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PHYSICAL INTERNET IN WAREHOUSE ON THE BACKGROUND OF GHG EMISSIONS

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Abstract. An excessively strict level of reducing the emission of greenhouse gases is a serious challenge to broadly understood logistics. Alternative ideas for reducing the emission of toxic substances in the area of supply chains are sought. Will the Physical Internet, a brave and right idea, be one of the answers? Persuading companies into cooperation and creating innovative technological solutions in the PI-nodes of individual levels are, however, a question of strategic significance, to be settled in the long years to come. The assumed level of reduction of greenhouse gases "cannot wait that long". Implementing the idea of the Physical Internet is a tempting proposition in terms of environmentally sustainable logistics, but in a (very) long term.

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1. INTRODUCTION

An excessively strict level of reducing the emission of greenhouse gases ("carbon dioxide emission reduced by 60%"), postulated by the "Biała Księga Transportu: Plan utworzenia jednolitego europejskiego obszaru transportu – dążenie do osiągnięcia konkurencyjnego i zasobooszczędnego systemu transport" (The White Book of Transport: Roadmap to a single European transport area – Towards a competitive and resource-efficient transport system") (Dyrekcja Generalna ds. Mobilności Transportu Unii Europejskiej, 2011), is a serious challenge to logistics. The simplest solution would be to attempt at reducing emissions of toxic fractions in exhaust gas, however, even with the engagement of the most innovative solutions, a 60% reduction in carbon dioxide equivalent (eCO2) emission seems an extremely difficult task, particularly considering the inevitable, stable growth in the flow of goods. As a result of these considerations, alternative ideas for reducing the emission of toxic substances in the area of broadly-understood logistics are sought. Will the Physical Internet be one of the answers?

2. PHYSICAL INTERNET

Internet as a means of exchanging information inspired researchers to transfer the idea of the flow and collection of information to the flow of goods. Dispersed networks, multifunctional nodes and alternative channels with increasing throughput are an (unequalled) reference model. This approach is based on an opinion expressed in the Physical Internet manifesto (Montreuil, 2012): the way in which physical objects (goods) are transported, stored, handled and delivered around the world is economically, environmentally and socially ineffective and unsustainable. The Physical Internet (PI or π), i.e. distribution based on infrastructure managed in a collaborative manner and organised like a computer network, is a response to this ineffectiveness. The major task of the network is to effectively assign resources (means of transport, linear infrastructure) so that they are correlated with current needs.

Symptoms of transport ineffectiveness and lack of sustainability (Montreuil Meller Thivierge, 2012):

- We ship air and packages.
- Empty mileage is rather a standard than an exception.
- Truck drivers are contemporary cowboys.
- Products are usually useless, stored where they are unneeded,
- and, at the same time, unavailable where needed.
- Production and warehouse resources are poorly exploited.
- Many products are never sold or used.
- Products do not reach the ones who need them most.

- Products are unnecessarily moved, and their paths cross.
- Fast and reliable intermodal transport is a dream.
- Delivery of products to and from cities is a nightmare.
- Logistic networks and supply chains are not both safe and solid.
- Smart automation and technological engineering are difficult to justify.
- Innovation is stifled.

The Physical Internet is a sustainable solution serving the organisation of supply chains, based on an open network available to all interested parties. Setting the form of cooperation similar to an outworking system (the yet unsolved barrier of implementation) aside, the purpose of the Physical Internet is to reduce the logistic capacity of nodal infrastructure and properly rationalise linear infrastructure, which is a straight response to the provisions of the mentioned Transport White Paper.

3. PI-CONTAINERS

The idea of Physical Internet, however, does not rely only on infrastructure. It "combines standardized, modular and intelligent containers with new logistics protocols and business models, resulting in a collaborative, highly distributed and leveraged logistics and distribution system" (Montreuil Russell Meller Ballot, 2010). One of its assumptions is, therefore, unification of package sizes from collective packaging through pallet unit loads to containers. It may be assumed that for the two latter ones, a considerable part of flows is presently executed with the use of typical, although not always standardised, unit loads. While there are several most popular formats of pallets, containers and smaller unit loads, there is full freedom in terms of their dimensions and weight, or even shape and resistance to damages.

Standardisation of packaging has a number of advantages – adjustment to larger, collective packaging, unification in terms of units/loads palletisation and containerisation, reusability option, self-support, safety of handled goods etc. One of the most serious drawbacks, however, is reverse logistics of empty packaging. Although, by definition, packaging should be prepared for folding or "compacting", the issues of reverse logistics of PI-containers is crucial, same as assurance of their appropriate condition or replenishment. The issue of ensuring the availability of containers in all sizes on request is also critical. Thus, despite using PI-containers to handle return transport of loads, providing for their unbalanced flows (obligatory empty mileage) and, consequently, local stocks, is required.

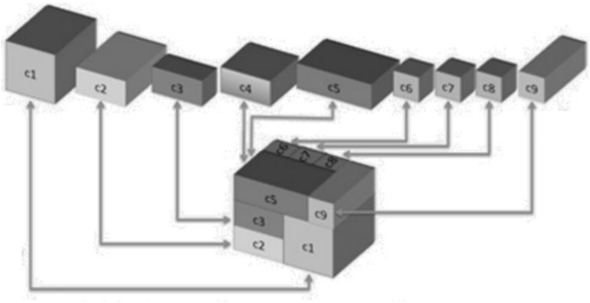

Fig. 1. Composition (and decomposition) of a unit load with PI-containers; (www.modulushca.eu)

However, the standardisation of packaging is worth its price, since it reduces the amount of cardboard wasted and not always properly processed in supply chains. It is a clear benefit to natural environment and likely savings to business.

Apart from PI-containers, promoters of the Physical Internet also distinguish two more groups of infrastructural elements: PI-nodes and PI-movers.

4. PI-NODES

The Physical Internet is inextricably linked to the standardisation of packaging. Setting their types and sizes aside, this fact favours managers of nodal infrastructure, often called PI-nodes. Notwithstanding the function (Montreuil Russell Meller Ballot (2010) list 9 of them) part of the PI-nodes must ensure the handling of containers. It does not matter if they will provide areas used for simple reloading operations, warehouses to store smaller or bigger packages between "reloading time frames", or warehouses used jointly by all users of the Physical Internet.

In the time of the PI, all shipments will be unified (apart from a small fraction of non-standard shipments that are outside the series of container types), which will presumably facilitate the process of reloading. The standardisation of packaging will allow standardised handling of packages. The initiative developed in relation to the Physical Internet prepared a number of publications concerning different types of reloading hubs based on full automation of the warehousing process. Its basic assumption is the use of “slice” containers (2.4m x 2.4m x 1.2/ 2.4/3.6/4.8/6.0/12.0m), multidirectional conveyors inside a warehouse, in semi-trailers and in railway cars. Using sets of containers allows free reconfiguration of deliveries for release from a warehouse. Smaller slice equals approximately 3 pallet units 2.35m high and with a base sized 0.8m x 1.2m.

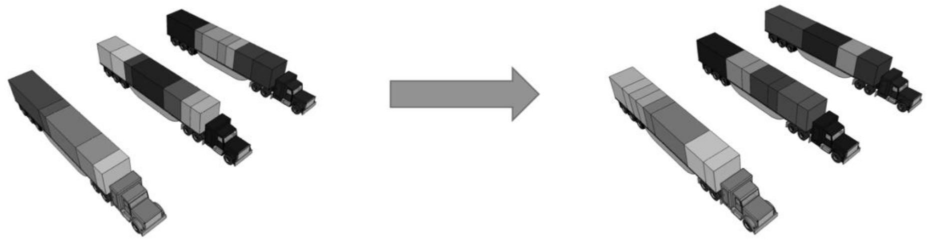

Fig. 2. Result of the functioning of a PI-node (Montreuil Meller Thivierge, 2012)

This method of service is therefore related to flows whose scale exceeds one typical pallet unit load and it refers to flows currently understood as "full pallet capacity", thus, to a considerable degree, distribution between producers and wholesalers. It does not include the distribution of packages handled by courier companies. It is hard to imagine one single technology able to handle both a "container"/slice and a DVD-package.

5. PI-MOVERS

Apart from systems of external transport (XXL PI-movers), handling smaller shipments is also necessary. The share of courier shipments smaller than a pallet unit load is steadily and quickly growing, which is why the use of PI-movers is recommended. As part of the PI-nodes infrastructure, PI-movers include PI-conveyors and PI-sorters. Although schematic solutions of such devices have been developed, their practical concept remains unspecified. While it is possible to create a specific transport system, the identification of packages on a conveyor belt is very difficult. In several years to come, this problem might be solved e.g. by the application of advanced RFID solutions.

Distribution of products to large commercial chains is related to distribution on the level of collective packaging which is frequently inhomogenous. The distribution is, therefore, "100% full pallet capacity", which represents slightly over 10% of total distribution. The remaining part concerns inhomogenous unit loads and collective packaging.

The solution presented in Figure 2 may be applied on a medium scale understood as the reloading of pallet unit loads (or their equivalents). A scheme for the functioning of the road – rails reloading node (Ballot et al., 2012), which fails to provide details used in the technology, but describes the technological process, has been developed. The solution is possible to be implemented in the so-called "full pallet capacity" distribution, assuming that one "honeycomb" contains three 2.35 m high pallet unit loads.

It might be imagined that the dispatching warehouse will create (try to create) new containers of individual honeycombs, reloading semi-trailers in an automated manner. Breaking down a unit load secured for transport and dividing it into PI-containers (depalletisation), however, is a much more complicated solution. In the case of PI-containers (in the scale of collective packages), far more advanced technological solutions are required and much more time is consumed. It will depend on the number of types of containers used and the number of possible "routes" per one unit load.

The broader the series of types of PI-containers, the more complicated the task for automatics. It may be assumed that the use of more than 3–4 containers is not automated, but robotised handling. This work may obviously be performed by warehouse employees.

One might assume that depalletisation, handling and repalletisation with the use of advanced automatic identification systems and innovative systems serving the automation/robotisation of flows and sorting will become available in the next few years. There is still an issue of operating time or, from a different perspective, system efficiency. Virtually every courier company in the Polish market has its own distribution system which guarantees package delivery on the next day after shipment. Centralisation of such a system, even with the consent of all market participants (competitors), will force the establishment of larger distribution centres in locations similar to the present ones. The term "larger" is very general and it might be replaced with "mega-" or "hyper-". Improving transport efficient by its integration and synergy effect is obviously possible, but concentrating all shipments in one large moloch, with delivery date one day after shipment, seems to exceed the capabilities of any modern, even the most advanced and innovative, technology. Today's flow of packages should be expanded, apart from the forecast of further growth, with the return flow of PI-containers.

6. PI-WORRIES

In the case of reloading points which handle the flows of every type of packaging (from transport containers to PI-containers with the size of collective packaging), it is necessary to separate flows and make considerable investments in individual technologies. The matter of expenditures is crucial (and yet unresolved). Open initiatives, including the ones which publish results of their work, are very often based on voluntary labour of their participants. If an initiative succeeds, it becomes a self-driving structure together with the growing number of interested parties and with the development of its participants, as a per cent value of users. Excellent examples for that include open source operating systems or road maps, and this analogy seems relevant in this case. In the case of the Physical Internet, it is hard to imagine gratuitous and considerable contribution of companies in initial development of an initiative. One might theoretically consider its functioning on the basis of cooperation between users – shared capital expenditures, operational costs and proportional distribution of profits, or charging fees for the execution of individual functions by owners of existing and properly located infrastructure. Although the system is associated with the outworking system, functions of balance between expenditures and profits or settlement functions may be assigned to objective algorithms. It seems to be the fundamental condition for making the idea of the Physical Internet real. However, investments involving collaboration, especially in the scale of robotised PI-nodes, made by competitive entities, seem utopian, although not impossible.

7. CONCLUSIONS

The Physical Internet is a brave and right idea. Hypothetical decisions of cooperating competitors, accompanied by real savings, are possible. Persuading companies into cooperation and creating innovative technological solutions in the PI-nodes of individual levels are, however, a question of strategic significance, to be settled in the long years to come. The assumed level of reduction of greenhouse gases "cannot wait that long". Implementing the idea of the Physical Internet is a tempting proposition in terms of environmentally sustainable logistics, but in a longer period than stated in the White Paper, mentioned in the beginning.

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BIOGRAPHICAL NOTES

Wiktor Żuchowski – Lecturer in Poznan School of Logistics. Area of scientific interests of author includes broadly understood logistics, with emphasis on warehousing. Recent attention focused on sustainable supply chains, especially sustainable warehouses, subject of forthcoming doctoral thesis. Author publication in those areas. In the Institute of Logistics and Warehousing (ILiM) responsible for the project management in scope of the warehouse processes optimization, organization and restructuring of the distribution network and the organization of logistics centres as Senior Expert in the Department of Logistics Knowledge Centre.