

BLOCKCHANE TECHNOLOGY: ESSENCE, BENEFITS AND PROSPECTS OF USE

ТЕХНОЛОГІЯ БЛОКЧЕЙН: СУТЬ, ПЕРЕВАГИ ТА ПЕРСПЕКТИВИ ВИКОРИСТАННЯ

The article examines the trends of rapid development of blockchain technology. Approaches to interpretation of the concept of "blockchain" in the works of domestic and foreign scientists are revealed. The principles which the development of blockchain technology is based on are determined. Examples of use of blockchain technology applications with class grouping are studied. Examples of application of blockchain technology in such areas as finance, international trade, smart cities, banking are given. The current state of development, opportunities for implementation and features of legal regulation of blockchain technology in Ukraine are described. The advantages and disadvantages of blockchain technologies are highlighted. The further directions of blockchain technology development are analyzed according to such scenarios as centralized programs are replaced by decentralized ones, development of programs for financial inclusion, increase of efficiency of international digital transactions, blockchain turns into "new Internet".

Key words: bitcoin, blockchain, cryptocurrency, distributed registry technologies, digital technologies, digital economy.

За останні кілька років відбувся вибух у діловому використанні блокчейн. Технологія має великий потенціал для забезпечення простоти та підвищення ефективності фінансових послуг, і вона готова викликати наступну хвилю інновацій фінансових послуг. Інтерес до використання блокчейну в інших галузях, таких як виробництво, торгівля та охорона здоров'я, зростає, і набирає обертів. Тим не менш, швидкість прийняття є повільною, і організації тільки починають розуміти потенційне застосування цієї технології. У статті досліджено тенденції стрімкого розвитку блокчейн-технології. Розкрито підходи до тлумачення поняття «блокчейн» в працях вітчизняних та закордонних науковців. Під блокчейн розуміється розподілена база даних, яка зберігає інформацію про всі транзакції учасників системи у вигляді «ланцюжка блоків». Встановлено, що підґрунтям функціонування блокчейну виступає низка принципів: принцип розподіленого реєстру, принцип децентралізації і відмови від посередництва, принцип консенсусу, принцип незмінності і стійкості, принцип довіри і прозорості. Досліджено приклади використання додатків блокчейн-технологій з групуванням за поколіннями. Перше покоління включає власне біткойн та подібні до нього криптовалюти. Друге покоління відчинило двері для масштабної діджиталізації економіки, оскільки на основі «розумних» контрактів теоретично можливо оцифрувати не тільки найпростіші транзакції, а й технологічні процеси, логістичні цепочки, юридичні конструкції та законодавчі норми. Обрис третього покоління тільки формуються і розповсюджуються на сфери державного управління, охорони здоров'я, науки, освіти та ін. Це додатки області яких виходить за рамки фінансових транзакцій та ринків. Авторами наведено приклади застосування технології блокчейн у таких сферах, як фінанси, міжнародна торгівля, розумні міста, банківська сфера. Охарактеризовано сучасний стан розвитку, можливості впровадження та особливості правового регулювання блокчейн-технології в Україні. Незважаючи на те що окремі органи влади поки що констатують невідповідність ринку, зокрема відсутність розвинених відносин у сфері криптоактивів, активізувалася нормотворчість у зазначеній сфері. Виокремлено позитивні та негативні сторони притаманні технології блокчейн. Проаналізовано подальші напрями розвитку технології блокчейн за такими сценаріями, як централізовані програми витісняються децентралізованими, розробка програм для фінансової інклюзії, підвищення ефективності міжнародних цифрових транзакцій, блокчейн перетворюється на «ню-Інтернет».

Ключові слова: біткойн, блокчейн, криптовалюта, технології розподілених реєстрів, цифрові технології, цифрова економіка.

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Introduction and problem statement. The last gold rush was cloud computing. Their supporters seemed to argue that there was no problem that could not be solved or at least mitigated by moving it "in the cloud." The same applies to the current gold rush. While Bitcoin is a clearly structured product that is associated with currency, the definition of blockchain is so vague that it no longer applies to any particular technology or solution and is used only as a marketing term. The problem is that blockchain is a limited technology. Like cloud computing, the advent of the blockchain is a sign of something new. The challenge is to understand, despite the bustle, what new opportunities there may be, what new solutions are opening up. Simply put, you need to understand what a blockchain can and cannot be.

Analysis of recent research and publications. Since the publication in 2008 of Satoshi Nakamoto's "Bitcoin: A Peer-to-Peer Electronic Cash System", which for the first time described in detail the basics of blockchain technology, interest in this technology and its application has grown rapidly among scientists around the world .

In 2012, only one article was published on blockchain technologies in Scopus databases, and in 2019, 5,738 scientific papers, which shows the growing interest of scientists in this topic. Among the leading countries in the number of publications are China and the United States. Among Ukrainian scientists, interest in the blockchain is only gaining momentum. In the last 10 years, they have published only 72 articles in international journals indexed

in the Scopus database [1]. Among the domestic scientific achievements are the works of L. Wenger, A. Gurova, G. Gartinger, K. Dokunina, M. Kirpachova, D. Lipnitsky, O. Melnichenko, N. Nagaychuk, O. Solodovnik, V. Stepura, N. Tretyak .

The purpose of this article is to determine the essence of the concept of "blockchain", the study of the current state and trends in its development.

Results of the research. Blockchain should be seen as a new technological paradigm. Technology has gathered several conceptually different ideas. Areas such as distributed storage registers, consensus algorithms, and cryptographic data protection mechanisms have been merged. Many aspects of blockchain technology have previously been actively discussed and promoted as separate solutions in technology circles. Blockchain is a storage logic that does not depend on a centralized server or group of servers. The technology generates and maintains a list of ordered records, called blocks. Each block contains a timestamp and, very importantly, a unique image of the previous block, so the technology "connects" data blocks, except for the ability to change the data in the generated blocks without changing the entire sequence. Due to the combination of technological solutions, the

blockchain has several distinctive features: openness, consistency of stored data, as well as the ability to publish and control in a decentralized network of logic (software code). All these aspects make blockchain an interesting and promising technology. Due to its distinctive features, blockchain technology offers to get rid of the "extra link" (arbitrator or arbitrator) in most business processes, and can take on roles that are traditionally important in the financial services sector.

Without a consistent approach to terminology, it is difficult to explore the possibilities offered by new technology. Not surprisingly, today it is difficult to understand what is beneficial to the blockchain, because it is based on something elusive. Table 1 presents approaches to the interpretation of the concept of "blockchain" by different scientists.

After analyzing modern scientific work, it can be concluded that the blockchain is a distributed database that stores information about all transactions of system participants in the form of a "chain of blocks". All blockchain users have access to the registry, which collectively confirms the truth of the information in the database. Blockchain can be used for financial transactions, user identification, creation of cybersecurity technologies, etc. [10].

Table 1

Approaches to the interpretation of "blockchain"

Author	Definition
Vlasov A.	"Chain of transaction blocks, built according to certain rules of the chain of formed transaction blocks, focused on ensuring the interaction of a large number of users with each other without the use of" trusted intermediaries" [2].
Voronov M., Chasovskikh V.	"Pure distributed peer-to-peer registry system that uses software consisting of algorithms that reconcile and integrate the information content of ordered and linked data blocks into a single unit based on cryptography and security technologies to ensure system integrity" [3] .
Hartinger R.	"Distributed database containing information about all operations performed by participants in the system. The information is stored in the form of a chain of blocks, each of which records a certain number of such operations" [4].
Drescher D.	"It is a fully distributed peer-to-peer accounting system that uses a software module that implements an algorithm that processes the information content of ordered interconnected data blocks as a whole using cryptographic and data protection technologies to ensure and maintain the integrity of this system" [5].
Lelu L.	"Distributed transaction database, which can be compared to a huge decentralized and distributed ledger, where the Internet is transparently protected and autonomously stored and converted and converted values and data, with no central supervisory authority. This book is active, compiled in chronological order, distributed, verified and protected from falsification through a system of distribution of trust (consensus) between participants (nodes). Each member of the network has an up-to-date copy of this "ledger", the contents of which are constantly synchronized with all other participants" [6].
Mogayar U.	"Exchange network for the movement of transactions, value, assets between equal partners without the help of intermediaries. Blockchain looks like a distributed database, a system in which information is stored not on a single centralized medium, but simultaneously on all computers that are in this system" [7].
Swan M.	"Multifunctional and multilevel information technology designed for reliable accounting of various assets. Potentially, this technology covers all areas of economic activity without exception and has many areas of application. Among them: finance and economics, operations with tangible and intangible assets, accounting in public and private organizations and organizations of mixed type".
Raval S.	"Database with large-scale replication of all transactions on the Bitcoin network. The blockchain uses a proof-of-work consensus mechanism to prevent the problem of double-spending on the Web, which has plagued cryptologists for decades. By double costs is meant the problem when a fraudster may demand payment a second time, denying the success of the first transaction" [8].

Source: compiled by the authors based on [9; 10]

The basis of the blockchain is a number of principles (Table 2):

In the book "Blockchain. Blockchain. Blueprint for a New Economy", Melanie Swan, a researcher and founder of the Blockchain Research Institute, identifies three conditional areas of application for this technology [11]:

Blockchain 1.0 is a currency (cryptocurrencies are used in various applications related to financial transactions, such as transfer systems and digital payments).

The first generation includes bitcoin and similar cryptocurrencies. The blockchain architectures that serve them are able to perform only the simplest transactions and have performance that degrades quickly [12].

Blockchain 2.0 is contracts (applications in the field of economics, markets and finance that work with different types of instruments – stocks, bonds, futures, mortgages, legal titles, assets and contracts);

It can be argued that the second generation has opened the door to large-scale digitalization of the economy, because on the basis of "smart" contracts it is theoretically possible to digitize not only the simplest transactions but also technological processes, logistics chains, legal structures and legislation. In recent years, leading players in global industry, trade and finance have been actively involved in the development of new generations of blockchains. Forbes published a list of Top 50 blockchain researchers, which included: Toyota, Samsung, Oracle, IBM, Apple, Bank of China, Bank of America, IMG, Alibaba [12].

Blockchain 3.0 – applications whose area goes beyond financial transactions and markets (extends to public administration, health, science, education, etc.).

The outlines of the third generation are just being formed, and alternative solutions have yet to undergo

natural selection. One of the contenders for survival in the new generation of blockchain is the use of "sharding" (from the English. Shard - a fragment, a piece) in creating a distributed system. In contrast to the current storage on each node of a complete copy of the database "sharding" is proposed to store on individual nodes only a fragment of the database. The complete base is formed as a mosaic consisting of all fragments that are stored separately. "Sharding" significantly increases the productivity of the system, which is especially important for use in finance and the real sector of the economy [12].

Developers of various complex information systems, in particular, developing the methodology of creating solutions within the concept of Smart City [14], began to work out the feasibility of using distributed registry technologies.

Various examples of the use of blockchain technology applications with grouping by classes are presented in table 3.

According to some estimates, if in 2017 the market capitalization of blockchain solutions and applications was about \$ 708 million, in 2024 it is expected to exceed \$ 60 billion. Blockchain technology can be used almost anywhere. Currently, the main areas of application include online payment systems, finance, international trade and global value chains. Consider in more detail the scope of blockchain technology [15]:

Cryptocurrencies, tokens and online payment systems. The first and most well-known application of blockchain technology was the creation of cryptocurrencies and online payment systems with fast, inexpensive and secure transactions and without intermediaries. In addition to cryptocurrencies such as bitcoin, Libra and Monero, cryptocurrencies also include protocol tokens, utility tokens, token stocks, natural asset tokens, and cryptocurrency money.

Decentralized finance. Decentralized finance is a field of rapid innovation. Financial instruments based

Table 2

Principles which the blockchain is based on

Principle	Characteristic
The principle of a distributed registry	The blockchain is built on the principle of the ledger and is distributed among all participants.
The principle of decentralization and non-mediation	The blockchain is not controlled by any central body, there are no third parties in this system of trust between the two participants. The principle of abandoning intermediaries, or removing a third trustee, is the essence of blockchain technology.
The principle of consensus	The fact of accepting or rejecting a transaction is the result of a distributed consensus, not the decision of some centralized institution.
The principle of immutability and stability	In a blockchain-based system, all records are irreversible and inaccessible to falsification. In other words, when something is registered in this system, it is stored permanently and is available for all participants, the records cannot be changed or deleted.
The principle of trust and transparency	Data, operations and consensus are shared. Working with a collective consensus mechanism, as well as using a huge open ledger, decentralized and shared between participants, entails trust, transparency and a sense of community. Free and free blockchain is completely transparent: it allows to access the source code of the platform, read information and history of all transactions or events that have occurred since the creation of the blockchain.

Source: [10]

Application of distributed registry technology in Blockchain applications

Application class	Areas of application
Blockchain 1.0	
Information about a specific transaction and its value assigned to the system	Cryptocurrencies in various applications related to financial transactions, such as transfer systems and digital payments
Blockchain 2.0	
Warranty obligations	Execution of guarantee obligations, tripartite arbitration, multilateral signature, agreements using Escrow accounts.
Financial transactions	Securities, shares of companies, crowdfunding, bonds, mutual funds, derivative financial instruments, annuities, pensions.
Private documents	Debt receipts, contracts, bets, signatures, wills, powers of attorney.
Documents requiring certification	Insurance certificates, property certificates, notarization of documents
Реєстрація нематеріальних активів	Registration of intangible assets
Blockchain 3.0	
Certificates and licenses certified by the state	Certificates of ownership of land and real estate, certificates of registration of vehicles, licenses to engage in certain activities
Identities certified by the state	Identity cards, passports, voter registration certificate, driver's license, birth, marriage and death certificates
Information and documentation related to medicine	Medical history of patients, information on the results of the survey, registration of access rights of medical staff to certain data and specific patients
Information and documentation in the field of education, science, culture	Data and information on students and teachers, scientists, cultural and artistic workers, various transactions in the field of education, science, culture (including performance indicators of institutions and individuals)
Information and documentation in the field of housing	Data and information on various transactions in the field of housing and communal services: indicators of consumption of electricity, water, telecommunications services, the operation of "smart home" systems, etc.

Source: [11]

on blockchain technology implemented through smart contracts.

International trade. In international trade, the use of smart contracts allows you to automatically, quickly and timely issue customs invoices, permits, licenses and certificates generated after payment of fees and charges. This can reduce overhead, customs clearance time and reduce corruption.

Value chains. Blockchain technology can increase transparency, traceability and reliability across all global value chains. Several successful pilot projects using blockchain technology suggest that this technology is likely to lead to revolutionary changes, from cost reduction and efficiency to new operating models. Two promising applications are tracking of goods from the stage of production and delivery to ensure quality and authenticity, as well as automated compliance with regulatory requirements for freight and trade.

Prospects for the use of blockchain technology in the non-financial sector are much broader. Thus, Gartner identifies 11 possible uses for the blockchain [16]:

Asset tracking. Tracking of physical assets in the supply chain to accurately determine location and ownership (tracking cars through lending processes, after-sales of works of art, and the location of shipping and spare parts).

Claims. Automatic claims processing in areas such as automotive, agriculture, travel, life and health insurance, and product recall processing.

Identification management. Records must be securely linked to the individual (management of records of educational attainment, patient health, electoral identity and national identity).

Internal accounting. The data to be protected remain within a separate organization (master data management, internal document management, order records, and treasury operations).

Loyalty and reward. Use to track loyalty points (for retailers, travel companies, etc.) providing internal rewards to employees or students.

Payment / Settlements. Use for payment between the parties or settlement of the agreement (royalty payments, settlement of shares, interbank payments, commercial lending, processing from purchase to payment and processing of money transfers).

Origin. Accounting for the movement of assets without tracking the location, reproducing the full history and ownership of the asset (tracking biological samples and organs; establishing the origin of wine, coffee and other products; authentication of components; tracking pharmaceuticals during their life cycle).

Joint storage of records. Data must be reliably distributed among several participants (corporate

announcements, booking management, flight recordings and regulatory reporting).

Smart Cities / IoT. Data tracking and management of smart space functions or IoT solutions (peer energy trading, electric vehicle charging administration, intelligent network management and sewage control).

Trade financing. Streamline the process of financing trade operations, including letter of credit management, simplifying trade financing and facilitating cross-border trade.

Trade. Improve the process of buying and selling assets, including derivative transactions, private equity trading and sports trading.

Analyzing the main areas of application of blockchains, it becomes clear that this technology has many advantages that make it attractive for widespread use in many fields. However, this technology is imperfect and not without its drawbacks, which today prevent the mass adaptation of the blockchain. Table 4 shows the advantages and disadvantages of blockchain technology.

In Ukraine, blockchain technology is of active interest to users. Thus, according to the Blockchain Research Institute, our country is represented in the list of 14 countries that are recognized leaders in the implementation of this technology [17].

As of 2019, about 100 companies operated and provided blockchain services in the blockchain industry market in Ukraine. But, unfortunately, not all companies present on the market are registered in Ukraine [16].

The state is also interested in technology. The first steps have already been taken to regulate the market of digital technologies, cryptocurrency and blockchain. Thus, the blockchain is included in the Strategy for the Development of the Financial Sector of Ukraine until 2025. In particular, the blockchain has become part of one of the five strategic goals of innovative development – to ensure the development of the FinTech market, digital technologies and regulatory platforms. By the end of 2022, it is planned

to develop and implement incubators at the state level for the development of investment startups, and by the end of 2024 – to create regulatory and technical "sandboxes" [16].

In Ukraine, rule-making in this area has intensified, despite the fact that some authorities still state the unpreparedness of the market, in particular the lack of developed relations in the field of cryptocurrencies. At the same time, the domestic legislation already has or plans to implement in the future the rules on preventing the use of cryptocurrencies for money laundering, the use of smart contracts, including with the means of identifying counterparties, and consumer protection. Thus, it is reasonable to hope that soon the innovative spheres of management will actively implement Blockchain technology on the basis of clear and understandable rules [18].

International experts believe that the introduction of blockchain technology is not inferior to the discovery of the Internet. Blockchain will allow to organize trade without intermediaries, to introduce many services into everyday life, to change the work of the banking sector. The report "Using Blockchain Technology for Sustainable Development: Prospects and Challenges" [15] of the United Nations Commission on Science and Technology identifies the following likely scenarios for the further development of blockchain technology:

Scenario 1: Centralized programs are being replaced by decentralized ones. Blockchain technology is seen as a tool for creating decentralized applications that replace centralized ones (based on centralized databases) because they provide greater security and transparency.

Scenario 2: Development of programs for financial inclusion. Blockchain technology is seen as a tool that will allow people to access low-cost financial services, conduct banking operations with networked but non-banking entities, for example, by creating mobile applications based on blockchain technology,

Table 4

Advantages and disadvantages of blockchain technology

Advantages	Disadvantages
<p><i>decentralization</i> – network members are equal to each other and can exchange data directly; <i>reliability (security, safety)</i> – almost excluded data substitution and hacking attacks, as special encrypted keys are used; <i>transparency</i> – all blocks are available for public viewing, you can check the history of any transaction; <i>versatility</i> – blockchain can be used in various fields; elimination of an intermediary – the ability to verify transactions without human intervention, ie without an intermediary, which minimizes the risk of error. According to this principle, the so-called "reasonable contracts" are concluded, automatically, in accordance with predetermined rules; <i>cost reduction</i> – network members, replacing existing data recording systems, significantly reduce their costs in the long run.</p>	<p><i>low adaptability</i> –with increasing intensity of transactions, the number of blocks and nodes decreases the efficiency of the entire system; <i>irreversibility</i> – it is impossible to cancel the transfer of blockchain data, even those which were made erroneously; <i>51% attack</i> – if in the blockchain of some coins (such as bitcoin) most of the computing power will belong to one device, the integrity may be compromised.</p>

Source: compiled by the authors based on [14]

for digital money transfers and microcredit services for a lower fee.

Scenario 3: increase the efficiency of international digital transactions. The main role of blockchain technology is to increase the efficiency of international digital transactions, reduce the cost of remittances and payment transactions in the supply chain and expand e-commerce.

Scenario 4: Cryptocurrency displaces fiat money. Another option for future blockchain technology is to displace or replace cryptocurrencies with fiduciary currencies. The prospects for displacing cryptocurrencies of paper money will depend on how well cryptocurrencies perform the functions of a medium of exchange, a measure of value and a unit of account.

Scenario 5: The blockchain becomes the New Internet. Another perspective for the development of blockchain technology is that it will be seen as a universal technology on a scale comparable to the scale of the Internet. Blockchain technology will become the "Internet of Value".

The development of a new industry (Industry 4.0) with its "smart" production, robotics, artificial intelligence, Big Data, IoT requires adequate solutions for storage and exchange of business information – such as high data availability and cybersecurity. Blockchain, which is based on a falsification-resistant distributed registry, can help solve a number of problems.

Conclusions. Blockchain technology is capable of making a breakthrough by revolutionizing the range from finance to healthcare, from public services to humanitarian work. Blockchain is the basic technology for cryptocurrencies, providing the ability to conduct open (peer-to-peer), secure and fast transactions. The scope of the blockchain has expanded to include a variety of financial transactions, the Internet of Things, healthcare systems, and supply chains. New prospects for further research into the development of blockchain technology open up.

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