Towards a worldwide Physical Internet

Mustapha Lounès / Benoit Montreuil // Canada

Aiming for a radical sustainability improvement, the Physical Internet Initiative (PI2) has the potential of revolutionizing the fields of material handling, logistics, transportation, and facilities design. It exploits the enabling concept of standardized, modular and smart container as well as the universal interconnectivity of logistics networks and services. Its underlying paradigm shift creates a tremendous breakthrough innovation opportunity for the material handling and facility logistics community in terms of equipment, systems, and facility design and operation.

The Physical Internet is a new paradigm that has the potential of revolutionizing notably the fields of material handling, logistics, and facilities design. This paradigm shift is based on the claim that „the way Physical objects are moved, handled, stored, realized, supplied and used throughout the world is not sustainable economically, environmentally and socially." To support this claim, Montreuil presents thirteen bold „unsustainability symptoms" (www.physicalinternetinitiative.org). Vehicles, carriers, and facilities are e. g. often substantially under- or wrongly utilized. As an illustration, road-based freight transportation services have been shown to have a less-than-10% overall efficacy. Furthermore, truckers have become the modern cowboys, fast and reliable multimodal transport is mostly a dream, and intra-city logistics is generally a nightmare with congested infrastructure.

Overall, modern economies have increased their dependence on transportation and logistics. This is leading to exponential growth in freight flows. In France e. g. a freight transport growth of 37 % is expected from the 2005 to the 2025 horizon forecasts, and for OECD countries the progression is the same. In developed countries, freight transportation is already responsible for nearly 15% of greenhouse gas emission such as CO_2 and this ratio is increasing despite ambitious reduction goals.

In view of these symptoms, the goal of the Physical Internet is to „enable the global sustainability of physical object movement, handling, storage, realization, supply and usage."

This draws away development and optimization from the multi-modality of the road, rail, maritime, and air transportation while supporting a co-competition culture between all stakeholders concerned (companies that are concurrently co-operating and competing as suppliers, business partners, competitors, and customers, are all in the same supply web). In order to achieve this objective and increase the accessibility of transportation options by enlarging the choices among modes of goods' movements, Montreuil proposes a radical sustainable improvement, the Physical Internet, a new paradigm that has the potential of revolutionizing, notably, the fields of material handling, logistics, transportation and facilities design (figures 1, 2 and 3).

Physical Elements of the Physical Internet

The three key types of physical elements enabling the Physical Internet are the containers, the nodes and the movers, as can be seen in figure 1.

Containers are the fundamental unit loads that are moved, handled and stored in the Physical Internet. As illustrated in figure 2, Physical Internet Containers come in modular dimensions. The nodes correspond to the sites, facilities, and physical systems of the Physical Internet. Figure 1 identifies a set of node types. The movers transport, convey or handle containers within and between nodes of the Physical Internet. They also come in a variety of types, as highlighted in Figure 1.

Evolving towards a worldwide Physical Internet - The impacts on Logistics and Transportation, Facilities and Material Handling Systems Design

Nowadays, logistics is at the same time very competitive but also very controversial for the generated negative externalities. Within this framework, growing freight transport aggravates congestion, accident, pollution, and noise risks. Forecasts predict that traffic levels will continue to raise significantly, especially freight traffic. It is important to work towards a form of mobility that is sustainable, energy-efficient and respectful of the environment. This means, that transport is to be made environmentally acceptable and climate-friendly, socially responsible and, at the same time, economically efficient.

In an ideal world all vehicles would run fully laden on every kilometre travelled. In this framework, freight transportation should involve intermodal freight transport in modular containers (Figure 2), using modes of transportation (truck, rail, ships, and planes) without any handling of freight itself when changing modes (Figures 1, 5, 6 and 7). This can be achieved by the deployment of the Physical Internet containers that combines standardized modular and smart containers with new logistics protocols and business models, resulting in a collaborative, highly distributed and leveraged logistics and distribution system. Thus, goods are containerized in containers of modular dimensions and, as data packets in the Digital Internet, are routed using their Physical Internet

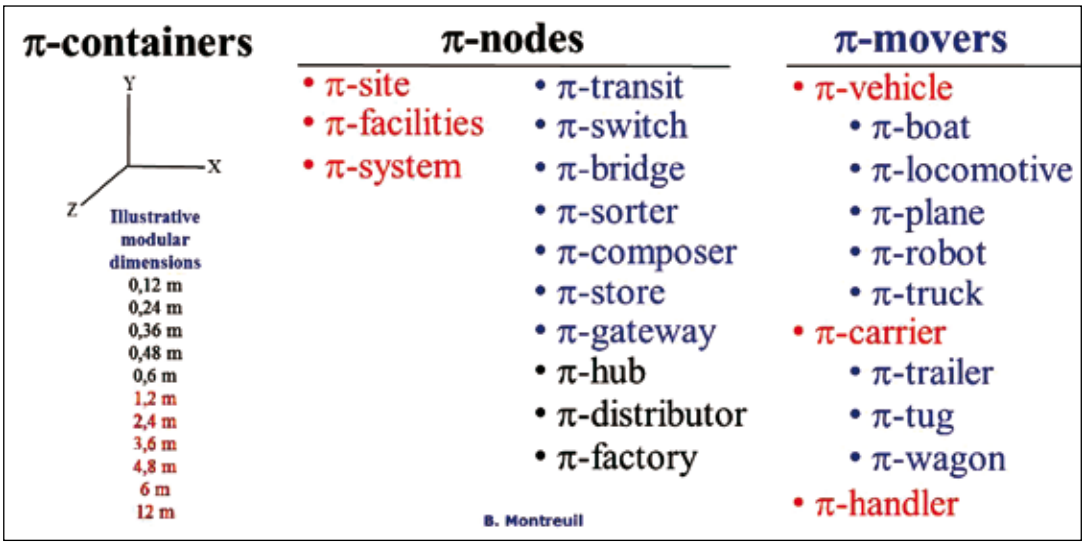

Figure 1: π-Elements of the Physical Internet

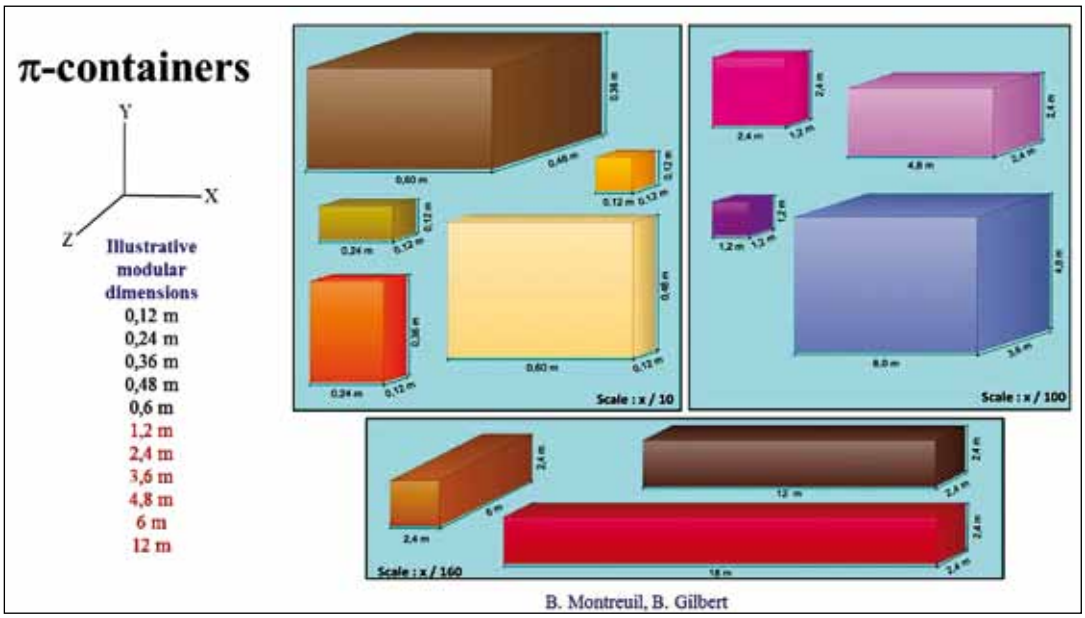

Figure 2: π-Container: Dimensionally and functionally modularized and standardized worldwide

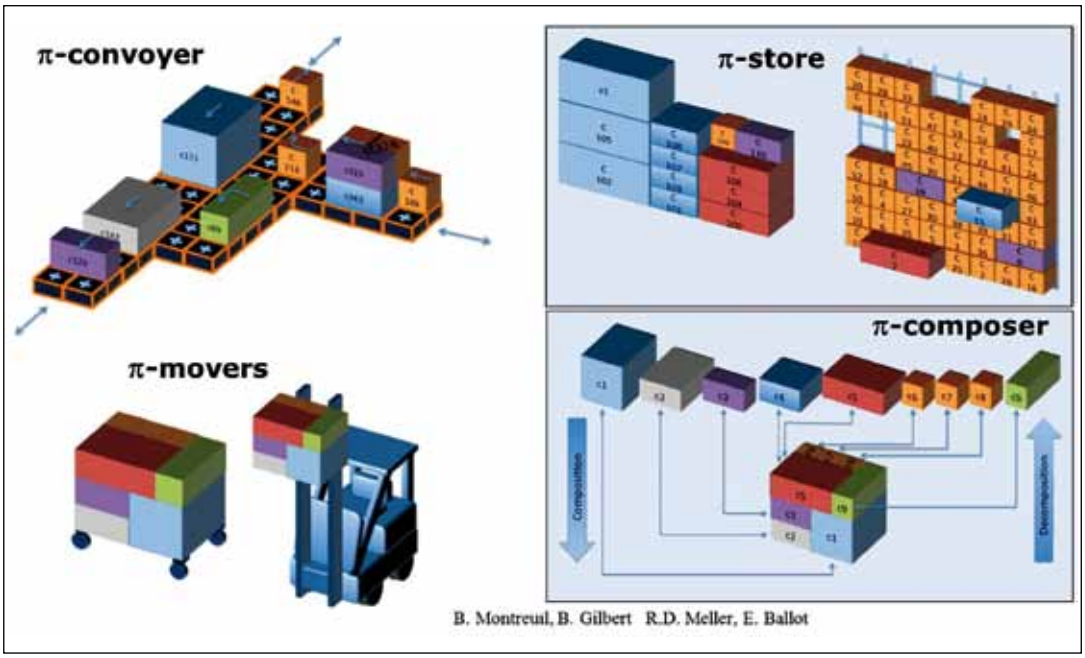

Figure 3: Evolve from material to π-container handling & storage systems

identifier towards their destination using highly efficient, shared transportation, storage, and handling systems. The use of the Physical Elements (figure 2) of the Physical Internet will significantly improve security, reduce damages and losses and simultaneously allow freight to be transported faster through the physical hubs.

The core of the PI2 (figure 4) is that with market-based voluntary standardization the entire system will gain efficiency. This may be best illustrated through a simple example: A supplier that currently distributes to U.S. customers through a network with 10 DCs, illustrated by figure 4(a), now has the opportunity to distribute through a combined network with hundreds of DCs, as illustrated in figure 4(b). Clearly, the combined network will be more efficient in many ways (assuming that any drawbacks associated with „hand-offs“ are addressed).

In the PI2, we are claiming that most of the symptoms enumerated in the prior section can be dramatically improved through the PI2.

For example, we hypothesize that up to 70% of trailer emptiness can be removed from transportation — while at the same time, there may be a 30% increase in the number of loaded (vs. unloaded) miles driven. In conjunction, the velocity of the supply chain can be increased so that pipeline inventories and the amount of goods stored along the way could be reduced. The economic, societal, and environmental impacts of a successful conceptualization and implementation of the PI2 are expected to be transformative.

That said, the PI2 cannot be realized without the widespread participation of the industry. There are many questions to answer, and all of them will need to be populated with industry data, as well as scrutinized and assessed by the industry. In short, significant industry collaboration and involvement will be necessary for this research effort to be successful.

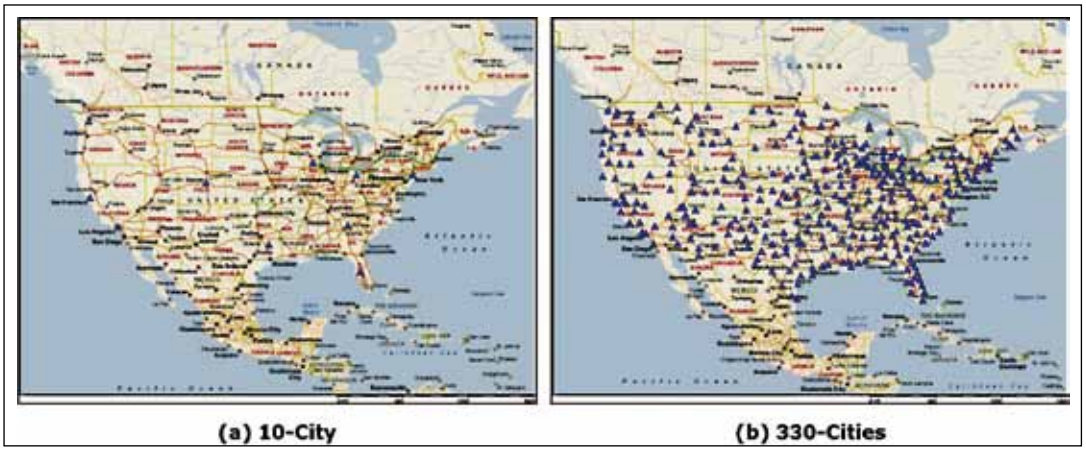

Figure 4: Distribution Networks

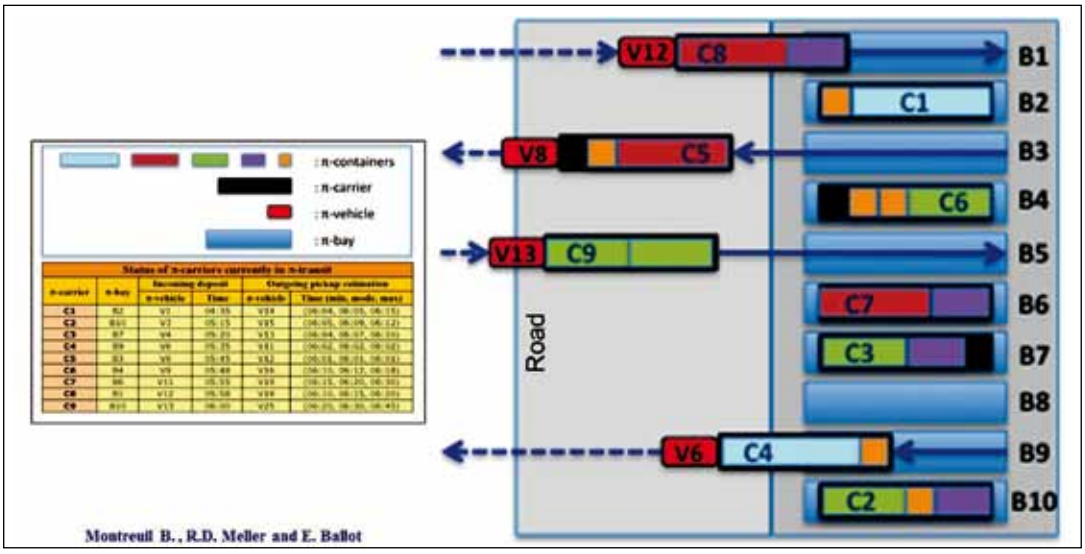

Figure 5: π-Transit sites allowing distributed multi-segment transport through the Physical Internet

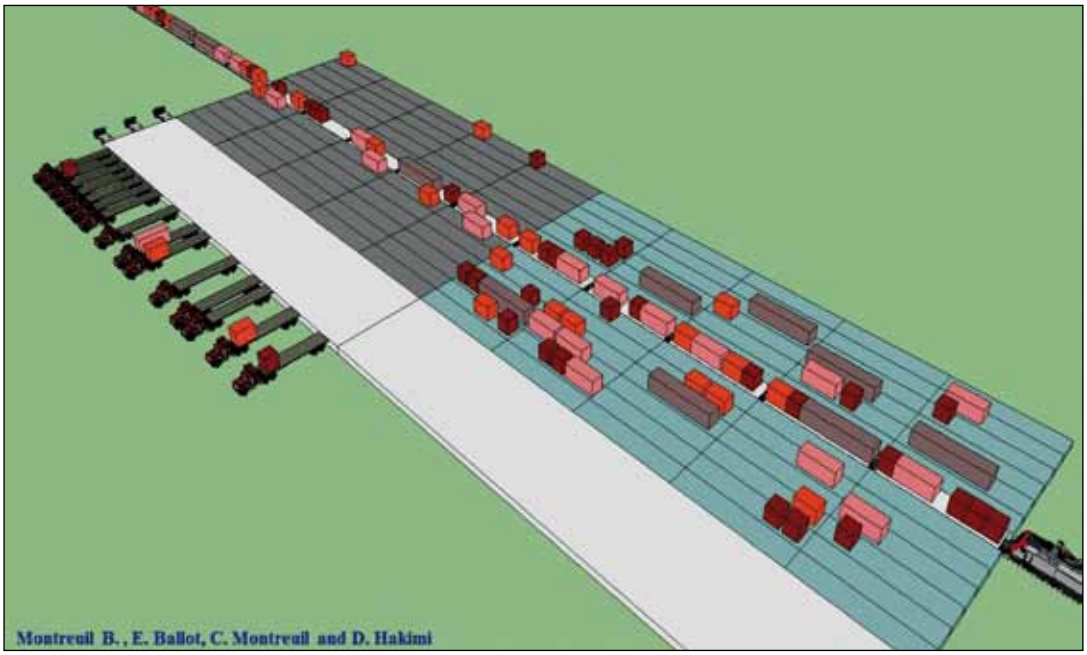

Figure 6: Road-Rail π-Hub designed for enabling distributed multi-segment transmodal transport of π-containers through the Physical Internet

Conclusion

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

Until now, only a small step has been made for the PI2, more are needed to shape this vision and, much more importantly, to give it flesh through real initiatives and projects

Physical Internet Simulation Laboratory

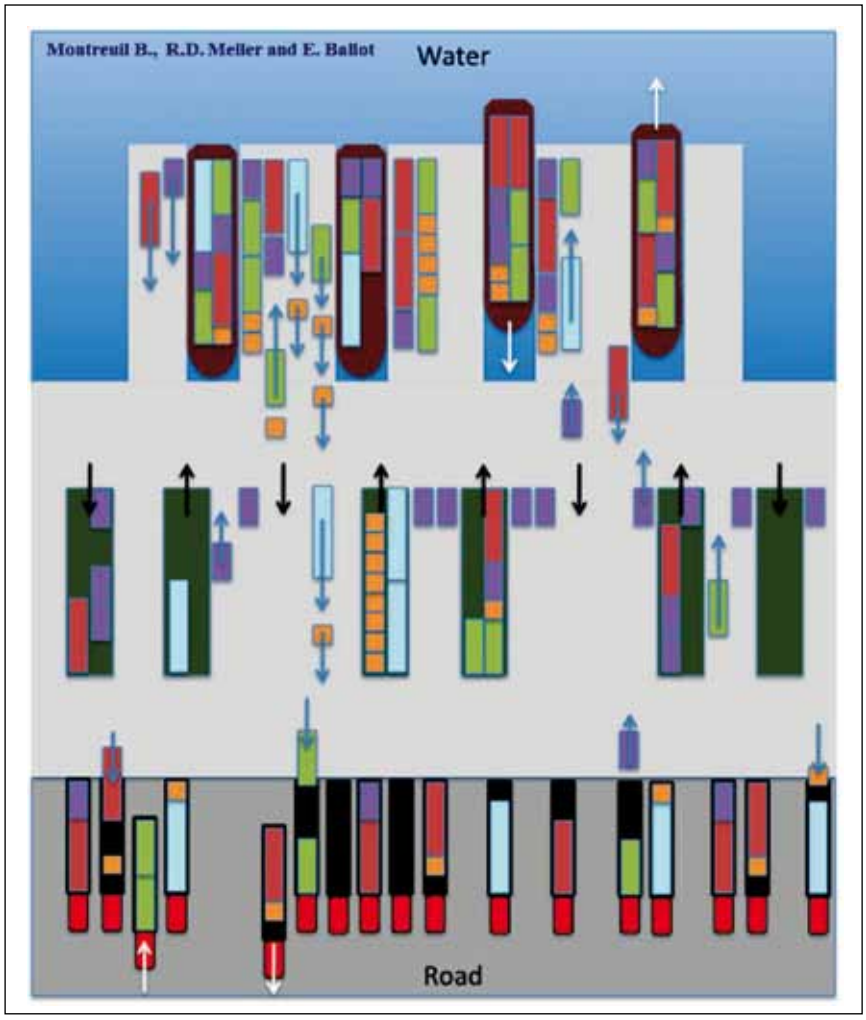

Figure 7: Road-Water π-Hub designed for enabling distributed multi-segment transmodal transport of π-containers through the Physical Internet
Illustrations: Authors

so as to influence our collective future in a positive way. Intensive collaboration between academia, industry and governments will be necessary, across continents, countries and localities.

The domain scope for future Physical Internet research, development and innovation is wide.

It encompasses the fields of logistics, transportation, supply chain management and operations research; industrial, mechanical, civil, software and automation engineering; information and communications technology; as well as the business, human, legal, social and urban fields to name a few.

Dr. Mustapha Lounès
Prof. Dr. Benoit Montreuil
Laval University
Quebec/ Canada
Mustapha.Lounes@cirrelt.ca
www.physicalinternetinitiative.org