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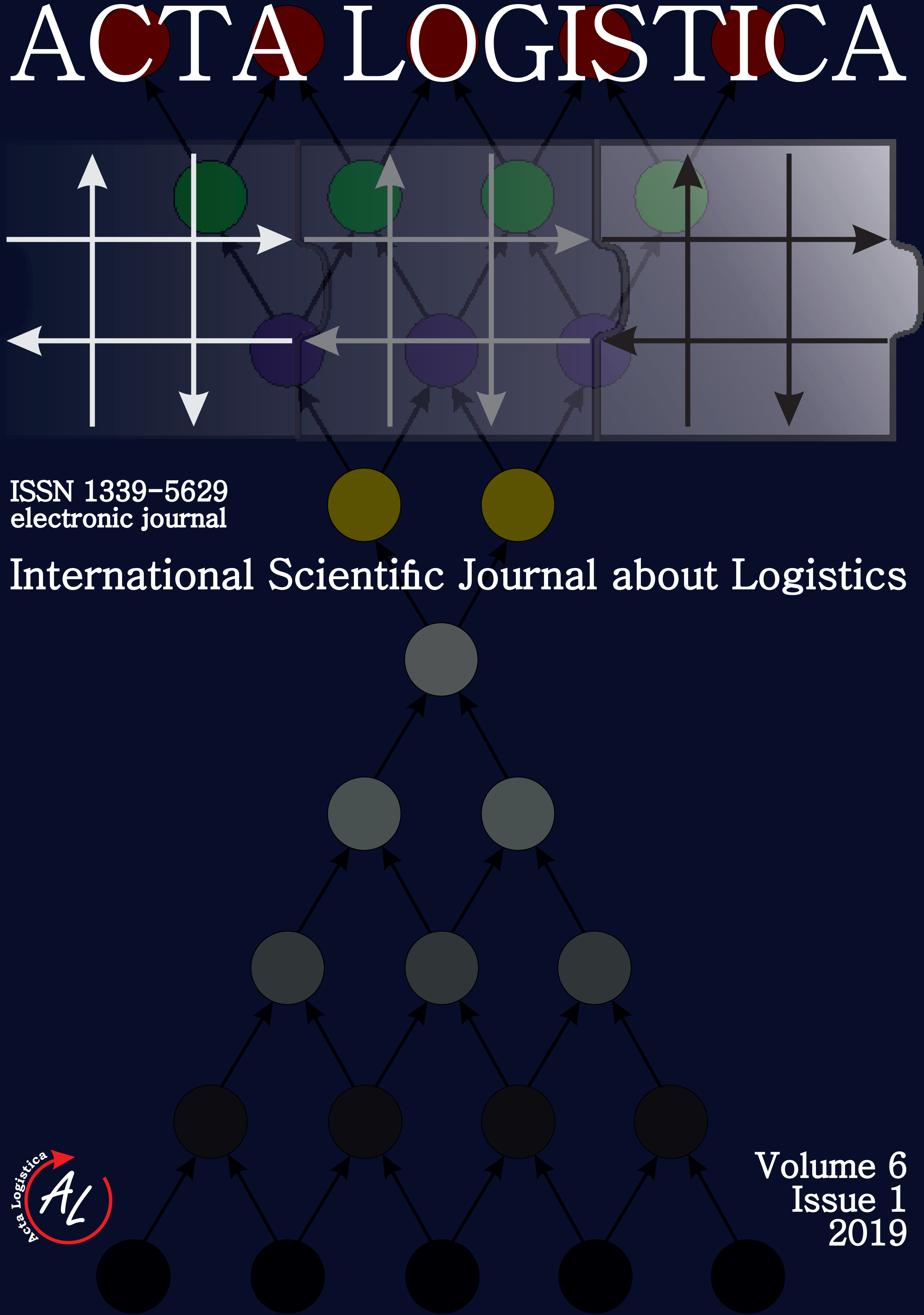

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EVALUATION OF SUPPLIERS' QUALITY AND SIGNIFICANCE BY METHODS BASED ON WEIGHTED ORDER

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Keywords: suppliers, products, cost, price, quantity
Abstract: The efficiency of the purchasing process co-decides on the success of the production organization. One of the basic tools for quality purchasing management is the selection and evaluation of suppliers. We can use a wide range of tools to evaluate suppliers, and this evaluation can be based on a large and diverse set of criteria. In the case of evaluating many potential suppliers according to a number of criteria, it is not possible to rely solely on the intuitive nature of the evaluation. Therefore, managerial tools based on the mathematical principles of multi-criteria decision-making have been increasingly important. The article deals with the analysis of the realized research focused on the use of mathematical methods in the evaluation of suppliers in an industrial enterprise. This article aims to analyse the possibility to use tools based on determining weighted order when evaluating suppliers. Data obtained from the research in a selected industrial enterprise in the Czech Republic was used for evaluation.

1 Introduction

Purchasing can be defined as the management of the organization's activities related to ensuring inputs for efficient work within the following processes. Given that the quality of the products that the organization can provide for its customers depends on the quality of the products it can get from its suppliers, purchasing is considered to be the core of business activities. Employees responsible for the implementation of purchasing activities must meet a wide range of knowledge in different areas (technical product specifications, legislative requirements, organization, language skills) and must have extraordinary personal abilities (communication, creation and maintenance of interpersonal relationships, high morale and loyalty to the organization) [1].

A prerequisite for efficient purchasing process is perfect knowledge of organization needs, flexible market analysis, effective management of the process following the vision, strategy and goals of the organization, effective work with suppliers [1].

Purchasing strongly affects the competitiveness of the organization. The purchase of low-quality or high-cost raw materials can negatively affect asserting the product on the market even before it is launched. Improving the quality of the purchasing process is fundamentally related to effective cooperation with suppliers [2]. It is also essential to collect and evaluate information about suppliers and compare their offers. We can use a variety of different procedures and methods to evaluate suppliers. One way of evaluating suppliers is to use multi-criteria decision-making methods [3,4]. These tools allow the synthesis of a broader range of criteria, and the resulting evaluation is then based on a multidimensional basis. The aim of the article is the experimental use of multicriteria decision-making tools for supplier evaluation. The evaluation is carried out for a selected manufacturing company in the Czech Republic. Three major long-term suppliers were included in the evaluation.

2 Evaluation tools

Evaluation of suppliers using multi-criteria decision-making methods is based on the quantification of a broader range of criteria. Manufacturing companies prefer primarily the criteria that affect the economic or business results of the enterprise. These criteria also affect the final product quality. In general terms, we can classify criteria for supplier evaluation into the following groups:

- criteria relating to products,
- criteria relating to the services provided,
- criteria relating to price and contractual conditions,
- criteria evaluating supplier behaviour and approach [1].

The specific form and number of criteria naturally affects the nature of the product but also the specifics of the given industrial area. In the application of multi-criteria decision-making tools, the first step, following the determination of the criteria being evaluated, is to determine their significance (weights). One of the ways to determine the weight is to use the scoring method. This method is one computationally less-demanding methods. However, the quality of the results is subject to the subjective nature of decision-making. The method is also referred to as 100 point allocation. The problem is that the solver needs to be able to perform a quantitative evaluation of the criteria importance. However, this is often very difficult due to the variety of criteria being followed with the value of bi in the given scale. The more important the criterion is, the higher the score. The solver does not have to choose only integers from a given scale but can assign the same value to even more criteria. The scoring method requires a quantitative evaluation of the criteria by the solver but allows a more differentiated expression of subjective preferences. Criteria weigh is determined according to formula (1).

$$v_i = \frac{b_i}{\sum_{i=1}^{k} b_i}, i = 1,2,\dots,k \qquad (1)$$

where: v_i - criterion weight.
b_i - value of the respondent's preferences

After determining weighs of the individual criteria, it is possible to use the multi-criteria decision-making tool for the analysis of specific suppliers (variants). For example, we can use the weighted order method [5]. This method is based on the weighted average of partial variants according to the individual criteria. The optimal variant is the one with the largest total weight. The principle of the method is that, for all criteria, their ranking is determined in terms of the degree of fulfilment of the individual criteria. Criteria values are therefore translated into their order in view of the quality for the given criterion [5]. This order then enters the overall rating, which also takes into account the weighting of individual criteria. In the first step, we first determine a partial evaluation of variants in terms of each criterion (h_{ij}), according to the relation (2).

$$h_{ij} = m + 1 - p_{ij} \qquad (2)$$

where: h_{ij} - evaluation of the variance according to each criterion,
m - the total number of variants,
p_{ij} - order value.

The calculation of the total value of the individual variants (H_j) is performed according to the relation (3).

$$H_j = \sum_{i=1}^{n} v_i \times h_{ij} \qquad (3)$$

where: n – the total number of criteria
v_i – criterion weight.
h_{ij} - evaluation of the variance according to each criterion,

The cumulative value thus determined represents the quality of a particular variant (supplier). We then rank the evaluated suppliers in descending order according to this value.

3 Experimental work

In the framework of the research carried out, three suppliers were also compared in a selected industrial enterprise. Seven key criteria were selected for the evaluation. All criteria, together with specific values for individual suppliers, are given in Table 1.

Criteria selection was made by purchasing department staff. In the first step, the 15 criteria used were selected. Within the framework of the workshop, the seven most important ones were selected. Using assembled descending order.

In the first step, the normalized weights of the individual criteria ⟨0.1⟩ were determined. Weights were determined using the scoring method. The individual criteria were evaluated on a point-rated basis, and a specific weight was determined using the relationship (1).

The scales were determined by a group of 20 experts. Everyone has expressed their preferences. Point values are determined as an arithmetic mean (rounded).

Table 1 Input values for the criteria for three selected suppliers

Criteria		Supplier 1	Supplier 2	Supplier 3
K_1	Price ($)	840	790	920
K_2	Maturity (days)	45	30	90
K_3	Quality (1-10)	9	8	10
K_4	Service (%)	85	90	89
K_6	Consignment (1-3)	1	1	2
K_6	Delivery date (days)	1	3	2
K_7	Supplier benefits (1-10)	7	8	9

The determined weights are shown in Table 2. The highest importance was assigned to criterion 1, i.e. the price of the product. In the second place, criterion 4 (service) was placed. The determined weights were further used in the evaluation of the individual suppliers.

Table 2 Criteria point rating

Criterion	K_1	K_2	K_3	K_4	K_5	K_6	K_7	$\sum$
Number of points	20	11	16	19	18	14	2	100
Weight	0.20	0.06	0.16	0.19	0.18	0.19	0.02	1

The input values of the criteria as listed in Table 1 were subsequently transformed into descending order. For criterion 1 (prices), for example, the values were ranked according to the advantage of individual suppliers. The lowest price quotation was marked as best (supplier 2). In the same way, a ranking of the values for all other criteria was performed. Specific information on the order of the criteria for the monitored suppliers is given in Table 3.

Table 3 Order of the criteria according to the input values

Criteria		Supplier 1	Supplier 2	Supplier 3
		Ranking		
K_1	Price	2.	1.	3.
K_2	Maturity	2.	3.	1.
K_3	Quality	2.	3.	1.
K_4	Service	2.	1.	3.
K_6	Consignment	2.	2.	1.
K_6	Delivery date	1.	3.	2.
K_7	Supplier benefits	3.	2.	1.

An assembled order of criteria is the basis for using the weighted order method. This method was applied to the monitored suppliers. Table 4 shows the process, solution and final evaluation.

Table 4 Comparison of suppliers using the weighted order method

Criterion	V_i	Supplier 1			Supplier 2			Supplier 3		
		p_{i1}	h_{i1}	V_ih_{i1}	p_{i2}	h_{i2}	V_ih_{i2}	p_{i3}	h_{i3}	V_ih_{i3}
K_1	0.20	2.	2	0.40	1.	3	0.60	3.	1	0.20
K_2	0.06	2.	2	0.12	3.	1	0.06	1.	3	0.18
K_3	0.16	2.	2	0.32	3.	1	0.16	1.	3	0.48
K_4	0.19	2.	2	0.38	1.	3	0.57	3.	1	0.19
K_5	0.18	2.	2	0.36	2.	2	0.36	1.	3	0.54
K_6	0.19	1.	3	0.57	3.	1	0.19	2.	2	0.38
K_7	0.02	3.	1	0.02	2.	2	0.04	1.	3	0.06
$\sum$				2.17			1.98			2.03
Order of suppliers				1.			3.			2.

Table 4 shows decompositionally the solution process for all three suppliers. Column V_i indicates the specified weights for each criterion. For each rated supplier, the order of the given criterion (p_i), the supplier's rating for each criterion (h_i) and the finite value calculation for a particular criterion (V_ih_i) are listed in Table 4. The sum of the final values of all the criteria is a crucial parameter for the evaluation. Based on this value, suppliers are then ranked in descending order. The formula (2) and (3) were used to calculate the values. The last row of Table 4 lists the final ranking of suppliers.

4 Results and discussion

Rating providers were analysed on the basis of seven relevant criteria. For all criteria, their weight was first determined. For the comparison of the suppliers, the weighted order method was used experimentally. The final order is shown in Table 4. Supplier 1 was determined as the most appropriate supplier based on the quantifiable criteria values. Here it is possible to mention that, from the point of view of the assembled order of criteria, this supplier ranked first only with one criterion (K6). In other cases, the values of all the criteria were ranked second (except for K7, which was ranked third). In general, however, this supplier's offer is the best one on the basis of the applied process. The second was Supplier No. 3 (2.03) and Third Supplier 2 (1.98), according to Table 4. The order of the individual criteria for these suppliers was largely inhomogeneous. In many cases, providers were evaluated as the best according to the selected criteria, but according to other criteria, they were assessed as the worst. If we were to make a strategic choice of a supplier, it is possible to recommend using supplier No. 1 on the basis of the analysed data and the applied procedure. However, it will always be crucial to take into account all the specifics of the given industrial area.

5 Conclusions

In the framework of the realized research, we used the principle of weighted order for the suppliers' evaluation, and for the weighting of the criteria, we used the method of evaluating on a point-rated basis. Both tools offer an interesting alternative for supplier ratings. A significant advantage is the low algorithmic requirements of both methods. At the same time, it is possible to synthesise a larger number of categorically different criteria in one indicator. Based on the above procedure, it is possible to identify the best variant (supplier), but also to assemble their order. In the case of difficult decision-making, one or more suppliers can be selected. It is often preferable to buy from multiple sources, eliminating dependence on only one supplier and making it possible to compare. This can make a significant contribution to improving the quality of the purchasing process. The efficiency of purchasing raw materials thus clearly promotes the competitiveness of the product and the organization.

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References

[1] BAZALA, J. et al.: *Logistika v praxi*, Praha, Verlag Dasfofer, 2004. (Original in Czech)
[2] JABLONSKÝ, J.: *Operační výzkum*, Praha, Professional Publishing, a.s., 2002. (Original in Czech)
[3] DAFT, R.L., MARCIC, D.: *Understanding Management*, Mason, Cengage Learning, 2009.
[4] FOTR, J., ŠVECOVÁ, L. et al.: *Manažerské rozhodování,* Praha, Ekopress, s r.o., 2010. (Original in Czech)
[5] CHANDRA, CH., GRABIS, J.: *Supply chain configuration: concepts, solutions and applications*, London, Springer, 2007.

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DISTRIBUTION FLOW IDENTIFICATION IN COOPERATION AND SUPPORT FOR ECOLOGICAL INNOVATION INTRODUCTION IN SLOVAK ENTERPRISES

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Keywords: ecological innovations, distribution flow, cluster analysis
Abstract: Innovations play an important role in achieving success of a company in a strong competitive environment. It is not sufficient just to innovate, but the more emphasis is placed on the creation of innovations implemented on the principle of sustainable development. This is the reason why ecological innovations are so important and why they have become the object of our survey which results are the topic of this paper. The paper presents the results of the survey monitoring the state of knowledge and usage of selected incentives within the distribution flows in cooperation and support for ecological innovation introduction in Slovak enterprises. The survey was realized by questioning in Slovak enterprises. The sample consisted of 517 enterprises that were selected by random selection from the population sample of the Slovak Republic. The surveyed questionnaires were processed into the database and subsequently evaluated quantitatively. Through a cluster analysis they were processed by cluster analysis in the STATISTICA program. Following the results, we can claim that in cooperation and support for ecological innovation introduction in Slovak enterprises, the distribution flows are mainly focused on sectoral innovation activity and less on regional and national innovation activity. The results show the difference in the use of selected incentives within the distribution channels in cooperation and support for the ecological innovation introduction in Slovak enterprises, which according to several authors is not a market failure, but from the point of view of a system approach to innovation, it is so called "innovation paradox".

1 Introduction

In a strong competitive environment in the market, the innovation presents an important tool for competitiveness. To implement innovation as a tool of competitiveness, it is important not only to master the implementation of the innovation process, but also to find inventions, financial resources, and many other aspects that are the incentives for successful innovation application in the market. They enter the innovation process both at the beginning but also during the implementation of innovation as a source. The sources representing the innovation capacity of the company are reimbursed by internal as well as external sources.

As stated by Straka et al. [1] the distribution logistics providing the physical, organizational and information link between resources and the innovation process plays an important role in order to ensure the most appropriate way of selecting, analysing and transporting these resources during the innovation process.

However, in the last period, it is not enough just to innovate, but the more emphasis is placed on the creation of innovations implemented on the principle of sustainable development, thus representing ecological innovation. The EU [2] also presents, it is necessary to realize ecological innovations that increase the protection of the environment and the competitiveness of EU industry, introducing technologies, processes and business models that use resources more effective.

Innovation Management implements ecological innovation through innovation of sustainable resources use and materials from the environment, including the growing importance of socio-economic development [3-6].

The interconnection of innovation management within the sustainable development policy is ensured by a distribution policy that links incentives, physical, organizational and information interconnection among the different activities of the innovation process.

The Innovation Management in this understanding is a dynamic factor of the economy, focusing on the far-reaching commercial use of innovation for the future direction of enterprises within an environmental-oriented strategy.

Such an understanding of innovation management in conjunction with distribution logistics, linking incentives, physical, organizational and information interconnection in the innovation process, regarding globalization trends representing a modern distribution philosophy, is based on factors of time, spatial structures, transport market boom, cluster formation [7].

For better overview in these factors influencing innovation and thus ecological innovation, it is necessary to know the chain of information, incentives and other factors within the distribution flows of the innovation process for their more efficient use, fulfilling the EU's objectives.

The EU's goal is to change Europe into a low-carbon economy that effectively uses resources. Environmental technologies are an important part of the EU economy [2].

Their annual turnover is 320 billion euros, and since 2004 they have reached 8 percent annual growth. EU share presents one-third of the world market that could double to more than € 2 200 billion by 2020 [2].

The European Union promotes ecological innovation through a range of programs and policies. Within the implementation of ecological innovations in enterprises, these programs and policies are projected into incentives that can be of a different nature at national level, such as subsidies from ministries, the Slovak Business Agency, through stimuli at regional level (such as clusters, respectively Business Angels) and at sector level in the form of contractors and clients.

In addition, the incentives for innovations at all levels can have a different form. This paper presents selected ones. All of these incentives focus on the stimulus of ecological innovations and obstacles to their realization.

Therefore, this paper is aimed at the identification of distribution flows in cooperation and support for the ecological innovation introduction in Slovak enterprises. with focus on external incentives of ecological innovation.

2 Methodology

The methodology of the paper is based on the questioning in Slovak enterprises. The sample consisted of 517 enterprises which were chosen by random selection from the population sample of the Slovak Republic. The sample of respondents was determined at a confidence level of 95%, with a tolerance error of +/- 7% of the standard deviation of 0.5, which at the given data represents the value of 196 respondents. The survey was realized both personally and electronically. 517 respondents fulfill conditions given by determined confidence level, standard deviation, and margin of error.

The survey was carried out through a questionnaire consisting of several parts, such as identification data, ecological innovation and their implementation in companies in Slovakia. The last part was aimed at distribution flows monitoring in cooperation and support for ecological innovation introduction in Slovak enterprises.

The questioning was implemented electronically, where we did not validate the position of the respondent representing the enterprise, but we assume that persons at lower positions like a manager would not have enough information on the issue. The surveyed questionnaires were processed into the database and subsequently evaluated quantitatively. Through a cluster analysis they were processed in the STATISTICA program. The cluster analysis was used for the evaluation regarding the determined survey objective, to monitor the clusters of information flows in cooperation and support for ecological innovation introduction in Slovak enterprises. Rimarčík [8] claims that the cluster analysis deals with how objects (statistical units) should be divided into groups to obtain the biggest similarity within the groups and the biggest difference among the groups. Within the algorithms of agglomerative hierarchical clustering we used the Ward's method that combines the clusters in which the increment of the total intragroup sum of squared deviations of individual values from aggregate diameters is minimal.

3 Result and discussion

Following the data obtained from the survey database, quantitative data evaluation shows that in a sample of respondents - Slovak enterprises - the distribution flow in cooperation and support for ecological innovation introduction is oriented mainly towards the sectoral level (see Table 1). Contractors have the largest representation from what follows mainly strong sectoral innovation activity and the support of ecological innovation in sectors. We understand clients as customers who can be represented by final consumers but also by any personal or corporate entity representing other processors, sales agents etc.

Table 1 Matrix of length

Selected incentives within distribution flows in cooperation and support for ecological innovation introduction in Slovak enterprises	Quantity	%
Contractors	257	49.71
Clients	127	24.56
Other .. (agencies, innovations centres etc.)	59	11.41
Ministries	47	9.09
Clusters	12	2.32
Business Angels	12	2.32
Slovak Business Agency	3	0.58

Subsequently, the data from the database were analysed by cluster analysis using the STATISTICA program (Figure 1). On the basis of more significant cluster diversity which has occurred at the 200 connection distance, where in the Euclidean distance among observed objects values have significantly increased. Regarding thus determined level we have identified two clusters.

Contractors and clients create a separate cluster 2 from the point of view of selected incentives within the distribution flows in cooperation and support for ecological innovation introduction in Slovak enterprises, which is specific due to its superiority in terms of other selected stimuli usage that form the second cluster.

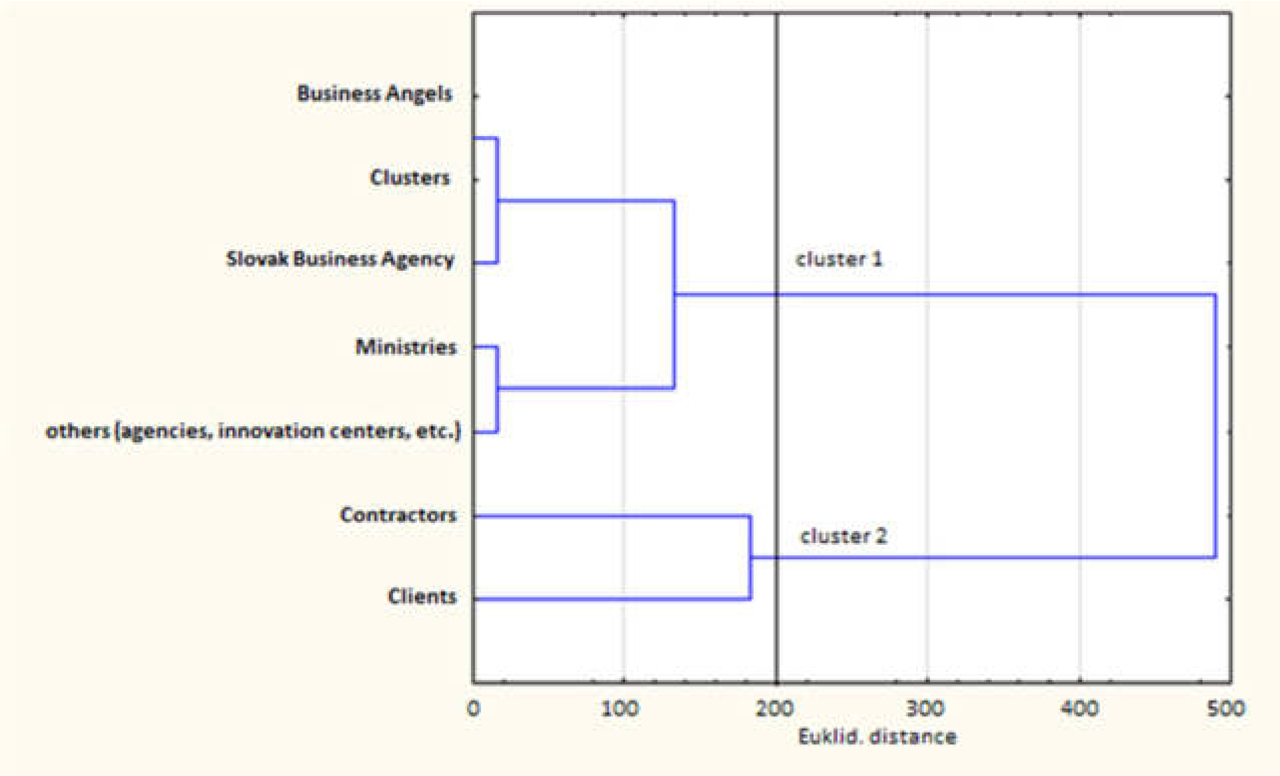

Figure 1 Cluster analysis of distribution flows to stimulus in cooperation and support for ecological innovation introduction in Slovak enterprises
Source: Own processing in STATISTICA program

So the cluster analysis pointed out to the fact how the objects (the selected incentives within the distribution flows in cooperation and support for the ecological innovations introduction in Slovak enterprises) are divided into groups to receive the greatest similarity within the groups and the greatest difference among the groups in terms of their use by enterprises to support the introduction of ecological innovation.

The first cluster groups selected incentives within distribution flows in cooperation and support for ecological innovation introduction in Slovak enterprises such as Business Angeles, Clusters, Slovak Business Agency, Ministries and others. This cluster of selected stimuli within the distribution flows in cooperation and support for ecological innovation introduction in Slovak enterprises is known and used in the business environment, but less than selected stimuli in the cluster 2.

The second cluster consists of contractors and clients, who according to the results presented in the Figure 1, represent the greatest incentives within the distribution flows in cooperation and support for ecological innovation introduction in Slovak enterprises.

Following the results, we can claim that in cooperation and support for ecological innovation introduction in Slovak enterprises, the distribution flows are mainly focused on sectoral innovation activity, because the mainly used incentives for support and cooperation for ecological innovation are contractors and clients representing the sectoral innovation activities, and less on regional and national innovation activity because in our survey they are presented by other incentives for cooperation and support and ecological innovations.

The results show the difference in the use of selected incentives within the distribution channels in cooperation and support for the ecological innovation introduction in Slovak enterprises, which according to several authors [9, 10] is not a market failure, but from the point of view of a system approach to innovation, it is so called “innovation paradox”. Oughton et al. [11] describes an innovation paradox as a discrepancy among the relatively higher need to spend resources on innovation and the relatively lower capacity and ability to absorb these resources. As Skokan [9] states, this issue is weakly elaborated. However, optimization of this state can be achieved by approaching the Focal Model, which presents combination of bottom-up and top-down approaches to planning and subsequent co-ordination to support innovation within the innovation system. According to EuroEkonóm [12] and Repková-Štofková [13] the Focal Model incorporates both aspects of planning (bottom-up and top-down), where the first one allows using creativity and potential of individuals (enterprises in need of innovation support) and the second one applies effective political processes (innovation system management). This is the way to prevent innovation paradoxes. Based on the given findings and literature analysis by inference we propose to develop innovations support bottom up, because the sectoral level, cooperation among enterprises, contractors and clients presents the strongest basis.

4 Conclusions

Regarding the results of the survey, the paper evaluates the state of knowledge and usage of selected incentives within the distribution flows in cooperation and support for ecological innovation introduction in Slovak enterprises. Based on the data obtained from the randomly selected sample of respondents, the highest activity of innovation support has been noticed by contractors and clients at sectoral level. Other stimuli from the cluster analysis point of view are in a cluster characterized by a low influence on the implementation of ecological innovation in Slovak enterprises, pointing to an innovation paradox concentrating on barriers when they are used. Therefore, in the future, it is important to focus on the barriers of the innovative capacities for development of ecological innovation at all levels of the innovation system and to implement measures to improve the use of these capacities. In the context of concentration on barriers to improve the use of mentioned capacities it is appropriate to implement the Focal Model approach to plan and coordinate innovation support, using both its aspects (bottom-up and top-down) and by their optimization to prevent innovation paradoxes.

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References

[1] STRAKA, M., MALINDŽÁK, D., STRAKOŠ, V., JANÁČEK, J., VIESTOVÁ, K., MARASOVÁ, D., ŠADEROVÁ, J., PETRAŠŠOVITŠOVÁ, B., TAKALA, J., HELO, P., KAUPPINEN, P., BALOG, M.: *Distribučná logistika,* Košice, Expres Publicity, 2005. (Original in Slovak)
[2] ŽIVOTNÉ PROSTREDIE: *Využívanie inovácií*. Online, Available: http://ec.europa.eu/environment/basics/green-economy/innovation/index_sk.htm [21 Dec 2018], 2018. (Original in Slovak)
[3] KOLLÁR, V., BROKEŠ, P.: *Environmentálny manažment*, Bratislava, SPRINT, 2005. (Original in Slovak)
[4] LOUČANOVÁ, E., TREBUŇA, P.: Eko-inovácie ako nástroj konkurencieschopnosti, *Transfer inovácií,* Vol. 29, pp. 76-80, 2014. (Original in Slovak)
[5] LOUČANOVÁ, E.: *Inovačné analýzy a stratégie*, Zvolen, Technická univerzita vo Zvolene, 2016. (Original in Slovak)
[6] TREBUNA, P., PETRIKOVÁ, A., PEKARČÍKOVÁ, M.: Influence of physical factors of working environment on worker's performance from ergonomic point of view, *Acta Simulatio*, Vol. 3, No. 3, pp. 1-9, 2017.
[7] ŠULGAN M., GANP J., MAJERČÁK J.: *Postavenie dopravy v logistike*, Žilina, Žilinská univerzita, 2008. (Original in Slovak)
[8] RIMARČÍK, M.: *Zhluková analýza.*, Online, Available: http://rimarcik.com/navigator/ca.html [22 Nov 2018], 2018. (Original in Slovak)
[9] SKOKAN, K.: Innovation Paradox and Regional Innovation Strategies, *Journal of Competitiveness*, Vol. 2010, No. 2, pp. 30-46, 2010.
[10] ADÁMEK, P., CSANK, P., ŽÍŽALOVÁ, P.: Regionální inovační systémy a jejich veřejná podpora, *Working Paper CES VŠEM*, Vol. 2007, No. 7., 2007. (Original in Czech)
[11] OUGHTON, CH., LANDABASSO, M., MORGAN, K.: The Regional Innovation Paradox: Innovation Policy and Industrial Policy, *Journal of Technology Transfer*, Vol. 2002., No. 27, pp. 97-110, 2002.
[12] EUROEKONÓM: *Prístup zdola – nahor (Ohniskový model)*, Online Available: https://www.euroekonom.sk/manazment/manazment-zmien/pristup-zdola-%E2%80%93-nahor-ohniskovy-model/ [20 Jan. 2019], 2019. (Original in Slovak)
[13] REPKOVÁ ŠTOFKOVÁ, K.: *Využitie znalostného manažmentu na podporu konkurencieschopnosti,* Manažment a sieťové podnikanie vo vedomostnej ekonomike, KEGA 070ŽU-4/2011, pp. 7-24, 2013. (Original in Slovak)

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DIGITALIZATION EFFECTS ON THE USABILITY OF LEAN TOOLS

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Abstract: Current industrial engineering methods and techniques due to the complexity of new knowledge-based methods need to be extended to technologies and tools for modelling and simulation of production processes, logistics flows, production facilities as well as product design. It is important to focus on the whole life cycle of the company as well as the product. The article deals with the effects of digitization on lean-manufacturing tools that are often used in industrial practice.

1 Introduction

The acceleration of ICT development has contributed to the creation of a new phenomenon - digital factory. Classical industrial engineering makes it possible to maintain competitiveness only in the short term as it is geared to address cost-optimization tasks. In the current turbulent world, it is necessary to react quickly and to see the competitiveness of the business in its customized products and services. The application of digital engineering techniques and technology to industrial practice creates the prerequisites for gaining market leadership and ensuring long-term sustainability for the future [1-5]. Westkämper highlights the professional diversity of industrial engineering in Germany and the Anglo-Saxon countries, but it reveals the potential for expanding industrial engineering in German-speaking countries. While in Germany industrial engineering is a discipline focused mainly on engineering - planning and management of production and assembly, streamlining of production technology, introduction of robotics and automation, but emphasis is placed on planning and management in Anglo-Saxon countries [6-9]. As for the Asian countries and the Pacific, industrial engineering has established itself as a discipline quite late. In 1998, the APIEMS/Asia Pacific Industrial Engineering and Management Society were established as an umbrella organization for industrial engineering from China, Japan, Korea, the Philippines, and Australia. The main emphasis is on operational research with a strong focus on informatics through simulation, modelling, artificial intelligence and algorithm development, with ergonomic aspects in the background [10].

2 Lean tools and Industry 4.0

To eliminate waste and losses across the value chain in a non-investment way is the philosophy of a substantial part of industrial engineering methods and tools. The aim is to get lean and high economic efficiency´s processes. Waste means costs and cause the 8 basic types of loss in 4 areas, such as [11-16]:

- Preparation of production:

1. Excessive documentation - drawings, product processes, preparations, tools.
2. Search - information, documents, undelivered data files, email.
3. Waiting - for information, material.
4. Unnecessary Relocation - Information, Documentation for Signatures,
5. Lengthy process of approval, control.
6. Unnecessary operations and additional work - poor processed directives, procedures, redundant information in the documentation, drawings, excess accounts, reports, duplication of the information flow.
7. Unnecessary movements - related to obtaining and clarifying information in other departments.
8. Correction and removal of errors, changes in documentation - inadequate control of production feedback.

- Production:

1. Incorrect working procedure - surplus movements and activities of the operator, resp. machine, improper operation.
2. Unnecessary movements - unnecessary manipulation and transfer of material and things not adding value, searching for material, tools, documentation, and other information.

3. Overproduction - production in advance, resp. with a delay, production of a larger quantity than the need of the customer or the downstream process.
4. Losses on machines - dwell time (failures, planned and unplanned downtimes, alignment).
5. Waiting - material is waiting for processing, operator waiting for material - unused wait time.
6. Surplus stocks - inter-operational stocks, stocks of raw materials, auxiliary materials, finished products.
7. Correction of errors and deficiencies in quality.
8. Low motivation and support of workers in the production of proposals for improvement, low interest in decision making.

- Logistics:

1. Surplus stocks - raw materials, materials, spare parts, repairs and maintenance.
2. Overproduction - finished products of finished production
3. Waiting - for material, spare parts, information, transportation.
4. Surplus manipulation - overlaying, translating, shifting, incorrect organization of warehouses, material flows in production.
5. Searching - material, documentation, information.
6. Unnecessary actions and movements - in human work, manipulation, movement and storage.
7. Unnecessary activities - duplicate information, selection from IT systems, rewriting reports.
8. Damage to stored items - errors in ordering items, material in terms of quantity, time, location.

- Administration:

1. Excess - information, transactions, documents.
2. Waiting - for documents, transactions, creating queues in front of workstations, workstations, processing.
3. Excessive document shifts in connection with signatures, multilevel control, approval.
4. Incorrect process design - Incorrect organization of workplaces and material flows, shifts between remote workplaces, buildings.
5. Ineffective communication - complex procedures, unclear details, ignorance of procedures and IT systems.
6. Searching - information, documents, incorrect and missing data.
7. Errors and duplicities - repeated evidence, rewriting of data.
8. Untapped skills and talents of staff - insufficient motivation and support for improvement suggestions.

The beginnings of introducing lean manufacturing into serial production in the automotive industry may be dated to the post-World War II era, when Japanese manufacturers have been in a difficult position as compared to the Western ones due to lack of production resources, material, financial and working resources. One of the pioneers of lean manufacturing in Japan was Toyota's Taiichi Ohno factory manager, who "updated" Ford's waste reduction system and created the Just in Time production system. The Toyota production system differs from Ford's lean production in two fundamental principles [11-15]:

1. focus on small quantities with parameters customized to customer requirements - customization compared to the mass production of one product,
2. cast machine set-up when changing the production program according to customer requirements - custom production compared to production according to market forecasts.

Lean production has become widely accepted in industrial practice in the 1980s and 1990s. It has become a very widespread approach to gaining high efficiency in enterprise production and logistics processes. In the manufacturing sector, a new paradigm of "Industry 4.0" emerged in 2011, which enable the implementation of information and communication technologies to create an intelligent network throughout the value chain, smart factory/intelligent factory. The question arises, as these two approaches are related, how they can be interconnected [17-21]. The comparison of Lean and Industry 4.0 is in Figure 1.

Based on the research of 260 applications of Industry 4.0 tools in the German industry [20,21], an analysis of the interdependence of the lean manufacturing elements with Industry 4.0 was performed. This study has shown, that lean manufacturing is a great potential for successful and sustainable deployment of Industry 4.0 to industry. Industry 4.0 essentially improves the lean manufacturing system and moves it to a much higher level. From an analysis of literary sources dealing with Industry 4.0 vs. Lean production, cited in Source [20,21], showed four interdependencies of these principles: Lean production as the basis for Industry 4.0 (2/3 authors), Industry 4.0 as Lean production, Industry 4.0 as Lean production efficiency, Industry 4.0 as a change to the Lean production principles (in connection with the integration of specific tools and industry methods 4.0). Influences Industry 4.0 and Lean tools considering the 7 types of losses are processed in Table 1.

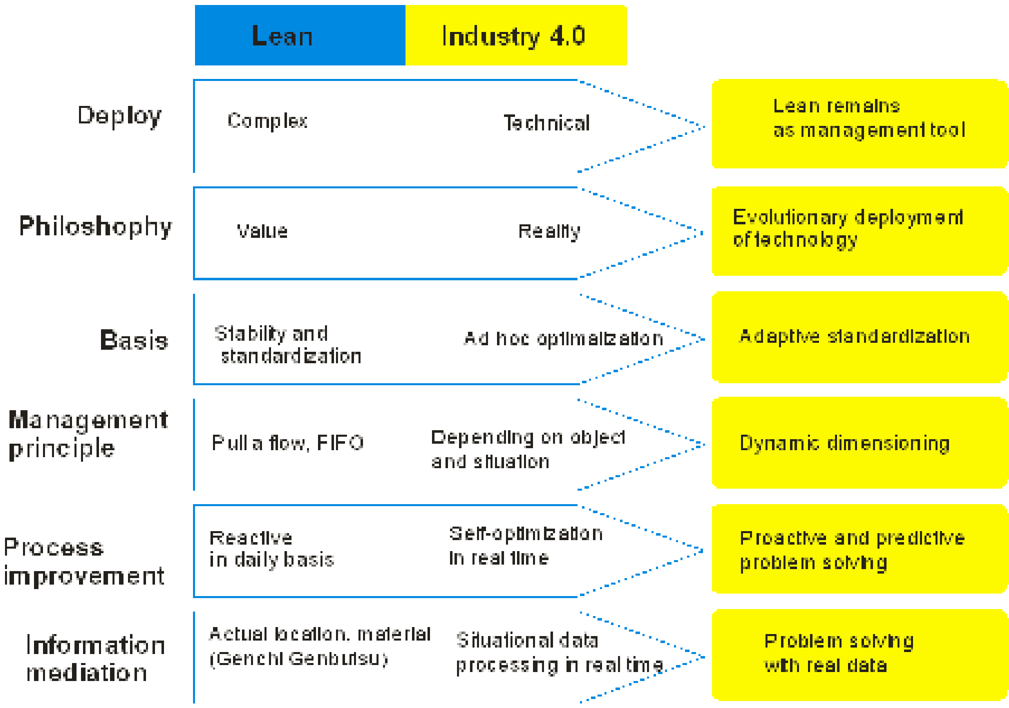

Figure 1 Comparison of Lean a Industry 4.0 [modified by 20,21]

Table 1 Matrix of length

Tools		7 types of losses in production													
Lean	**Industry 4.0**	**overproduction**		**transport**		**moves**		**waiting**		**inventory**		**unnecessary processes**		**mistake**	
Cell production	Sensors and regulators	+		+	+	+	+	+	+	+	+		+		
Reduction of set up	IoT	+	+					+	+	+	+	+		+	+
Quality control	Cloud computing						+		+	+			+	+	
TPM	Data analysis		+		+			+	+		+			+	+
Production balancing	3D printing		+					+	+	+	+		+		+
Kanban	Simulation and virtualization	+			+		+	+		+					+
Reduction of WIP	Robotics	+			+		+		+	+			+		+
Supply relationship	Augmented reality	+			+		+	+		+				+	+
Jidoka						+		+						+	
CIM						+		+				+		+	

The impact of Industry 4.0 on companies using lean manufacturing principles is not adequately explored. A concept that combines the established principles, methods and tools of lean manufacturing with information and communication technologies from Industry 4.0 is lacking. According to source [6], the first research was launched on successfully implemented projects in the automotive industry (24 workshops were a survey of workshops). The goal was to identify the Industry 4.0 framework for industry-leading sophisticated production systems. In the first phase, the main principles and methods were identified on the basis of lean manufacturing research. The second phase was focused on structure analysis and the identification of specific Industry 4.0 technologies. The outputs of these phases were processed into the Industry 4.0 impact matrix on Lean production systems, Table 2. The impact / synergy of Industry 4.0 with lean tools is + (+ / weak, ++ / higher, +++ / highest possible impact).

Since research in this area is at the beginning, this matrix is to be understood as a dynamic framework that can be further supplemented by new knowledge.

Table 2 Matrix of impact Industry 4.0 on Lean Manufacturing [modified by 6,13,20,21]

Lean tools	***Data collection and processing***				***Communication Machine-Machine***		***Interaction man - machine***	
	Sensors and regulators	*Cloud computing*	*Big data*	*Data analysis*	*Integration*		*Virtual reality*	*Augmented reality*
					vertical	*horizontal*		
5S	+	+	+	+	+	+	++	+++
Kaizen	+	++	+++	+++	+++	+++	+++	+++
JIT	++	++	+++	+++	+++	++	+	++
Jidoka	+	+++	+++	+++	++	++	+	+
Heijunka	++	++	+++	+++	+++	++	++	+
Standardization	++	+++	+++	+++	++	++	+++	+++
Tact	+	+	+++	+++	+++	+++	+	+
Pull	++	+	+	+	+++	+++	+	+
man - machine	+	+	+	+	+	+	+++	+++
People and teamwork	+	+	+	+	+	+	+++	+++
Reducing of waste	+	+	++	+++	+++	+++	+	+

Initially, the introduction of lean manufacturing has eliminated waste from non-products, excess processes, time losses, inefficient movement of materials and workers, surplus stocks and overproduction. At present, it covers the entire value chain of the business, from the initial stage of the life cycle through development, supply, and production to distribution. It is a philosophy with implemented a multi-dimensional approach. Lean toolbox synergistically with digitalization creates an efficient and flexible high quality system by minimal cost.

3 Conclusions

The philosophy of a substantial part of industrial engineering methods is to eliminate waste and losses across the value chain. Industrial engineering applies the available tools, methods and techniques that have the greatest contribution to achievement the objectives at the lowest possible investment. The potential obvious of simulation and digital technologies largely helps in presently to manage the product lifecycle, from the process of product development through design of new resp. optimization of existing production systems.

From the above analysis, it is possible to note the great influence and compatibility of Lean tools with Industry 4.0 tools, especially in connection with Kaizen, Standardization and Tact. Kaizen is the philosophy of continuous improvement, that needs to be implemented in the enterprise so, that all employees of the company are identified with it. The goal of standardization is to stabilize processes, thereby improving productivity, quality and efficiency. Standardization of processes, procedures, production activities, logistics, etc. can be considered as one of the conditions in connection with enterprise automation process and systems, which is part of Industry 4.0. Tact is the basic indicator of Lean Manufacturing that shows how fast products are to be produced. It is especially important in terms of supply chain synchronization, which is important in terms of increasing the efficiency of processes in the dynamic of the supply chain. It is appropriate to build on the established Lean Manufacturing principles in company, to intensify its and to gradually link to Industry 4.0 tools.

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References

[1] GREGOR, T., KRAJCOVIC, M., WIECEK, D.: *Smart Connected Logistics*, In: Procedia Engineering. vol. 192, Transcom 2017, 12th International Scientific Conference of Young Scientists on Sustainable, Modern and Safe Transport. High Tatras, Grand Hotel Bellevue, Slovakia. 31. 05. – 02. 06. 2017, pp. 265-270, 2017.

[2] BINASOVA, V., BUBENIK, P., DULINA, L., DURICA, L., EDL, M., KRAJCOVIC, M., MICIETA, B.: Delegate MASs for Coordination and Control of One-Directional AGV systems: a Proof-of-Concept,

The International Journal of Advanced Manufacturing Technology, Vol. 94., No. 1-4., pp. 415-431, 2018.

[3] ČARNOGURSKÝ, K., DIAČIKOVÁ, A., ĎAŇKOVÁ, A., LACH, M.: Practical Importance of CSR in Cross-sector Cooperation, *Procedia: Economics and Finance*, Amsterdam: Elsevier, Vol. 34, pp. 244-251, 2015.

[4] KLOS, S., PATALAS-MALISZEWSKA, J.: The impact of ERP on maintenance management, *Management and Production Engineering Review,* Vol. 4, No. 3, pp. 15-25, 2013.

[5] LACIAK, M., SOFRANKO, M.: *Designing of the technological line in the SCADA system PROMOTIC,* Proceedings of the 2013, 14th International Carpathian Control Conference, ICCC 2013, 2013.

[6] NASH, M., POLING, S. R.: *Mapping the total value stream: A Comprehensive Guide for Production and Transactional Processes*, CRC Press, New York, USA, 2008.

[7] NYHUIS, P., WIENDAHL, H-P.: *Fundamentals of Production Logistics: Theory, Tools and Applications,* Springer, Hannover, Germany, 2009.

[8] OTTOVA, M., KUDRNA, J., POOR, P., EDL, M.: New Possibilities of Knowledge Transfer by Playing Manager Games, *Procedia - Social and Behavioural Sciences,* Vol. 174, pp. 3738-3742, 2015. doi:10.1016/j.sbspro.2015.01.1107

[9] SANIUK, S., SAMOLEJOVA, A., SANIUK, A., LENORT, R.: Benefits and barriers of participation in production networks in a metallurgical cluster - research results, *Metalurgija,* Vol. 54, No. 3, pp. 567-570, 2015.

[10] Apiems – 2002 – conference, Online, Available: https://apiems.org/4th-apiems-2002-conference/ [15. Dec. 2018], 2002.

[11] PASCAL D.: *Lean Production Simplified,* CRC Press, 2015.

[12] ROTHER, M., HARRIS, R.: *Creating continuous flow*, USA: The Lean Enterprise Institute, 2001.

[13] ROTHER, M., SHOOK, J.: *Learning to See,* USA: The Lean Enterprise Institute, 2003.

[14] GREGOR, M., HODON, R., BIŇASOVÁ, V., DULINA, Ľ., GAŠO, M.: Design of Simulation-Emulation Logistics System, *Modern Machinery MM Science Journal*, Vol. 2018, No. Oct., pp. 2498-2502, 2018.

[15] STRAKA, M.: Alfa, a.s. distribution logistics system, *Acta Montanistica Slovaca,* Vol. 15, No. 1, pp. 34-43, 2010.

[16] HUDÁK, R., VARGA, R., HUDÁK, J., PRASLIČKA, D., BLAŽEK, J., POLÁČEK, I., KLEIN, P.: Effect of the fixation patterns on magnetic characteristics of amorphous glass-coated sensoric microwires, Proceedings of the 15th Czech and Slovak Conference on Magnetism Košice, Slovakia, June 17-21, 2013 *Acta Physica Polonica A,* Vol. 126, No. 1, pp. 417-418, 2013. doi:10.12693/APhysPolA.126.417

[17] WICHER, P., STAŠ, D., KARKULA, M., LENORT, R., BESTA, P.: A computer simulation-based analysis of supply chains resilience in industrial environment, *Metalurgija,* Vol. 54, No. 4, 2015.

[18] STRAKA, M., MALINDZAK, D.: Algorithms of capacity balancing of printing machineries for Alfa Foils, a.s. planning system, *Acta Montanistica Slovaca,* Vol. 14, No. 1, pp. 98-102, 2009.

[19] ZEESHAN., S.: *Improve your Business Value through Value Stream Mapping*, Online, Available: https://www.linkedin.com/pulse/enhance-customer-value-through-stream-mapping-ذيشان-سيد-, [15. Dec. 2018], 2015.

[20] KOLBERG, D., ZÜHLKE, D.: Lean Automation enabled by Industry 4.0 Technologies, *IFAC-PapersOnLine*, Vol. 48, No. 3, pp. 1870-1875, 2015.

[21] WAGNER, T., HERRMANN, Ch., THIEDE, S.: Industry 4.0 Impacts on Lean Production Systems, *Procedia CIRP,* Vol. 63, pp. 125-131, 2017.

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IN THE ISSUES OF MATHEMATICAL MODELLING LOGISTICS PROCESSES

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Keywords: form of characteristic equation, solution basis, symmetries

Abstract: Mathematical modelling came to logistics from economics. Economic models have been used for quite some time, but the results obtained force us to develop new branches of the theory. The solution of the characteristic equation is the basis of these algorithms as a rule. The classical solution of the characteristic equation from geometry is used. The solution is based on two postulates: the type of the characteristic equation is not changed and the solution is obtained in an orthogonal basis. The transformation matrix change the form of the characteristic equation is proved. The symmetries of space vary it. Solutions for complex non-linear processes should be considered in a non-orthogonal basis. This basis is primary. The orthogonal basis appears from it or in a particular case.

1 Introduction

Mathematical modelling takes one of the most important stages in logistic processes. Calculations of various types of resources taken by logistics from the classical economy. Economic theory has been using mathematical modelling for quite some time [1]. The theory of optimal control [2], optimization methods, functional analysis [3] is used in solving management problems everywhere. Modern modelling methods, such as tropical mathematics [4], were developed on the basis of classical works.

From the point of view of mathematics, the main task of economic calculation is the solution of the characteristic equation $\lambda\vec{v} = \mathbf{T}\vec{v}$, where $\vec{v}$ – a certain vector is in multidimensional space, a $\mathbf{T}$ – transformation matrix, a λ – set of scalars determining the solution of the problem. Each element of the vector $\vec{v}$ belongs to one mathematical set. Widely used set of integers to simplify the task. The works of Kantorovich limit the space to certain restrictions [5,6]. Tropical mathematics imposes additional restrictions, for example, on the used operations [7].

The correct solutions are not always obtained, which forces us to develop new methods of mathematical modelling. The solution of the problem, as a rule, comes from two postulates: the form of the characteristic equation is not changed, the solution is in the orthogonal basis. Consider how these postulates are implemented in reality.

2 Characteristic equation

The solution of the characteristic equation is based on the Cartesian method [8]. It has such postulates as outlined in Chapter 1. The method is used in geometry for conic sections on Euclidean plane (space) only. More complex curves are processed on approximation exclusively.

An alternative plane representation model has been proposed [9]. He suggested that the construction of linguistic rules must be considered additionally. We obtain the Euclidean plane as a text by Galilee definition of the nature according to Leibniz method of similarity. As the basic postulates were used: permutation, mirror, and unitary matrix symmetries by Dieudonne; table automorphisms and transfer symmetry by H. Weyl; definition of symmetry by M. Born; and binary automorphisms by F. Bachman [10].

Isaac Newton proposed the first classification of plane curves [11]. To the first class he assigned conical sections with the equation $Ax^2 + 2Bxy + Cy^2 + Dx + Ey + F = 0$ The method of obtaining the characteristic equation $\mathbf{T}\vec{v} = \lambda\vec{v}$ for them was found, but it took years and studies by Klein to obtain solutions for the parabola [8]. The second class of curves is determined by the general equation $Ax^3 + 3Bx^2y + 3Cxy^2 + Dy^3 + 3Ex^2 + 6Fxy + 3Gy^2 + 3Hx + 3Ky + L = 0$. The method of solving this equation has not been found so far. Newton's classification has higher grades. We briefly described the classification for analytic geometry. Algebraic and differential geometry studies differentiable curves at the present time. We apply its methods, and also such a property of the Euclidean plane as symmetry [9].

Let there be an arbitrary figure Φ -- planar differentiable curve in the Euclidean plane $R \times R$ in a Cartesian coordinate linear system defined by the parametric equation: $\begin{cases} x = f_x(t) \\ y = f_y(t) \end{cases}$, where $x, y, t \in R$. Functions $f_x(t)$ and $f_y(t)$ are sine and cosine, where $t = n\tau$, $n \in Z$, $\tau \in R$. We carry out any transformation of the figure Φ defined by the matrix $\begin{pmatrix} a & h \\ g & b \end{pmatrix}$, where $a, b, h, g \in R$. It is necessary to obtain the parameters of the transformed figure (to solve the characteristic equation).

The permutation symmetry $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ is defined on the Euclidean plane, so for a own orthogonal basis $0e_1e_2$ there must exist a symmetric frame $0e_1'e_2'$ with respect relation to the straight line AB (Figure 1). The basis $0e_1'e_2'$ is orthogonal, but the set of reference frames gives four non-orthogonal bases: $0e_1e_1'$, $0e_1e_2'$, $0e_2e_1'$, $0e_2e_2'$. Particularly interesting are the first two, since it is the vector that determines the angle of the figure's tilt. The hypothesis of preserving the balance of symmetries [9], as a syntactic rule for constructing the Euclidean plane, leads to the appearance of a local basis.

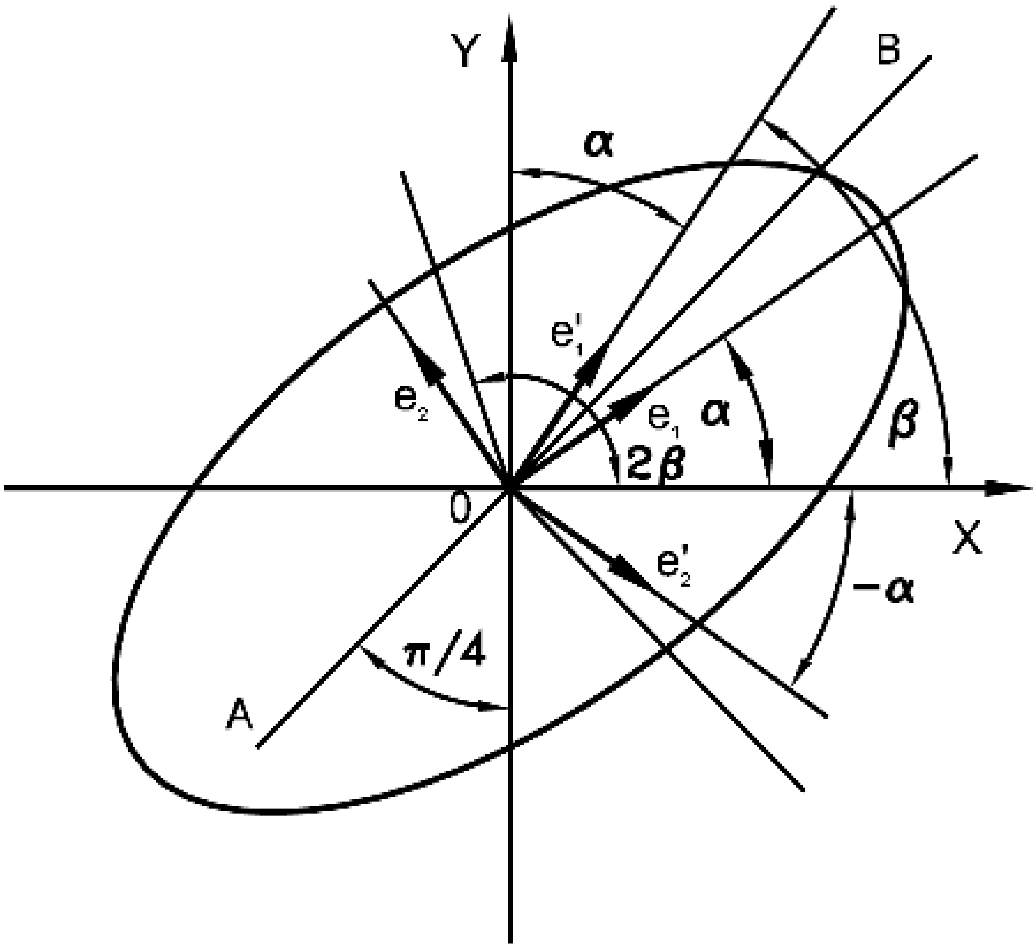

Figure 1 Non orthogonal basis

The basis defined the direct method of linear transformations. We may formulate next system of parametric equations, namely:

$$\begin{cases} cf_x(t+\alpha) = af_x(t+\beta) + hf_y(t+\beta) \\ df_y(t+\alpha) = gf_x(t+\beta) + bf_y(t+\beta) \end{cases} \tag{1}$$

where β -- angle of permutation symmetry. Non orthogonal basis [12] is form from the corners α and β. Let consider the solution of the characteristic equation for the centrally symmetric conic sections. Only equation of own angle α take of the classic method [13,14]: $\tan 2\alpha = \frac{2(bh+ag)}{(a^2+h^2)-(b^2+g^2)}$. Parameters semiaxes considered difficult in the classical method, since they represent a radical dependence.

A new direct analytical method for the linear transformation was proposed earlier. He is free from radicals, so it is more simple and accessible for further mathematical derivations. The method is based on the permutation symmetry and other symmetries [8].

The general solution for planar curves has been sought for a long time. If the result of the calculations obtained systems: $\begin{cases} x = mf_x + nf_y \\ y = mf_x - nf_y \end{cases}$, $\begin{cases} x = -mf_x + nf_y \\ y = mf_x + nf_y \end{cases}$, $\begin{cases} x = mf_x + knf_y \\ y = -nf_x + kmf_y \end{cases}$, $\begin{cases} x = kmf_x + nf_y \\ y = -knf_x + mf_y \end{cases}$ than solution may be find [15]. The angle β in the basis is the defining angle. The solution is obtained when $\beta \in \{0, \pm\pi/2, \pm\pi\}$.

Theorem.

An arbitrary non-singular transformation $\mathbf{T}$ can change the characteristic equation $\mathbf{T}\begin{pmatrix} f_x(t) \\ f_y(t) \end{pmatrix} = \begin{pmatrix} \lambda_x f_x(t) \\ \lambda_y f_y(t) \end{pmatrix}$ to an equation $\mathbf{T}\begin{pmatrix} f_x(t) \\ f_y(t) \end{pmatrix} = \begin{pmatrix} \lambda_x f_y(t) \\ \lambda_y f_x(t) \end{pmatrix}$.

Proof.

Let us suppose the opposite. Let us assume an transformation $\mathbf{T}$ is not exist. Let us be a curve with parametrical equations system $\begin{cases} x = f_x(t) \\ y = f_y(t) \end{cases}$ is satisfying the initial conditions of this publication. Let us apply a linear transformation $\begin{pmatrix} 0 & k \\ n & 0 \end{pmatrix}$ to it, where $n, k \neq 0$, then the resulting trivial solution of the characteristic equation will be equal $\begin{cases} x' = kf_y(t) \\ y' = nf_x(t) \end{cases}$. The conversion $\mathbf{T}$ is not singular, since $\det \mathbf{T} = -nk \neq 0$. The equation changed its appearance.

Thus, we obtain that the characteristic equation has the form $\lambda\vec{v}' = \mathbf{T}\vec{v}$, where $\vec{v}' \in \left\{ \begin{pmatrix} x \\ y \end{pmatrix}, \begin{pmatrix} -x \\ -y \end{pmatrix}, \begin{pmatrix} y \\ x \end{pmatrix}, \begin{pmatrix} -y \\ -x \end{pmatrix} \right\}$. Not considered members of the set are obtained from the mirror and permutation symmetry.

Analytical solution found for the following types of transformation systems:

$$\begin{cases} x = f_x + nf_y \\ y = f_y \end{cases}, \begin{cases} x = f_x \\ y = nf_x + f_y \end{cases}, \begin{cases} x = f_x + nf_y \\ y = kf_x + f_y \end{cases}.$$

The solution algorithm is divided into three steps:

1. We calculate the transformation parameters as in the case of centrally symmetric conic sections.

2. We perform an additional transformation $\mathbf{P}$ depending on the angle β. If the angle β is negative, then the transformation is $\mathbf{P} = \begin{pmatrix} \cos\beta & -\sin\beta \\ \cos\alpha & \sin\alpha \end{pmatrix}$, if positive, then $\mathbf{P} = \begin{pmatrix} -\cos\beta & \sin\beta \\ \cos\alpha & \sin\alpha \end{pmatrix}$.

3. Rotate the curve by its own angle α and multiply it by the coefficients founded in item 1.

3 Conclusions

The own angle determines the orthogonal basis. This is the principle of the classical method for solving the characteristic equation. The angle of the permutation symmetry determines its own angle. These two angles form a non-orthogonal basis. This basis and symmetry angle is primary. This all follows from the proposed method. The characteristic equation has a more complicated form than generally accepted.

This article does not correct the mathematical model used in economics and logistics. It provides only the contours of future decisions. The author of the publication, although he was educated as an economist engineer, does not consider himself the right to make changes to the existing theory.

References

[1] LEONTIEF, WASSILY W.: An Alternative to Aggregation in Input-Output Analysis and National Accounts, *Review of Economics and Statistics*, Vol. 49 No. 3, pp. 412-419, 1967.

[2] KANTOROVICH, L.V.: *The Best Use of Economic Resources*, New York, Pergamon Press, 1965.

[3] LEIFMAN, LEV J.: (ed.) *Functional analysis, optimization, and mathematical economics: A collection of papers dedicated to the memory of Leonid Vital'evich Kantorovich,* New York, The Clarendon Press, Oxford University Press, 1990.

[4] SPEYER, D., STURMFELS, B.: Tropical mathematics, *Mathematics Magazine*, Vol. 82 No.3, pp. 163-173, 2009.

[5] CUNINGHAME, G., RAYMOND, A.: *Minimax algebra, Lecture Notes in Economics and Mathematical Sciences*, New York, Springer, 1979.

[6] HOPP, W., SPEARMAN, M.: *Factory Physics,* New York, Waveland Press, 2011.

[7] FITZSIMMONS, J, FITZSIMMONS, M. BORDOLOI, S.: *Service Management: Operations, Strategy and Technology,* 8th ed., New York, McGraw-Hill, 2014.

[8] EFIMOV, N.V.: *Quadratic forms and matrices*, Science, Moscow, 2012.

[9] LOZHKIN, A., DYUKINA, N.: *Structurization of analytical geometry on the base of symmetries*, LAP, Saarbruken, 2012.

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[10] BACHMAN, F.: *Aufbau der geometrie aus dem spiegelungsbagriff,* Springer-Verlag, Berlin, 1959. (Original in German)
[11] STILLWELL, J.: *Mathematics and Its History,* Springer-Verlag, New York, 2010.
[12] ALEKSANDROV, P.: *Lectures on analytical geometry, supplemented by the necessary information from the algebra,* Ripol-classic, Moscow, 2002.
[13] LOZHKIN, A., ABRAMOV, I., BOZEK, P., NIKITIN, YU.: The issue of calculating elliptic trajectories, *Manufacturing technology,* Vol. 14, No. 4, pp. 561-566, 2014.
[14] BOZEK, P., POKORNY, P., SVETIK, J., LOZHKIN, A., ARKHIPOV, I.: The calculations of Jordan curves trajectory of robot movement, *International journal of advanced robotic systems,* Vol. 7, 2016.
[15] BOZEK, P., IVANDIC, Z., LOZHKIN, A., LYALIN, V., TARASOV, V.: Solutions to the characteristic equation for industrial robot's elliptic trajectories, *Tehnički vjesnik – Technical Gazette,* Vol. 23, No. 4, pp. 1017-1023, 2016.

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CONCEPTING FREIGHT HOLDING PROBLEMS FOR PLATOONS IN PHYSICAL INTERNET SYSTEMS

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Abstract: For the sustainability of future logistics systems, Physical Internet is one of the most determined idea. Initial solutions and ideas exist, but the development in this area is far from complete. In our opinion, vehicle technology trends such as interconnected, autonomous vehicles and the platooning system are an important opportunity for the development of logistics network. This research aims to investigate how these new types of processes can be modelled using the results of a freight holding problem. The article surveys the possibility of reconfiguration of the platoons in the Physical Internet system by creating a virtual transfer point.

1 Introduction

Given the increasing attention for the worldwide sustainability receiving from academics and specialists it is important to create a more efficient and effective supply chain model. One of the most widespread concepts of the future logistics network is the Physics Internet system.

Physical Internet (PI) is a new concept designed to implement the digital world into the processes of the physical world. One of the most important elements of this is the so-called PI containers, which are also based on the digital world. As in the Internet network, not data, but data packets flow, in the PI network goods as a standard packet will be store or transport. The expected efficiency can be achieved with a properly established network of elements in the network. The Physical Internet-based logistics network has recently been the subject of increased interest in both environmental, economic and social benefits, so it can be said that the developments and research have not yet been completed [1,2].

According to our opinion, the results of the vehicle technology development open up important opportunities for logistics systems [3]. Transport is one of the most dominant factors in the sustainability of the logistics network, and we can define the primary goal of reducing it's wastes. Transport, which means bridging geographical differences, is most often carried out by road. It can occur in any form from heavy-duty vehicles (HDVs) to small electric vehicles typically from cities. Among the trends in vehicle technology in our article, we concluded that the examination of the platoon systems could bring further improvements in logistics systems [3]. It is indispensable to ensure the communication of the vehicles in order to establish the platoon vehicle tracking system, so they become connected. This system was mostly examined from the side of the vehicle related results, and their logistical utility have not been shown so far.

This research focuses on the potential from development of platoon systems and connected vehicles. Using the results of the existing freight holding problem, we analyse how we can model these new types of processes in a Physical Internet-based network. After presenting the concept of Physical Internet in this article, we will survey the results of the freight holding problem research area. Finally, we present the structure of a future model which provides a dynamic, real-time reconfiguration for the platoons. This implies the creation of virtual transfer points, which is providing a meeting point for convoys to exchange their vehicle members. The transfer point can be placed anywhere in the network where two or more vehicles are carrying out the reconfiguration can safely stop (stops, parking lots, resting places, waiting stations, etc.). The purpose of the model is to optimize the location of the virtual point.

2 Physical Internet and vehicle platoons

The current operation of a global logistics system is unsustainable from a social, economic and environmental point of view [1]. There are basically no limits for customers to buy any product in any quantity from anywhere. Companies are constantly facing to this demand of performance, which they are less able to meet with their current system. To prove this, thirteen general symptoms have been presented in the article written by Montreuil [1]. The researchers created the theoretical concept of Physical

Internet in order to achieve effective and sustainable global operation. The point of the idea is to revolutionize logistics networks, including the storage, handling, and transportation of physical objects across the globe [2].

The concept of the Physical Internet has used the foundations of the digital world and developed the operational features of the future network by its analogy. The foundations of the new paradigm were laid down by Montreuil (Figure 1) [4].

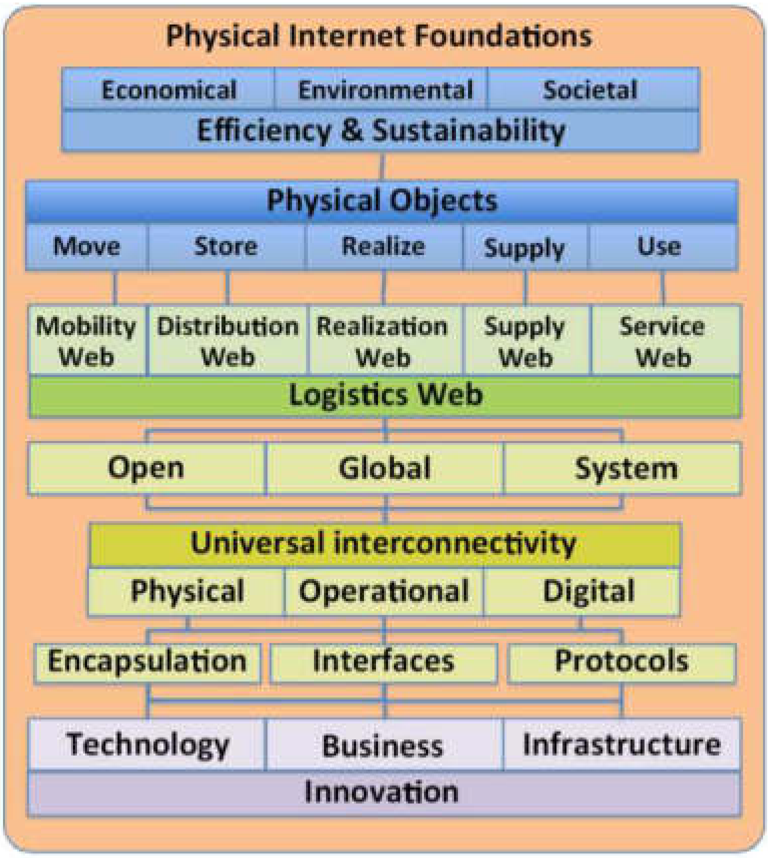

Figure 1 Physical Internet Foundations [4]

This is one of the most important concepts for the future network, but the breakthrough is still waiting. The primary goal of the Physical Internet is to define economic, environmental and social efficiency and sustainability. It uses a completely new approach to achieve this, because the physical objects would be handled in a standard container for specific purposes [1]. One of the strongest ideas follow the model of the ISO containers, and the sizes can be constructed according to that. [5] In the network, these packets carry the necessary information, and without knowing what is exactly in it, the next user or manager capable of doing all the required tasks, such as storage, loading or transportation.

The second cornerstone of the PI network is world-wide interconnectivity, at a physical, operational and digital level. Interconnectivity as a logistic quality feature ensures seamless information exchange and communication between entities in the network [4]. This concept is parallel to the trend in vehicle technology such as connected vehicle and the vehicle platoon system. The vehicle platooning concept, like the Physical Internet, was created to eliminate the prevailing negative effects, such as excessive energy consumption, congestion or pollution. In order for the vehicles to be able to ad-hoc create platoons, communication between them is essential. Currently, this is limited to a manufacturer's vehicle in practice, this method not feasible in more widely area, since currently there is no standard language [6]. For this reason, we can say that for this research, the most important feature for us is the universal interconnectivity of the Physical Internet, which would ensure that everyone 'speaks the same language' in our system.

The collectively called Cooperative Adaptive Cruise Control (CACC) system allows to the vehicles for following each other very closely. Thanks to this technology, it is possible to build a system where the leading vehicle is automatically followed by other vehicles. In this case, only the first vehicle should be manually driven so the other vehicles are connected to the driver using wireless communication technology and are controlled by it. With the platoon system, the vehicles are moving much closer to each other compared to manual driving, bringing both economic and social benefits [7].

To ensure the platoon system, vehicle routes must be synchronized. Vehicle synchronization means connecting two or more vehicle routes. According to the same authors, the spatial dimension of synchronization determines the place where the vehicle can be synchronized (at fixed points or at variable points), and the temporal dimension determines the sequence where the vehicles meet (at the same time or with precedence). Types of synchronization are summarized in the first table by distinguishing between temporal and spatial synchronizations [8].

Table 1 Type of synchronization [8]

		Temporal synchronization	
		Simultaneous	With precedence
Synchronization	Fixed transfer point	**Fixed point, Simultaneously**	**Fixed point, Priority**
	Variable transfer point (design result)	**Variable point, Simultaneously**	**Variable point, Priority**

During using their logistical application, vehicles from the same or different directions, but are in one direction can be organized in one platoon. The next figure (Figure 2) shows an example of a platoon formed by two vehicles, the number 2 vehicle makes a detour to create a connection [7].

According to our opinion, the greatest benefit of this can be achieved by using Physical Internet-based network, since in this case the open, global logistics system are available. We consider the system based thinking important, because in order to create a platoon, some vehicles can make a detour to extend their own route. In this case, the vehicles make a compromise and differ from their planned route in favour of reach the promised savings by the platoon [9].

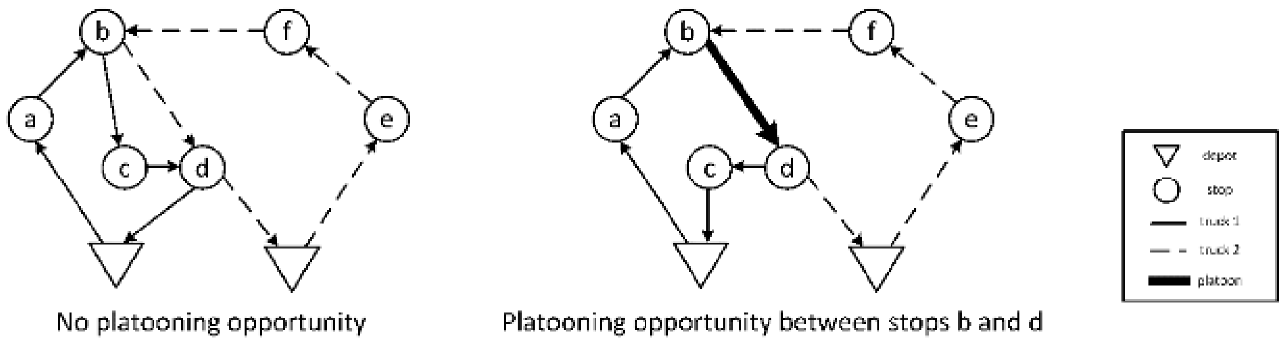

Figure 2 Route modification in order to create a platoon [7]

3 Freight holding problem

The operation of transfer-based networks can have significant advantages over direct point-to-point networks, such as reducing operating costs. The reduction is caused by the fewer roads made by the vehicles, as not all vehicles have to make the full journey between their starting station and their destination, because of use specified transfer points may establish joint routes. The freight holding problem is related to reloading at such transfer points. When a vehicle arrives at a transfer point, it is necessary to decide how long to wait for it to be worth it so waiting for a decision can lead to extra costs or save costs. Most of the publications on the issue are related to public transport, but there are some studies are dealing with holding decision problem for freight and logistics systems. Vehicle tracking is not a novelty in the logistics, and the exact location of the vehicles available with this. It can be said that, unlike passenger transport, in logistics systems, goods and vehicles are in an environment with a lot of data. In the following, we review the achievements of the transfer and freight holding problem. In our article, we base on four articles from the related research, two is based on public transport systems and two related to freight transport [10].

Randolph Hall et al. [11] examined the optimum waiting time at the transfer station. The target function minimizes the waiting time obviously this should be between two consecutive bus arrival times. The aim is to find the departure time when the total waiting time for all passengers is minimal. By increasing the expected arrival time of the next bus, they got four different target function values. From the results it can be concluded that as soon as the delay has increased significantly, it is better to start the bus immediately, otherwise while the value of the target function was lower than zero waiting time, it is better to hold the bus [11].

Xu Jun Eberlein et al. [12] uses real-time data. In their articles, they examined what stations and for how long it is worth to hold for the bus to minimize the waiting time for all passengers. It is important to note that in this case, minimizing the waiting time of the passengers involves minimizing the change of travel. Therefore, it is believed that the problem examined here is the most common for high-frequency transfer lines. Taking into account the assumptions of their method, the analysis has found that real-time information on vehicle routes may be sufficient to determine the holding decision and the real-time passenger demand information may not be necessary. Additionally, holding the vehicle does not have a significant impact on subsequently followed vehicles, which means that the length of the rolling horizon can be very small, which allows for real-time application of the algorithm [12].

Chen and Schonfeld [13] consider a number of logistical problems that could interfere with the operation of the system. In this work, the fast scheduling decisions are optimized in the changing environment. A vehicle control method has been developed that can help operators determine during an optimization process whether already vehicles should be dispatched immediately, or held for other certain vehicles. The decision-making methodology helps when the coordinated freight operations are disrupted. The target function is the sum of the costs of holding and non-holding. For each finished vehicle on the transfer point, a binary variable indicates the holding decision. To simplify the problem, authors start from a single hub operation that shows a symmetric demand between any incoming and outgoing routes [13].

Yanshuo Sun and Paul Schonfeld [14] examined the effect of correlation between vehicle arrival times. Most of the solutions found in the literature make vehicles arrive independent of mathematical simplification. This, however, sacrifices realism, since there are correlations in the real world. For example, as a result of bad weather or congestion, a bunch of vehicles may arrive. The impact of positive correlations, the vehicles arrive in groups. The proposed model is similar to the previous article, because they also use to help the driver optimization decision, taking into account the various types of costs. Making obligation is necessary when a vehicle is ready and when a new vehicle arrival forecast is available. Figure 3 shows a simplified case where two incoming trucks arrive at the specified transfer terminal and depending on the arrival time of the vehicle, need to determine the start or hold of the outbound train [14].

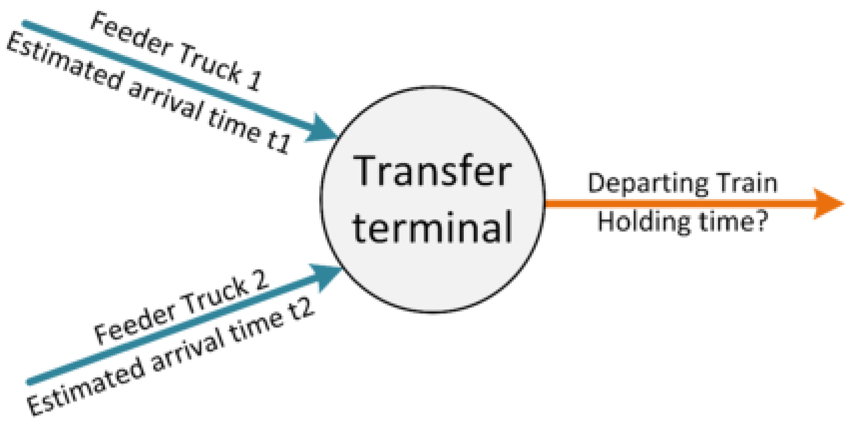

Figure 3 An example of two delayed arrivals [14]

Although there is only one decision variable, solving this optimization problem is difficult due to the goal is not convex. This means that any search algorithm may end on a local optimum. Based on their calculation results, it was determined that the correlation between the arrival time of the vehicles did not influence the expected value of the total cost. This has made the problem simpler, so it is enough to make the holding decision independently for every ready vehicle [14].

We can see that there are many solutions to the holding decision-making. Their common feature is that the target function is determined by time, such as waiting time or holding time. Public transport results clearly show that savings can be achieved by holding. The next two publications on freight transport examined the impact of the characteristics of the real system, as a result, some data is worth to be considered, but some factors are worth to be ignored. For example, designing with real-time based data can provide additional savings (reduction in waiting time). On the other hand, it is not worth considering the correlation of vehicle arrival times, as it has no effect on the expected value of the total cost.

4 Structure of the proposed model for platoons

Vehicle tracking systems have a big impact on logistical networks. In order to get maximum potential benefits of the platoon opportunity, it is required modernize the transport networks. If the required infrastructure is available, the constraints of the operating environment can be disregarded while examining the decision models, such as road width or road quality.

In the defined network, the functionality of the Physical Internet system can then be assumed. Thus, the fixed and predefined transfer centres are open for PI users, and vehicles and platoons are able to communicate and make decisions between each other. In our article, we investigate a general network based on the Physical Internet system where we can complete the network of existing terminals with virtual transfer nodes. In further analysis, we will define these virtual transfer point locations.

In the network, vehicles move in a platoon from the starting position to the destination. The creation of platoon is motivated by the common goal, because if they are connected and follow each other, they can enjoy the benefits of the platoon, even making compromises of detours [10]. As discussed in the second chapter, there are vehicles in the system, which are connected to the platoon by leaving their - presumably the shortest- original route and they join the platoon with a small detour [10]. We consider it worthwhile examining the benefits of the system if we define further virtual nodes in addition to the fixed transfer locations. These virtual transfer points provide the reconfiguration of platoons which allow a vehicle to connect to platoon which has more favourable route for the vehicle compared to its original platoon.

The problem to be examined is that if there is an additional possible node (crossroads, stops, parking) for the existing terminal system of a general PI network, where it should be located depending on the current shipments, so what should be the x and y coordinates of the location of the virtual reconfiguration point. The information needed for configuration is carried by each vehicle as its starting point, destination, departure time, and arrival time to the destination.

When determining the virtual transfer point, information about the vehicles need to be examined. It will then necessary to define the reconfigurations that have a great advantage for the network. The logistics network is defined by vehicles, roads, fixed stations, open terminals and virtual transfer points, starting locations and destinations. Thus, there are predefined open terminals in the logistics network. They are fixed and are capable of receiving and transhipping more vehicles. Each predetermined centre is characterized by a service time corresponding to the transhipment time. Accordingly, a platoon incorporating the current number of vehicles dispatch the specified intervals. In addition to this, there is a virtual transfer point in the current study where vehicles can change platoon, so they can reconfigure themselves. In the PI logistic network, relocation requires that the vehicle that wants to change the platoon need to arrive sooner or at the same time as the platoon to which it want to connect. Otherwise, the vehicle cannot exchange the platoon. This means that in the presented model we assume IV. type of synchronization based on categorization by Makonwska et al. [8].

The proposed structure for the virtual transfer point is explained via an example (see Figure 3).

In the example, objects labelled with 1,2,3 are the starting points, and the objects labelled 1’, 2’, and 3' are the destinations. The first figure (Figure 4-1) shows the initial state, where from each starting points the vehicles with common destination dispatch to form a platoon and arrive at the one or more destination. In this case, there is the advantage and disadvantage of platoon systems, as there are vehicles that make a detour for the benefit of the platoon. As we can see on the figure, these are the 4,5,10 and 11 vehicles. In the network, each base station is accessible to each destination, and each destination is directly accessible in both directions. Analysing the Physics Internet system, we interpret a global and open network. The second figure (Figure 4-2) on the right shows the purpose of the presented model, thus creating a virtual transfer point. By defining a virtual transfer point, the platoons can save additional unnecessary routes, thus achieving a more sustainable operation in the system. At this transfer point, the reconfiguration is made, taking into account the previously mentioned synchronization conditions.

The problem defined by the example is the optimization of the virtual transfer point location. The structure of the proposed model is shown in Figure 5.

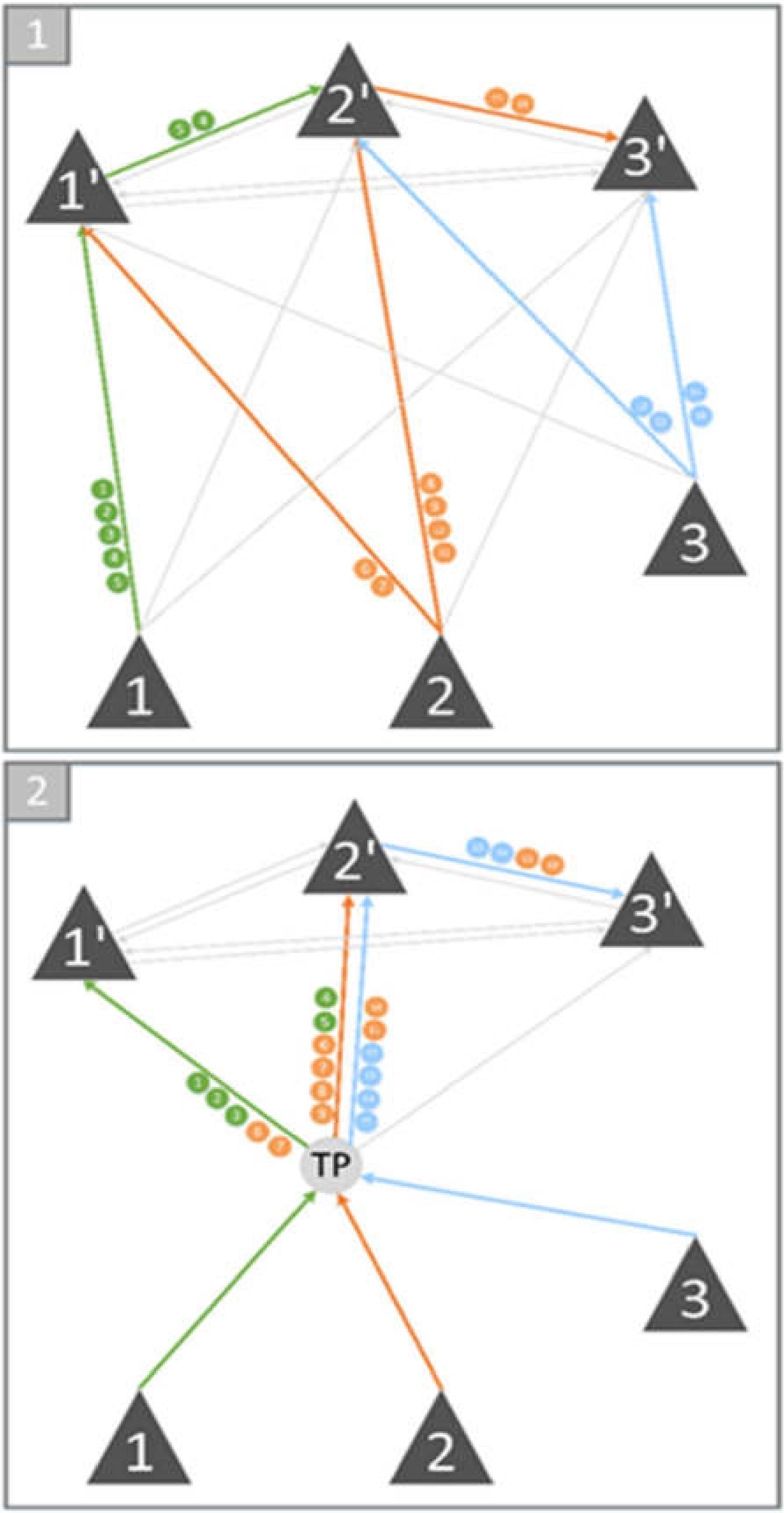

Figure 4 Example of the virtual transfer point optimization in Physical Internet network

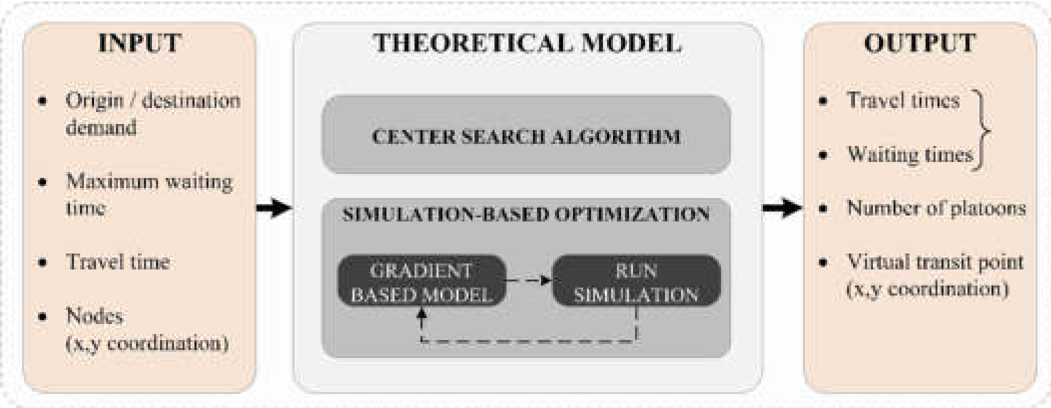

Figure 5 Theoretical model for virtual transfer point optimization in Physical Internet network

The following information is the input of the model:

- the predefined origin-destination demand,
- maximum waiting time,
- travel times between stations and
- the location of the origin and destination (*x* and *y* coordination).

Assuming the fourth type of synchronization, as the model input requires interpreting a maximum waiting time that the sooner coming platoon have to wait in order to the reconfigure to the later arriving platoon.

The task of the model is to optimize the location of the virtual transfer point, for which we have two options:

- One is a centre search analytical algorithm and;
- the other is a simulation-based optimization.

Analytically we use the result of centre search using coordinates algorithm. Figure 6 illustrates the process of reviewing the simulation optimization process. Accordingly, we determine the beginning of the simulation, transport in routes, terminal locations and demand values. At each origin stations, the system will generate platoons from the ready vehicles at specified times. Then the simulation assigns an initial virtual transfer point. The vehicle platoons go through the assigned transfer point before the destination. When a platoon arrives at the virtual transfer location, the model executes the real-time reconfiguration taking into account the defined maximum waiting time. Based on these, the following decisions can be made for the vehicles belonging to the platoon:

- Stay connected to their own platoon;
- Configuration themselves for a more favourable platoon;
- Waiting for a favourable platoon arriving within a maximum waiting time.

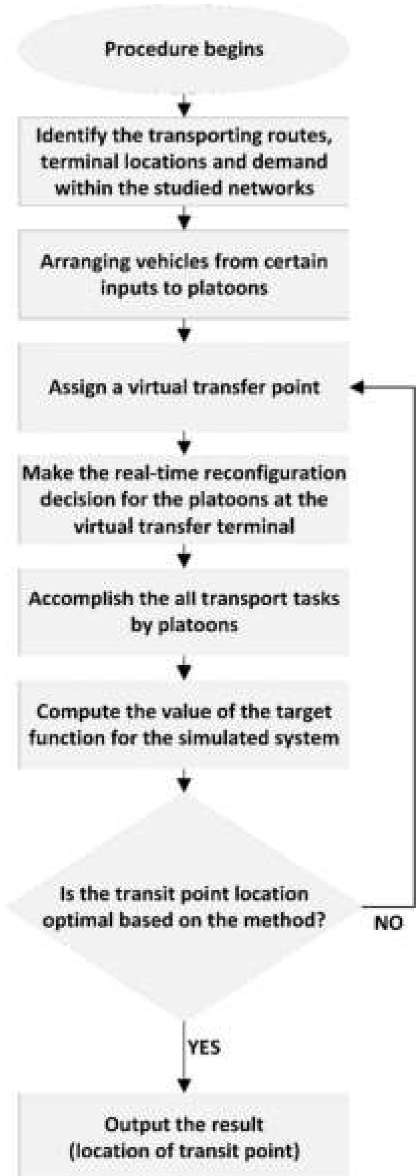

Figure 6 Virtual transfer point optimization in Physical Internet network

After making the decisions, the simulation performs the required transport tasks and then calculates the value of the specified target function after all the transport tasks have been completed. The next step in the process is to examine the optimal location of the virtual transit point based on the gradient method. The perfect method goes to the optimal location by using the largest reduction direction. So, run the simulation multiple times from a particular location to the coordinate in all directions, the simulation selects the *x*, *y* coordinate pair that has the lowest target function value. If the method does not find a better location placement for the simulation, the process is over and get the result of the *x* and *y* coordinates of the virtual transfer point. In case of the location is not optimal because of the simulation will find a more favourable position in the direction of the coordinate, the simulation will run again after assign the new location of the virtual transfer point.

In optimization, the goal is to minimize the time spent in the system by all vehicles. The distance travelled is directly proportional to time and the virtual transfer points do not have creation and deleting costs, so, in our opinion, the time is the most important feature of the system.

The time spent in the system for a vehicle is interpreted as follows, the arrival time of the vehicle at the departure station to the destination via the transit point, including the all travel and waiting times. Comparing the two methods with a lower target value of the transit point – so the lower sum of time spent in the system by all vehicle is accepted.

5 Conclusion and future works

Physical Internet is one of the most determined ideas for the future logistics system. Its fundamental goal is social, economic and environmental sustainability, which is realized through the open global logistics system. The cornerstone of an open system is to ensure the flow of wireless communications and information. If we assume these features, we can achieve a number of other benefits by implementing vehicle technology trends. Such as connected vehicles or platooning systems associated with interconnection. In this article we examined how we can model new types of processes using existing freight holding solutions.

In the process that we define, the vehicles used platoon system in a Physical Internet-based environment. To make better use of the benefits of the platoon system, we defined a virtual transfer point in the network where the platoons can reconfigure themselves. By using the reconfiguration, the vehicles can continue their routes in a platoon what is more advantageous to them, with synchronization conditions, a system-level based improvement can be achieved. This can be achieved with a system-level improvement. The purpose of the model is to find the optimal location for the virtual transfer point for reconfiguration.

The results of defining the virtual transhipment for the platooning reconfiguration as defined in the Physical Internet system belong to the basic phase of our research work. The next step in future research is to create a simulation model for the validation of the presented design, and then to examine the results of the simulation through its analysis.

References

[1] MONTREUIL, B.: Toward a Physical Internet: meeting the global logistics sustainability grand challenge, *Logistics Research,* Vol. 3, No. 2-3, pp. 71-87, 2011. doi:10.1007/s12159-011-0045-x

[2] TREIBLMAIER, H., MIRKOWSKI, K., LOWRY, P. B.: *Conceptualizing the Physical Internet: Literature Review, Implications and Directions for Future Research,* 11th CSCMP Annual European Research Seminar, Vienna, 2016. doi: 10.1007/s12159-015-0126-3.

[3] BOHÁCS, G., PUSKÁS, E.: Korszerű járműipari megoldások a Fizikai Internet megvalósítására, *Logisztikai,* Trendek és legjobb gyakorlatok, Vol. 4, No. 2, pp. 28-32, 2018. (Original in Hungarian) doi:10.21405/logtrend.2018.4.2.28

[4] MONTREUIL, B., MELLER, D. M., BALLOT, E.: Physical Internet Foundations, *IFAC Proceedings Volumes,* Vol. 45, No. 6, pp. 26-30, 2012. doi:10.3182/20120523-3-RO-2023.00444

[5] LANDSCHÜTZER, C., EHRENTRAUT, F., JODIN, D.: Containers for the Physical Internet: requirements and engineering design related to FMCG logistics, *Logistics Research*, Vol. 8, No. 8, pp. 1-22, 2015. doi:10.1007/s12159-015-0126-3

[6] MAITI, S., WINTER, S., KULIK, L: A conceptualization of vehicle platoons and platoon operations, *Transportation Research Part C: Emerging Technologies,* Vol. 80, No. July, pp. 1-19, 2017. doi:10.1016/j.trc.2017.04.005

[7] BHOOPALAM, A. K., AGATZ, N., ZUIDWIJK, R: Planning of truck platoons: A literature review and directions for future research, *Transportation Research Part B: Methodological,* Vol. 107, No. January, pp. 212-228, 2018. doi:10.1016/j.trb.2017.10.016

[8] MANKOWSKA, D. S., BIERWIRTH, C., MEISEL, F: *Modelling the Synchronization of Transport Means in Logistics Service Operations*, International Conference on Computational Logistics, Vol. 6971, pp. 74-85 2011. doi:10.1007/978-3-642-24264-9_6

[9] JANSSEN, R., ZWIJNENBERG, H., BLANKERS, I., de KRUIJFF, J.: *Truck platooning; driving the future of transportation - TNO whitepaper*, TNO whitepaper, 03 March, 2015.

[10] LARSSON, E., SENNTON, G., LARSON, J: The vehicle platooning problem: Computational complexity and heuristics, *Transportation Research Part C: Emerging Technologies,* Vol. 60, No. November, pp. 258-277, 2015. doi:10.1016/j.trc.2015.08.019

[11] RANDOLPH, H., MAGED, D. , QUAN, L.: Optimal holding times at transfer stations, *Computers &*

Industrial Engineering, Vol. 40, No. 4, pp. 379-397, 2001. doi:10.1016/S0360-8352(01)00039-0

[12] EBERLEIN, X. J., WILSON, N. H. M., BERNSETIN, D.: The Holding Problem with Real–Time Information Available, *Transportation Science,* Vol. 35, No. 1, pp. 1-18, 2015. doi:10.1287/trsc.35.1.1.10143

[13] CHEN, C.F., SCHONFELD, P.: Alleviating Schedule Disruptions at Intermodal Freight Transfer Terminals, *Transportation Research Record: Journal of the Transportation Research Board,* Vol. 2238, No. 1, pp. 32-43, 2011. doi:10.3141/2238-05

[14] SUN, Y., SCHONFELD, P.: The Holding Problem with Real-Time Information, *Transportation Research Part B: Methodological,* Vol. 90, No. August, pp. 218-240, 2016. doi:10.1016/j.trb.2016.05.003

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