Blockchain Technology in Transportation as a Part of the Efficiency in Industry 4.0 Strategy

Dmitriy Muzylyov[1(✉)] and Natalya Shramenko[1,2]

[1] Kharkiv Petro Vasylenko National Technical University of Agriculture, 44 Alchevskyh St., Kharkiv 61002, Ukraine
murza_l@ukr.net
[2] Ukrainian State University of Railway Transport, 7 Feierbakh Sq., Kharkiv 61050, Ukraine

Abstract. The research is directed to the design of the theoretical bases. They prove the application relevance of smart approaches in transport logistics. The article explains the advantages of using blockchain technology during products transportation according to Industry 4.0 Strategy. The analysis of application history of various systems at cryptocurrencies transaction allowed to mark out main risks at the launch of the described network. The space of relations for participants of transport logistics was constructed. It is regulated by the principles of a blockchain. The main results of blockchain functioning were included in the table according to the offered smart principles for the regulation of financial and business relations. The main implementation conditions of a similar project are defined. The criterion for finding the best option of a blockchain network is presented in mathematical form. The principles of the constant exchange of information between databases are established and schematically described. They will allow supporting a system in the working state and increase efficiency. The main condition of blockchain technology development is mathematically formalized at its realization in the transportation process of goods according to Industry 4.0 Strategy. The best option must be chosen according to the submitted recommendatory table. The offered criteria are the first step for the definition of blockchain network which will meet completely all requirements for a successful project start.

Keywords: Blockchain · Transportation · Cryptocurrency · Transaction · Benefits · Smart · Approach · Industry 4.0 · Strategy · System

1 Introduction

The modern virtualization level of logistic processes and regularly necessity for fast information exchange between participants of the supply chain predetermines the use of various smart technologies. The using of such approaches as modeling based on neural networks and fuzzy-logic [1–3] for the training of robotic elements at the transport system is now not surprising anybody. This fact is now a part of our reality.

V. Tonkonogyi et al. (Eds.): InterPartner 2019, LNME, pp. 216–225, 2020.
https://doi.org/10.1007/978-3-030-40724-7_22

But the application of blockchain technologies is innovative for the transport industry, as well as for Industry 4.0 in whole [4].

The first publications began to appear in the Internet communities devoted to reviews of the cryptocurrency market. These articles said about creation prospects of similar projects in the transport industry [5]. It is not surprising because the blockchain technology was directly created for carrying out the decentralized transactions with various electronic currencies. They got real expression in a money equivalent in the subsequent. The maximal interest in a blockchain was in the middle of 2017 and the beginning of 2018. This fact was caused by a substantial increase in cryptocurrency price in relation to fiat money. The similar popularity led to the creation of various startups, in particular, to projects emergence based on blockchain platforms in the transport systems. But at the first stage there were more problems, than opportunities to realization.

An important element for the development of Industry 4.0 Strategy must be not only using smart technologies for direct production but also must apply a timely and high-quality transport servicing. This will increase efficiency in Industry 4.0 Strategy. The transport logistics also must be comparable on the level to Industry 4.0 technology according to the German experts [6].

2 Literature Review

Full realization and launch of blockchain in the transport system are now nearest than earlier. Some unreality and certain difficulties don't interfere to start using smart technology in the sphere of logistics [7]. Now some projects have already gone out from a period of testing a blockchain to its practical application in the transportation process [8]. This is a good example of expediency for the implementation of this innovative technology. At the same time, participants of logistic interaction use mainly similar technology for documentary and information support.

Data transaction processes were considerably accelerated after implementation of blockchain. All users of transport servicing have such opinions (both customers and carriers). In particular, the passing time of transit cargo traffics was reduced to 40% during testing of a blockchain platform at the organization of shipping for container cargoes [9]. A similar reduction of temporary indicators during the processing of transit cargoes through seaport allowed to reach significant saving also in a money equivalent.

Experts also analyzed the use of blockchain test model of in logistics not only for transferring information resources but also for their storage and processing. As a result, the needs of each participant were fully satisfied in the round-the-clock access to the considerable volume of data. The known method of creation of cloudy storages with simultaneous use of technologies of cloudy mining was applied as a basis of project realization [10]. It also became one of the main arguments testifying to the fast era beginning of using blockchain technologies at the decision of logistic problems.

The latest works in the sphere of studying the potential of using a blockchain network are devoted to mapping the ample opportunities to apply innovative technology in the logistics sphere and supply chain management (SCM) [11].

The value of a blockchain is very interestingly presented for increasing the effective management of the processes occurring in supply chains. The Austrian scientist recommends in own research to carry out in logistic companies immediately implementation of new technology in the production process [12].

The attractiveness of technology and the possibility of receiving a large income predetermined appearance of startups. The logistics sphere did not become an exception. Features of implementation are described for similar projects in supply chains in the given research [13].

In work [14] the author carried out a comparison of the functioning principles of the standard supply chain with the SCM system into which the innovative technology of cryptocurrency is integrated. Comparison results show the priority of smart methods management. Especially in coordination of work with the sphere of Industry 4.0 [15].

Researchers described the application history of technology blockchain in different types of supply chains [16]. This work became the first recommendation for the potential use of the system at the organization of logistic processes in the future.

Despite the lack of the developed conception of blockchain using in the logistics sphere, its full implementation in delivery process on different kinds of transport, integration of all carriers and consumers of their transport servicing at uniform system already is rather a reality, than a dream. And the use of similar methods in the solution of the logistic problems will allow accelerating many times not only a transfer of information component but also guarantees the security and timeliness of mutual settlements between participants.

Using a blockchain in the agro-logistics sphere is a very promising direction for Ukraine as an agrarian country [17]. Especially at the management stage of the interaction between harvesting and transport complexes [18]. Only initial investments and the creation of trading platforms are required for the implementation of similar projects in the countries where a business is focused on the agricultural industry. These exchanges markets must fully correspond to Industry 4.0 Strategy. They will help to coordinate faster actions of all participants in the supply chain and to guarantee minimum costs during goods transportation.

3 Research Methodology

It is necessary to compare possible risks and future benefits which will arise after implementation of projects based on blockchain in the sphere of transport logistics before launching any new technology. At the same time, the organization of similar systems must be based on the principles described in the last researches [19].

The main advantages of the blockchain implementation in transportation process:

- Almost absolute safety of realizing financial transactions between the carrier, the customer of the transport servicing and also the goods producer;
- Creation of own document flow database which increases the speed of information exchange;
- Data transaction is carried out only by the digital way, without using paper documents;

- The blockchain reduces risks of not receiving money after transportation process performance;
- Waiting time of payment for servicing is instant;
- Unlimited quantity of participants in a system;
- The legality of transactions with a possibility of exchange on any world currency at any time;
- The system uses a single (universal) currency for carrying out mutual settlements between participants;
- Participants location in the general structure is a certain guarantee of each member reliability that increases credibility level in a logistics system working by blockchain technology.

Unfortunately, the implementation of new technologies occurs not always according to usual standards and without negative nuances. Therefore, the list of the possible reasons is given below for cases when the expected effect can't be received:

- Mistrust of potential participants to new technologies depends on significant risks of money loss;
- The complexity of attracting investors is connected to unknown date of getting the first profit from made investments;
- The wrong advertising campaign affects launch terms of the project (they can last a long time);
- Lack of experience in the companies in the implementation of blockchain technology on transport and Industry 4.0 in whole;
- An individual blockchain setting considering transportation features;
- The correctness of the choice of a cryptosystem from a set of alternatives for guaranteeing the work reliability of system;
- Lack of enough investments at the first stage that does not give the chance to launch a blockchain;
- A probability of external intervention that will lead to failures in work;
- Lack of the legislative base for relations regulation between the participants carrying out the activity using blockchain technology.

Comparing possible risks and estimated benefit from the implementation of similar projects on transport, it cn be seen that they are identical in the quantitative ratio. But blockchain should be used according to an evaluation criterion on a qualitative level due to a considerable simplification of financial and information aspects between members.

The next step at the implementation of innovative technologies is the description and structural representation of participants in the system and showing the basic principles of their interrelations. Work of scientists from Copenhagen Business School became one of the last attempts to present the structure of the relations between participants of logistic processes based on blockchain technology [20].

Relations of transport logistics members must be correlated according to the scheme (see Fig. 1). It will allow implementing blockchain technology in the transportation process of goods produced by the principles of Industry 4.0 Strategy.

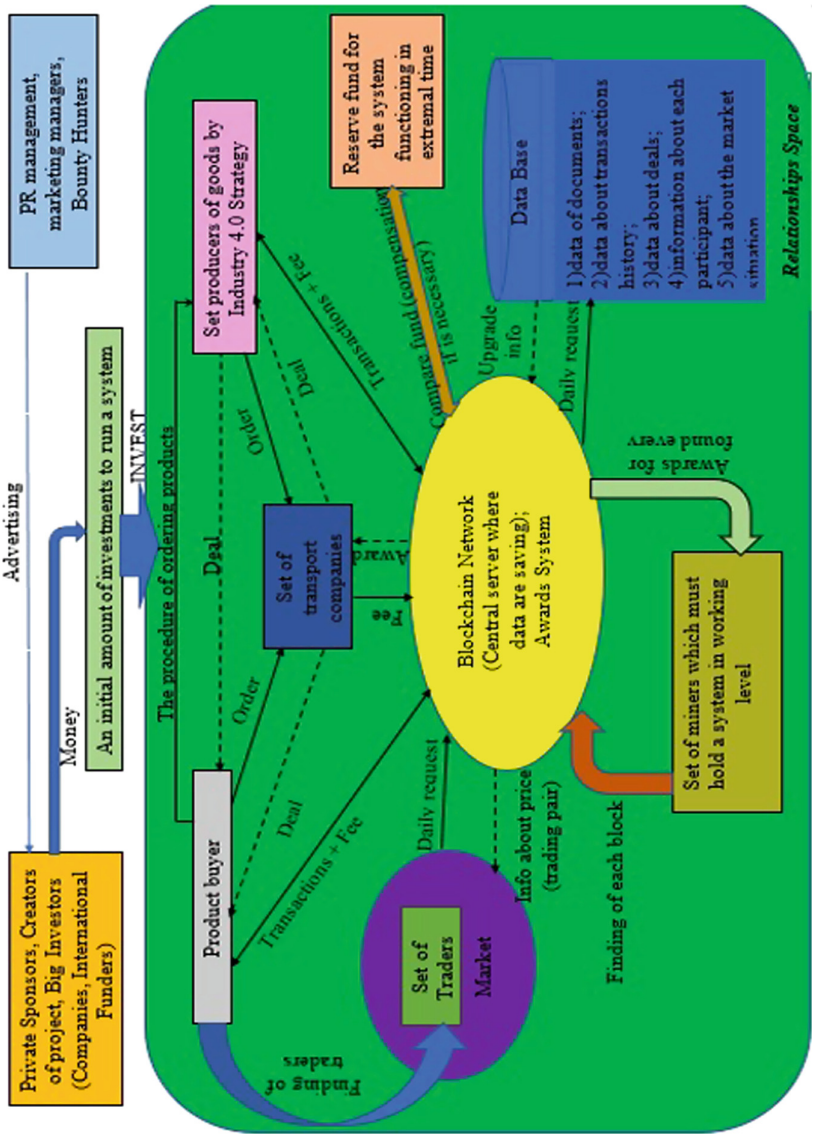

Fig. 1. Conceptual scheme of the relations between participants of the Blockchain network in the transport system.

Design of the relations on the submitted scheme (Fig. 1) will allow receiving several main results. They are presented in Table 1 with explanations of possible benefits.

Figure 1 does not display a possible option of deals directly through the blockchain network. But it is real. It is necessary to provide a possibility of the digital contracts signing in this way. However, at the first stage of the system working, i.e. at the start,

Table 1. The main results from using blockchain technology in the transportation sphere.

Resulting position	Benefits (comment to achieved result)
High level of the trust between participants	The deals will be made very fast without external agents
Only one kind of currency is used to make payment	This reduces the charge of the transaction and makes the amount of payments cheaper
Fast transactions	The probability to lose money is reduced
Transparency of remittances	Money cannot be using for illegal actions
The system has enough amount of money	Each participant will get awards in-time during the period according to contract
The payment history can't be deleted	Each transaction can be checked

this procedure needs to be excluded. It will allow increasing system security and will give time to participants for beginning to cooperate with each other with more trust.

The results presented to Table 2 unambiguously emphasize the attractiveness of projects implementation based on blockchain networks in the transportation sphere. These positive nuances completely reflect all advantages of smart methods which are fully correlated with Industry 4.0 Strategy.

Table 2. Necessary conditions to provide the blockchain conception in the transport system

Condition name	What must be	Risk
Starting and working capital	Good roadmap (strategy) to achieve necessary amount of money	The goals of roadmap don't reach in-time
Trading platform	Good quality of token	The exchangers from TOP-20 don't list token on their platforms
Regulation law	A guarantee of the stable system functioning	The government doesn't support this type of financial relations
Kind of Blockchain	Powerful and other features must be equal to requirements of the system	The kind of blockchain network can be chosen wrongly because the creators of the system have no experience in this field

Set of participants N_p can be presented mathematically as the following formula:

$$N_p = \{C_i, P_i, TRC_i, TRA_i\}, i = 1, \ldots, k, \quad (1)$$

where C_i – set of customers (buyers); P_i – set of producers; TRC_i – set of transport companies which have the necessary capacity for transporting specific cargoes; – set of traders from markets trading with produced goods according to Industry 4.0 strategy.

The set of participants presented in formula (1) is the minimum required for the full network functioning. At the same, time the main condition of system developing must the next:

$$N_p \Rightarrow +\infty \tag{2}$$

This means that the participants' quantity in a system must be increased regularly. This aspect will promote the attraction of new investments in a blockchain network which serves the main financial processes. Therefore, the working level of the network will be achieved according to the next requirements (see Table 2).

The main criterion to choose an optimal blockchain network:

$$BC_{opt} = \begin{cases} N_{mnrs} \geq N_{mnrs}^{\min} \\ T_{trans} \rightarrow \min \\ L_{saf} \rightarrow \max \\ A_{fee} \rightarrow \min \end{cases}, \tag{3}$$

where N_{mnrs} – number of miners which finding blocks in system, miners; $N_{mnrs}^{\min}$ – minimal quantity of miners which needs to provide a working level; T_{trans} – transaction time (speed), trans/sec.; L_{saf} – safety level, %; A_{fee} – system fee per one transaction, token/trans.

The security level of the network must be at the same time relevant to several criteria. The reliability assessment of the network is described as a mathematical formula considering the parameter of the minimum errors and opposition to the hacker attacks (4):

$$L_{saf} = f(N_{er},\ N_{discl},\ N_{hack}) \rightarrow \max, \tag{4}$$

where N_{er} – number of errors inside of network, unit/time period; N_{discl} – quantity of disclaimers, unit/time period; N_{hack} – number of hacker attacks finished with steal of money, unit/time period.

The principles of constant information exchanging between data blocks in the blockchain network can be shown at the next scheme (see Fig. 2).

This scheme is the simplified model showing the minimum exchange of information between the main databases in a blockchain network.

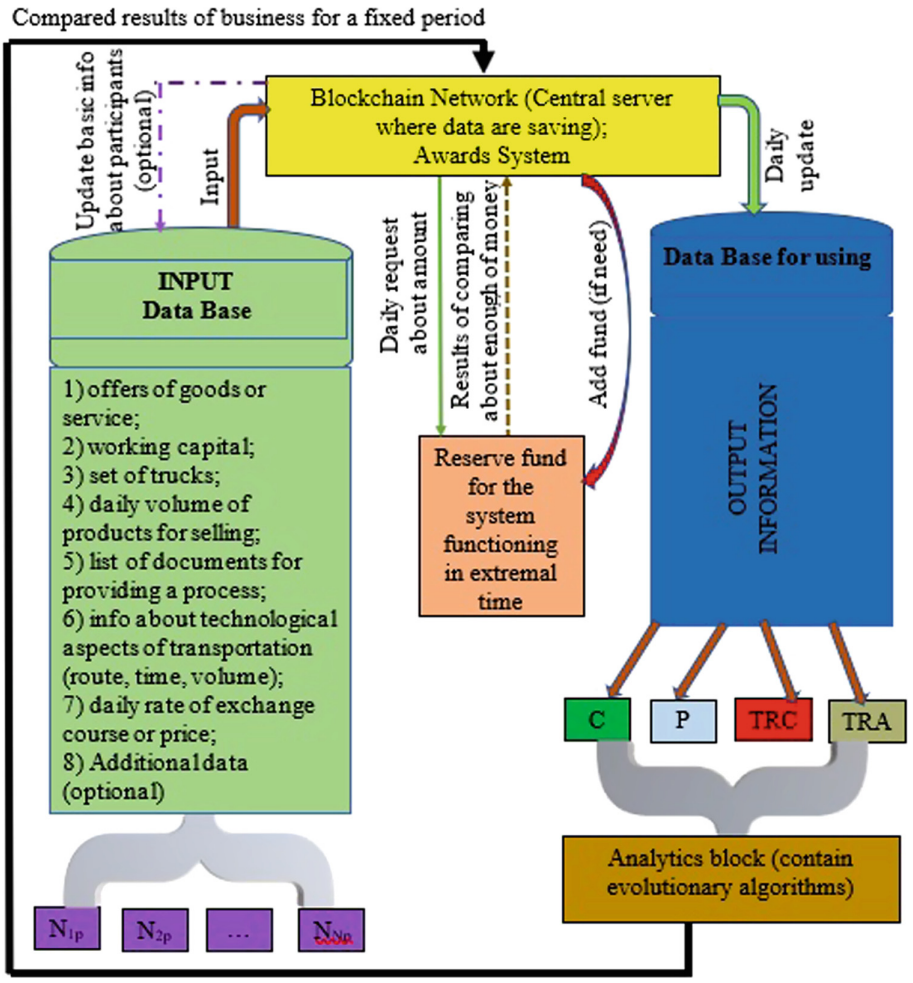

Fig. 2. Structure of constant information exchanging between data blocks in the blockchain network.

4 Results

The choice of the network must be based on the following table version (see Table 3). Some suggestions about this aspect were given in the initial compared table [21].

EOS is the most perspective network according to comparison results. It has the largest transactions speed. But the speed of the financial transactions is not the main criterion for finding the best option of blockchain. It is necessary to be guided also by formulas 3–4 for choosing a network.

Table 3. Compared table for choosing the best option of a blockchain network

Kind of Blockchain	Launch date	Own network	Type of algorithm	Transaction time, trans/sec
Bitcoin (BTC)	2009	Blockchain 2.0	SHA256	7
Ethereum (ETH)	2015	MainNet of Ethereum	EtHash (PoW)	20
Stellar (XLM)	2014	Stellar Main Net	xCrypt	1000
EOS	2018	EOS.io	PoS	2800
Cardano (ADA)	2017	n/a (will appear until 2020)	PoS	50–200
WAVES	2016	Waves Platform	PoS (LPos)	1000
NEO	2014	NEO	PoW	1000

5 Conclusions

The theoretical researches results showed some difficulties to implement blockchain technology in manufacturing at the current moment, especially in the transport sphere. It relates to the lack of the theoretical bases describing blockchain realization ways in transport logistics according to Industry 4.0 Strategy. The constructed space of relations between participants allowed understanding the basic principles of system functioning based on a blockchain. This will increase the efficiency of the delivery process. The offered mathematical criterion for finding the best blockchain network guarantees the high speed of transactions, acceptable security level and the minimum quantity of errors during systems' work. It is planned to carry out the reliability assessment of 2–3 blockchain types in future researches. In this case, approbation will be done at the transport systems of grain delivery.

References

1. Shramenko, N., Muzylyov, D., Karnaukh, M.: The principles of the choice of management decisions based on fuzzy logic for Cargo delivery of grain to the seaport. Int. J. Eng. Technol. (UAE) **7**(4.3), 211–216 (2018)
2. Shramenko, N., Pavlenko, O., Muzylyov, D.: Information and communication technology: case of using Petri nets for grain delivery simulation at logistics system. In: CEUR Workshop Proceedings, vol. 2353, pp. 935–949 (2019)
3. Shramenko, N., Muzylyov, D.: Forecasting of overloading volumes in transport systems based on the fuzzy-neural model. In: Ivanov, V., et al. (eds.) DSMIE 2019. Lecture Notes in Mechanical Engineering, pp. 311–320. Springer, Cham (2020)
4. How blockchain is revolutionizing the world of transportation and logistics [Infographic], Winnesota Regional Transportation. https://www.winnesota.com/blockchain. Accessed 15 June 2019
5. Holder, S.: How blockchain technology could transform trucking. https://www.trucks.com/2017/09/21/blockchain-technology-transform-trucking. Accessed 21 June 2019

6. Schroeder, W.: Germany's Industry 4.0 strategy Rhine capitalism in the age of digitalisation. https://www.fes-london.org/fileadmin/user_upload/publications/files/FES-London_Schroeder_Germanys-Industrie-40-Strategy.pdf. Accessed 19 June 2019
7. Blockchain in Cargo transportation: three main conditions for providing, SharesPro. https://sharespro.ru/news/982-blockchain-gruzoperevozkah. Accessed 11 June 2019
8. Novikova, K.: TOP-5 blockchain projects in the logistics sphere, Homepage DigitalForest Ltd. https://digiforest.io/blog/blockchain-in-logistics. Accessed 20 Jan 2019
9. Klein, D.: Technology of blockchain in transport logistics, CryptoFox. https://crypto-fox.ru/article/p2p-kreditovanie. Accessed 27 Apr 2018
10. Heutger, M., Kückelhaus, M., Chung, G.: Blockchain in logistics: perspectives on the upcoming impact of blockchain technology and use cases for the logistics industry. DHL Customer Solutions & Innovation, Germany (2018)
11. Petersen, M., Hackius, N., von See, B.: Mapping the sea of opportunities: blockchain in supply chain and logistics. It – Inf. Technol. **60**(5–6), 263–271 (2018)
12. Treiblmaier, H.: The impact of the blockchain on the supply chain: a theory-based research framework and a call for action. Supply Chain Manag.: Int. J. **23**(6), 545–559 (2018)
13. Poszler, F., Ritter, A.C., Welpe, I.: Blockchain startups in the logistics industry: the technology's potential to disrupt business models and supply chains. In: Schröder, M., Wegner, K. (eds.) Logistik im Wandel der Zeit – Von der Produktionssteuerung zu vernetzten Supply Chains, pp. 567–584. Springer, Wiesbaden (2019)
14. Mukri, B.: Blockchain technology in supply chain management: a review. Int. Res. J. Eng. Technol. **5**(6), 2497–2500 (2018)
15. Waista, A.: Industry 4.0 – building digital ecosystem. https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf. Accessed 29 June 2019
16. Dujak, D., Sajter, D.: Blockchain applications in supply chain. In: Kawa, A., Maryniak, A. (eds.) SMART Supply Network. EcoProduction (Environmental Issues in Logistics and Manufacturing), pp. 21–46. Springer, Cham (2019)
17. Ehmke, T.: Blockchain: change is coming to agricultural supply chains. https://www.cobank.com/knowledge-exchange/general/blockchain-change-is-coming-to-agriculture-supply-chain. Accessed 29 June 2019
18. Muzylyov, D., Kravcov, A., Karnayh, N., Berezhnaja, N., Kutiya, O.: Development of a methodology for choosing conditions of interaction between harvesting and transport complexes. East. Eur. J. Enterp. Technol. **2**(3), 11–21 (2016)
19. Wang, S., Qu, X.: Blockchain applications in shipping, transportation, logistics, and supply chain. In: Qu, X., Zhen, L., Howlett, R., Jain, L. (eds.) Smart Transportation Systems 2019. Smart Innovation, Systems and Technologies, vol. 149, pp. 225–231. Springer, Singapore (2019)
20. Hald, K., Kinra, A.: How the blockchain enables and constrains supply chain performance. Int. J. Phys. Distrib. Logist. Manag. **49**(4), 376–397 (2019)
21. Cryptocurrency comparison table. https://www.ig.com/en/cryptocurrency-trading/cryptocurrency-comparison. Accessed 27 June 2019