody>
<tr>
<td>Making</td>
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<tr>
<td>Dis/Assembling</td>
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<tr>
<td>Recycling</td>
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<td>Processing</td>
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<tr>
<th>Deployment Centers</th>
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<tbody>
<tr>
<td>Objects not yet requested by customer / user, prepositioned for convenient demand fulfilment</td>
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<thead>
<tr>
<th>Logistics Hubs</th>
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<tr>
<td>Ordered objects on their way to destination</td>
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<tr>
<td>Consolidating</td>
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<tr>
<td>Crossdocking</td>
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<tr>
<td>Sorting, Swapping</td>
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<td>Transshipping</td>
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<th>Customer Interfaces</th>
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<td>Showcasing</td>
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<td>Trying</td>
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<td>Purchasing</td>
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<td>Picking</td>
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<td>Returning</td>
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<th>Retail stores</th>
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<td>Smart Lockers</td>
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<td>Click-&amp;-Collect Drives</td>
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<tr>
<th>Factories</th>
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<td>Assembly centers</td>
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<td>Personalization Centers</td>
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<tr>
<td>3D Printing Centers</td>
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<td>Recycling Centers</td>
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<th>Warehouses, Depots</th>
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<tr>
<td>Mixing Centers</td>
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<td>Distribution Centers</td>
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<td>Fulfillment Centers</td>
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<th>Transit Hubs</th>
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<tr>
<td>Crossdocking Hubs</td>
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<tr>
<td>Delivery Hubs</td>
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<tr>
<td>Airports, Railyards, Ports</td>
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<tr>
<td>Multimodal Hubs</td>
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</table>
Focus on Logistic Hub Capabilities
Synchronous and/or Asynchronous Extramural Activities

Driver Swapping

Carrier Swapping (semi-trailer, railcar...)

Tractor Swapping (e.g. trucks needing to recharge)

Transport Container Transshipment (unimodal or intermodal)

Tractor parking, fueling, charging, servicing
Driver waiting, eating, resting, cleaning

Carrier parking, servicing
Container parking, servicing
Focus on Logistic Hub Capabilities
Synchronous and/or Asynchronous Intramural Consolidation Activities

Goods De/Containerization & Sorting

Handling Container & Rack Crossdocking

Handling Container Reshuffling


Expected Convenient and Reliable Delivery or Pickup with Minutes, Hours, maybe a few Days
With Minimal Stock Smartly Flowed and Deployed Between Suppliers and Customers
Hyperconnected Logistics Infrastructure
Enabling Multimodal and Omnisource Transportation

OMNISOURCE TRANSPORTATION

Smart Dynamic Leveraging

<table>
<thead>
<tr>
<th>Dedicated Fleet</th>
<th>Smart Contracts with Service Providers</th>
<th>On-Demand Spot Market Crowdsourcing</th>
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<tr>
<td>(Own &amp; Partners)</td>
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Multimodal Transport

Coping with Time and Price Sensitivity of Customers Demand Variability and Uncertainty

Economic, Environmental & Societal Sustainability

Code | Range | Logistics Web
--- | --- | ---
Blue | Long | Plane 3 and above
Yellow | Medium | Plane 2
Red | Short | Planes 0 and 1
Expanding on the notions of postal / zip codes
- Needs multi-party authoritative agreement
- Focus on logistics purposes, in harmony with others
- Evolutive with demand and logistics patterns & density
Urban Space Structuring: Urban Areas in Megacity

Illustrative application in Shenzhen, China
Highlighting urban areas, local cells, and relative demand density

- Area 1
- Area 2
- Area 3
- Area 4
- Area 5
- Area 6

- 6 Urban areas
- 103 Local cells
- 3468 Unit zones

Space clustering created by Ph.D. student Simon Kwon and Professor Benoit Montreuil for illustrative and benchmarking purposes: it is not meant to be prescriptive.
Urban Area 4
Shenzhen, China
Hyperconnected Logistics Infrastructure
Logistics Web with Multi-Plane Mesh Networks

Inter-Block Global-Hub Network
Inter-Region Regional-Hub Network
Inter-Area Gateway-Hub Network
Inter-Cell Local-Hub Network
Inter-Zone Access-Hub Network
Inter-Client P/D-Point Network

Inter-Block Global-Hub Network

Inter-Region Regional-Hub Network

Inter-Area Gateway-Hub Network

Inter-Cell Local-Hub Network

Inter-Zone Access-Hub Network

Inter-Client P/D-Point Network

- Dynamic Multi-Party Design and Management
- Account for Competition, Cooperation, Coopetition
- Aim for Efficiency, Fairness, Resilience, Sustainability
- Should be Simple to Leverage, Operate, and Evolve

Urban Logistics Web: Gateway-Hub Network in Megacity

Space clustering and logistics web created by Ph.D. student Simon Kwon and Professor Benoit Montreuil for illustrative and benchmarking purposes; they are not meant to be prescriptive.
Urban Logistics Web: Adding the Local-Hub Network

Space clustering and logistics web created by Ph.D. student Simon Kwon and Professor Benoit Montreuil for illustrative and benchmarking purposes; they are not meant to be prescriptive.
Urban Logistics Web: Adding the Access-Hub Network

Space clustering and logistics web created by Ph.D. student Simon Kwon, MS student Praveen Mthukrishnan, and Professor Benoit Montreuil for illustrative and benchmarking purposes: they are not meant to be prescriptive.
Urban Logistics Web: Focus on Networks in Urban Area 5

Space clustering and logistics web created by Ph.D. student Simon Kwon, MS student Praveen Mthukrishnan, and Professor Benoit Montreuil for illustrative and benchmarking purposes: they are not meant to be prescriptive.

Inter-hub links not displayed not to overload map
Hyperconnected Continental Logistics Infrastructure
Road-Based Regional-Hub Network

This design has most inter-hub legs to be half-day max, notably enabling most truckers to return home everyday

Illustrative partial road-based regional-hub network in China
Highlighting main regional and gateway hubs and subset of direct-ship inter-hub links
Inter-regional-hub logistics network created by Ph.D. student Onkar Kulkarni and Yaarit Cohen, and Professors Benoit Montreuil and Mathieu Dahan for illustrative and benchmarking purposes: it is not meant to be prescriptive.

Illustrative partial air-based + road-based regional-hub networks in China.
Hyperconnected Logistics Infrastructure
Embracing Modularity, Scalability, and Mobility of Facilities

Leveraging Modular Access Hubs

Sample demand dynamics in a local cell

Illustration of periodic modular hub capacity relocation


under review for journal publication
Hyperconnected Logistics Infrastructure
Embracing Modularity, Scalability, and Mobility of Facilities

UPS’s mobile access hub in Munich

Leveraging Mobile Access Hubs

Hyperconnected Digital Logistics Infrastructure
Towards Cloud-Based Digital Supply Chain Interconnectivity Platforms

Seamless, Trustworthy, Ubiquitous Monitoring, Traceability & Transactions

Simple Links
Exploitation of industry-wide supply chain monitoring concepts from Consumer Forum Group

Internet-of-Things
Widespread exploitation of smart connected devices, and of sensor-actuator networks

BlockChain
Exploitation of emerging distributed ledger technology for SC trust insuring platform

Marketplace
Match, orchestrate & optimize supply & demand for fast, seamless & fair contracts

Example: https://convoy.com/

Transparency, tracking, traceability, smart contracts and distributed routing
Enabled by Analytics, AI, Data Science, Digital Twins, Heuristics, Machine Learning, Optimization, Simulation
Logistics receives, unpacks, sorts, moves, stores, picks, packs, ships, transports, and delivers goods

At each step, people, equipment, and products can become vectors propagating pandemic viral diseases

Vector-Free Logistics

The overall multi-party logistics system in a large territory, and ultimately all around the world, is designed, engineered, implemented, operated and managed not to be an infection vector, protecting the workers, the customers, and the population from diseases, while not being encumbered into inefficiency, rigidity and unsustainability

Joint work with Professor Leon McGinnis
Conclusion

• The potential benefits are huge, notably in terms of capability, efficiency, equity, resilience, safety, security, and sustainability.

• Leadership is needed in steering toward implementation at large scale.

• Roadmap is needed, as ALICE PI Roadmap, focused on hyperconnected logistics infrastructure.

• Starting in industries having to rethink their supply chain and logistics, notably toward post-Covid-19 New Normal.

• Key challenge is the existing legacy and the competitive arena.

• Governance is to be mandatory to align the early efforts of multiple parties, manage risks, and guide toward full-scale implementation.
Thanks \quad Xièxiè

Questions, comments, feedback, suggestions are most welcome!

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