

## Conclusions from the analysis of blockchain solutions

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The development of blockchain technology and distributed ledgers indeed contributes to enabling the delivery of various digital services, such as financial services, registry management, and tokens, including non-fungible tokens (NFTs). In blockchain systems, decisions are made based on the so-called consensus mechanism, which is a method of selecting a single version of transaction history that all nodes consistently agree upon. Although this technology is classified as emerging, it has a history of over ten years, and its ongoing implementations, including in the public administration sector, demonstrate its evolution and its status as one of the most promising technologies in terms of ensuring data immutability. The published ISO (International Organization for Standardization) standards and numerous implementations using business models executed in the DAO (Decentralized Autonomous Organization) architecture undoubtedly support the development of blockchain.

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### 1. History and principles of blockchain technology

The first and most popular implementation of blockchain technology is Bitcoin. On October 31, 2008, Satoshi Nakamoto – whose identity is still unknown, possibly a group of people – released the so-called "Whitepaper"<sup>1</sup> of Bitcoin, which contained explanations of the idea and purpose that guided its creators:

“I’ve been working on a new electronic cash system that’s fully peer-to-peer, with no trusted third party” – “What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party”.

For those who want to learn about blockchain technology, I recommend starting with studying what guided the creators of this technology: <https://bitcoin.org/bitcoin.pdf>.

The first block of Bitcoin – the so-called “genesis block” – as a record of executed transactions, was generated on January 3, 2009, and the Bitcoin network is still maintained and developed. The phenomenon of this technology is based on building trust in the network – that is, relying on records contained in a block by

completely unknown people through nodes in the peer-to-peer network.

In creating blockchain technology, Satoshi Nakamoto included the following fields of science:

- Game theory
- Cryptography
- Computer networks and data transmission
- Economic and monetary theory.

Satoshi Nakamoto combined several previous inventions, such as the B-money protocol and the HashCash algorithm, to build a fully decentralized system of electronic money that is not dependent on a central authority for money issuance or transaction approval and validation. The most important innovation was the use of a distributed computational system – called the consensus mechanism – “proof of work” to establish global consensus on the state of transactions. All nodes in the peer-to-peer network send all new transactions to all other nodes, then everyone uses these transactions, as well as information from the previous block and a timestamp, as components to build the next block.

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<sup>1</sup><https://bitcoin.org/bitcoin.pdf>

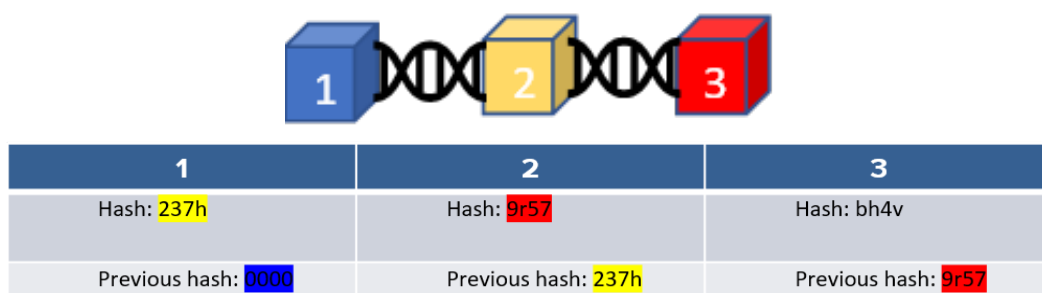


Fig. 1. “Creating a blockchain”

So far, since 2009, there have been several thousand systems based on blockchain technology. The most popular of them are in the area of “DeFi” – decentralized finance – broadly defined financial services that were not necessarily previously subject to supervision. Blockchain technology is also successfully used in other areas, such as actuarial science, central registries, voting, supply chain management, or NFT (Non-Fungible Token) covering digital art, and has practical applications in virtually every industry, starting from banking, medicine, insurance, energy, administration, production, logistics, and tourism.

## 2. Standardization of blockchain technology

In order to contribute to the smooth and secure adoption of new technologies in Europe, CEN and CENELEC have established a Joint Technical Committee “CEN-CLC/JTC 19 Blockchain and Distributed Ledger Technologies” to provide recommendations on the successful adoption of new technical standards related to blockchain technology in Europe. The Joint Committee is responsible for developing standards for blockchain and distributed ledger technologies, including organizational frameworks, methodologies, product assessment schemes, blockchain technology guidelines, and data services.

The Committee focuses on identifying and implementing already available or developing International Standards, and collaborates closely with the ISO/TC 307 Blockchain and distributed ledger technologies Technical Committee. Additionally, CEN-CLC/JTC 19 focuses on specific European legal and political requirements, supporting the development of the European Union's Digital Single Market.

Although blockchain technology is still considered a developing technology in many reports, the International Organization for Standardization (ISO) has developed and

published nine standards related to blockchain technology through its Technical Committee – ISO/TC 307, including<sup>2</sup>:

1. ISO/TR 23455:2019 – “Blockchain and distributed ledger technologies – Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems.” Published in September 2019.
2. ISO/TR 23244:2020 “Blockchain and distributed ledger technologies – Privacy and personally identifiable information protection considerations.” Published in May 2020.
3. ISO/TR 22739:2020 “Blockchain and distributed ledger technologies – Vocabulary.” Published in July 2020.
4. ISO/TR 23576:2020 “Blockchain and distributed ledger technologies – Security management of digital asset custodians.” Published in December 2020.
5. ISO/TS 23258:2021 “Blockchain and distributed ledger technologies - Taxonomy and Ontology.” Published in November 2021.
6. ISO/TS 23635:2022 „Blockchain and distributed ledger technologies — Guidelines for governance.” Published in February 2022.
7. ISO 23257:2022 “Blockchain and distributed ledger technologies — Reference architecture.” Published in February 2022.
8. ISO/TR 23249:2022 “Blockchain and distributed ledger technologies – Overview of existing DLT systems for identity management.” Published in May 2022.
9. ISO/TR 3242:2022 “Blockchain and distributed ledger technologies – Use cases.” Published in October 2022.

<sup>2</sup> List of published Standards of Blockchain and distributed Ledger  
<https://www.iso.org/committee/6266604/x/catalogue/p/1/u/0/w/0/d/0>.

This creates the opportunity for wider use of this technology by governments of many countries, central institutions such as central banks, insurance institutions, notaries, voting systems, or applications in medicine, transportation, and energy. It is a promising technology, but like any developing technology, it carries risks and the need to audit systems both before and during operation.

The European Union plans to establish detailed frameworks for the functioning of distributed ledger technology by the end of 2024, allowing for fully secure use of blockchain in the European financial market. Providers of blockchain financial services and licensed cryptocurrency issuers will be required to register their legal entity and establish a presence within the European Union. This will make cryptocurrencies a full-fledged financial instrument. Cryptocurrencies approved in one country will be automatically honored in all member states.

Moreover, the large number of open-source blockchain-based system implementations, such as Bitcoin and Ethereum, means that they are increasingly well-tested by a large community and will enable faster implementation<sup>3</sup>. They provide developers with tools to adapt these tools to specific business models.

### 3. Blockchain in the context of ensuring personal data security

Based on my experience, implementing blockchain technology throughout an entire, already functioning organization is not common practice. Individual service implementations aimed at meeting customer needs are much more successful than those directly related to back-office operations. In many cases, these are services that incorporate innovation, the undeniable added value of which is the indisputability of information. The story of PKO BP bank in the Polish market illustrates this point, as it was the first to apply the so-called “durable medium”, which eliminated physical documents (paper or recorded on CDs) and their electronic equivalents sent in the iPKO service. The durable medium fulfills the legal definition of delivering documents, just like handing over a piece of paper<sup>4</sup>. Allowing for the

search of the blockchain network to confirm the authenticity (source of origin), integrity (lack of interference), and availability (for the required time, e.g. the duration of the contract) of the given document.

The above-mentioned “durable medium” solution in the first phase of implementation concerned non-personalized documents, i.e. public documents, e.g. Tariff, Regulations, then the bank, while ensuring compliance with the requirements of the GDPR<sup>5</sup>, implemented a blockchain solution for personalized documents containing personal data, i.e. with data intended only for a specific recipient, e.g. account statements or contracts. The technology used by PKO BP is the so-called closed blockchain, i.e. the right to access specific documents is only possible for authorized persons, while the role of a trusted third party is played by the National Clearing House (KIR).

Despite many statements<sup>6</sup> resulting directly from the features of systems operating on the basis of blockchain technology, e.g. access to data stored in a distributed register and opinions of environments related to ensuring information security or personal data protection, experience over the years shows the evolution of blockchain technology and its implementations that are in accordance with the General Regulation on the Protection of Personal Data.

### 4. Blockchain implementations

From the report titled “Blockchain Technology and its Use Cases in the Public Sector”, prepared by the Observatory of Public Sector Innovation (OPSI) in collaboration with the ELeaders<sup>7</sup> Working Group of Senior Digital Government Officials, it is evident that 46 countries worldwide have launched or are in the planning stages of over 200 blockchain-related initiatives.

<sup>3</sup> Sachin S. Shetty, Charles A. Kamhoua, Laurent L. Njilla, “Blockchain and security of distributed systems”, PWN 2020.

<sup>4</sup> <https://fintech.pkobp.pl/blockchain-w-banku/>.

<sup>5</sup> Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

<sup>6</sup> <https://www.gov.pl/web/cyfryzacja/blockchain>.

<sup>7</sup> <https://oecd-opsi.org/wp-content/uploads/2018/06/Blockchains-Unchained-Guide.pdf>.

Tab. 1. “Blockchain – Top 10 types of projects and industries”

Rank	Types of projects (count)	Industries
1	Strategy/Research (42)	Government Services (173)
2	Identity (Credentials/Licenses/Attestations) (25)	Financial Services (73)
3	Personal Records (Health, Financial, etc.) (25)	Technology & Internet of Things (26)
4	Economic Development (24)	Healthcare (23)
5	Financial (20)	Real Estate (22)
6	Land Title Registry (19)	Supply Chain (19)
7	Digital Currency (Central Bank Issued) (18)	Energy (13)
8	Benefits/Entitlements (13)	Transportation (13)
9	Compliance/Reporting (12)	Education (8)
10	Research/Standards (12)	Telecom (4)

According to the aforementioned report, projects related to the implementation of public services are at the top of the list.

## 5. What makes a successful implementation?

A successful implementation of a system based on blockchain technology, meaning its production launch and uninterrupted operation for at least two years or the period for which it was established, requires making many managerial decisions and taking actions different from those used in existing IT technologies. Therefore, it is necessary to determine:

1. What we expect from blockchain technology, as not all projects are worth implementing using blockchain. Primarily, these should be innovative processes/services focused on the needs of network customers (transaction registration carried out between any network actors, smart contracts). The classification of blockchain technology maturity levels 1.0, 2.0, 3.0 indicates implementations based not only on transaction registers but also on self-

executable contracts and advanced systems integrating AI and IoT<sup>8</sup>.

2. The initial course of implementing innovative services for stakeholders, considering their needs not only at present but also in the future. This information is crucial and determines subsequent decisions, such as building a business model - increasingly carried out in the DAO (Digital Decentralized Autonomous Organization) architecture – decentralized autonomous organization<sup>9</sup>, infrastructure and application architecture, consensus mechanism type, smart contracts applied (use case of smart contracts), accountability, interoperability, etc.
3. The implementation team and defining the competencies of team members, including supervision, risk management, and broadly understood compliance.

Specific management levels and nine types of managerial decisions needed to apply blockchain-based systems in the public sector are presented in “Blockchain governance in the public sector: A conceptual framework for public management<sup>10</sup>.”

## 6. Conclusions

1. Blockchain technology implementations demonstrate a high level of trust in the technology and solid preparation for its deployment and decision-making at various management levels.
2. Systems based on distributed ledger technology carry out transactions in real-time, so they should be approved by a formal audit and correctness check before launch. Erroneous transactions are impossible to reject because all transactions are agreed upon and recorded in real-time across all network nodes. This creates so-called backup copies of transaction data in the form of a block chain (as in Figure 1). The consensus mechanism is the mechanism approving the correctness of

<sup>8</sup> A. Slater, “Blockchain – not only Cryptocurrencies”, *ICAN Review Management*, p. 113 (2021).

<sup>9</sup> M. Michniewicz, “Security audit of systems based on blockchain technology”; K. Śmiałek, A. Kominek, “Technological dimension of personal data protection”, FNCE 2021.

<sup>10</sup> Evrim Tan, S. Mahula, J. Cromptvoets, “Blockchain governance in the public sector: A Conceptual Framework for public management”, *Government Information Quarterly*, 39(1), 101625 (2022).

transactions. Blockchain-based systems focus on confirming transactions between participants/actors of the system/network and, by design, do not require collecting personal data sets. However, thanks to cryptographic achievements (digital signatures, timestamping), and the evolution of consensus mechanisms, they provide a relatively secure way of storing and managing information (including personal data).

3. Standards developed by experts and issued by the International Organization for Standardization: ISO/TR 23455:2019, ISO/TR 23244:2020, ISO/TR 22739:2020, ISO/TR 23576:2020, ISO/TS 23258:2021, create the possibility of more widespread use of blockchain by governments of many countries and central institutions.
4. Many countries are implementing or planning to implement transaction systems in the public sector for digital services based on blockchain technology.

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## Technologia łańcucha bloków (blockchain) – analiza i wnioski pod kątem ochrony danych osobowych

M. MICHNIEWICZ

Rozwój technologii blockchain i rejestrów rozproszonych umożliwia realizację usług cyfrowych, w tym dostarczanie różnego rodzaju wartości tj. usługi finansowe, prowadzenie rejestrów, różnej maści tokenów (NFT), dla aktorów w sieci z nieosiągalnym dotychczas poziomem zaufania. Każdy może ufać każdemu bez zaufanej trzeciej strony. W systemach blockchain decyzje podejmowane są w oparciu o tzw. mechanizm konsensusu, który jest metodą wybierania jednej wersji historii transakcji, na którą konsekwentnie wyrażają zgodę wszystkie węzły. Technologia ta choć klasyfikowana jest jako rozwijająca się, posiada ponad 10-letnią historię, a kolejne wdrożenia również w sektorze administracji publicznej, ukazują jak ewaluuje i sięga do rangi najbardziej obiecującej technologii w kontekście zapewnienia niezaprzeczalności danych. Rozwojowi blockchain niewątpliwie sprzyjają opublikowane standardy ISO – Międzynarodowej Organizacji Standaryzacyjnej oraz liczne wdrożenia w których stosowane modele biznesowe realizowane w architekturze DAO (zdecentralizowanej autonomicznej organizacji).

**Słowa kluczowe:** blockchain, DAO, sektor publiczny.