Future Hubs on the Background of the Physical Internet Implementation

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The Physical Internet (PI) is the matter of time. There is not any other concept of future logistics so simple and so complicated at the same time. Simple, because we all do it now with data. Complicated, because goods are not as flexible as figures. The range of required transformation of hubs technology before implementing of the Physical Internet is massive. Some technologies require only modification, other inventions, not possible nowadays. But it can be assumed that from technological point of view it will be possible to improve the hubs to the required level till 2050. There is still an unsolved matter of financing and organization.

Keywords: The Physical Internet, hub, terminal.

1. INTRODUCTION

The Physical Internet (PI) is the matter of time. There is not any other concept of future logistics so simple and so complicated at the same time. Simple, because we all do it now with data. Complicated, because goods are not as flexible as figures. There are attempts to involve future hubs into the Physical Internet, but still on a highly theoretical level. How will today's hub transform into PI hubs? Which services should be created, which will evolve.

2. THE IDEA OF THE PHYSICAL INTERNET

The way in which data are transferred now is widely known. The idea of the Physical Internet inventors and supporters is to shift the way of data transfer into supply chain. PI of physical goods means decentralization, redundancy, disperse responsibility and direct things communication (the Internet of Things), on the other hand easy access, proven technology (on the data exchange field) and flexibility.

The Physical Internet is a sustainable solution serving the organisation of supply chains, based on an open network available to all interested parties[1].

The main purpose of the Physical Internet implementation is the reduction of the logistic capacity of nodes (hubs) and rationalisation of linear infrastructure which is a straight response to the provisions of the White Paper on Transport (Directorate – General for Mobility and Transport).

There are many question marks to resolve before PI implementation, including the form of open cooperation, packages standardization (and transport of oversize packages) and availability of handling technology in hubs.

3. HUBS IN PI

From the physical logistics point of view the Physical Internet should lead to multi-functionality of network nodes. Hubs functionality should be significantly increased and finally all function should be automated. The theoretical idea of future hubs is described in publications (e.g. Ballot, Montreuil, & Meller, 2014), but the first step has to be made.

One of the assumptions of the Physical Internet is standardization of load units, starting with S containers of actual parcel size, to XL containers, which can be compared with today's standard 20 or 40-feet containers. In between there are "slices" of XL container – L size, and M size containers, similar to pallet units. Additional assumption is

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[1] from www.modulushca.eu

that all PI containers will fit into each other, creating bigger ones, similarly to the packages of data. Full standardization is a must. The suitable sizes of PI containers as open standard are complemented by full real time identification and routing via open hubs (based on www.modulushca.eu). Hubs managers are standing in front of a demanding challenge.

The complexity of hubs' types in the PI can be described by table of their types and sizes of PI containers handled (see Table 1). In the table over 20 basic hubs types can be indicated, without considering the size of containers served. In reality many basic functions will be offered by single multimodal hub.

Table 1. Types of hubs required between modes and according to the size categories independent of the types of service networks.

Hub types	Ship	Train	Barge	Aircraft	Truck	Light vehicle	Manual*
Ship	L: ✓ M: S:	L: ✓ M: S:	L: ✓ M: S:	Ø	L: ✓ M: ✓ S:	Ø	Ø
Train		L: ✓ M: S:	L: ✓ M: ✓ S:	L: ✓ M: ✓ S:	L: ✓ M: ✓ S:	L: ✓ M: ✓ S:	Ø
Barge		L: ✓ M: S:	Ø	L: ✓ M: ✓ S:	L: ✓ M: ✓ S:		Ø
Aircraft				L: M: ✓ S: ✓	L: M: ✓ S: ✓	L: M: ✓ S: ✓	L: M: S: ✓
Truck					L: ✓ M: ✓ S: ✓	L: ✓ M: ✓ S: ✓	L: ✓ M: ✓ S: ✓
Light vehicle						L: ✓ M: ✓ S: ✓	L: M: ✓ S: ✓
Manual*							L: M: S: ✓

* Manual = on foot, bike, etc.

Source: (Ballot, Montreuil, & Meller, 2014)

As an example the bimodal hub simplified concept was created by Ballot, Montreuil and Meller (2014). The authors have even prepared detailed concept and reloading process, including preliminary selection of technology.

The conclusion is clear – the logistic network, including its nodes, has to be ready for the Physical Internet. There is even a preliminary timetable of implementation, which assumes full functionality of the PI in the year 2050 in fast movable consumer goods logistics. The time horizon is long, nevertheless hubs should start preparations.
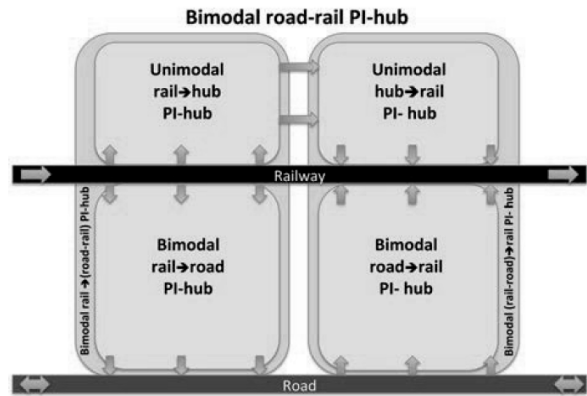

Fig. 1. Simplified conceptual model of a road/rail PI-hub.
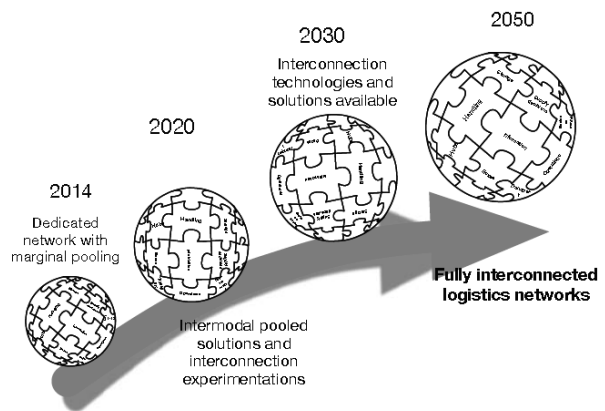*Source: (Ballot, Montreuil, & Meller, 2014).*

Fig. 2. Illustrating the path with 3 milestones between interdependent subsystems of actual logistics towards the target Physical Internet logistics system for FMCG.
Source: (Modulushca.eu, 2014).

4. HUB CHALLENGES

The first challenge are PI containers. The innovative containers turnover is connected not only with reloading, but additionally with decapsulation / encapsulation (which in logistics means deconsolidation and consolidation of load units) and whole return logistics of empty containers, including responsibility for containers availability on demand of customers. The idea of containers assumes their modularity, which means, among others, the possibility of 'folding' to reduce volume of the unproductive return transport. But still the capacity for empty containers stock and return transport is unavoidable.

The second challenge is taking part in the open network. Hubs have to be prepared to interconnectivity with other network nodes - glocal (global + local) planning, financing, performance and liability. Even working hours and availability

of resources must match the requirements of the network. Harmonising with the global conditions will lead the hub to highest level of cooperativity. Maintaining a high level of performance requires a considerable amount of work, investments and daily outlays.

The last challenge is communication to second power. Involvement in global network requires huge among of data to exchange, store and secure. One wrong element of the communication network will lead to congestion in the whole system, with scale wider that only one hub. And will probably lead the hub out of the PI network. To minimize the interruption of the supply chain the certification will be required, meaning entry barrier to, the so called, open network.

5. MAIN HUB TYPES

In the scope of HubHarmony (Harmonization benchmark for inland multimodal hubs)[2] project the three main types of inland hubs have been identified:

- dry port, responsible for connection of the sea port with other hubs,
- inland terminal, as intermediary between dry ports and freight centres,
- freight centre, the direct "plug" of customers to the Physical Internet

operational procedures harmonization evaluation and scope of service offers at inland multimodal hubs. It will create a clear evaluation methodology to support future harmonization efforts[2].

Types of the inland hubs can be differentiated be supported modes:

- dry port served mainly trains, barges and trucks,
- inland terminal mainly trucks, trains and barges,
- freight centres mainly trucks, light vehicles and manual mode.

The above division is consistent with the supported PI containers for three main inland hubs, as shown in table 2.

Table 2. Sizes of the PI-containers, serviced in particular hub types.

Size of PI-containers handled	Hub type			
	Sea port	Dry port	Inland terminal	Freight centre
XL	100%	95%	30%	5%
L		5%	65%	20%
M			5%	40%
S				40%

Source: Hubharmony project materials.

HubHarmony aims to develop a better understanding of sustainable transport systems, through development of a harmonization benchmark for multimodal hubs and to improve hub processes and gain synergies from the hub network. Project main goals is benchmark of
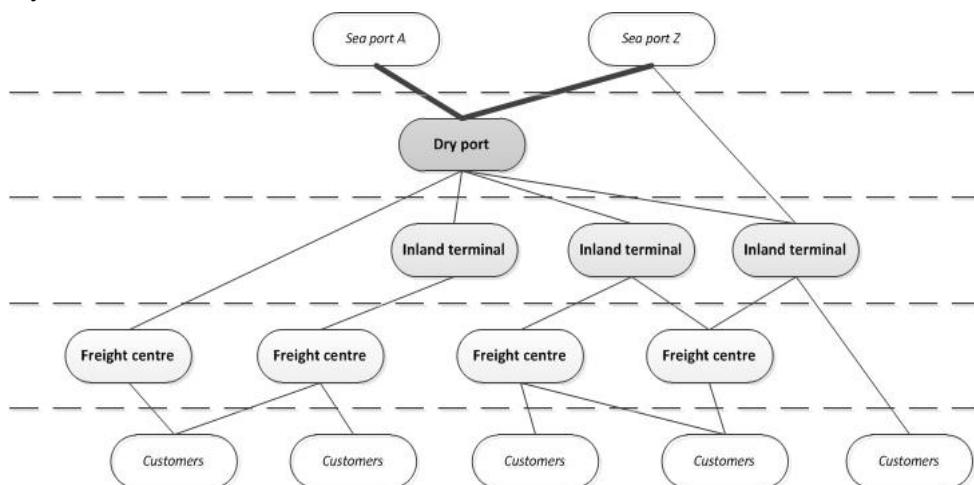
Fig. 3. Draft of three different types of inland terminals.
Source: Hubharmony project materials.

6. FUTURE HUB SERVICES AND THEIR FUNCTION

The Physical Internet will lead to the implementation of additional services, required to execute its ideas. Taking into consideration the idea of the PI described above the new services can be connected of communication and PI containers handling.

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[2] www.hubharmony.eu

First of all even open system have be managed. This means it will require management and coordination. This part of the PI system will require human activity, as minimal as support for a developed IT system. The service will still be necessary with the scope defined during phases of the PI system formation.

The PI will require additional IT support. The entire system should arise from many local systems – it is unimaginable to create one huge system. This means an expanded net of interfaces, ready to cooperate with outside customers. The range of services is very wide, starting from everyday PI-containers turnover management, through planning and forecasting, to massive databases with historical data.

The currently used most popular bar codes are not enough to identify a smaller PI-container encapsulated inside the bigger ones. The technology, not used today, will allow to recognize every item or a PI-container, which will be crossing the gates of hub. In this way, full access to the data indicating flows will be possible. Nowadays, available technologies, e.g. RFID (Radio Frequency Identification) – identification with radio waves usage (Czerniawski, 2010) are not exact or powerful enough to penetrate some materials (e.g. water, steel), whereas it is possible to read tags attached on the outer container now.

Efficient stuffing requires planning and deciding which size of container(s) will be appropriate. With assumption of limited PI-containers size range, the software of stuffing planning is required. The service of PI-containers fulfilment calculation and simulation is supplement, offered on the open market for customers without access to dedicated software.

In all logistics processes, mistakes happen. Automatics will minimalize "human" factor influence, but still some margin of mistake has to be taken into consideration. It is required to equip every PI-container (minimum L size ones) with sensors (impact, humidity, temperature etc.), informing immediately about any hazard to safety. This will help to identify place, time and source of mistakes and eliminate it.

XL and M containers can be handled with dedicated equipment (fork-lift-trucks, reach stackers etc.) or manually (S size ones). M-size containers are similar to pallet units (goods form on wooden pallet for fork-lift-truck support) and there are available solutions prepared especially for transport with wooden pallets. This technology can be adopted for L containers, too.

Nonetheless, the additional size PI-containers, which are not popular or used till now, will require additional equipment to manipulate.

Similarly, the same as in the case of mechanical manipulation, automatic handling of M (as pallet units) and S (as boxes) PI-containers is widespread today. There are some solutions of automatic guided vehicles (AGVs) for containers handling, but rather on the prototype level. Finally, solutions of automatic handling of XL and L containers are issues that need to be developed in the near future.

The PI implementation will lead to minimization of total inventory in the supply chain nodes. Nevertheless, it is impossible to eliminate the stock completely. The stock of containers (full and empty) has to be taken into consideration.

Nowadays, distribution warehouses are mainly prepared to store pallet units, while containers are usually stored on storage yards. The new solutions, related to storage of untypical (for today) storage units, will be required along with dedicated technology, which means adapted (fork-lift)-trucks, reach stackers, stacker cranes and racks.

Folding and unfolding solutions exist only for S containers today. The idea of the Physical Internet bases on the return transport of reusable containers. To reduce the return transport volume, folding of the other containers is crucial.

Probably it will be possible to fold (and unfold) the M-size containers manually. In case of XL and L containers the special equipment has to be invented, or the existing ones have to be adapted. There are attempts to fold XL containers as an invention of last years. To fold XL container, an adapted fork-lift-truck, cranes and reach stackers are used. There is still no solution, prepared for L containers.

Fig. 4. Foldable container example.
Source: www.staxxon.com

One of the basis of the Physical Internet concept is automation of flows. One of the most complicated tasks for automats (in this case - robots) is stuffing and unstuffing (encapsulation

and decapsulation) of M and L size containers. This operation requires not only specialized equipment, but a special logic, too. Additionally, the equipment for stuffing M containers will be, probably, different than for stuffing of containers of L-size. The first operation can be made alternatively manually, while the second one - with some difficulty with adapted equipment.

According the PI ideas all containers before passing them into the Physical Internet network have to be hermetically closed, to avoid unwanted exchange of fluids and odours. The assumption is that equipment, dedicated to this activity, will be necessary. As a result, the service of hermetic encapsulation (and decapsulation) have to be invented.

Additional service related to PI is coupling of L containers as slices of XL size PI-containers. It is possible to imagine equipment for handling loose L containers as one XL container with new, invented handle. But it requires huge changes in a port and a terminal. Alternative solution is coupling (some way) the L container into XL container, which then can be handled with existing reach stacker. Nevertheless, some L containers require power connection, what can be important barrier for full automatization.

Today, before loading, every container should be checked in terms of weight and correct goods alignment. Similar service should be offered for planned XL, L and M PI-containers, what will assure stability of goods during transportation, in any mode. Control in case of L and M containers requires dedicated equipment which need to be invented or adapted.

The usage of returnable containers requires stable access to the stock of empty containers. The balance of containers will require reverse logistics organization and management. One of the most important services will be reverse logistics of empty containers, understood as assurance of full access to empty containers on demand.

Full support will require complicated logistics services e.g. storing and transport with advance planning and forecasting. Independently from expenses, all containers should be available for every PI user on demand with assumed time of reaction.

All PI-containers will require to be serviced, e.g. assembly, cleaning, hygienisation, repairing and finally utilization. The services will be offered on a wider scale than today for many different types of containers. This lead to demand of wider and most sophisticated services than today. The services will depend not only on the size and type of container, but also on its previous and future content.

The range of required transformation of hubs technology before the implementation of the Physical Internet is massive. Some technologies require only modification, others inventions, not possible nowadays. But it can be assumed that from technological point of view it will be possible to improve the hubs to the required level till 2050. There is still the unsolved matter of financing and organization.

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