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SELECTED APPLICATIONS OF THE BLOCKCHAIN NETWORK IN THE ECONOMY 4.0

Kamil KARSKI

Lima Reklama, Rybnik; karskikamil@gmail.com

Purpose: The paper focuses on a trial of defining the assumptions of the fourth industrial revolution and presenting selected applications of modern Blockchain technology. The aim of this article is to draw attention to the growing importance of modern technologies having a significant impact on the development of the world economy and to show the opportunities of their potential introduction to the market.
Design/methodology/approach: The article is both theoretical and empirical. Literature research allowed to determine main pillars that Industry 4.0 is based on. From among them, the invention was selected, which has a wide range of impact both on the production environment and on the society.
Findings: The article shows the essence of new technologies in the Industry 4.0 and the selected applications of one of them. The article defines the impact of new technologies on economic development and provides a general research of new technologies in new World Economics.
Research limitations/implications: Blockchain network is a dynamically developing technology that can be, used in many different areas of life, unfortunately it is still in its infancy and its implementation is very slow.
Practical implications: One of the applications of the Blockchain network is the implementation to production systems that make order management more flexible and guarantee non-failure production which is also encrypted.
Social implications: Blockchain technology could redefine how people are using public services as daily bases.
Originality/value: The article contains description of new technology in modern economics. The article may be useful for researchers working on that subject and or the practitioners trying develop production or services using such invention for their clients.

Keywords: Blockchain, Industry 4.0, Smart factory, Data protection, Financial Service.

Category of the paper: Research paper.

1. Introduction

Nowadays most enterprises face great difficulties which have a considerable impact on their continued existence on the market. A strong competitive environment, switching production processes according to changing consumer demands, the accuracy of effective decisions, or the speed of processing data accruing from the market – are the main, but not the only challenges faced by organizations. The aforementioned aspects affect an increasingly complex production system that provides huge amounts of data. It turns out that a company is not able to manage such a large amount of knowledge due to the lack of tools and platforms that are necessary for mutual cooperation of all areas of the company's activity. To remedy it, a concept was developed, that would combine knowledge, simulation, learning and optimization to improve modern production systems.

The concept of Industry 4.0 was coined at the industrial technology fair in Hanover 2011 (German – Industrie 4.0). Considerations had begun on what the changes would involve, when they would take place and what their effect would be. During the technological event, it turned out that in fact the fourth industrial revolution has already commenced and humanity is currently dealing with it. Taking into account other breakthroughs that lasted for decades and were limited to industry only, the fourth revolution can be described as a holistic one, as it covers almost every area of human life.

The first revolution began around 1760 and lasted until roughly 1840. There had been a shift from using muscle strength to using mechanical force. The development started with the construction of the railway and the invention of the steam engine, which lead to the introduction of mechanical production. The popularization of the steam drive made the production not only more efficient, but also much faster. Due to the use of rail transport, the distribution time of goods thus produced was significantly shortened (Schwab, 2018).

The second industrial revolution, which dates back to the turn of the 19th and 20th centuries, enabled mass production – that began with the introduction of a production line and electricity (Iwański, Gracel, 2016).

The third industrial revolution took place in the 1960s. It is commonly referred to as the computer or digital revolution. Successively, significant improvements were made: in the semiconductor industry – the invention of transistors (Issacson, 2016) and large operating systems such as BSD. In the following years, personal computers and the Internet began to appear. The communication technology involved satellite TV and cellular connections, and Toyota developed a modern production and logistics model *Just In Time* (Czyżewski et al., 2017).

Industry 4.0 marks the fourth industrial revolution. It can be described as Economy 4.0. It brings together technology and value chain organization (Hermann et al., 2015). It is assumed that this revolution means a vision of smart factories based on intelligent cyber-physical

systems. The implementation of this idea will allow for the development of intelligent, autonomous production systems, capable of self-configuration, self-control and self-repair. The main pillars on which this revolution is based are (Erboz, 2017):

- Big Data and Analytics,
- Autonomous Robots,
- Simulation,
- Industrial Internet of Things (IIoT),
- Computing Cloud,
- Horizontal and Vertical System Integration,
- Additive Manufacturing (3d printing),
- Cyber Security,
- Augmented Reality.

The author decided to describe a selected issue from a wide spectrum of the phenomena accompanying the fourth industrial revolution, which is the use of Blockchain network in a smart factory.

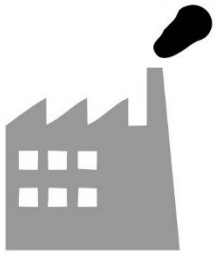
Industry 1.0	Industry 2.0	Industry 3.0	Industry 4.0
			
Steam Engine	Electricity	Computers	Big Data, IIOT, AI

Figure 1. Industrial Revolutions. Source: own work.

2. Characteristics of Blockchain network

The emergence of distributed ledger technology (DLT) – blockchain networks, can be compared to the internet revolution. The main assumption of distributed registers is to move away from centrally managed information to its encryption at each member of the data exchange system. It is also associated with the risk of interference in its structures by users, who might try to falsify the results of calculations in individual blocks that store data (Walch, 2017).

The year 2008 is considered to be the launch of the Blockchain network. For more than 12 years after this invention, there has been a strong link between the decentralized data registry and the creation of the Bitcoin cryptocurrency. The assumptions of this network were developed in the so-called Nakamoto Manifesto. It was probably created by one person or a group of anonymous cryptographers (Nakamoto, 2008). Since then, the interest in this technology and the potential use of this network for applications other than the world of finance and cryptocurrencies has increased rapidly. In turn, another version of the block system – Etherum – was proposed by 19-year-old Vitalik Buterin (Wood, 2014). In its implementation, the so-called Smart Contracts could be used. Contrary to the Bitcoin cryptocurrency, the Etherum network enables a much faster information exchange, which is 14-15 seconds, respectively, where the average Bitcoin exchange time is about 10 minutes (Kumar, Tripathi, 2019).

In the original Buterin project, there was a message, similar to Nakamoto's, that an open-source, global, decentralized register of contracts, transfers of property rights and the possibility of settling transactions should be created, on a principle that works like in the Bitcoin cryptocurrency case. Financial and technology industry companies such as Microsoft, Intel, Toyota, Credit Suisse, saw great opportunities using Etherum for their purposes, because it was programmable, while Bitcoin did not include this functionality (Petković, 2017).

To understand how the Blockchain network works, the following diagram was used (Hassan, Jain, Chandna, 2017):

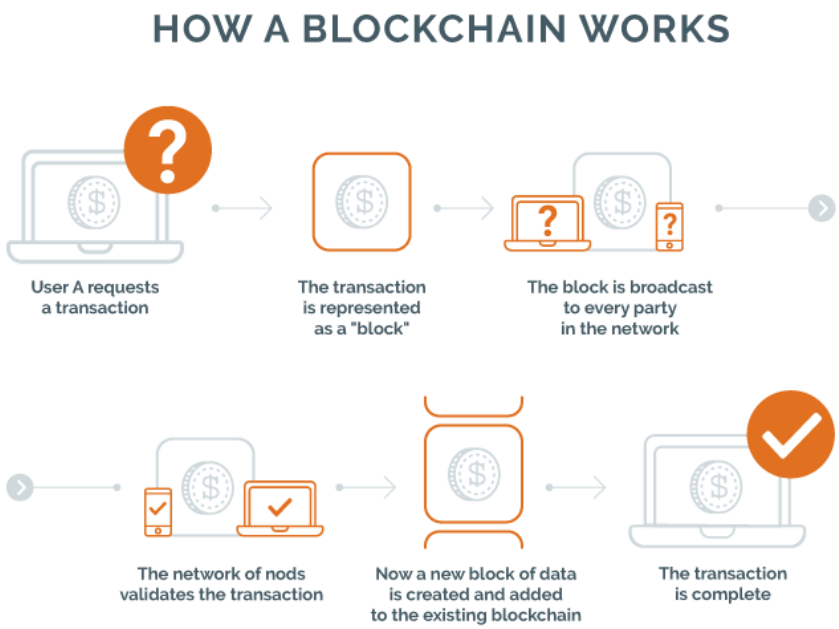


Figure 2. How blockchain technology works, from: "Blockchain, Cryptocurrency And Bitcoin" by N. Hassan, N. Jain, Chandna V.K., Copyright 2018 by JECRC Foundation.

- In order to send or receive a bitcoin or to send any information, the user must make a transaction that is distributed to each participant in the network. Cryptographic algorithms add a record in the ledger for each user.
- Complex mathematical algorithms add the transaction to the public digital ledger. There is only one ledger and it is updated at the same time for each network participant, which guarantees durability and correctness of the operation. The network of nodes then validates the transaction.
- A new block transaction is added chronologically to the main Blockchain. No previous operation can be changed or deleted. Hence, it is difficult to counterfeit, because the transactions are cryptographically encrypted throughout the procedure, but remain publicly
- The operation is complete.

Initially, Bitcoin's Blockchain did not have a large size, but in later years, with the increase in the number of transactions, the size of the ledger increased significantly and in 2014 it exceeded 20 gigabytes. The amount of energy needed to maintain the network exceeded Ireland's energy demand (O'Dwyer, Mallone, 2014).

From the very beginning of the implementation of Blockchain technology and its use in the creation of digital currencies, it has become clear that cryptocurrencies are only a pretext to create innovative solutions. Big Data analysts, engineers and IT specialists have proposed the implementation of Blockchain technology for contract registration, voting during political elections, writing notarial deeds, placing orders or any other official documents.

The hash function is used to create blocks, which enables the transfer of data or large data sets. In computer science, this is often referred to as a hash (character string). Its task is to create a new string with a fixed, pre-programmed value, which is encoded to an unreadable form from any sequence of characters, e.g. passwords, texts or computer files. The most important advantages of the hash function are (Foroglou, Tsilidou, 2015):

- Unidirectionality and irreversibility – the created hash is one of a kind. It is very easy for a processor to compute a dataset hash, but it is not possible for such a process to go the other way. Having a hash created, there is no contingency to recover the original data.
- Overlap tolerance – two different datasets will not produce the same hash.
- Time stamping − both single operations or entire blocks are synchronized between all network participants.

Individual transactions are hashed separately to ensure the integrity of the transaction registry. The particular users avail themselves of their own key, which is not certified and that reflects the assumptions about the decentralization and anonymity of this system.

3. Selected applications of Blockchain network

The fourth industrial revolution is represented by many components that interpenetrate and form a coherent whole. Each concept has a greater or lesser impact on human life. Blockchain is an example of innovation in Economy 4.0, which, in the author's opinion, penetrates technical, social and financial spheres, or – in the near future – will find its application in genetics.

3.1. Financial system

The financial system is a system of interacting financial institutions, capital markets and other elements of the financial system infrastructure. It is the part of the economic system which enables the provision of services that allow the circulation of purchasing power in the economy. The main features and functions of the financial system can be distinguished (Pietrzak, Polański, Woźniak 2012):

- Monetary – provides the non-financial entities with money and enables its circulation in the economy.
- Capital-redistributive – enables the flow of free funds from those entities that command them to those who need them.
- Controlling – regulates cash flows, in particular over the funds invested, borrowed and redistributed in the past.

The last function is the most important in modern economy, as it ensures the verification of financial flows and guarantees the stability of the entire financial order. An inseparable element of this system is the task of eliminating the risk in the form of imposing restrictions and rules of conduct on market participants. The current infrastructure consists of a large number of participants whose task is to process and record cash transactions, exchange of securities, derivatives and others. Processing institutions may at any time indicate the owner of the assets and the parties that have been trading.

The operation of the financial system to date has been working for nearly a century, but the ossifying structures did not allow smaller entities to decide about the future of the financial world, and also prevented the implementation of new revolutionary innovations.

Bitcoin, as the first cryptocurrency in history, is treated by the media as a future-oriented settlement system between members and as so called digital gold. Unfortunately, as noted by the author of this paper, despite many advantages that Bitcoin has, it is still a tool that is difficult to use (a small error during the transaction is enough and the funds will be irretrievably lost because the operations are irreversible) and very susceptible to speculation. These disadvantages do not allow Bitcoin to be considered a reliable means of payment. According to the creator's or creators' assumptions, the number of coins is limited to 21 million and their mining will take place in the next few years (Satoshi, 2008).

Such limited supply makes Bitcoin a tool resistant to hyperinflation, unlike empty fiat money, the unlimited printing of which increases the debt of many countries. The financial system must settle its reckonings with the central unit of account, and therefore a third participant in the transaction must be present. In case of private entities, it is a banking system, while financial institutions simultaneously settle their own operations, using special units called clearing houses. Each of the centers has dozens of departments that deal with a single element of the accounting chain, that ultimately leads to validation of the transaction. In Polish banking system, an example of a clearing house that executes payment orders between banks is Krajowa Izba Rozliczeniowa S.A. (National Clearing House), established in 1992, which was established on the initiative of the Polish Banks Association, 16 largest banks and the National Bank of Poland (Marciniak-Neider, 2011).

Blockchain enables a replacement of all types of transactions, i.e. operations in securities, trading in receivables, funds and contracts (Mainelli, Milne, 2016).

3.2. Smart factories

The world of finance is certainly the place where Blockchain technology will find the widest application. In addition to banking, Blockchain can be successfully used in smart factory management and cyber-security.

A smart factory is defined as a plant that is designed to come to the aid of the employed human resources and machines in order to achieve more efficient production realizations. It is based on elements of the Industrial Internet of Things (IIoT), cyber-physical systems as well as artificial intelligence (AI). As a result, it will lead to the fact that a given plant will be "intelligent" enough to repair machines and devices on its own, to control the production process and to make corrections along with changes in the order. Using the resources of a smart factory will enable the production of individualized goods in accordance with the criteria presented by a particular customer. This will take place as part of mass production, so the time to deliver the order will not differ from that in case of large-scale production.

Enterprises that will implement Blockchain network technologies in their smart factories will reduce costs resulting from errors in orders. They will be able to avoid the use of defective materials from suppliers who suddenly changed their sub-contractors (Angrish, Hasan, Starly, 2018).

Having access to his Blockchain, the client is able to track the production process on an ongoing basis and make corrections, which he deems appropriate. Thanks to this transparency in production, the ordering party can be sure that their individualized order will not be subject to production faults resulting from human factor errors. Also, in case of external factors, e.g. natural disasters, the entire order is easy to recreate for the participants of this private Blockchain network.

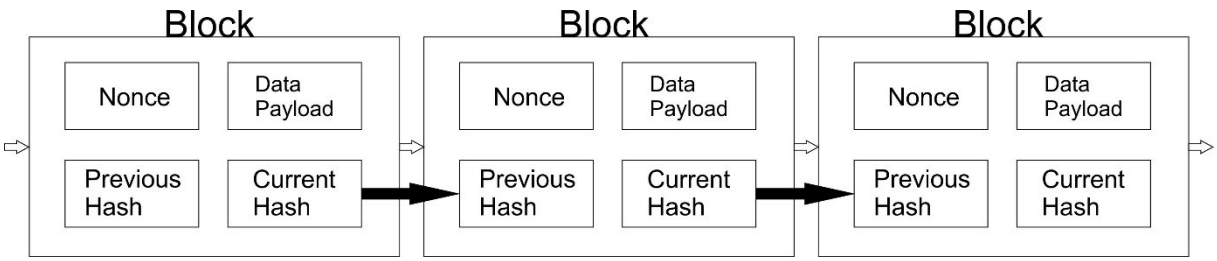


Figure 3. Schemat wprowadzania kolejnych danych do zlecenia w sieci Blockchain. Source: own work.

This proposed solution will fully automate the order processing. The smart factory itself, in the initial period of its existence, will be supervised by highly qualified personnel. Soon, with further expansion of the tools and platforms of the fourth industrial revolution, the human factor will be completely eliminated and will be replaced by the Industrial Internet of Things (IIoT) and Artificial Intelligence (AI). The next generation of smart factories created in this way will be completely automated. The cyber-physical system will itself determine how many prefabricates it needs for production (using the Japanese Just-In-Time method), will send a notification to the customer about the progress in production, will organize logistics and distribution of the product to the customer by means of autonomous self-propelled vehicles or drones to the recipient, who may also turn out to be ... a smart factory.

For the customer, the benefits resulting from the implementation of the Blockchain network are undeniable. Also, companies that implement this invention will not only save material resources, finances and time, but also significantly improve their cyber-security.

The factories of the future will be particularly vulnerable to data theft and industrial espionage. Many companies will change their production model to additive manufacturing – 3D printing (Sturm et al., 2017). This type of production only requires a physical 3D printer and a digital object, which will make the production faster and cheaper. The listed advantages are a potential field for criminal activity from the hackers' point of view. The stolen design can easily be used to produce replacements, leaving the company with a loss of sales revenues and putting consumers at risk of using non-genuine parts. Another risk may be sabotage by manipulating the design by adding some internal flaws that are difficult to detect. From the outside, the product will not differ from the prototype, while the internal structure, slightly changed parameters or a different material may contribute to the creation of huge losses for the attacked company.

3.3. E-voting

Observing the political situation in Belarus (August 2020) due to the presidential elections and the resulting riots, it is justified to work on the electronic voting system and to implement it for general use.

One of the ways in which the Blockchain network is used, that inspires the most trust among citizens, is political elections. Blockchain provides information on the course of voting, which is verified by the multilateral cooperation of thousands of computers and a publicly available digital code.

The above-mentioned features significantly increase the trust between citizens and the government, as the voter's personal data and the right to privacy are subject to special protection, and additionally, they promote greater involvement in exercising their electoral rights. Younger voters will be more likely to vote online via mobile devices than the traditional way, waiting in long queues to get a ballot paper and select their candidate.

Blockchain architecture secures every vote in a cryptographic manner, and the collection of election results takes place in a decentralized manner. There is no need to wait for the official announcement of the results by the central election commission, which receives the results from local election commissions. The main problem with this solution is still the slow verification of each operation, but in the future this problem will be solved.

The following conditions must be met to recognize a modern voting method as meeting the requirements of a democratic and law-abiding state (Curran, 2018):

- Publicly verifiable – each person involved in the elections can monitor the voting process on an ongoing basis and confirm the results of the election.
- Transparent – Blockchain architecture enables transparent voting supervision.
- Reliable and consistent – the election results should be the same for every verification unit, and the network itself should be resistant to hacking attacks.
- Ensuring anonymity – the ballot card cannot be assigned to the voter, but the voters can verify their votes.
- Third party controlled.

4. Summary

- A breakthrough Blockchain technology started a revolution, as it did with the computer revolution and the invention of the Internet. The fourth revolution proceeds more violently and much faster than the previous ones, it covers all spheres of human life.
- Blockchain architecture, which has an enormous potential, will find applications in many areas of the economy and social life, including:
  - The world of finance and cryptocurrencies.
  - Production technology.
  - Political elections.
  - Supply chain management.
  - Power engineering.
  - Digital offices.

Without a shadow of a doubt, the use of Blockchain technology increases the efficiency of business operations and improves the quality of life of citizens. The greatest advantages of this invention are decentralization and network security. Combined with other elements that make up the fourth industrial revolution, the companies planning to build smart factories will make a significant leap in competition with their competitors.

Financial institutions are closely watching the development of Blockchain technology and how it affects the behavior of participants. It offers individual users the speed of operation and low transaction costs, and through its decentralization, it will additionally guarantee anonymity and privacy. The world's financiers are not in favor of humanity settling massively through Blockchain, as they would lose their profits and control over the flow of funds and financial market participants. The biggest inconvenience, when conducting a transaction, is the risk of a mistake in sending the funds, as the transactions are inherently irreversible and there is no trusted third party to control the flow.

Citizens of a country that implement the architecture of dispersed blocks into its administration and public life will gain tools that will allow them to deal with many official matters without leaving their home. All government services, i.e. taxes, contributions, notarial deeds, land registers, will be publicly verifiable and transparent, and the political elections conducted will be scattered, undeniable, and most importantly, every citizen will be able to verify the voting results.

While Blockchain technology offers many benefits to society, its widespread use is still in its infancy as it is a complex code and a non-intuitive environment. The interface is still much more complicated and unclear than the ones of banking platforms or the Internet. Another issue is the lack of trust of people in unknown technologies and inventions.

The paper presents only selected examples of the applications of this technology, it is not yet widely known and used, but its enormous potential means that there will be more and more practical adhibitions.

The fourth industrial revolution offers many inventions and facilities for mankind, but one has to bear in mind that technological evolution is much faster than social evolution. It must be remembered that in highly developed countries there are still people who, for various reasons, have been socially and digitally excluded. Not everyone will be the beneficiary of the fourth revolution, because there are still regions in the world where the products of the second revolution (i.e. electrification) have not yet occurred, so it is even less possible to present Economy 4.0 inventions to these societies.

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