Toward a Physical Internet

A Global Sustainability Focused Collaborative Networking Initiative

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Presentation Outline

The Claim

The Symptoms

The Vision

The Initiative

Conclusion

www.physicalinternetinitiative.org

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Macroscopic Positioning

CLAIM

The way **physical objects** are **moved, handled, stored, realized, supplied and used** throughout the world is **not sustainable** economically, environmentally and socially

GOAL

Enabling the global **sustainability** of physical object movement, handling, storage, realization, supply and usage

VISION

Evolving towards a worldwide **Physical Internet**

Supporting the claim

CLAIM

The way **physical objects** are **moved, handled, stored, realized, supplied and used** throughout the world is **not sustainable** economically, environmentally and socially

Thirteen unsustainability symptoms
Leading Us Toward Hitting the Wall Real Hard

1. We are shipping air and packaging
2. Empty travel is the norm rather than the exception
3. Truckers have become the modern cowboys
4. Products mostly sit idle, stored where unneeded, yet so often unavailable fast where needed
5. So many products are never sold, never used
6. Products do not reach those who need them the most
7. Products unnecessarily move, crisscrossing the world
8. Getting products in and out of cities is a nightmare
9. Fast & reliable multimodal transport is a dream or a joke
10. Production and storage facilities are poorly used
11. Networks are neither secure nor robust
12. Smart automation & technology are hard to justify
13. Innovation is strangled

We are shipping air and packaging

Unsustainability symptom 1

Trucks and containers are often half empty at departure, with a large chunk of the non-emptiness being filled by packaging

Overall, most goods travel by road. In the UK, 65% of all freight is moved by road, or about 160 billion tonne kilometres out of 240 billion tonne kilometres.

In the USA, for example, there are 40,000 public carriers and 600,000 private fleets. With so many operators competition is likely to be more intense and pricing more flexible. [1]

Transportation costs are the single largest contributor to total logistics costs, with trucking being the most significant subcomponent.

Trucking costs account for roughly 50% of total logistics expenditures and 80% of the transportation component.

Trucking revenues in 2005 increased by $74 billion over 2004, but carrier expenses rose faster than rates, eroding some of the gain.

Fuel ranks as a top priority at trucking firms as substantially higher fuel prices have cut margins. The U.S. trucking industry consumes more than 650 million gallons of diesel per week, making it the second largest expense after labor.

The trucking industry spent $87.7 billion for diesel in 2005, a big jump over the $65.9 billion spent in 2004. [2]

References: 1]: "Transport in Logistics", Chap. 12 in An Introduction to Supply Chain Management, Ed. By Donald Waters [Palgrave Macmillan] (2003)
[2]: Wilson R. A., "Economic Impact of Logistics", Chap. 2 in Logistics Engineering Handbook , 2008

Empty travel is the norm rather than the exception
Unsustainability symptom 2

Vehicles and containers often return empty, or travel extra routes to find return shipments

Vehicles leaving loaded get emptier and emptier as their route unfolds from delivery point to delivery point

Statistical evidence that around 30 per cent of truck-kilometres are run empty, illustrating huge inefficiency in road haulage and enormous potential for increasing back loading.

In Britain, the proportion of truck-kilometers travelled empty felt from 33 per cent in 1980 to 27 per cent in 2004, yielding significant economic and environmental benefits. [1]

Other things being equal, if the empty running percentage had remained at its 1980 level, road haulage costs in 2004 would have been £1.2 billion higher and an extra 1 million tonnes of carbon dioxide would have been emitted by trucks (McKinnon, 2005).

Reference: [1]: McKinnon A., “Road transport optimization” Chap. 17 in Global Logistics New Directions in Supply Chain Management (2007), Ed. by Donald Water

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Truckers have become the modern cowboys
Unsustainability symptom 3

So many are always on the road,
so often away from home for long durations

Their family and social life is precarious,
as well as their personal health

The shift workers with the lowest mean hours of daily sleep are truck drivers, at 3.5 hours/24 hours

Fatigue and sleep deprivation are important safety issues for long-haul truck drivers

A National Transportation Safety Board study examined the effects of duty shifts and sleep patterns on drivers of heavy trucks involved in single-vehicle accidents and found that 62 of 107 accidents (58%) reported by drivers were deemed to be "fatigue-related" [1]

The American Trucking Association (ATA) has estimated that the driver shortage will grow to 111,000 by 2014 [2]

References: [1]: "Consequences of Insomnia, Sleepiness, and Fatigue: Health and Social Consequences of Shift Work ", http://cme.medscape.com/viewarticle/513572_2
[2] : Wilson R.A. "Economic Impact of Logistics", in Chap. 2 in Logistics Engineering Handbook, 2008

Products mostly sit idle, stored where unneeded, yet so often unavailable fast where needed

Unsustainability symptom 4

Manufacturers, distributors, retailers and users are all storing products, often in vast quantities through their networks of warehouses and distribution centers,
yet service levels and response times to local users are constraining and unreliable




Stocks are increasingly maintained at a higher level
in response to longer and sometimes unpredictable delivery times, as well as changes in distribution patterns.

In 2005, the average investment in all business inventories was $1.74 trillion,
which surpassed 2004's record high by $101 billion.

Reference: Wilson R.A. "Economic Impact of Logistics", in Chap. 2 in Logistics Engineering Handbook, 2008

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So many products are never sold, never used
Unsustainability symptom 5

A significant portion of consumer products that are made never reach the right market on time, ending up unsold and unused while there would have been required elsewhere

Rusting new cars in disused airfields

Products do not reach those who need them the most

Unsustainability symptom 6

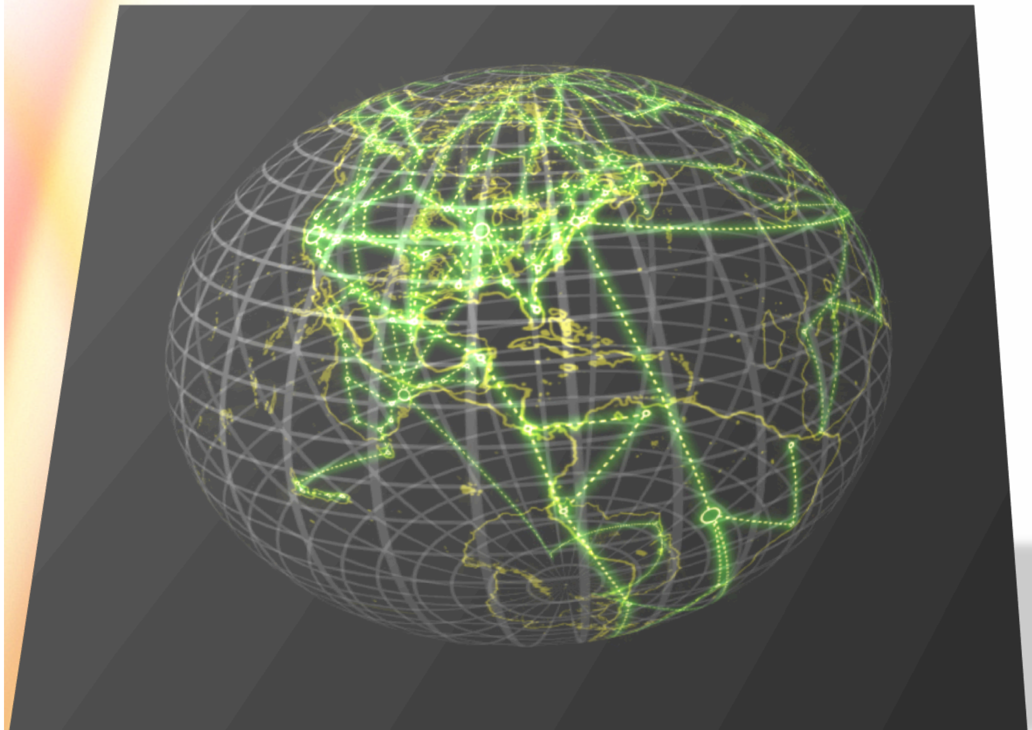
This is specially true in less developed countries and disaster-crisis zones

Countries most affected by high prices are those: which import large quantities of food, whose populations spend a large part of their income on food, where inflation is already high, where there is already food insecurity and which have large urban populations.

References: "World Food Programme (WFP)", http://www.wfp.org/node/7904
"Problems in developing logistics centres for ports in the Escap region"; Chap5, http://www.unescap.org/ttdw/Publications/TFS_pubs/pub_2194/pub_2194_ch5.pdf

Products unnecessarily move, crisscrossing the world

Unsustainability symptom 7



Products commonly travel thousands of miles-kilometers which could have been avoided by making or assembling it much nearer to point of use

Reference: "Virtual Warehousing", Jeroen van den Berg Consulting, 2001

Getting products in and out of cities is a nightmare

Unsustainability symptom 8

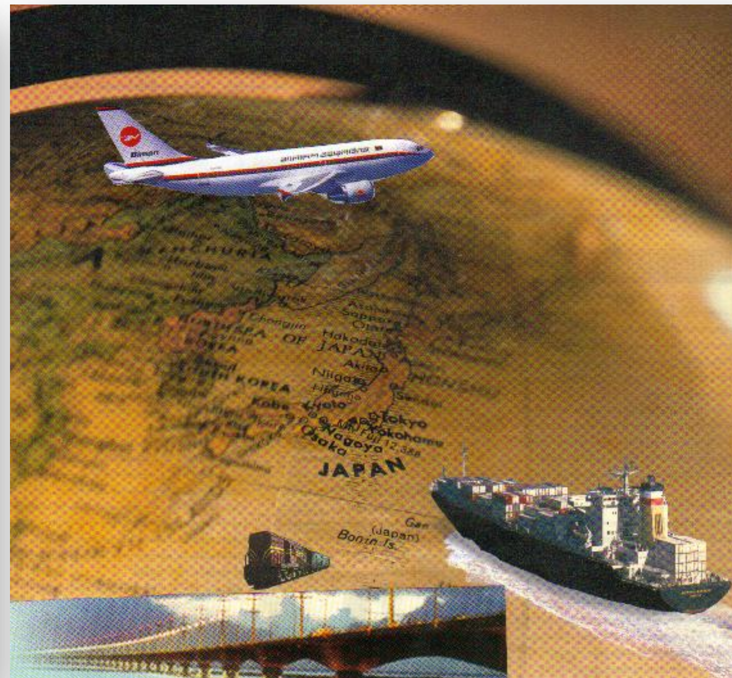
Most cities are not designed and equipped for easing freight transportation, handling and storage, making the feeding of businesses and users in cities a nightmare

References: « Transport des marchandises en ville », www.transports-marchandises-en-ville.org
"Problems in developing logistics centres for ports in the Escap region", Chap5, http://www.unescap.org/ttdw/Publications/TFS_pubs/pub_2194/pub_2194_ch5.pdf

Fast & reliable multimodal transport is a dream or a joke

Unsustainability symptom 9

Synchronization is so poor, interfaces so badly designed, that multimodal routes are most often cost inefficient and risky



Reference: Crainic, T.G. and Kim, K.H., "Intermodal Transportation, Chap8 in Handbooks in Operations Research and Management Science", C. Barnhart and G. Laporte (Eds.), 2007

Production and storage facilities are poorly used
Unsustainability symptom 10

Most businesses invest in storage and/or production facilities which are lowly used most of the times, or yet badly used, dealing with products which would better be dealt elsewhere, forcing a lot of unnecessary travel

When the production function is considered to be a part of the supply chain, there is obviously much that can be done to improve environmental and social performance at this stage [1]

The transport and storage of goods are at the centre of any logistics activity, and these are areas where a company should concentrate its efforts to reduce its environmental impacts [2]

[1]: McIntyre K., "Delivering sustainability through supply chain management", Chap.15 in Global Logistics New Directions in Supply Chain Management, (2007)
[2]: Cooper J., Browne M. and Peters M., "European Logistics: Markets, management and strategy", Blackwell, London (1991)
Chopra & Meindl, "Facility Decisions and Distribution Network ", 2009_E4.5

Networks are neither secure nor robust

Unsustainability symptom 11

There is extreme concentration of operations in a limited number of centralized production and distribution facilities, with travel along a narrow set of high-traffic routes

This makes
the logistic networks
and supply chains
of so many businesses,
unsecure in face of robbery
and terrorism acts,
and not robust in face of
natural disasters
and demand crises

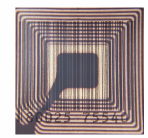
References: Chopra & Meindl, "Facility Decisions and Distribution Network" - 2009_E4.5
"Terrorism - Supply Chain Effects", http://www.weforum.org/pdf/CSI/Terrorism.pdf
"The New Supply Chain Challenge - Risk Management in a Global Economy", FM Global, 2006 , http://www.fmglobal.com/assets/pdf/P0667.pdf
Peck H., "Supply chain vulnerability, risk and resilience", Chap.15 in Global Logistics New Directions in Supply Chain Management, (2007)
"Managing Supply Chain Risk", Video produced by CFO Research Services, http://www.fmglobal.com/VideoPlayer.aspx?url=/assets/videos/CFO_SupplyChain.wm
"Security, Risk Perception and Cost-Benefit Analysis", Joint Transport Research Centre OCDE Summary & Conclusions – Discussion Paper #2009-6, March 2008

Smart automation & technology are hard to justify

Unsustainability symptom 12

Vehicles, handling systems and operational facilities have to deal with so many types of materials, shapes and unit loads, with each player independently and locally deciding on his piece of the pie

This makes it very hard to justify smart connective technologies (e.g. RFID), systemic handling and transport automation, as well as smart collaborative piloting software



References:
Montreuil B., Facilities Location and Layout Design Chapter 9. in Logistics Engineering Handbook (2008)
Hakimi D., Leclerc P-A., Montreuil B., Ruiz A., « Integrating RFID and Connective Technologies in Retail Stores », RFID in Operations and Supply Chain Management - Research and Applications, Erich Schmidt Verlag, 148-171, 2007.Spada Sal,"Material Handling Control System Software Extends Supply Chain Visibility "nov.15, 2001
http://www.arcweb.com/ARCReports2001/Material%20Handling%20Control%20System%20Software%20Extends%20Supply%20Chain%20Visibility.pdf
Sunderesh S. H., Material Handling System – Chapter-11 in Logistics Engineering Handbook (2008)
McKinnon A., Road transport optimization – Chap. 17 in Global Logistics New Directions in Supply Chain Management - eBook (2007) Fifth Edition, Edited by Donald Waters
Decker C. et al."Cost-Benefit Model for Smart Items in the Supply Chain" (2008)
Myerson J.M. "RFID in the Supply Chain - A Guide to Selection and Implementation" - IT Consultant Philadelphia, Pennsylvania USA - Auerbach Publications 2007

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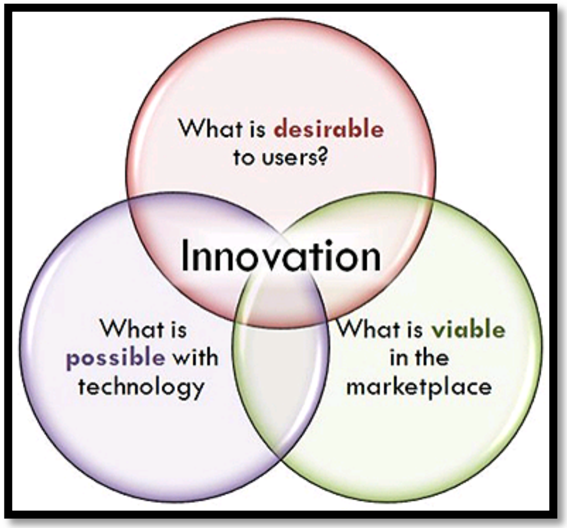
Innovation is strangled

Unsustainability symptom 13

Innovation is bottlenecked,
notably by lack of generic standards and protocols,
transparency, modularity and systemic open infrastructure

This makes breakthrough innovation so tough,
justifying a focus on marginal epsilon innovation



References: "RFID Tags: Advantages and Limitations", http://www.tutorial-reports.com/wireless/rfid/walmart/tag-advantages.php
"RFID hype is blurring limitations, study claims ", http://www.usingrfid.com/news/read.asp?lc=d59745mx97zf
"RFID_Internet of Things in 2020 - Roadmap for the future", Infso D.4Networked Enterprise & RFID Infso G.2Micro & Nanosystems, 2008

Thirteen unsustainability symptoms
Leading Us Toward Hitting the Wall Real Hard

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Expliciting the Overall Goal Toward Global Sustainability

Environmental goal

Reduce by an order of magnitude
global energy consumption and greenhouse gas emission
associated with logistic, production and transportation

Economic goal

Unlock highly significant gains
in global logistic, production, transportation
and business productivity

Societal goal

Increase the quality of life
of both the logistic, production and transportation workers
and the overall population by making valuable objects
much more accessible across the world

References: Dablanc L., "Urban Goods Movement and Air Quality Policy and Regulation Issues in European Cities", Journal of Environmental Law Advance Access, 2008
McIntyre K., "Delivering sustainability through supply chain management", Chap.15 in Global Logistics New Directions in Supply Chain Management, 2007
Esty D. C. and Winston A.S. "Green to Gold "; 2006

The Inspiration for the Vision

June 2006: The Spark

- **A great front page one-liner**
  - Interesting yet mainstream supply chain articles
  - **Nothing like what I perceived a Physical Internet should be**
- I rapidly got passionate about the question
  What should or could be a full blown Physical Internet?
  - **What would be its key features?**
  - **What capabilities would it offer that are not achievable today?**
- Another question surfaced rapidly:
  Why would we need a Physical Internet?

The Digital Internet

Building Upon and Expanding Beyond the Information Highway Metaphor

When the digital world was looking for a way to conceptualize how it should transform itself, it relied on a physically inspired metaphor:

Building the information highway

References "BCNET's Optical Regional Advanced Network Upgrade Completed", http://www.bc.net/news_events_publications/newsletters/Dec_2007/ROADM_Completion.htm
"What the Telecom Industry May Look Like in 10 Years", http://kennethmarzin.wordpress.com/2008/01/24/what-the-telecom-industry-may-look-like-in-10-years/

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The Digital Internet

Building Upon and Expanding Beyond the Information Highway Metaphor

Well, they have done that and went farther, reshaping completely the way digital computing and communication is now performed

They have invented the Internet, leading the way to the World-Wide Web

They have enabled the building of an open distributed networked infrastructure that is currently revolutionizing so many facets of our societal and economic reality

References: « Internet 2, le Web de demain », /http://www.futura-sciences.com/fr/doc/t/telecoms/d/internet-2-le-web-de-demain_582/c3/221/p1
http://www.20minutes.fr/article/353755/Economie-Surendettement-Christine-Lagarde-ne-veut-pas-interdire-le-credit-revolving.php
« rE-veille: réflexions sur l'aventure Internet », http://reveille.wordpress.com/

The Essence of the Digital Internet

The Digital Internet is about the interconnection between networks in a way transparent for the user, so allowing the transmission of formatted data packets in a standard way permitting them to transit through heterogeneous equipment respecting the TCP/IP protocol

References: Kurose J., Ross K. and Wesley A. "Computer Networking: A Top Down Approach Featuring the Internet", 3rd edition., July 2004.
Parziale L., Britt D.T., Davis C., Forrester J., Liu W., Matthews C. and Rosselot N. "TCP-IP Tutorial and Technical Overview", 2006. http://www.redbooks.ibm.com/redbooks/pdfs/gg243376.pdf
"Interconnection of access networks, MANs and WANs ", http://images.google.ca/imgres?imgurl=http://www.exfo.com/

Toward a Physical Internet
Digital Internet as a Metaphor for the Physical World

Even though there are fundamental differences
between the physical world and the information world,
the Physical Internet 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

Exposing 13 Key Features of the Physical Internet Vision

VISION

Evolving towards a worldwide **Physical Internet**

Thirteen Key Features of the Physical Internet Vision

1. Encapsulate merchandises in world-standard modular containers
2. Aim toward universal interconnectivity
3. Evolve from material to container handling & storage systems
4. Exploit smart networked containers embedding smart objects
5. Evolve from point-to-point hub-and-spoke transport to distributed multi-segment transmodal transport
6. Embrace a unified multi-tier conceptual framework
7. Activate and exploit an open global supply web
8. Design products fitting containers with minimal space waste
9. Minimize physical moves and storages by digitally transmitting knowledge and materializing products as locally as possible
10. Prioritize webbed reliability and resilience of networks
11. Deploy capability certifications and open performance monitoring
12. Stimulate business model innovation
13. Enable open infrastructural innovation

Digital Internet:
From information to packets

- **The digital Internet does not transmit information, it transmits packets embedding information**
- **Information packets are designed for ease of use in Internet**
- **The information within a packet is encapsulated and is not dealt with explicitly by Internet**
- **The packet header contains all information required for identifying the packet and routing it correctly to destination**
- **A packet is constructed for a specific transmission and it is dismantled once it has reached its destination**

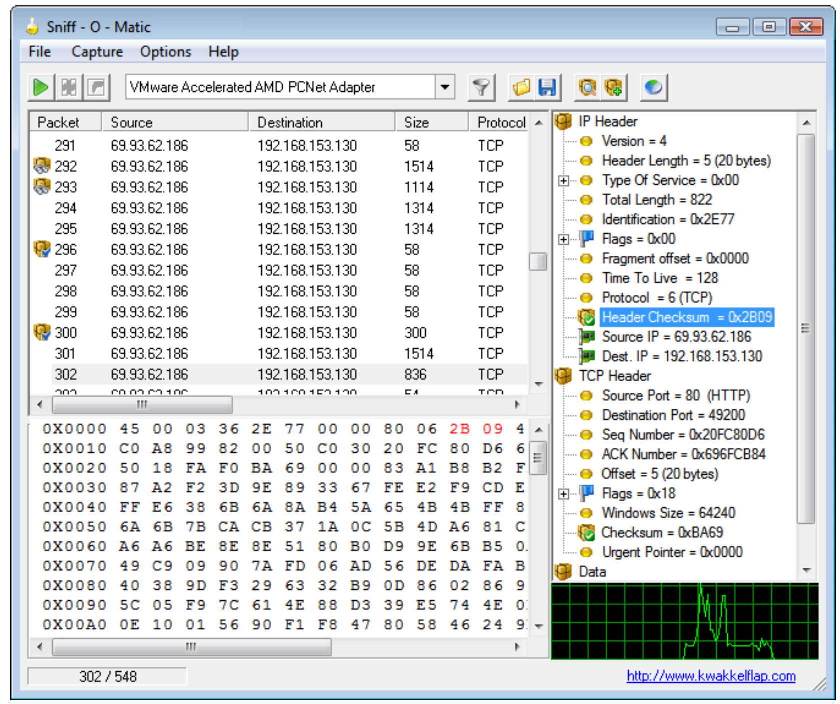
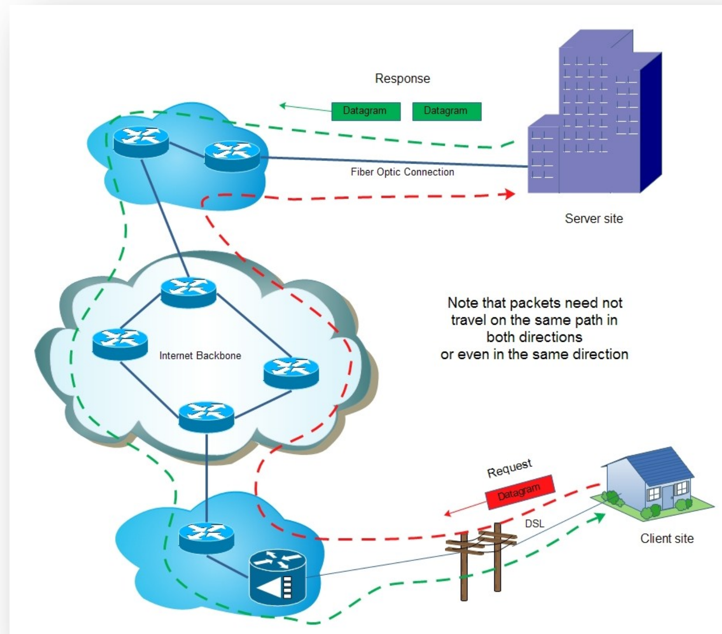


Image: http://www.softlist.net/program/sniff_-_o_-_matic-image.html

Digital Internet:
From information to packets

- **The Digital Internet is based on a protocol structuring data packets independently from equipment**

- **In this way, data packets can be processed by different systems and through various networks**
  - **Modems, copper wires, fiber optic wires, routers, etc.**
  - **Local area networks, wide area networks, etc.**
  - **Intranet, Extranet, Internet, Virtual Private Network, etc.**



References: Kurose J., Ross K. and Wesley A. "Computer Networking: A Top Down Approach Featuring the Internet", 3rd edition., July 2004.
Parziale L., Britt D.T., Davis C., Forrester J., Liu W., Matthews C. and Rosselot N. "TCP-IP Tutorial and Technical Overview", 2006. http://www.redbooks.ibm.com/redbooks/pdfs/gg243376.pdf

Physical Internet

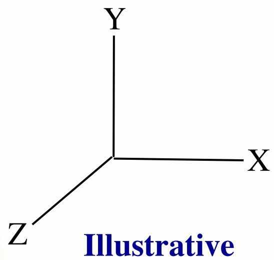
1. Encapsulate merchandises in world-standard smart green modular containers

π-containers are key elements enabling the interoperability necessary for the adequate functioning of the Physical Internet

- Merchandise is unitized as content of a π-container and is not dealt with explicitly by the Physical Internet
- From the cargo container sizes down to tiny sizes
- Conceived to be easily flowed through various transport, handling and storage modes and means
- Environment friendly materials with minimal off-service footprint
- Smart tag enabled, with sensors if necessary, to allow their proper identification, routing and maintaining
- Various usage-adapted structural grades
- Conditioning capabilities (e.g. temperature) as necessary
- Sealable for security purposes

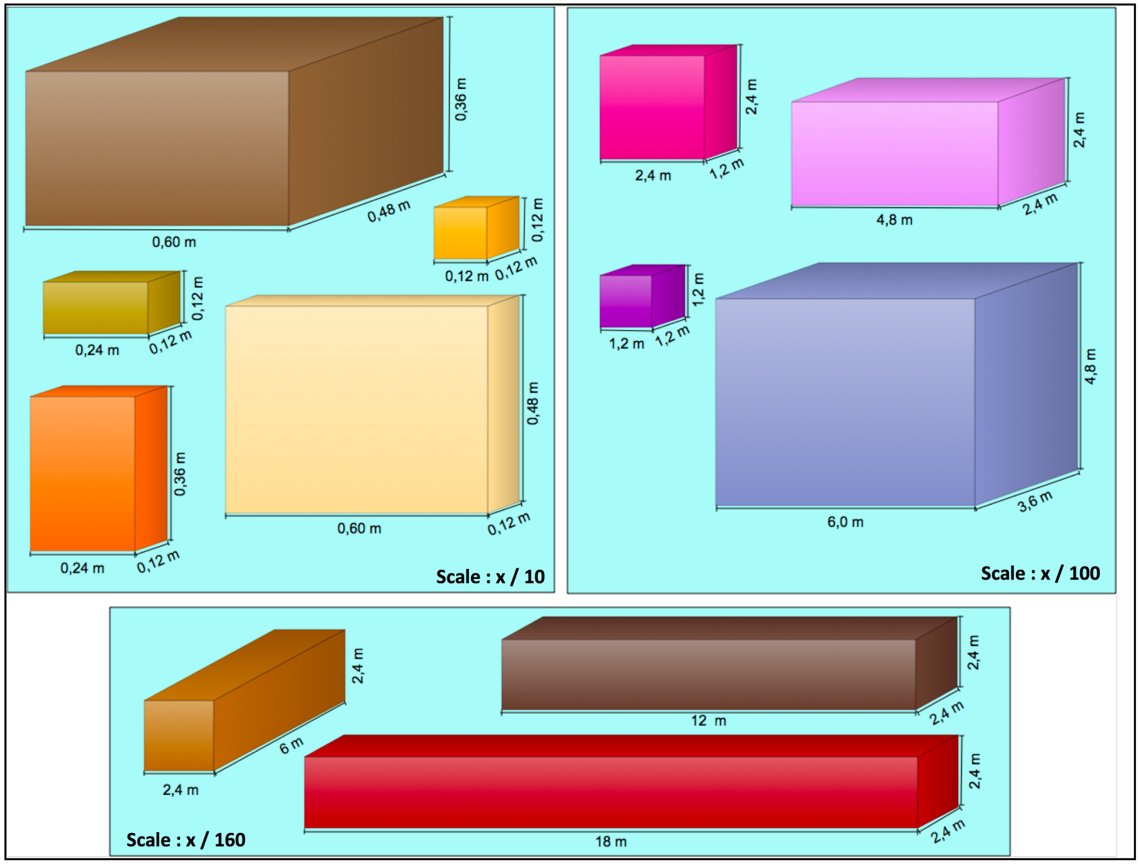
π-Containers:
Dimensionnally and functionnally modularized and standardized worldwide

π-containers



Illustrative modular dimensions

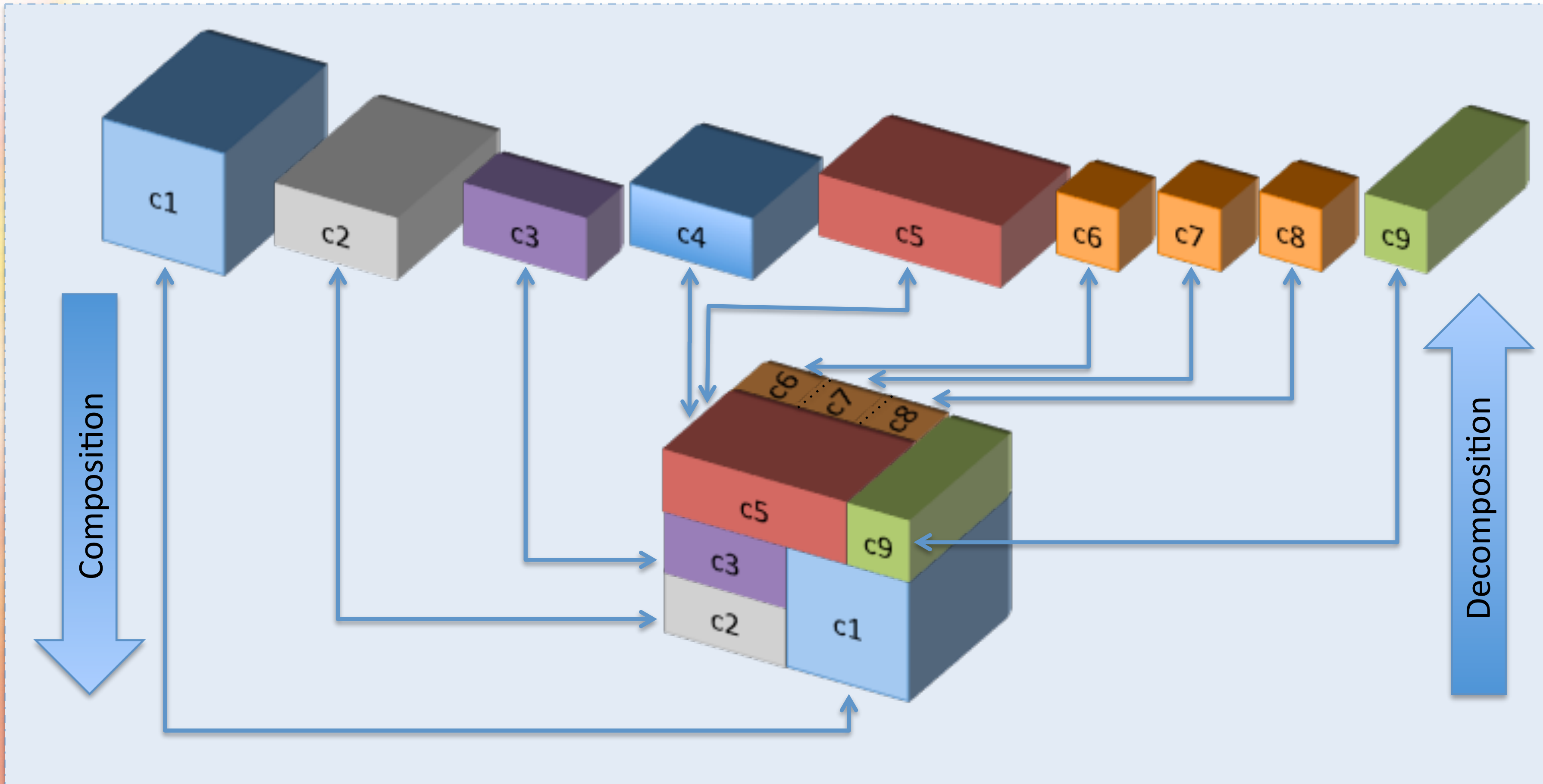
0,12 m
0,24 m
0,36 m
0,48 m
0,6 m
1,2 m
2,4 m
3,6 m
4,8 m
6 m
12 m



Reference: B. Montreuil, B. Gilbert

π-Containers

Easy to handle, store, transport, interlock, load, unload, construct and dismantle, compose and decompose



Physical Internet
2. Aim toward universal interconnectivity

High-performance logistic centers and systems,
making it fast, cheap, easy and reliable
to interconnect π-containers through modes and routes,
with an overarching aim toward universal interconnectivity

References:
Crainic, T.G. and Kim, K.H., Intermodal Transportation, Chapt. 8, Transportation, Handbooks in Operations Research and Management Science, C. Barnhart and G. Laporte (Eds.), North-Holland,, 467–537, 2007
Goetschalckx M. “Distribution System Design”. Chap. 13 in Logistics Engineering Handbook, 2008

Physical Internet
2. Universal Interconnectivity

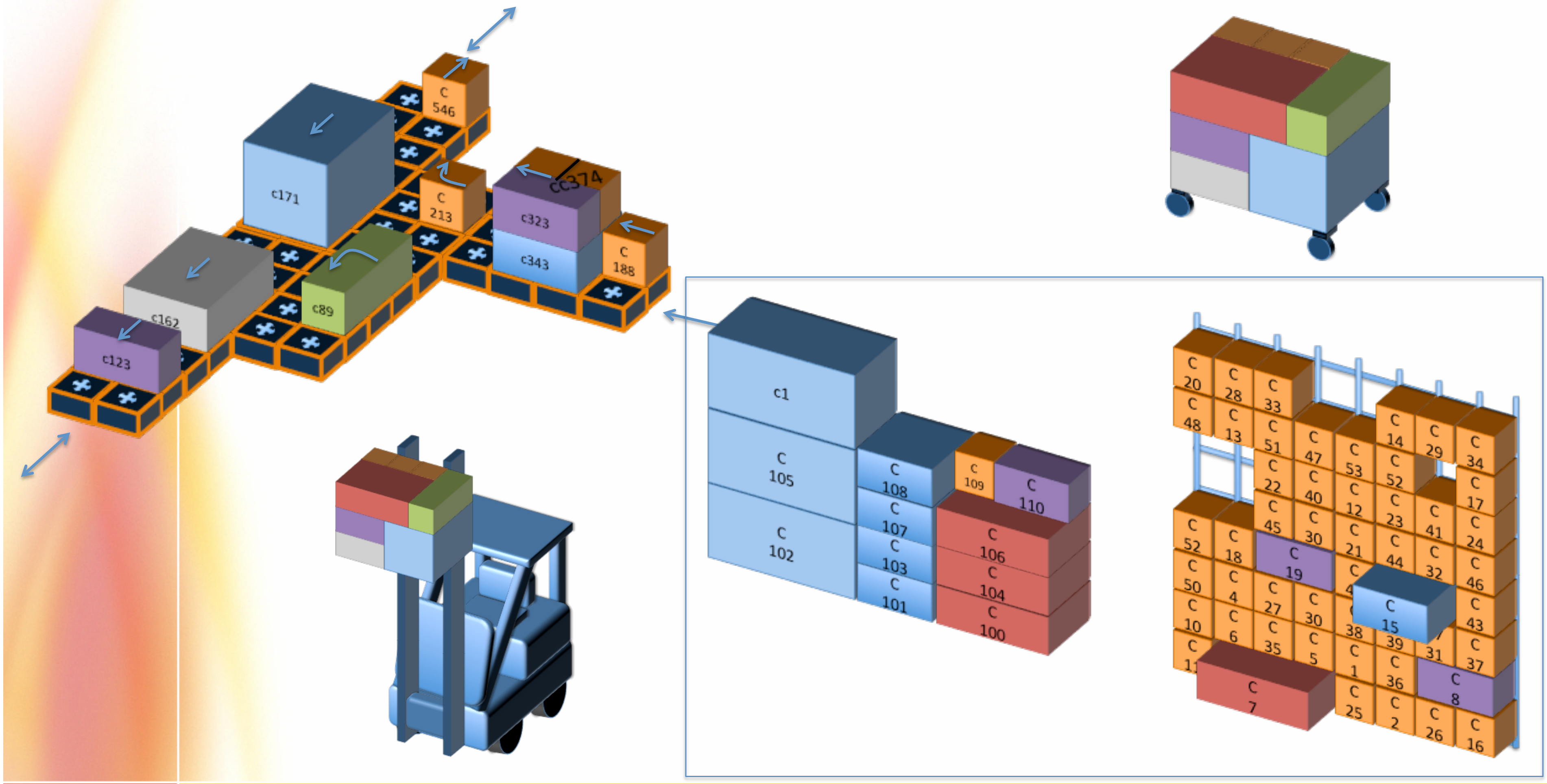
- The nodes of the Physical Internet will concurrently be routing and accumulation sites within the networks, as well as interfaces with the exterior, such as inbound-outbound ports
- As currently conceived, sorting, storage and handling physical objects are brakes to interconnection
  - Be it in train sorting yards or in crossdocking platforms
- However there exist exceptions:
  - Such as the recently implemented container port terminals
- There is a need to generalize unloading, orientation, storage and loading operations, widely applying them the modular containers of the Physical Internet in a smart automated way
- The objective is to make load breaking almost negligible temporally and economically

References: Crainic, T.G. and Kim, K.H., Intermodal Transportation, Chap. 8, Transportation, Handbooks in Operations Research and Management Science, C. Barnhart and G. Laporte (Eds.), North-Holland, 467–537, 2007
Chopra & Meindl, Facility Decisions and Distribution Network - 2009_E4.5

Physical Internet
3. Evolve from material to π-container handling & storage systems

π-container handling and storage systems,
with innovative technologies and processes
exploiting the characteristics of π-containers
to enable their fast, cheap, easy and reliable
input, storage, composing, decomposing,
monitoring, protection and output
through smart, sustainable and seamless
automation and human handling

Physical Internet
3. Evolve from material to π-container handling & storage systems

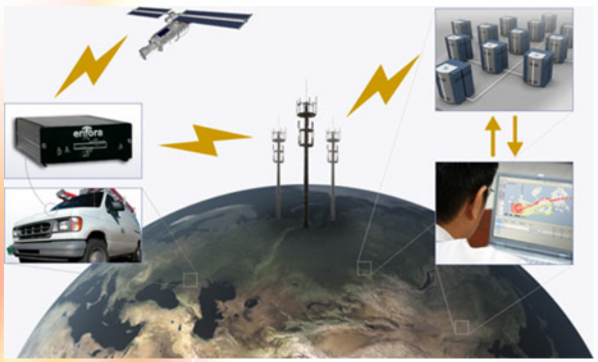


Reference: B. Montreuil, R.D. Meller et E. Ballot

Physical Internet
4. Exploit smart networked containers embedding smart objects

Exploiting as best as possible
the capabilities of smart containers
connected to the Digital Internet and the World Wide Web,
and of their embedded smart objects,
for improving performance as perceived by the clients
and overall performance of the Physical Internet

Physical Internet and the Internet of Things



- **The Internet of Things is about enabling ubiquitous connection with physical objects equipped with smart connective technology, making the objects ever smarter and enabling distributed self-control of objects through networks**
  - **It exploits technologies such as Internet, Web, RFID and GPS**

The Physical Internet is to exploit as best as possible the capabilities of smart objects, embedded in smart containers, for improvement performance as perceived by the client and user, and for overall performance of the Physical Internet

References: Johnson M. E., "Ubiquitous Communication: Tracking Technologies within the Supply Chain", Chap.20 in Logistics Engineering Handbook, 2008
Scott D. M., "Electronic Connectivity and Soft ware" Chap.20 in Logistics Engineering Handbook, 2008
"Building a Smarter Container", RFID Journal, http://www.rfidjournal.com/article/articleview/655/1/1/

Physical Internet

5. Evolve from point-to-point hub-and-spoke transport to distributed multi-segment transmodal transport

Distributed multi-segment travel
of π-containers through the Physical Internet,
with distinct carriers and/or modes
taking charge of inter-node segments,
with transit nodes enabling synchronized
transfer of π-containers and/or carriers between segments,
and with web software platform
enabling an open market
of transport requesters and transport providers

A typical cowboy haul from Québec to Los Angeles

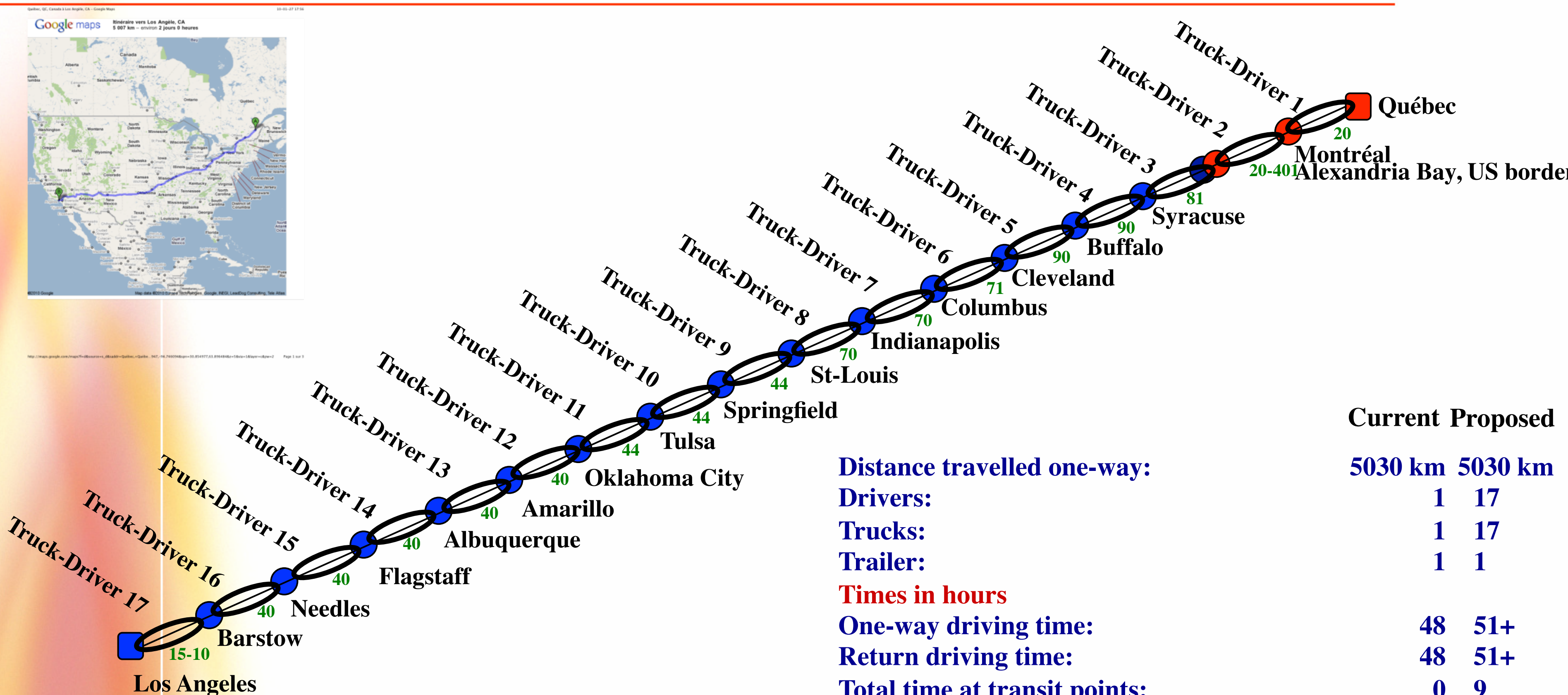
One-way Distance travelled : 5030 km
Drivers: 1, Trucks: 1, Trailer: 1

One-way driving time: 48 hours
Return driving time: 48 hours
One-way trip time: 120 hours
Return trip time: 120+ hours

Driving time for driver: 96 hours

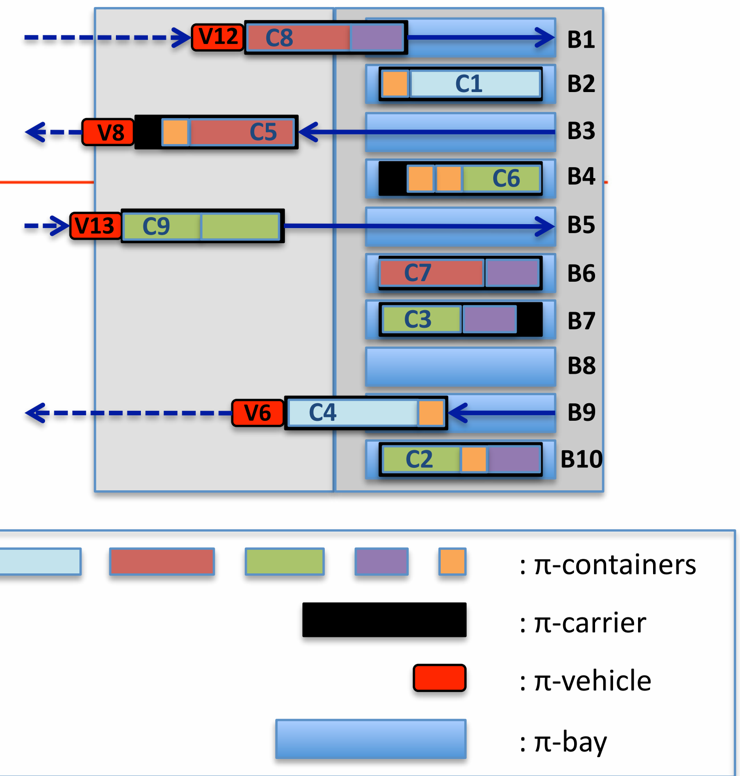
Trip time for driver: 240+ hours

Multi-segment travel from Quebec to Los Angeles



	Current	Proposed
Distance travelled one-way:	5030 km	5030 km
Drivers:	1	17
Trucks:	1	17
Trailer:	1	1
Times in hours		
One-way driving time:	48	51+
Return driving time:	48	51+
Total time at transit points:	0	9
Total one-way trip time:	120	60+
Average driving time per driver:	96+	6
Average trip time per driver:	240+	6,5

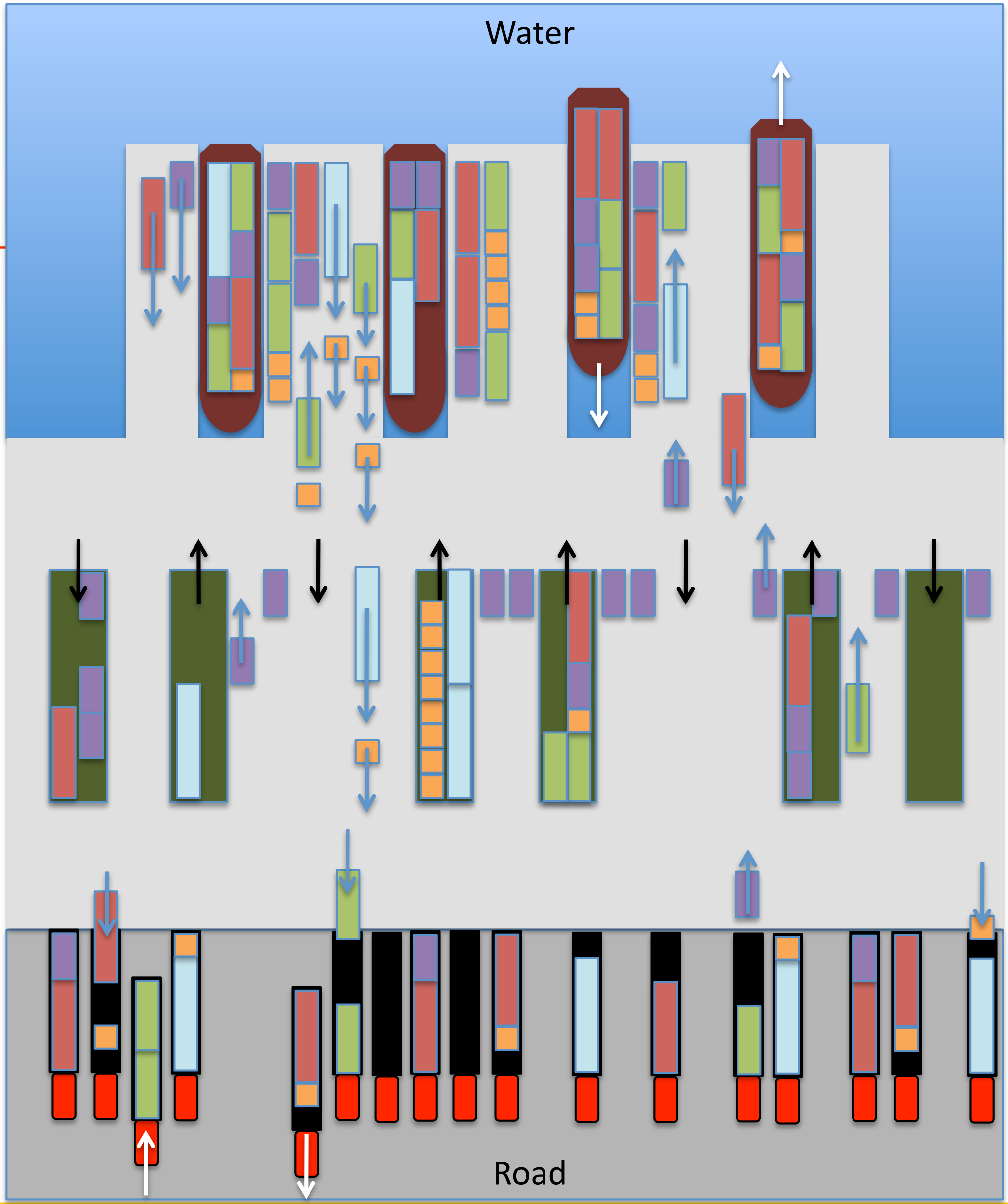
π-Transit sites
allowing distributed multi-segment transport
through the Physical Internet



Status of π-carriers currently in π-transit					
π-carrier	π-bay	Incoming deposit		Outgoing pickup estimation	
		π-vehicle	Time	π-vehicle	Time (min, mode, max)
C1	B2	V1	04:35	V14	(06:04, 06:05, 06:15)
C2	B10	V3	05:15	V15	(06:05, 06:09, 06:12)
C3	B7	V4	05:20	V13	(06:04, 06:07, 06:10)
C4	B9	V6	05:35	V11	(06:02, 06:02, 06:02)
C5	B3	V8	05:45	V12	(06:01, 06:01, 06:01)
C6	B4	V9	05:48	V16	(06:10, 06:12, 06:18)
C7	B6	V11	05:55	V19	(06:15, 06:20, 06:30)
C8	B1	V12	05:58	V18	(06:10, 06:15, 06:20)
C9	B10	V13	06:00	V25	(06:20, 06:30, 06:45)

Reference: B. Montreuil, R.D. Meller et E. Ballot

Road-Water π-Hub designed for enabling distributed multi-segment transmodal transport of π-containers through the Physical Internet

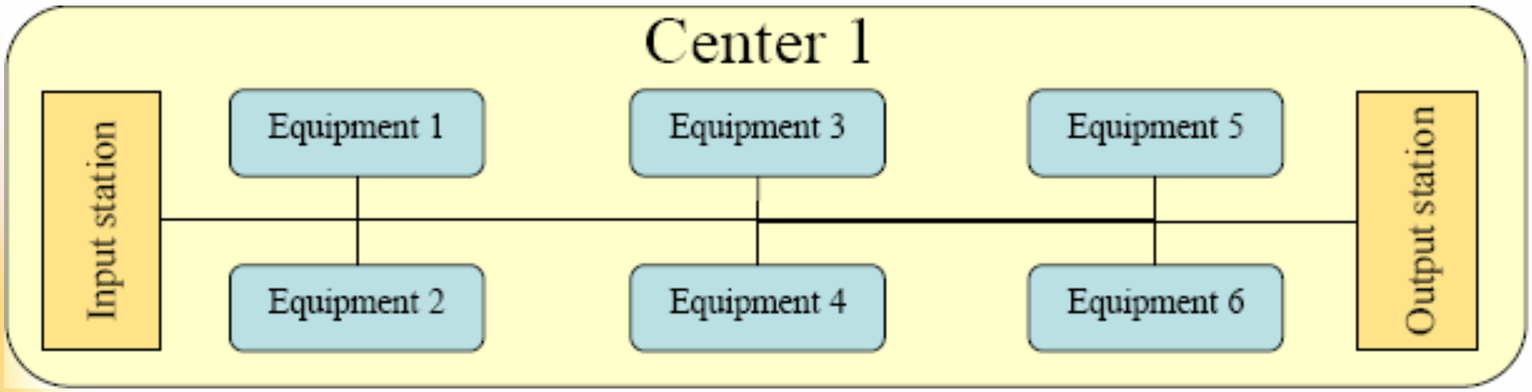


Reference: B. Montreuil, R.D. Meller et E. Ballot

Physical Internet

6. Embrace a unified multi-tier conceptual framework

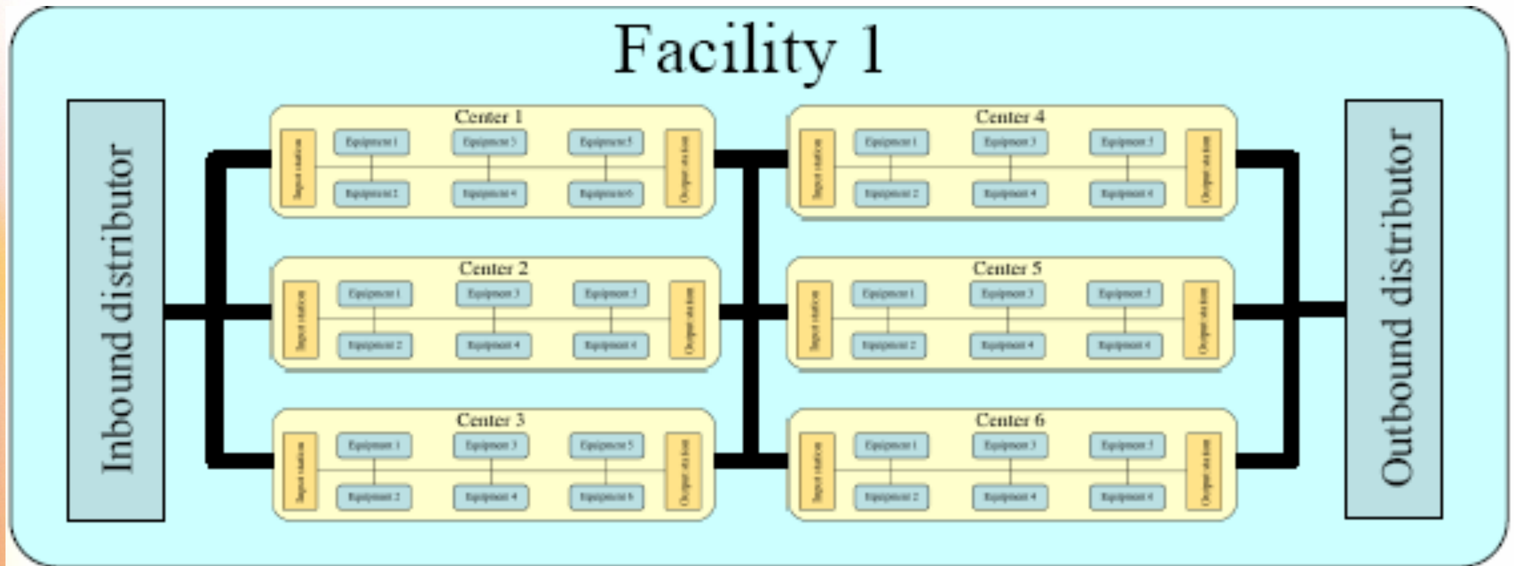
Intra-Center Inter-Processor Network



Physical Internet

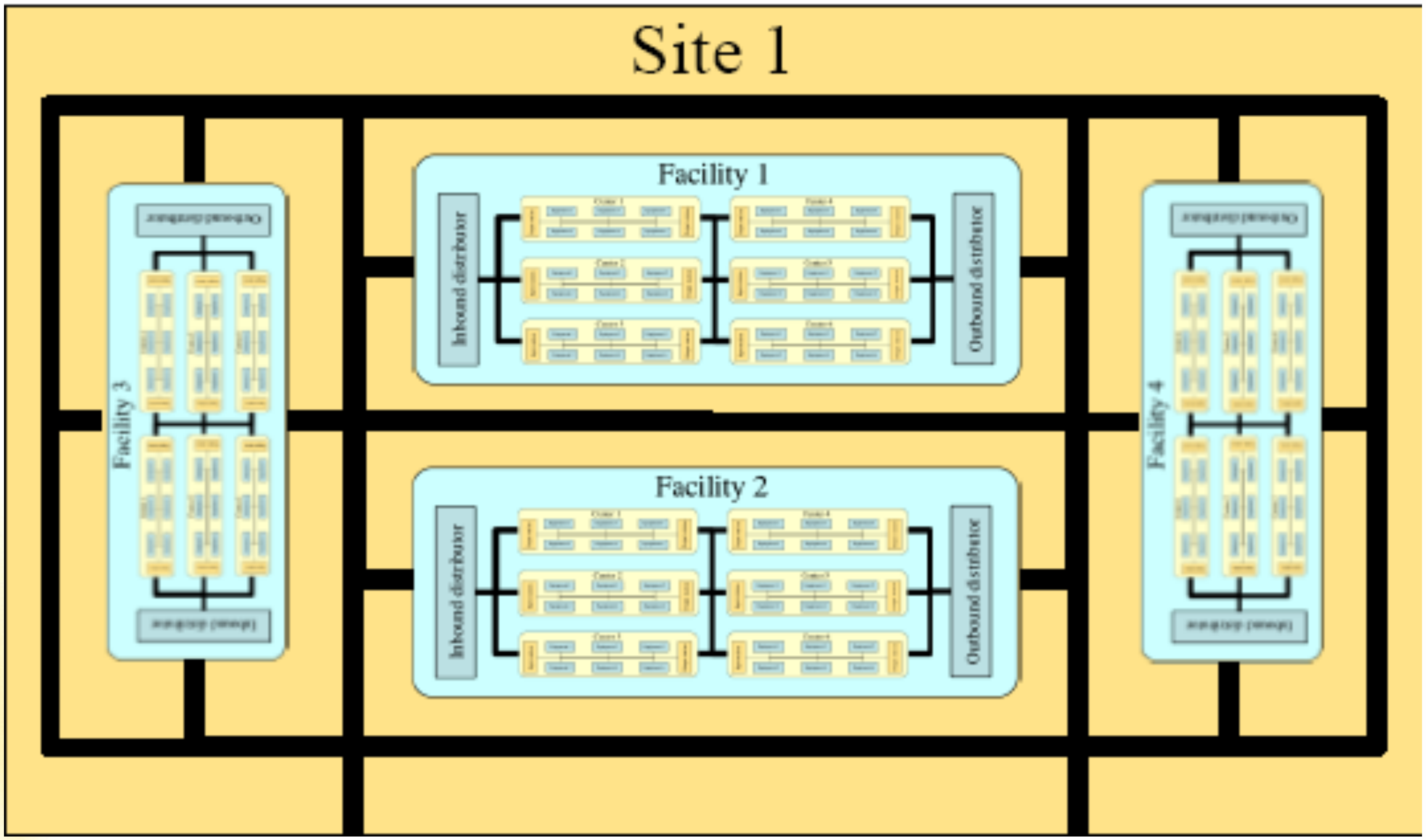
6. Embrace a unified multi-tier conceptual framework

Intra-Facility Inter-Center Network



Physical Internet

6. Embrace a unified multi-tier conceptual framework

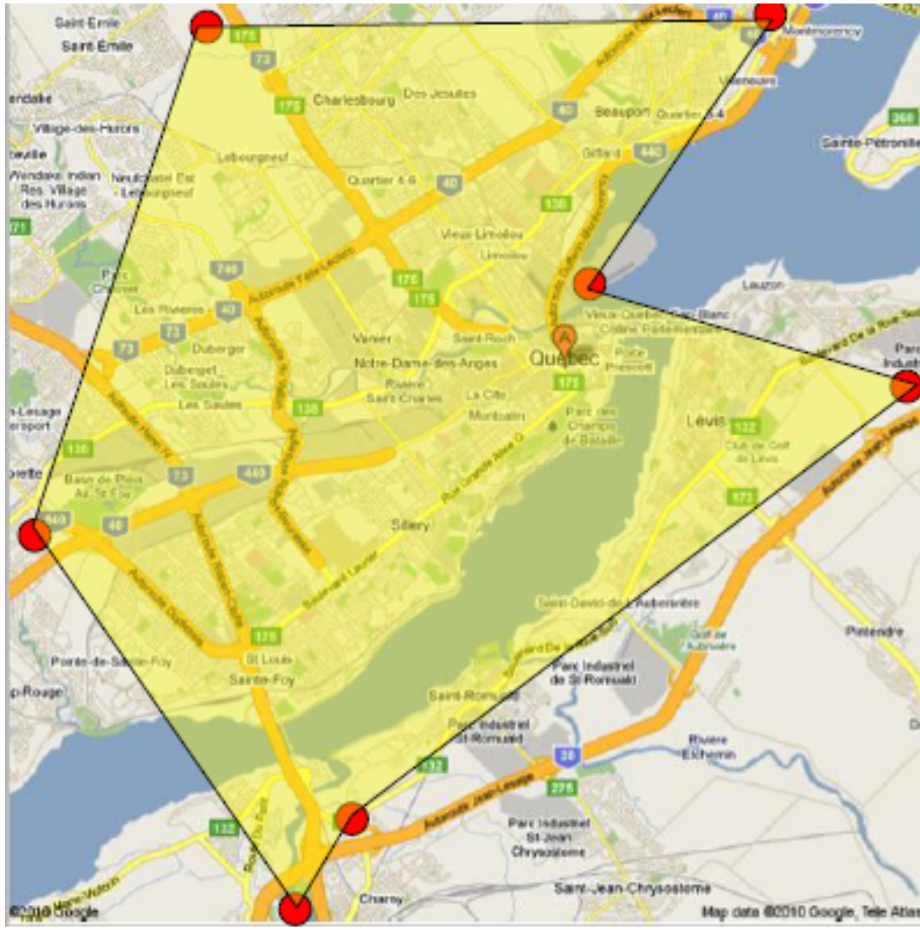


Intra-Site Inter-Facility Network

Physical Internet

6. Embrace a unified multi-tier conceptual framework

Intra-City Inter-Site Network



π-transits / π-hubs

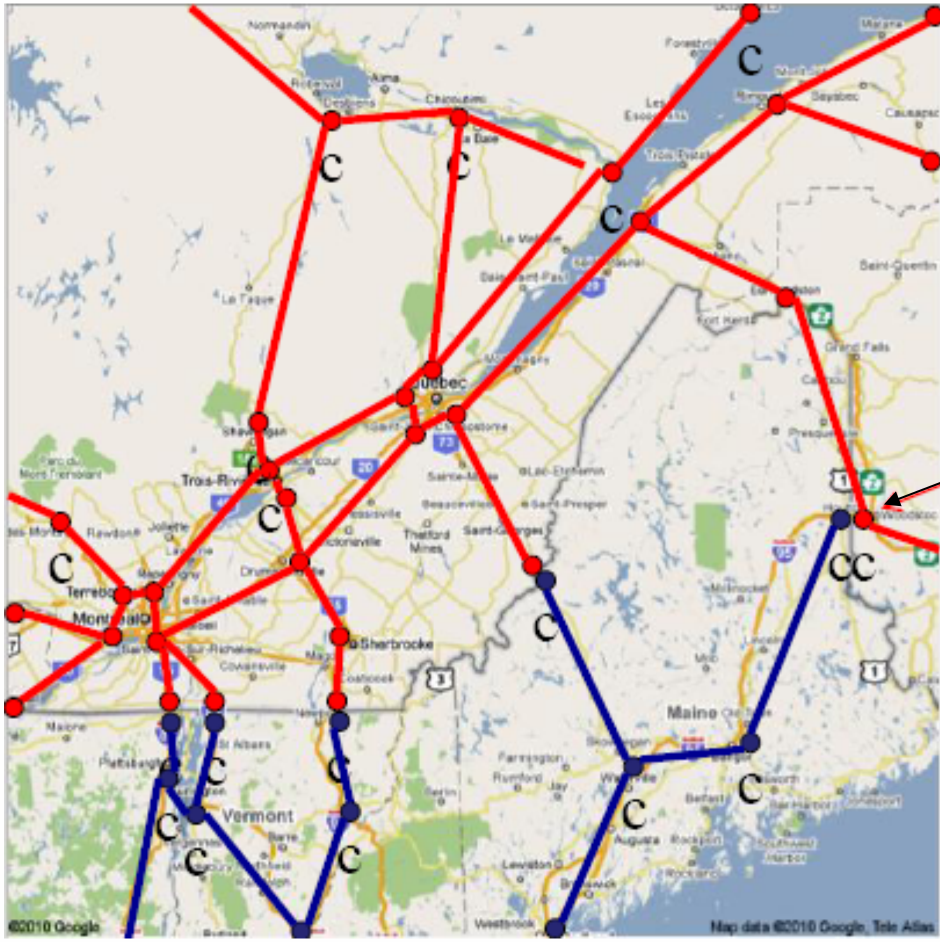
Toward π-enabled sustainable city logistics

Physical Internet

6. Embrace a unified multi-tier conceptual framework

Intra-State Inter-City Network

Québec, Canada

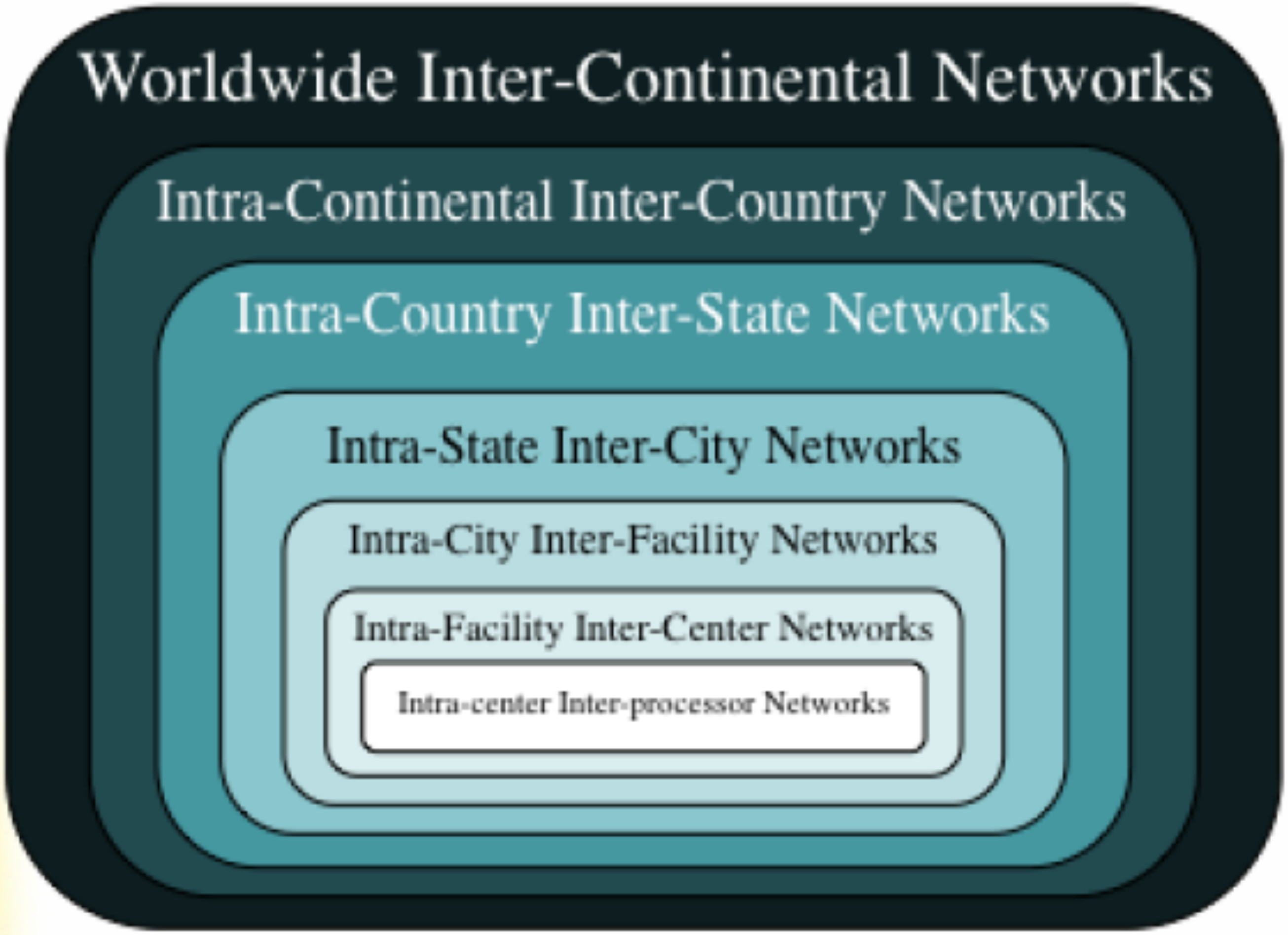


Transit nodes

North eastern states, U.S.A.

Physical Internet

6. Embrace a unified multi-tier conceptual framework



Physical Internet
7. Activate and exploit an Open Global Supply Web

**An open web of product realization centers,
distribution centers, warehouses,
hubs and transit centers
enabling producers, distributors and retailers
to dynamically deploy their π-container-embedded products
in multiple geographically dispersed centers,
producing, moving and storing them
for fast, efficient and reliable response delivery
to distributed stochastic demand for their products**

*Enabling Physical equivalents of
Intranets, Virtual Private Networks,
Cloud Computing and Cloud Storage*

References: Montreuil B., Labarthe, O., Hakimi, D., Larcher, A., & Audet, M. Supply Web Mapper. Proceedings of Industrial Engineering and Systems Management, Conference, IESM, , Conference Montréal, Canada, May 13-15, 2009
Hakimi D., B. Montreuil, O. Labarthe, "Supply Web: Concept and Technology", 7th Annual International Symposium on Supply Chain Management, Conference Toronto, Canada, October 28-30, 2009Montreuil, B., Hakimi, D. , B. Montreuil, O. Labarthe, "Supply Web Agent-Based Simulation Platform" Proceedings of the 3rd International Conference on Information Systems, Logistics and Supply Chain Creating value through green supply chains, ILS 2010 – Casablanca (Morocco), April 14-16<.

Contrasting Independent Supply Networks and an Open Supply Web

Factories: 4
DCs: 16
Max lead time: 3
Mean lead time: 1,75

Company 1

Factory: 1
DCs: 4
Max lead time: 3
Mean lead time: 1,73

Company 2

Factory: 1
DCs: 4
Max lead time: 3
Mean lead time: 1,78

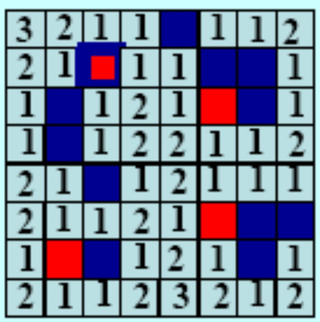
Company 3

Factory: 1
DCs: 4
Max lead time: 3
Mean lead time: 1,75

Company 4

Factory: 1
DCs: 4
Max lead time: 3
Mean lead time: 1,73

Open supply web with current DCs

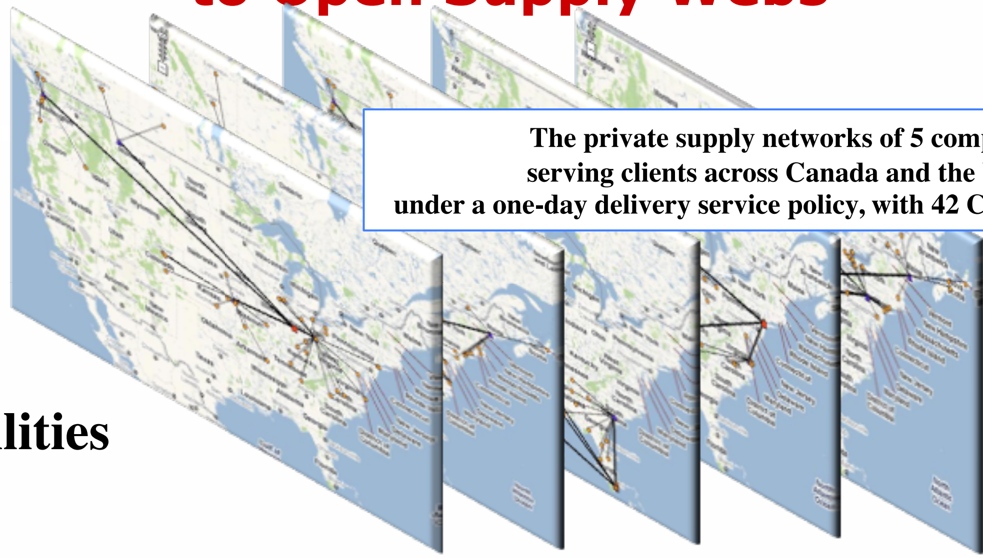


Factories: 4
DCs: 16
Max lead time: 3
Mean lead time: 1,08

Open supply web optimized DCs

Factories: 4
DCs: 3
Max lead time: 3
Mean lead time: 1,48

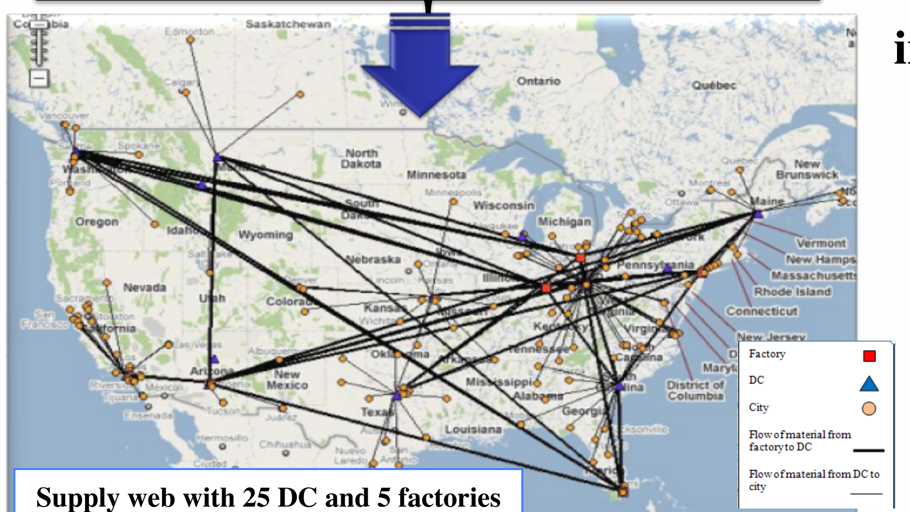
From Private Supply Networks to Open Supply Webs



The private supply networks of 5 companies
serving clients across Canada and the U.S.A.
under a one-day delivery service policy, with 42 CD and 5 factories

47 facilities

Insuring one-day delivery by each company in its served markets



30 facilities

Supply web with 25 DC and 5 factories

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

Physical Internet

8. Design products fitting containers with minimal space waste

Products designed
to minimize the load they generate on the Physical Internet,
with dimensions adapted to standard container dimensions,
with maximal volumetric and functional density
while containerized

Reference: Seliger G., "Sustainability in Manufacturing - Recovery of Resources in Product and Material Cycles" (Ed. by Günther Seliger, Sringer Verlag, 2007

Physical Internet
9. Minimize physical moves and storages by digitally transmitting knowledge and materializing products as locally as possible

Exploiting extensively
the knowledge-based dematerialization of products
and their rematerialization in physical objects at point of use

As it will gain maturity,
the Physical Internet is expected to have
ever more open distributed flexible production centers
capable of locally realizing for clients
a wide variety of products
from digitally transmitted specifications

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Physical Internet

10. Prioritize webbed reliability and resilience of networks

The overall Physical Internet network of networks should warrant its own reliability and that of its containers and shipments.

The webbing of the networks and the multiplication of nodes should allow the Physical Internet to insure its own robustness and resilience to unforeseen events.

For example, If a node or a part of a network fail, the traffic of containers should be easily reroutable, as automatically as possible

Reference: Peck H., "Supply chain vulnerability, risk and resilience", Chap. 14 in Global Logistics New Directions in Supply Chain Management, 2007

Physical Internet
11. Deploy capability certifications and open performance monitoring

Multi-level Physical Internet capability certification
of containers, handling systems, vehicles,
information systems
ports, distribution centers,
roads, cities and regions,
protocols and processes,
and so on

Physical Internet

11. Deploy capability certifications and open performance monitoring

Live open monitoring of really achieved performance
of all PI certified actors and entities,
on key performance indices on critical facets
such as speed, service level, reliability, safety and security

Such live performance tracking is openly available worldwide
to enable fact-based decision making
and stimulate continuous improvement.

Open information is to be provided in respect of confidentiality of specific transactions

Physical Internet
12. Stimulate business model innovation

Innovative business models
for commercializing
Physical Internet enabled offers by various parties,
including revenue models for the various actors

What are to be the π-enabled equivalents of Amazon, eBay and Google?

How are the manufacturers, distributers, retailers, transporters, logistics providers and solutions providers going to evolve so as to best exploit the Physical Internet?

Physical Internet
13. Enable Open Infrastructural Innovation

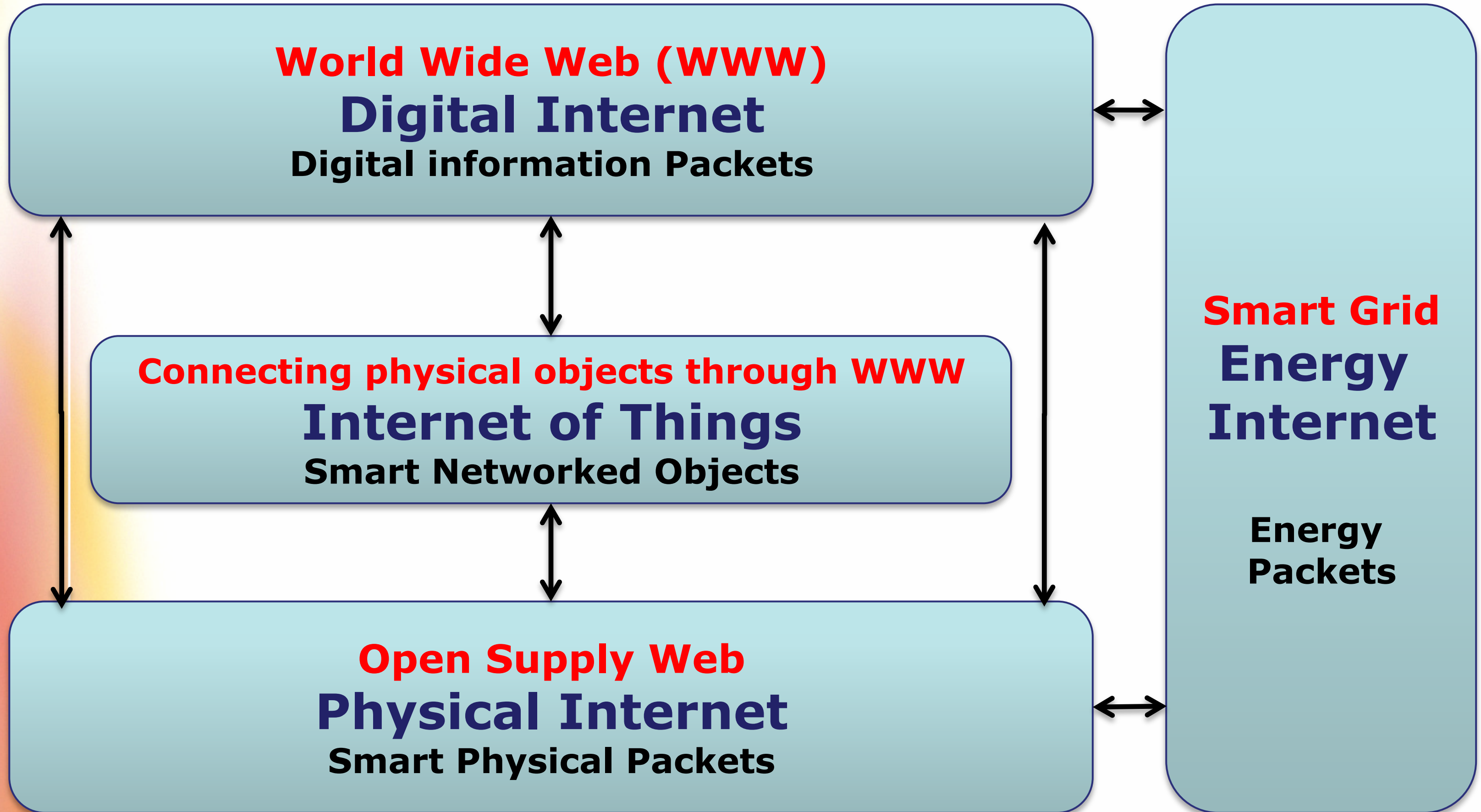
Systemic coherence and means interoperability must enable the transparent usage of heavy handling, storage and transport means currently existing or to come in the future, that are currently so hard to use, reducing their potential positive environmental impact

The Physical Internet homogeneity in terms of container modules encapsulating objects should allow a much better utilization of means, thus increasing the capacity of infrastructures by the exploitation of standardizations, rationalizations and automations through currently unreachable innovations.

Thirteen Key Features of the Physical Internet Vision

1. Encapsulate merchandises in world-standard modular containers
2. Aim toward universal interconnectivity
3. Evolve from material to container handling & storage systems
4. Exploit smart networked containers embedding smart objects
5. Evolve from point-to-point hub-and-spoke transport to distributed multi-segment transmodal transport
6. Embrace a unified multi-tier conceptual framework
7. Activate and exploit an open global supply web
8. Design products fitting containers with minimal space waste
9. Minimize physical moves and storages by digitally transmitting knowledge and materializing products as locally as possible
10. Prioritize webbed reliability and resilience of networks
11. Deploy capability certifications and open performance monitoring
12. Stimulate business model innovation
13. Enable open infrastructural innovation

Positioning the Physical Internet



Realizing the Vision

VISION

Evolving towards a worldwide **Physical Internet**

The Physical Internet:
Global systemic sustainable vision stimulating and aligning action around the world

- Individual initiatives by businesses, industries and governments are necessary but are not sufficient
- There is a need for a macroscopic, holistic, systemic vision offering a unifying, challenging and stimulating framework
- There is a need for an interlaced set of global and local initiatives towards this vision, building on the shoulders of current assets and projects, to help evolve from the current globally unsustainable state to a desired globally sustainable state

Physical Internet Implementation
Progressive Deployment, Cohabitation and Certification

- ☞ The development of such a systemic Physical Internet will not be achieved overnight in a Big-Bang logic but rather in an ongoing logic of cohabitation and of progressive deployment
  - As long as the actors find value in its usage
  - From the moment they will integrate the Physical Internet norms
- ☞ A smooth transition starting with rethinking and retrofitting, then moving toward more transformative phases
- ☞ The Physical Internet could therefore constitute itself progressively through the multi-level certification of:
  - Containers
  - Handling and storage technologies, distribution centers, production centers, train stations, ports, multimodal hubs
  - Information systems (e.g. reservation, smart labels, portals)
  - Urban zones and regions, inter-country boundaries

Physical Internet Initiative
Open collaborative networking

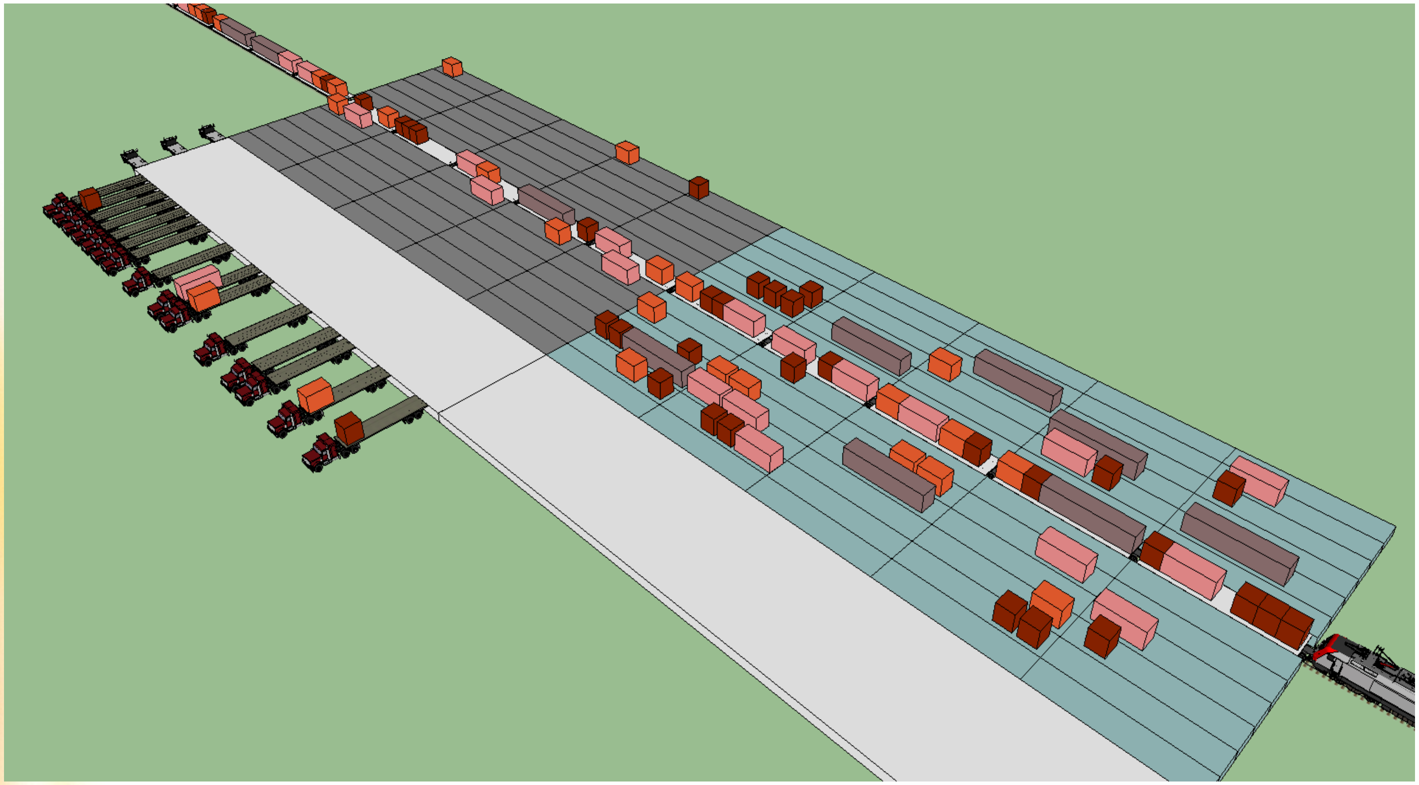
- A growing network of academic, industrial and institutional contributors
  - America:
    - Canada (CRRELT, Laval, Polytechnique Montréal, UQAM
    - U.S.A. (CELDI, U. Arkansas, Virginia Tech, Auburn U., Georgia Tech)
  - Europe:
    - France (Mines ParisTech)
    - Germany (Franhofer, Berlin TU)
    - Netherlands (Erasmus)
    - Switzerland (EPFL)
- Ongoing and in-the-works projects in Canada, France, Switzerland and U.S.A., involving about 20 companies
- Web site and collaborative space:

www.physicalinternetinitiative.org

Physical internet Initiative

OpenFret: a France-Switzerland-Canada collaborative research project focused on a sensitive problem in France

Designing Road-Rail Hub π-Hub for enabling distributed multi-segment transmodal transport of π-containers through the Physical Internet



Reference: B. Montreuil, E. Ballot, C. Montreuil et D. Hakimi

Physical internet Initiative
Ongoing work on the foundations

Founding principles
- Instrumentality
- Responsibility
- Metasystemization
- Openness
- Universality

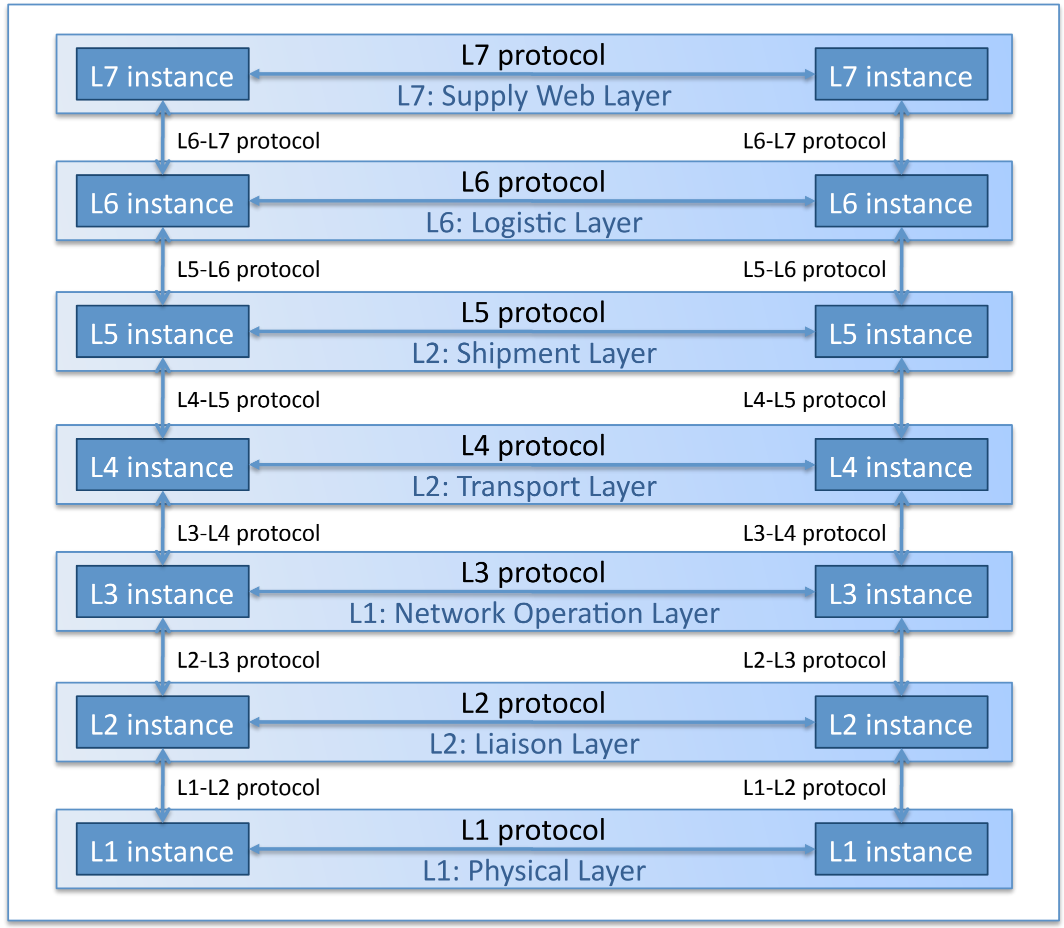
Organization principles
- Interconnectivity
- Uniformity
- Accessibility
- Unicity
- Encapsulation
- Agentification
- Contracting
- Certification

B. Montreuil, É. Ballot, R. Glardon : www.physicalinternetinitative.org

Physical internet Initiative
Ongoing work on the foundations

Open Physical System Interconnection OPSI Model

Layer	Digital Internet	Physical Internet
1	*Physical*	*Physical*
2	*Data Link*	*Liaison*
3	*Network*	*Network Operation*
4	*Transport*	*Transport*
5	*Session*	*Shipment*
6	*Presentation*	*Logistic*
7	*Application*	*Supply Web*



B. Montreuil, É. Ballot, F. Fontane

2010-2012: The acceleration

- **Realization of several major research projects**
  - Involving industrial and institutional partners
- **Emergence of demonstration projects in the field**
- **Extension of core research team**
  - **Domain scope:**
    - Deeper into and Beyond Industrial Engineering, Transportation, Logistic and Supply Chain Management
    - Towards Business, Human, Legal, Social, Urban domains
    - Mechanical, civil, automation engineering and IT
  - **Application area:**
    - Container, Handling systems, Ports, Cities, etc.
  - **Geography:**
    More within countries, more countries, more continents
- **Buildup of community and momentum**
- **Next-stage initiative structuring and financing**

Prospects

- So much to do!
- So much potential impact in the world!

- So many stakeholders!
- So much passion to generate, align and nurture!

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Conclusion(1/2)

This presentation has outlined a bold paradigm breaking vision for the future of how we handle, store, transport, realize, supply and use physical objects across the world

It proposes to exploit the Internet, which has revolutionized the digital world, as an underlying metaphor for steering innovation in the physical sphere

The outlined Physical Internet does not aim to copy the Digital Internet, but to inspire the creation of a bold systemic wide encompassing vision capable of providing real sustainable solutions to the global problems associated with the way we are currently operating and heading

Conclusion(2/2)

**A small step has been made here,
a lot more are needed to really shape this vision
and, much more important,
to give it flesh through real initiatives and projects
so as to really influence in a positive way
our collective future**

**A lot of collaboration
between academia, industry and governments
will be necessary, across continents, countries and localities**

Your help is welcome

www.physicalinternetinitiative.org

Questions and comments are welcome

Benoit.Montreuil@cirrelt.ulaval.ca

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