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REVIEW PAPER

PHYSICAL INTERNET (PI): A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT. **Background:** The Physical Internet is a young concept. This term has existed since 2006. But since the last five years (from 2012 - world, from 2014 - Poland) this concept has been intensively discussed in theory and practice. Currently, two facts are diagnosed: small number of conferences and scientific articles and small number of project implementations. Accordingly, the Physical Internet could be treated as a pilot concept.

Material and methods: The aim of the paper is to review of scientific articles dedicated to Physical Internet topic (the authors' article solely regards the physical aspects of the problem). Method of systematic review of literature was used. Systematic review of literature was divided into four steps: initial recognition of literature in PI topic, selection of publications in criteria of two streams: scientific and practice, analysis of content of publications and final conclusions. The analysis aims at identifying considerable articles in the Physical Internet topic area. The article has a fundamental influence on further concept shaping. The research time span includes scientific articles published in the years 2004 – 2017. The research subject was Web of Science and Scopus databases.

Results: As regards to the theoretical stream, the Scopus scientific database is a slightly larger source of the knowledge about the Physical Internet than Web of Science (number of articles, number of citations). From the point of view of ranking in citations, the Web of Science is better than Scopus (both old and new publications). As to the theorists, the most worldwide renowned (cited) people (Web of Science and Scopus) are: E. Ballot, B. Montreuil, S.L. Pan and Y. Sallez.

Conclusions: One might distinguish two Physical Internet evolution phases from 2004 to 2017: years 2004 – 2012 (the Physical Internet occurrence, no interest in the concept and return to its thematic scope) - when the physical internet concept assumptions were developed and clarified and years 2013-2017 (renaissance of the Physical Internet as a future concept of efficient supply chain management) - when the concept was introduced (implemented) in logistic reality. The first period of the Physical Internet is characterised by the focus on its theoretical assumptions, the second one is characterised by the domination of presenting application and implementation solutions (pilot projects mainly with the case study status).

Key words: Physical Internet, literature review, Web of Science, Scopus.

INTRODUCTION

There is and there will probably always exist a temporal-spatial gap between suppliers and receivers. The logistics task is to plan and perform the goods flow in the supply chain in the most effective way. Although the functioning conditions of logistic systems get changed, the logistics task still remains the same.

As to the contemporarily functioning logistic systems, they use less than a half of their (mainly transport and warehousing) resources. In logistic systems one observes an excessive amount of resources compared to the needs but this enables quite elastic performance of logistic processes at the expense of the decrease in the conducted activity profitability.

The decrease in the profitability results in the necessity to implement a new model

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of managing logistic systems. Therefore, one observes strong tendencies to integrate the logistic systems and commence cooperation in various activity areas because one might gain considerable benefits by cooperation (integration).

A number of expectations is related by contemporary logistics to the Physical Internet concept. It is a new concept of logistic management in supply chains. The concept is based on the physical mobility of logistic resources. Therefore, the Physical Internet is to make it possible for currently inefficiently used resources to be used more effectively.

It is shown by present observations that the issues of common resource creation [Cygler, 2013] are also more and more frequently raised by companies. This regards both the material ones (means of transport, warehouse spaces) and the non-material ones (knowledge, skills). Nowadays, resource obtainment issues are considered by companies to belong to key benefits from the cooperation [Brito, Costa e Silva, 2009]. There are examples of various sharing logistics undertakings in the work.

THE PHYSICAL INTERNET CONCEPT, TERM AND OBJECTIVE

As of now, the Internet use in logistics has been mainly related to managing the information flow in logistic processes – monitoring the fulfillment of online purchases or supplies and to solving problems in this flow. As information might be transmitted by the world wide web network, why should one not do the same with goods that might be sent by means of the global logistic network? This requires close cooperation of cooperators (process integration, resource sharing). This makes it possible to increase the efficiency of global goods stream flows – action elasticity and performance improvement combined with the reduction of operational costs. An original 4-level concept of the integration measurement in the supply chain is based on 19 different descriptions as presented in the works [Cyplik et al., 2014; Hadas et al., 2015]. The supply chain configuration, business models and value creation patterns are redefined by the Physical Internet. This is because the need for searching for a system solution is more and more noticeable. The system solution is to enable the increase in the process performance efficiency and logistics development with the simultaneous obtainment of economic, social and environmental balance [Montreuil et al., 2012].

All supply chain partners – manufacturers, providers of transport services, retailers – will be able to function independently by using a common logistic network. Its natural feature is the ability to make self-adaptations to the need of changes that occurred at a given moment [Hajdul, Nowak, 2014; Wasilewski 2015]. The Physical Internet concept should be a necessary future option of improving the activity efficiency in supply chains.

The Physical Internet is a term that was first mentioned in 2006 by Benoit Montreui from Université Laval in Canada. As regards to the article entitled ”The Physical Internet. A survey of logistics” published in ”The Economist”, it includes the first presentation of the Physical Internet assumptions on a dozen or so pages [Montreuil, 2006]. The ”Physical Internet manifest” [http://physicalinternet initiative.org/, 15.05.2017] by Benoit Montreui published in 2012 was an expansion of the Physical Internet assumptions. The author of the manifest presented more precise and detailed guidelines of the Physical Internet practical use as a result of his several-year work on the PI concept development.

The „Physical Internet” catchword was first mentioned in Poland during the Polish Logistics Congress LOGISTICS 2012 as part of the paper by Russell D. Meller from the University of Arkansas [http://www.logi-stics.pl/logistics/logistics-2012/, 15.05.2017]. Professor Meller presented the results of simulation research. It indicated that it was possible for the supply chain to obtain considerable benefits by shortening supply cycles with a decrease in the negative impact on the environment.

The Physical Internet aims at ensuring the stability, global mobility of a physical object and the ability to collect, store, sell and use it [http://www.modulushca.eu, 15.05.2017]. This is predominantly the ability to provide the most efficient method to relocate the goods to a given place in a short period of time.

The Physical Internet is organised similarly to data packages sent within the traditionally perceived digital Internet. This concept radically transforms the present idea of goods design, relocation and distribution. It is absolutely essential for all supply chain participants [Montreuil et al., 2012] to have the above method in which the goods relocation process is known and performed at each relocation stage in an optimal and efficient way . Beforehand, the process was ensured to be open, efficient and environmentally friendly. These were ensured apart from the traditionally perceived but frequently omitted, unnoticed and inefficient logistic solutions. The production area is also really important part of the supply chain but happens to be frequently unnoticed and strategically and operationally unappreciated [Kolinski, 2017; Kolinski, Sliwczynski, 2015].

THE PHYSICAL INTERNET THEORY AND PRACTICE

The team of authors conducted world literature research that indicated 2 periods of enhanced publicising activities in the Physical Internet area [Web of Science, 2017]:

- the first period of time related to the Physical Internet catchword occurrence (2006 and consecutive years), a decrease in the interest in this topic occurs after this period of time,
- the second period of time related to the occurrence of world conferences on the Physical Internet (2013 and consecutive years).

As of now, there have been 3 conferences specifically on the Physical Internet in the global scale. The first one took place in Quebec, Canada (2014); the second one in Paris, France (2015); the third one in Atlanta, USA (2016), and the fourth one is planned to be in Graz, Austria (2017) [http://www.pi.events/, 15.05.2017].

To the best of the authors' knowledge, the Physical Internet problems have so far occurred only as single conference papers. They are sporadically grouped as at least a separate dedicated discussion panel.

The Physical Internet is a young concept that has been factually discussed in theory and practice for the last 4 years (since 2012 – worldwide, since 2014 – in Poland). However, this concept is getting dynamically developed. This is confirmed by the small number of conferences and scientific articles and moderately small number of implementation projects to be currently considered as pilot solutions (index of projects – bookmark: Research and Innovation Roadmaps - annex) [http://www.etp-logistics.eu/?page_id=292, 15.05.2017].

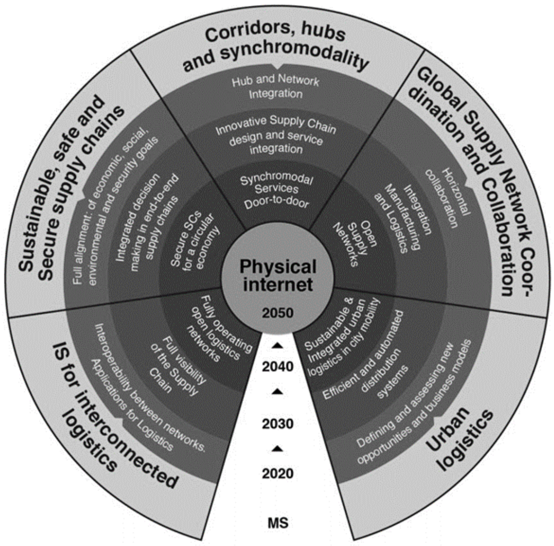
Being supported by consulting companies, business practitioners and theorists have already drafted the Physical Internet fulfillment stages (milestones) [http://www.etp-logistics.eu/?page_id=24, 15.05.2017]:

- 2020 – full alignment of economics, environmental, social and security goals,
- 2030 – integrated decision making in end-to-end supply chain,
- 2040 – safe and secure supply chains for circular economy,
- 2050 – Physical Internet.

Business actions are focused on 5 major problems [http://www.etp-logistics.eu/, 15.05.2017]:

- sustainable, safe and secure supply chains,
- corridors, hubs and synchromodality,
- information systems for interconnected logistics,
- global supply network coordination and collaboration,
- urban logistics.

A detailed scope of actions within each of the above major problems is presented in figure 1.



Source: http://www.etp-logistics.eu/wp-content/uploads/etpalice/Road_map_Alice_PIE.jpg , 15.05.2017

Fig. 1. Physical Internet roadmap

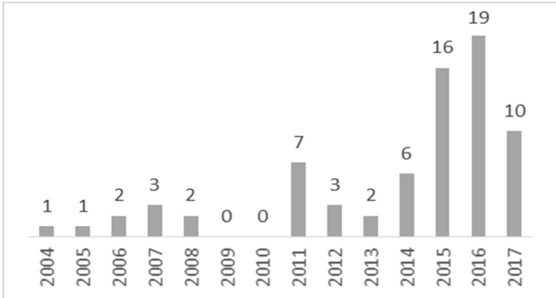
One might generally distinguish two interest streams within the Physical Internet:

- technical-technological stream – focused on unification and integration problems of logistic units in the supply chain and the infrastructure to facilitate the flow of these units,
- organisational stream – related to developing the concept of managing the flow of logistic units which is predominantly based on the possibilities to share its own resources and competences with other supply chain participants.

The next part of this article is devoted to making a systematic review of the literature on the Physical Internet (the authors' article solely regards the physical aspects of the problem). The analysis aims at identifying considerable articles in the Physical Internet thematic area. The articles need to have a fundamental influence on further concept shaping. The research time span includes scientific articles published in the years 2004 – 2017. The recognised Web of Science and Scopus databases will be a research subject.

ANALYSIS OF SCIENTIFIC ARTICLES IN THE WEB OF SCIENCE DATABASE

In the Web of Science database one identified a total number of 72 articles. In their titles, abstract or key word there was a key word "Physical Internet". A detailed distribution of the articles in particular years is presented in figure 2.

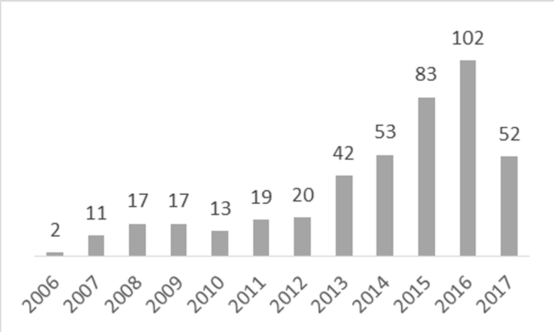


Source: own study

Fig. 2. Number of articles in the Web of Science database

As regards to the number of articles, two publicising activity periods of time are revealed. The first one was in the years 2004 – 2008. This is a period of time when the Physical Internet appeared as a new concept of managing logistic systems. When this period of time was finished, one there were initially no signs of interest in the Physical Internet problems and then there was a gradual decrease in the interest in the them (years 2009 – 2013 with a peculiar irregularity in 2011). The second publicising activity period of time was in the years 2014 – 2017 (in the entire work there are data obtained in 2017 when the article was being written). During this period of time there occurred international conferences on the Physical Internet. An apparent and systematic increase in the annual number of publications (with less intensity in 2016) is noticeable in this time span. Therefore, one might state that the Physical Internet entered the renaissance phase again due to the international conferences.

In the Web of Science database there are totally 431 citations of the "Physical Internet" catchword according to the same searching criteria. In figure 3 there is a detailed citation distribution of articles in particular years.



Source: own study

Fig. 3. Citation number of articles in the Web of Science database

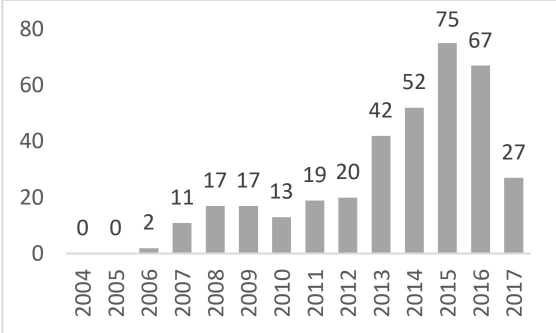
Due to the general results obtained, further detailed analyses were presented by the article authors in 2 time spans: 2004 – 2012 and 2013 – 2017. A comparison of the most significant obligatory criteria in the scientific literature is presented in table 1 and the detailed criteria features are presented in figures 4 and 5.

As to the citation number, one might also observe two different time spans. From 2006 to 2012 the citation number of the articles was maintained at a moderately low constant level. The citations started to form an apparently increasing curve as late as from 2013 to 2017. Based on analysing the citations in the entire span of years (2006 – 2017) one should state that the Physical Internet citations typically form an exponential curve (there were no records of the Physical Internet catchword in the first two years after the catchword had occurred in 2006).

Table 1. Comparison of selected publication criteria in the Web of Science database

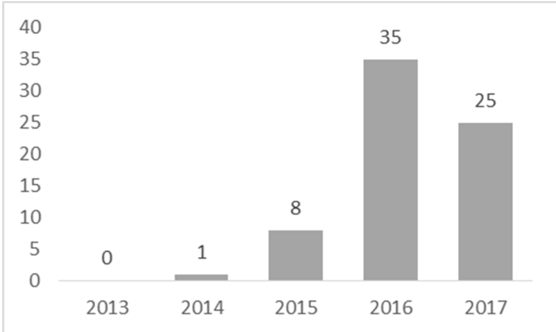
Criterion	2004 – 2012	2013 – 2017
Number of years	14	5
Number of publications	19	53
Number of citations	362	69
Average number of citations per publication	19.05	1.30
Annual average number of citations per publication	1.36	0.26

Source: own study



Source: own study

Fig. 4. Web of Science citation number of articles published in the years 2004-2012



Source: own study

Fig. 5. Web of Science citation number of articles published in the years 2013-2017

When making a separate result comparisons of the works published in the time spans 2004 – 2012 and 2013 – 2017, one should pay attention to an annual increase in the citation number in both spans (2017 not finished yet). One might realise by the comparison of figure 4 and 5 with table 1 that the ratio of citation number to the number of publications is not favourable. Such a citation state is caused by the increase in the number of publications. This result is occurring in a number of new thematic topics within the Physical Internet scope of problems and, as a consequence, the citation number gets dispersed.

The article authors selected 10 most frequently cited works (top 10 citations) – the works published in the years 2004 – 2012 and have been cited till 2017. The articles were selected out of all the articles issued from the very beginning of the Physical Internet existence in the Web of Science database to this article formulation moment. The above research results are presented in table 2.

Table 2. List of the 10 most cited articles from 2004-2017 published in 2004-2012 in the Web of Science

Title	Authors	Publication Year	Number of citations
Internet skills and the digital divide	van Deursen, Alexander J. A. M.; van Dijk, Jan A. G. M.	2011	102
Uncovering space-independent communities in spatial networks	Expert, Paul; Evans, Tim S.; Blondel, Vincent D.; Lambiotte, Renaud	2011	93
Optimal traffic networks	Barthelemy, Marc; Flammini, Alessandro	2006	43
Leakage Fault Diagnosis for an Internet-Based Three-Tank System: An Experimental Study	Zhou, D. H.; He, Xiao; Wang, Zidong; Liu, Guo-Ping; Ji, Y. D.	2012	34
Online hybrid test by internet linkage of distributed test-analysis domains	Pan, P; Tada, M; Nakashima, M	2005	32
What is the real size of a sampled network? The case of the Internet	Viger, Fabien; Barrat, Alain; Dall'Asta, Luca; Zhang, Cun-Hui; Kolaczyk, Eric D.	2007	18
An internet graph model based on trade-off optimization	Alvarez-Hamelin, JI; Schabanel, N	2004	11
Visualizing Internet evolution on the autonomous systems level	Boitmanis, Krists; Brandes, Ulrik; Pich, Christian	2008	10
On the spatial properties of internet routes	Matray, Peter; Haga, Peter; Laki, Sandor; Vattay, Gabor; Csabai, Istvan	2012	7
Degree distribution of the FKP network model	Berger, Noam; Bollobas, Bela; Borgs, Christian; Chayes, Jennifer; Riordan, Oliver	2007	5

Source: own study

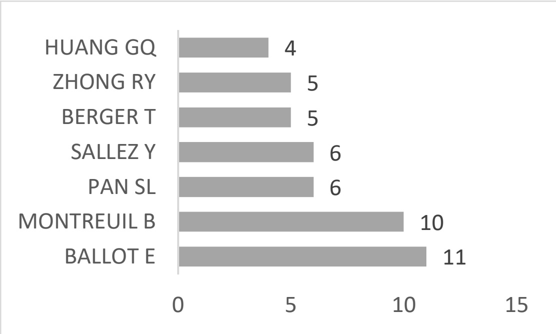
Next, the same (top 10 citation) procedure was applied to the articles published between 2013 and 2017 (11 papers published and citied in the time span as above). The article selection results are presented in table 3.

Table 3. List of the 10 most cited articles from 2013-2017 published in 2013-2017 in the Web of Science

Title	Authors	Publication Year	Number of citations
Interconnected logistic networks and protocols: simulation-based efficiency assessment	Sarraj, Rochdi; Ballot, Eric; Pan, Shenle; Hakimi, Driss; Montreuil, Benoit	2014	13
Analogies between Internet network and logistics service networks: challenges involved in the interconnection	Sarraj, Rochdi; Ballot, Eric; Pan, Shenle; Montreuil, Benoit	2014	12
In-transit services and hybrid shipment control: The use of smart goods in transportation networks	Arnas, Per Olof; Holmstrom, Jan; Kalantari, Joakim	2013	8
A decomposition-based approach for the selection of standardized modular containers	Lin, Yen-Hung; Meller, Russell D.; Ellis, Kimberly P.; Thomas, Lisa M.; Lombardi, Barbara J.	2014	6
Perspectives of inventory control models in the Physical Internet: A simulation study	Pan, Shenle; Nigrelli, Michele; Ballot, Eric; Sarraj, Rochdi; Yang, Yanyan	2015	5
On the Activeness of Physical Internet Containers	Sallez, Yves; Montreuil, Benoit; Ballot, Eric	2015	4
Routing Management in Physical Internet Crossdocking Hubs: Study of Grouping Strategies for Truck Loading	Pach, Cyrille; Sallez, Yves; Berger, Thierry; Bonte, Therese; Trentesaux, Damien; Montreuil, Benoit	2014	4
On the activeness of intelligent Physical Internet containers	Sallez, Yves; Pan, Shenle; Montreuil, Benoit; Berger, Thierry; Ballot, Eric	2016	3
Smart box-enabled product-service system for cloud logistics	Zhang, Yingfeng; Liu, Sichao; Liu, Yang; Li, Rui	2016	2
A crowdsourcing solution to collect e-commerce reverse flows in metropolitan areas	Pan, Shenle; Chen, Chao; Zhong, Ray Y.	2015	2
The Cross docking under uncertainty: state of the art	Walha, Faiza; Chaabane, Sondes; Bekrar, Abdelghani; Loukil, Taicir	2014	2

Source: own study

The article authors also decided to select the authors of the most frequently cited articles in the Web of Science database. In this case, the research was oriented to identifying the authors with the largest contribution to the Physical Internet concept (top 7). The analysis results are presented in figure 6.



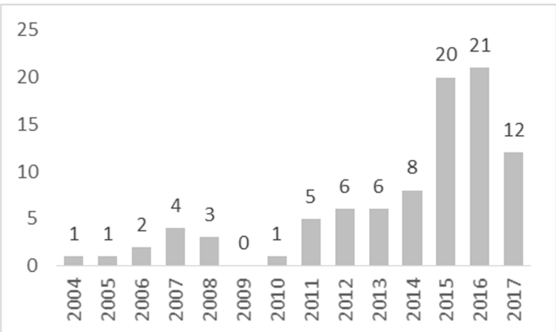
Source: own study

Fig. 6. The most frequently cited authors in the Web of Science database

According to the citation number, the authors of publications might be divided into two groups. In the Web of Science database: E. Ballot and B. Montreuil are in the lead. Other authors: S.L. Pan, Y. Sallez, T. Berger, R.Y. Zhong and G.G. Huang have less of an interest by half.

ANALYSIS OF SCIENTIFIC ARTICLES IN THE SCOPUS DATABASE

In the Scopus database there are totally 90 identified articles with the Physical Internet keyword in the title, abstract or key words. A detailed citation distribution of articles in particular years is presented in figure 7.

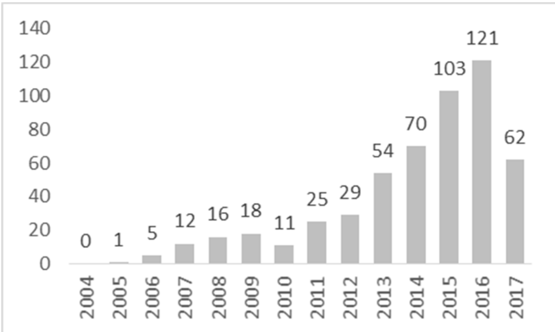


Source: own study

Fig. 7. Number of articles in the Scopus database

As to the number of articles, three publicising activity periods of time become apparent. The first one was in the years 2004 – 2010. This is a period of time when the Physical Internet appeared. When this period of time was finished (second period), the interest in the Physical Internet thematic area became stable (years 2011 – 2014) and approximately 6 articles were annually published. The third publicising activity period of time was between 2015 and 2017 (in the entire work there are data obtained in 2017 when the article was being written). During this period of time there occurred international conferences on the Physical Internet. An apparent and systematic increase in the annual number of approximately 20 publications is noticeable in the time span. This is the Physical Internet renaissance phase.

In the Scopus database there are totally 527 citations of the "Physical Internet" catchword according to the same searching criteria. A detailed citation distribution of articles in particular years in presented in figure 8.



Source: own study

Fig. 8. Citation number of articles in the Scopus database

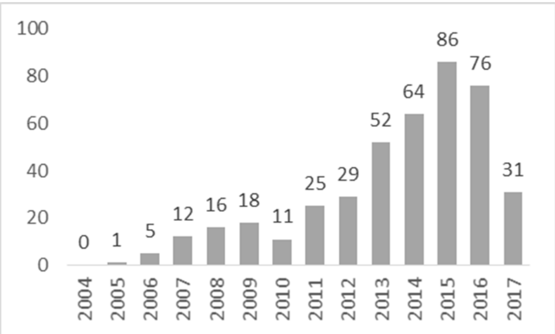
As to the citation number one might also observe two different time spans. Between 2004 and 2012 the citation number of the articles was maintained at a moderately low constant level with a slightly increasing tendency. The citations started to form an apparently increasing curve as late as from 2013 to 2017. Based on analysing the citations in the entire span of years (2004 – 2017) one should state that the Physical Internet citations typically form an exponential curve (there were no records of the Physical Internet catchword in the first two years after the catchword occurred in 2005).

Due to the general results obtained, further detailed analyses will be presented by the article authors in 2 time spans: 2004 – 2012 and 2013 – 2017. A comparison of the most significant obligatory criteria in the scientific literature is presented in table 4 and the detailed criteria features are presented in figures 9 and 10.

Table 4. Comparison of selected publication criteria in the Scopus database

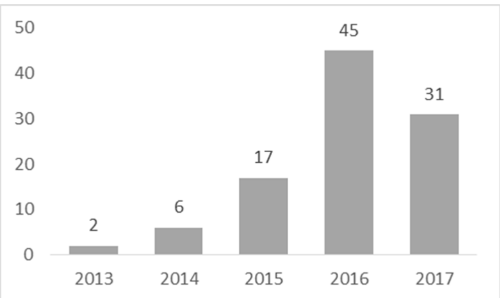
Criterion	2004 – 2012	2013 – 2017
Number of years	14	5
Number of publications	23	66
Number of citations	426	101
Average number of citations per publication	18.52	1.53
Annual average number of citations per publication	1.32	0.31

Source: own study



Source: own study

Fig. 9. Citation number of articles published in the Scopus database in the years 2004-2012



Source: own study

Fig. 10. Citation number of articles published in the Scopus database in the years 2013-2017

When making a separate result comparisons of the works published in the time spans 2004 – 2012 and 2013 – 2017, one should pay attention to an annual increase in the citation number (2017 not finished yet). One might realise by the comparison of figure 9 and 10 with z table 4 that the ratio of the citation number to the number of publications is not too favourable. The authors seem to return to the concept as drafted in the years 2004 – 2012 The publications from the time span have been frequently cited in recent years. Presently, there occur a number of Physical Internet implementation concepts and, as a consequence, there is a huge dispersion of the articles and the citation number is decreased. Thus, one might distinguish two apparent Physical Internet stages: the concept development and implementation.

The article authors selected 12 most frequently cited papers (top 10 citations) – the works published in the Scopus database in the years 2004 – 2012 and have been cited up to 2017. The articles were selected out of all the articles issued from the very beginning of the Physical Internet existence in the Scopus database to this article formulation moment. The above research results are presented in table 5.

Next, the same (top 10 citation) procedure was applied to the articles published between 2013 and 2017 (13 papers published and citied in the time span as mentioned above). The article selection results are presented in table 6.

The article authors also decided to select the authors of the most frequently cited articles in the Scopus database. In this case, the research was oriented to identifying the authors with the largest contribution to the Physical Internet concept (top 7). The analysis results are presented in figure 11.

Table 5. List of the 10 most cited articles from 2004-2017 published in 2004-2012 in the Scopus database

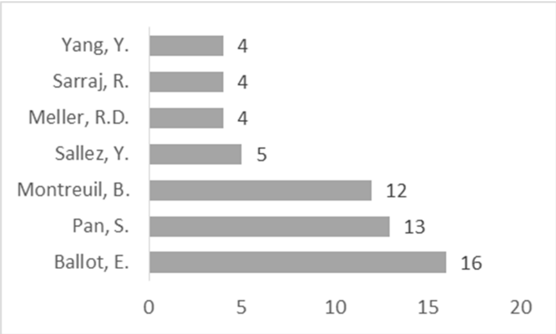
Title	Authors	Publication Year	Number of citations
Internet skills and the digital divide	van Deursen, Alexander J. A. M.; van Dijk, Jan A. G. M.	2011	119
Uncovering space-independent communities in spatial networks	Expert, Paul; Evans, Tim S.; Blondel, Vincent D.; Lambiotte, Renaud	2011	99
Online hybrid test by Internet linkage of distributed test-analysis domains	Pan, P; Tada, M; Nakashima, M	2005	48
Leakage fault diagnosis for an Internet-based three-tank system: An experimental study	Zhou, D. H.; He, Xiao; Wang, Zidong; Liu, Guo-Ping; Ji, Y. D.	2012	40
Optimal traffic networks	Barthelemy, Marc; Flammini, Alessandro	2006	27
Visualizing Internet evolution on the autonomous systems level	Boitmanis, Krists; Brandes, Ulrik; Pich, Christian	2008	21
What is the real size of a sampled network? The case of the Internet	Viger, Fabien; Barrat, Alain; Dall'Asta, Luca; Zhang, Cun-Hui; Kolaczyk, Eric D.	2007	21
An Internet graph model based on trade-off optimization	Alvarez-Hamelin, J.I.; Schabanel, N.	2004	11
On the spatial properties of internet routes	Mátray, Péter; Hága, Péter; Laki, Sándor; Vattay, Gábor; Csaba, István	2012	8
On the network geography of the Internet	Mátray, Péter; Hága, Péter; Laki, Sándor	2011	5
Degree distribution of the FKP network model	Berger, Noam; Bollobás, Béla; Borgs, Christian; Chayes, Jennifer; Riordan, Oliver	2007	5
PIPPON: A physical infrastructure-aware peer-to-peer overlay network	B. Hoang, Doan; Le, Hanh; Simmonds, Andrew	2007	5

Source: own study

Table 6. List of the 10 most cited articles from 2013-2017 published in 2013-2017 in the Scopus database

Title	Authors	Publication Year	Number of citations
Interconnected logistic networks and protocols: Simulation-based efficiency assessment	Sarraj, Rochdi; Ballot, Eric; Pan, Shenle; Hakimi, Driss; Montreuil, Benoit	2014	13
Analogies between Internet network and logistics service networks: Challenges involved in the interconnection	Sarraj, Rochdi; Ballot, Eric; Pan, Shenle; Montreuil, Benoit	2014	13
Internet atlas: A geographic database of the Internet	Durairajan, Ramakrishnan; Ghosh, Subhadip; Tang, Xin; Barford, Paul; Eriksson, Brian	2013	11
Physical Internet foundations	Montreuil, Benoit; Meller, Russell D.; Ballot, Eric	2013	10
In-transit services and hybrid shipment control: The use of smart goods in transportation networks	Arnas, Per Olof; Holmstrom, Jan; Kalantari, Joakim	2013	10
A decomposition-based approach for the selection of standardized modular containers	Lin, Yen-Hung; Meller, Russell D.; Ellis, Kimberly P.; Thomas, Lisa M.; Lombardi, Barbara J.	2014	7
Perspectives of inventory control models in the Physical Internet: A simulation study	Pan, Shenle; Nigrelli, Michele; Ballot, Eric; Sarraj, Rochdi; Yang, Yanyan	2015	6
On the activeness of Physical Internet containers	Sallez, Yves; Montreuil, Benoit; Ballot, Eric	2015	5
Containers for the Physical Internet: requirements and engineering design related to FMCG logistics	Landschützer, Christian; Ehrentraut, Florian; Jodin, Dirk	2015	4
A crowdsourcing solution to collect e-commerce reverse flows in metropolitan areas	Pan, Shenle; Chen, Chao; Zhong, Ray Y.	2015	3
Proposition of a hybrid control architecture for the routing in a Physical Internet cross-docking hub	Sallez, Yves; Berger, Thierry; Bonte, Thérèse; Trentesaux, Damien	2015	3
Routing Management in Physical Internet Crossdocking Hubs: Study of Grouping Strategies for Truck Loading	Pac, Cyrille; Sallez, Yves; Berger, Thierry; Bonte, Thérèse; Trentesaux, Damien; Montreuil, Benoit;	2014	3
Layer 1-informed internet topology measurement	Durairajan, Ramakrishnan; Sommers, Joel; Barford, Paul	2014	3

Source: own study



Source: own study

Fig. 11. The most frequently cited authors in the Scopus database

According to the citation number, the authors of publications might be divided into two groups. In the Web of Science database: E. Ballot (predominant leader), S.L. Pan and B. Montreuil (second position) are in the lead. Other authors: Y. Sallez, R.D. Meller, R. Sarraj and Y. Yang have less of an interest by three times.

CONCLUSIONS

The literature research conducted by the authors make it possible to formulate the following conclusions:

- one might distinguish two Physical Internet evolution phases from 2004 to 2017: years 2004 – 2012 (the Physical Internet occurrence, no interest in the concept and return to its thematic scope) and years 2013-2017 (renaissance of the Physical Internet as a future concept of efficient supply chain management);
- one might distinguish 2 Physical Internet phases within 2004 – 2017: years 2004 – 2012 when the physical internet concept assumptions were developed and clarified; years 2013 – 2017 when the concept was introduced (implemented) – logistic reality;
- the first period of the Physical Internet is characterised by the focus on its theoretical assumptions, the second one is characterised by the domination of presenting application and implementation solutions (pilot projects mainly with the case study status);
- as regards to the theoretical stream, the Scopus scientific database is a slightly larger source of the knowledge about the Physical Internet than Web of Science (number of articles, number of citations);
- as to the practical stream, the authoring researchers are divided into 2 explicit categories: the researchers interested in the Physical Internet technical and technological aspects (engineers) and the researchers interested in organisational aspects of the concept performance (managers);
- as to the theorists, the most worldwide renowned (cited) people (Web of Science and Scopus) are: Ballot, B. Montreuil, S.L. Pan and Y. Sallez;
- from the point of view of the higher ranking in citations, the Web of Science is better than Scopus (both old and new publications);
- as to the practitioners, the dominating thematic topics are; standardisation of logistic units in the supply chain, sharing logistic resources (warehouse surfaces, means of transport), communication and monitoring of the goods flow in the supply chain based on advanced telecommunication solutions and computer aid.

This article is its authors' own attempt to synthetically present the state-of-the-art knowledge about the Physical Internet. The scientific databases of knowledge were searched by typing such entries as „Physical Internet" and „literature review" to be found among titles, abstracts and key words. In this way one found only 3 articles in the Web of Science database [Maslaric et al., 2016; Zijm, Klumpp 2017; Sallez, 2015] and 1 article in the Scopus database [Sallez, 2015] (this item also occurs in the Web of Science, common article). Nevertheless, a literature review of the Physical Internet topics was in fact performed only in one article [Maslaric et al., 2016] only in a very simplified form as revealed by reading the found publications thoroughly. This shows there is a deficiency of review publications on the Physical Internet problems.

The theoretical and practical works with reference to the Physical Internet roadmap (figure 1) have already been started. It will be revealed in approximately next 30 years' time whether the Physical Internet is an appropriate functioning option of supply chains in contemporary reality. Therefore, one should expect new scientific and practical, not only logistics-related impulses that might change the presently selected trend.

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FIZYCZNY INTERNET (FI): SYSTEMATYCZNY PRZEGLĄD LITERATURY

STRESZCZENIE. Wstęp: Fizyczny Internet jest młodą koncepcją – termin funkcjonuje od 2006. Jednak na przestrzeni ostatnich czterech lat (od 2012 – świat, od 2014 – Polska), koncepcja ta jest intensywnie dyskutowana w teorii i praktyce. Na chwilę obecną diagnozuje się zarówno małą liczbę konferencji i artykułów naukowych, jak również stosunkowo małą liczbę projektów wdrożeniowych, które póki co należy traktować w kategorii rozwiązań pilotażowych.
Metody: Celem artykułu jest przegląd artykułów naukowych dedykowanych tematyce Fizycznego Internetu (autorzy koncentrują się jedynie na nurcie teoretycznym tej koncepcji). Zastosowaną w artykule metodą badawczą jest systematyczny przegląd literatury. Przeprowadzony przez autorów systematyczny przegląd literatury obejmuje cztery kroki: wstępne rozpoznanie literatury z zakresu Fizycznego Internetu, wybór publikacji oraz ich podział na dwie kategorie: naukowa i praktyczna, analiza treści publikacji, sformułowanie wniosków końcowych. Celem analizy jest identyfikacja znaczących artykułów (w tym także osób) w tematyce Fizycznego Internetu, mających podstawowy wpływ na dalsze kształtowanie się tej koncepcji. Zakres czasowy badań obejmuje artykuły naukowe za okres 2004 – 2017. Przedmiot badań stanowią uznane bazy naukowe Web of Science oraz Scopus.
Wyniki: W ramach nurtu teoretycznego nieco szerszym źródłem wiedzy nt. Fizycznego Internetu jest baza naukowa Scopus niż Web of Science (liczba artykułów, liczba cytowań). Z punktu widzenia wyższego miejsca w rankingu cytowań zdecydowanie lepszą bazą jest Web of Science niż Scopus (dotyczy to zarówno starszych jak i nowszych publikacji). W przypadku teoretyków najbardziej poważanymi (cytowanymi) osobami na świecie (Web of Science i Scopus) są: E. Ballot, B. Montreuil, S.L. Pan i Y. Sallez.
Wnioski: W latach 2004 – 2017 wyróżnić można dwie fazy ewolucji Fizycznego Internetu: lata 2004 – 2012 (pojawienie się Fizycznego Internetu, okres braku zainteresowania koncepcją i powrotu do tematu) - okres opracowywania i doprecyzowania założeń koncepcji Fizycznego Internetu oraz lata 2013-2017 (okres renesansu Fizycznego Internetu jako przyszłościowej koncepcji efektywnego zarządzania łańcuchami dostaw) - okres wprowadzania (wdrażania) tej koncepcji w życie, w rzeczywistość logistyczną. Pierwszy okres Fizycznego Internetu cechuje się koncentracją na podstawach teoretycznych koncepcji Fizycznego Internetu, drugi okres charakteryzuje się dominacją prezentacji rozwiązań aplikacyjnych, wdrożeniowych (pilotażowe projekty głównie o statusie case study).

Słowa kluczowe: Fizyczny Internet, przegląd literatury, Web of Science, Scopus

PHYSIKALISCHES INTERNET (FI): EINE SYSTEMATISCHE LITERATURÜBERSICHT

ZUSAMMENFASSUNG. Einleitung: Das Physikalische Internet ist ein ziemlich neues Konzept – der Begriff selbst funktioniert erst seit 2006. Jedoch im Zeitraum der letzten vier Jahre (seit 2012 – die Welt , seit 2014 – Polen) wird dieses Konzept intensiv in Theorie und Praxis diskutiert. Im Moment nimmt man sowohl eine kleine Anzahl von Konferenzen und wissenschaftlichen Beiträgen, als auch die relativ beschränkte Anzahl von innovativen Einführungsprojekten, die gegenwärtig noch als Pilotprojekte angesehen werden müssen, wahr.
Methoden: Das Ziel des Artikels ist es, die der Thematik des Physikalischen Internets gewidmeten Beiträge zu ermitteln (die Autoren konzentrieren sich allerdings lediglich auf die theoretischen Kernpunkte dieses Konzeptes). Die im vorliegenden Artikel angewandte Forschungsmethode beruht auf der systematischen Literaturübersicht. Die von den Autoren durchgeführte systematische Literaturübersicht umfasst vier Schritte: eine einleitende Ermittlung der Fachliteratur bezüglich des Physikalischen Internets, die Auswahl von Publikationen und deren Aufteilung auf zwei Kategorien: auf eine wissenschaftliche und eine praktische, die Analyse von betreffenden Veröffentlichungen und die Formulierung von Schlussfolgerungen. Das Ziel der Analyse ist es, die belangvollen Beiträge (darunter auch deren Autoren) zum Physikalischen Internet, die die weitere Ausgestaltung des Konzeptes wesentlich beeinflussen, zu identifizieren. Das Zeitintervall umfasst die wissenschaftlichen Beiträge, die im Zeitraum 2004–2017 entstanden sind. Zum Forschungsgegenstand sind die weltweit angesehenen Datenbasen von Web of Science und Scopus geworden.

Ergebnisse: Im theoretischen Ansatz stellt die Datenbank Scopus eine breitere Wissensquelle zum Physikalischen Internet als die der Web of Science (angesichts der Anzahl von Artikeln und Zitierungen) dar. Angesichts des höheren Ranges innerhalb von Zitierungen gilt die Web of Science als eine bessere Datenbank (das bezieht sich sowohl auf die älteren, als auch auf die neueren Publikationen). Was die in diesem Bereich meist angesehenen (zitierten) Theoretiker in der Welt (Web of Science i Scopus) anbetrifft, dann kann man zu ihnen: E. Ballot, B. Montreuil, S.L. Pan und Y. Sallez zählen.
Fazit: In den Jahren 2004–2017 kann man zwei Evolutionsphasen des Physikalischen Internets hervorheben, und zwar: den Zeitraum 2004–2012 (Auftauchen des Physikalischen Internets, dann ein Desinteresse für dieses Konzept und die Rückkehr zum Thema) – die Zeitperiode der Ausarbeitung und Präzisierung von Konzeptannahmen des Physikalischen Internets und die Jahre 2013–2017 (der Zeitraum des Aufblühens des Physikalischen Internets als eines Zukunftskonzeptes für ein effizientes Management von Lieferketten) – die Zeitperiode der Einführung des Konzeptes in die Praxis, in die logistische Wirklichkeit. Die erste Zeitperiode des Bestehens des Physikalischen Internets charakterisiert sich durch die Konzentration auf die theoretischen Grundlagen des Konzeptes des Physikalischen Internets, die andere dagegen durch die Dominanz der Projizierungen von Anwendungs- und Einführungslösungen (in Form von Pilotprojekten, hauptsächlich mit dem Status von Fallstudien (case study).

Codewörter: Physikalisches Internet, Literaturübersicht, Web of Science, Scopus

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