Improving the efficiency and reliability of the supply chain using blockchain technology

Case RX clothing company

Nikita Mezenev

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Description

Mezenev Nikita

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Abstract

In response to the increasing complexity and demands within the logistics sector, the world is looking for new solutions, and one of them is the application of smart contracts as a transformative technology. The background of this research highlighted the challenges faced by traditional logistics systems, including issues related to transparency, security, and efficiency.
The primary objectives were the following:
- to explore the potential areas, trends, and applications of blockchain technology in the logistics industry;
- developed and integrate smart contracts into logistics operations and assess their impact on the clothing; company performance;
- define risks associated with implementation.
Employing a methodical implementation approach, the study scrutinized the intricacies of smart contract development, deployment, and integration with existing logistics frameworks. It included organizing of coding process for smart contract creation and connecting it to the existing company operating environment.
Conclusions of the study revealed substantial improvements in process automation, real-time tracking, and data integrity. The seamless execution of contractual obligations through self-executing code excluded the need for use the documentation. Additionally, the implementation of smart contracts demonstrated enhanced transparency and among the whole supply operation.
The research encompassed a comprehensive examination of blockchain through a literature review to elucidate the significance and pertinence of the subject (Section 3). Furthermore, instances of companies implementing blockchain technologies were expounded upon for practical illustration (Section 3.2). Subsequent attention was dedicated to elucidating the terminology essential for a thorough grasp of the internal mechanics of the blockchain system, constituting an entire section (Section 4).
Refining the focus on the application scope of blockchain, the study explored a pragmatic remedy— the adoption of smart contract technology (Section 5). This exploration was then subject to detailed scrutiny through an in-depth analysis of a specific company's case, which served as the focal point of the research (Section 6). The conclusive segment of the work encapsulates a final analysis derived from the research conducted on blockchain utilization, specifically delving into smart contracts (Section 7). The conclusions drawn in response to the initially posited questions in the thesis are furnished in the concluding Section 8.

Keywords/tags (subjects)

Blockchain in logistics, smart contract, smart contract for clothing industry

Miscellaneous (Confidential information)

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1 Introduction

Currently, logistics is a vital component of sustaining life and the economy and is growing every year. Logistics is crucial to the flow of goods since it facilitates constant communication between producers, warehouses, different intermediary companies, and customers.

Logistics is the engine of competition. By applying logistics approaches, logistics companies strive to increase the quantity and quality of services and services. The functioning interaction of all elements of the logistics chain directly affects the success of the enterprise. Transport logistics is one of the main areas of logistics, responsible for the supply of raw materials and finished products with subsequent distribution to consumers. Transportation can be considered successful if the vehicle has the right level of equipment and excellent technical condition, the transportation is controlled by a competent driver, a freight forwarder, the cargo is delivered on time, there is no doubt about the safety and integrity of the cargo. Transport logistics is not confined to one country but extends to many states. Thus, international transportation contributes to communication and the process of globalization.

The main issues that are solved during the transportation of cargo, there are tasks for choosing the carrier, the optimal route, the optimal mode of transport and rolling stock, which are reduced to the maximum reduction of costs. While domestic transportation can be limited to road and rail vehicles, international transportation is difficult to do without air and water vehicles.

The importance of logistics in world trade cannot be overestimated. It allows companies to expand the geography of their markets and participate in global competition. Thanks to logistics, goods can travel across oceans and continents, manage complex supply chains and get on store shelves in different parts of the world.

1.1 Motivation for the research and the historical context

At this point, four radical changes in the means used for production are distinguished, which have led to an increase in business productivity and, consequently, to a change in society.

According to the Encyclopedia Britannica the first industrial revolution, late 18th and early 19th century, is associated with the transition from manual to machine labor, based on the invention of the steam engine. This process contributed to the formation of capitalist society, replacing the feudal system.

The second industrial revolution, the late 19th and early 20th centuries, was characterized by the mass standardization of production, urbanization, the development of transportation networks and electrification.

The third industrial revolution, the second half of the 20th century, began with the advent of personal computers that accelerated paperwork, production automation and digitalization, which became the basis for subsequent changes (Industrial Revolution | Definition, History, Dates, Summary, & Facts, 2023).

The fourth industrial revolution, or Industry 4.0, is happening right now. With the development of the Internet, increased computer performance and the growing importance of accuracy in business, more and more technological innovations are being introduced into companies' business processes, such as the Internet of Things, AI and so on. Also, in addition to further automation and increased business intelligence, the context of business is also changing - whereas in the past the only objective was to benefit the owners, now more and more companies are expanding their responsibilities, and prioritizing benefits for all stakeholders. For example, in August 2019, 181 CEOs signed a statement on prioritizing stakeholder interests (Business Roundtable Redefines the Purpose of a Corporation to Promote ‘An Economy That Serves All Americans’, 2019).

Due to the report published by the National Academy of Science and Engineering returning to the technological side of the revolution, it is worth noting that states are also interested in this transformation. For example, Germany is implementing the Industrie 4.0 initiative, based on the government's High Tech 2020 strategy and aimed at the digitalization of industry (Forschungsunion, 2021).

One more example is the Dominican Republic that signed agreement with the Spain which will be the pillar of increasing industrial added value, qualification of employment in the sector and development and deployment of digital solutions for the industry utilizing Industry 4.0 (Forschungsunion, 2021).

Thus, we can see that the fourth industrial revolution and its inherent digitalization is a consequence of the development of technology and society. It is bound to be followed by several more industrial revolutions. Also, it is worth noting that the pace at which these revolutions are taking place is increasing between the first and the second it took almost a century, between the second and the third it took half a century, and between the third and the beginning of the fourth - literally 20-30 years, which means that the fifth will happen in the foreseeable future. For this reason, to succeed in it, it is necessary to take all possible advantage of the present one.

Summing facts above it is worth to consider one of the milestones of the industry 4.0, specifically, blockchain.

1.2 Relevance of the topic

The development of scientific and technological progress and digitalization contributed to the formation of the so-called digital economy. There are different interpretations of this term. So, according to one of them, the digital economy is understood as functioning in a hybrid reality, which is the result of the merger of the real and virtual worlds and is distinguished by the ability to perform all the most necessary actions in the real world through the virtual. Among the main conditions for the possibility of implementing this process are high efficiency and low cost of information and communication technologies, as well as the availability of digital infrastructure.

digital technologies find extensive application across diverse domains, including the field of logistics, through which planning, and management of material, service and information flows are carried out. Logistics chains deal with a variety of goods, including multiple stages and covering different regions of the world. As a result, difficulties arise in tracking supply chains, checking documentation and goods, since the transfer of information does not always coincide with the actual movement of cargo, as well as with prompt response to various circumstances (Kostyukova, 2020).

In recent decades, lots of unordinary digital technologies have begun to rewrite the rules of the game in many industries, and logistics is no exception. One of the most important innovations in this area has become the blockchain.

One of such ambiguous technologies is blockchain, its application is extensive. Despite the abundance of projects using this technology and successfully implementing it into operational activities, there is still significant untapped potential, particularly for incorporating the technology.

According to Gartner's schedule on the subject of blockchain, it has not yet entered the phase of productive implementation.

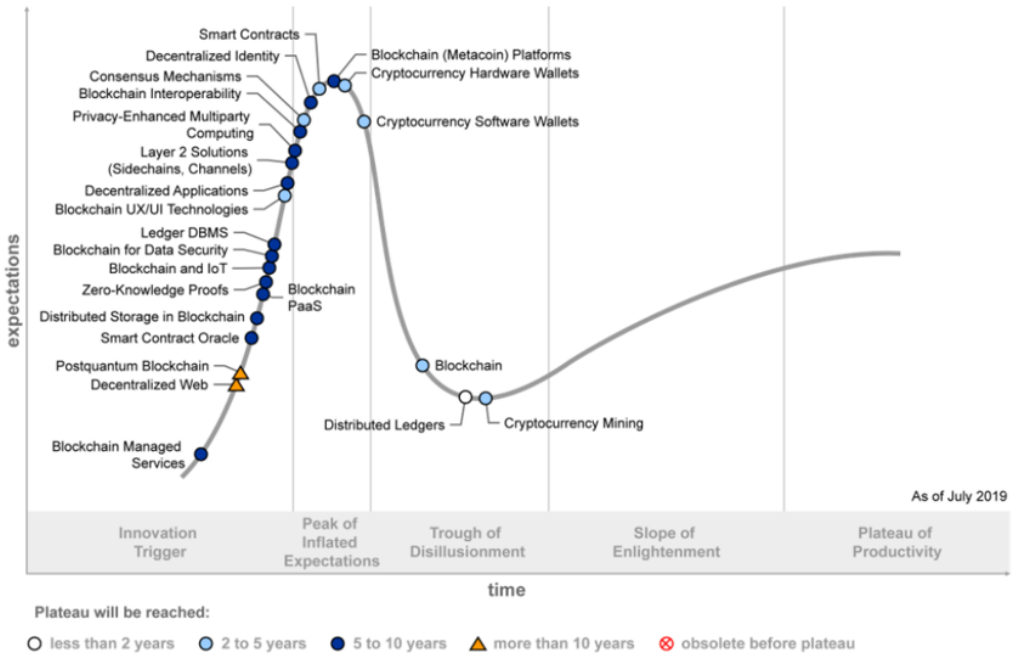

Figure 1. Hype Cycle for Blockchain Technologies (Gartner, 2019)

As illustrated in Figure 1, the majority of products utilizing blockchain technology have not yet reached the stage of productive implementation and demonstrate notable overvaluation. Nevertheless, certain products, like mining and distributed ledger, are nearing the stage of integration into existing value chains and operational processes.

Most sources say that the use of blockchain technologies will begin soon, as Gartner writes: “Blockchain does not yet allow for a digital business revolution in business ecosystems, and perhaps not earlier than 2028, when Gartner expects the blockchain to become fully scalable from a technical and operational point of view” (Gartner, 2019)

As observed in the chart, the majority of technologies are anticipated to commence implementation within the company over the next decade. However, there are technologies that might require more than 10 years for integration. The primary obstacle impeding progress is the complexity associated with transforming existing systems.

In the last ten years, the popularity of blockchain technologies has grown greatly, this can be explained by the growing popularity of the bitcoin network in 2017, as well as the popularity of this type of payment among businesses in the shadow sector. Mining has also become a popular method of earning money, although in 2019 popular giants such as Intel claimed that they abandoned this type of activity due to its economic inefficiency. Despite this, as you can see from the graph below, the network volume continues to grow. This may be due to both the growth of the shadow economy and the prospects of this technology (Kshetri, 2019).

The number of users in this network is growing every year, which may indicate either the regular creation of new wallets by wallet agents operating in this network to create products, or an increase in interest in this technology.

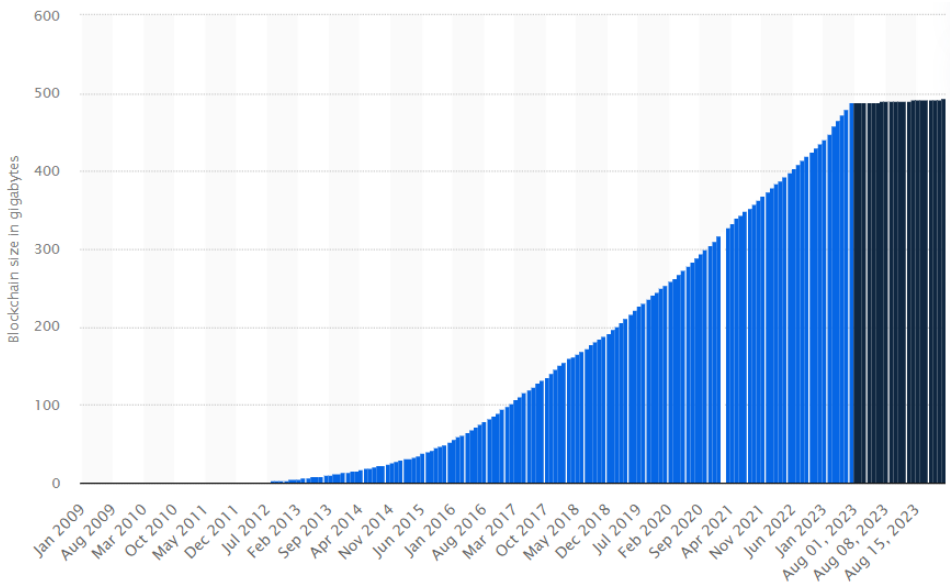

Figure 2. Bitcoin Network Growth Gigabytes (Blockchain size, 2023)

Overall, the graph demonstrates considerable upward trend in the information that is kept in the Bitcoin network. It means that popularity of a blockchain (Bitcoin Network in this case) grows rapidly with the approximate CAGR = 44,6% over a 10-year period, from 2013 to 2023. This means that there is sense to apply blockchain in a data/money exchange between companies, otherwise it would not be so popular.

1.3 Objectives

In this study, it is proposed to investigate and implement the use of blockchain technology in logistics supply chain and consider how would the logistics chain be improved. One of the stages of the thesis work includes case of implementation of the blockchain technology into a small company in order to show potential use case of the smart contracts' technology. For the purpose of to reveal the topic in more detail during the writing of the thesis, detailed answers to the following goals will be given:

1. What are the potential areas, trends, and applications of blockchain technology in the logistics industry, and what advantages and limitations can be identified?

2. How can blockchain be developed and implemented in a logistics project for a company like RX to optimize and secure logistics processes, and what are the pros and cons of its implementation and effectiveness?

3. What are the risks associated with its implementation and what improvements can be expected in terms of cost-effectiveness?

1.4 Limitations of the research

1) When it comes to logistics and the economy at large, blockchain technology is still relatively new. Even if most people are aware of how the blockchain system functions, there isn't always an appropriate tool to integrate the system at the ideal point in the service or product production process.

2) Furthermore, it would be costly to implement fully autonomous blockchain system into the chosen company, because to develop prototypes or conduct pilot projects. However, the part of the logistics process will be done with the smart contract.
3) The implementation of blockchain in a real logistics system may face unexpected legal difficulties as the blockchain digitalization is still the “grey” zone due to lack of legislation rules. However, the experiment of the implementation in the RX company example will be done without expecting any commercial benefits, on the contrary, the idea is to examine technical way of the application and provide analysis of its relevance in nowadays business.
4) Processing data requires special care about confidentiality; however, it would cost extra fees, therefore during the transaction follow-up open sources would be used to check the transaction status.

1.5 Introduction of the RX company business

RX company is the clothing company that sells clothing operating in 3 cities in Kazakhstan. The company does not have its own production line, it is engaged in the resale of things that were bought in large batches wholesale mostly brands of Turkish tailoring. The company has the form of ownership of IE (Individual Entrepreneur).

The function of marketing is well performed by the social networking site Instagram. As of December 2023, a total of about 57 thousand people are subscribed to 3 Instagram accounts of the RX company, which indicates a good market share for a retail store and loyalty of the customers.

Additionally, the company's location in the Asian market allows it to cooperate with a giant like China. In the future, it is planned to order tailoring of its own brand from Chinese subcontractors.

The case study will include the implementation process of the smart contract on the buying 1 unit of the furniture, especially coat rack, for the RX company branch.

2 Methodology and research

2.1 Approach of research

The approach to the study of this research is developed to provide a comprehensive analysis of the impact of blockchain on the modern world of logistics and the possibility of implementing some blockchain practices (smart contracts) in the case of a real company. The methods used allow to capture various aspects of the topic and to obtain objective data for further analysis.

The research framework adopts an inductive approach to enhance comprehension and assessment of smart contracts within the realm of blockchain technology. This framework emphasizes the use of induction as a method (concept) of analysis to draw general patterns and conclusions from specific blockchain use cases. In the philosophy and science of the New Age, induction as a method of scientific research was first developed by F. Bacon (Bacon F. - Works in Two Volumes (1977/78), 1978). Bacon founded the ground for the inductive logic. Bacon conceived the inductive method as the approach through which the idea could systematically progress from individual facts to their broader generalizations. The inductive method developed by Bacon, which is the basis of science, should, in his opinion, investigate the intrinsic forms of matter, which are the material essence of the property belonging to the subject - a certain kind of motion. Thus, in this paper, this "property of the subject" will be the smart contract, and the subject itself will be the blockchain. Gradually moving from general facts about blockchain and its features in this paper, the scope will be narrowed down to smart contracts and their advantages in logistics, and then the application of smart contract will be presented on a concrete example of a company.

Within the scope of the research, a literature review on the topic of blockchain was conducted to comprehensively address the importance and relevance of this subject (Section 3). Additionally, practical examples of companies that have experienced the implementation of blockchain technologies were provided (Section 3.2). Subsequently, terminology necessary for a thorough understanding of the internal workings of the blockchain system was examined, constituting an entire section (Section 4).

Narrowing down the application scope of blockchain led to the exploration of a practical solution — the application of smart contract technology (Section 5). This was further scrutinized through a

detailed analysis of a specific company's case, serving as the research subject (Section 6). In the concluding part of the work, a final analysis is presented based on the conducted research on the use of blockchain, specifically smart contracts (Section 7). Conclusions drawn in response to the questions posed at the beginning of the thesis are provided in the final Section 8.

2.2 Selection of research methods

- Data collection on the subject of the topic and literature review.

An extensive review of current research, articles and publications related to the study of blockchain's popularity and applications will be conducted. This step aims to provide a comprehensive overview of the present state of the field and pinpoint emerging trends in the utilization of the technology.

In selecting the literature for the study of blockchain and smart contracts, the following selection criteria were emphasized: relevance, authority, and scientific significance of the sources. Academic databases such as ScienceDirect, ACM Digital Library were used to search for articles and publications. Special attention was paid to peer-reviewed journals, as well as specialized books and monographs (for example, the work of Satoshi Nakatomo), which provide a deeper analysis of the topic under study. Citation chain and including contemporary publications in recent years were also important criteria. In addition to the previous sources, the Internet was used to keep up to date with the latest news in the blockchain field, for example, the DHL website was an essential source. An important aspect of the selection process was to analyze the practical applications of the technology in different industries (e. g. the work of Konstantinidis's, I. et al., and Kostyukova's, E.).

- Surveys and interviews: Interviews will be conducted with the company's manager, as well as a survey of the company's employees. The questions will be aimed at identifying their perceptions of blockchain, their experience of using it, and their assessment of the effectiveness of smart contracts in the company. In the concluding chapters answers will be analyzed to understand the relevance of the technology.

- Statistical analysis of data: The data collected will be statistically analyzed to identify correlations and trends. This step will allow scientists to obtain quantitative results and objective indicators of

blockchain's impact on the company and get feedback on the relevance of using this technology. The data obtained will be systematized and analyzed with regard to the goals and objectives. Moreover, recommendations will be offered for further steps in integrating the technology into business.

- PESTLE analysis of smart contracts in a company allows us to assess the impact of political, economic, socio-cultural, technological, legal and environmental factors on the implementation and use of smart contracts in business processes:

1) Political factors (legislation):
    - Exploring the legal framework governing the use of smart contracts in different jurisdictions.
    - Assessing policy support or constraints on blockchain technology and smart contracts.
2) Economic factors (costs and benefits):
    - Analyzing the economic aspects of smart contract implementation: development costs, personnel training, potential cost savings and business process efficiency improvements.
3) Sociocultural factors (acceptability of the technology):
    - Study of the level of readiness of employees and customers to use smart contracts.
    - Examining sociocultural expectations of transparency and data management in business.
4) Technological factors (trends in blockchain technology):
    - Assess current and future technology trends in blockchain and smart contracts.
    - Explore opportunities for further process improvements.
5) Legal factors:
    - A discussion of the legal aspects of using smart contracts, such as enforcement, obligations, and protection of parties' rights.
    - Study of possible legal risks and ways to mitigate them.
6) Environmental factors:
    - Consideration of environmental aspects of blockchain technology, such as energy efficiency and sustainability.

- Study of the impact of using smart contracts on the environmental sustainability of business processes.

PESTLE analysis allows companies to take an informed approach to the implementation of smart contracts, considering external factors that may affect the success of the project. This analysis helps create a strategy that considers the specifics of the environment and minimizes potential risks.

3 Essentials of Blockchain Technology: Unraveling the Core Concepts

3.1 Fundamentals of blockchain technology

Distributed ledger systems, better known as blockchain, are digital decentralized databases (DBs) designed to keep a record of every data transfer that occurs on their network. Each participant's computer becomes a node when it joins the network and works with its own copy of the database, synchronizing it. Each transaction is validated by all users and there is no need for a third-party approver (Konstantinidis et al., 2018)

Developments based on distributed ledger systems are applicable to a wide range of activities. Having gained popularity due to the popularity of cryptocurrency, blockchain is currently used in the development of "e-government" (e.g., guaranteeing the integrity of government elections), in healthcare, energy, banking, supply chain management, and so on. In the logistics business, we can distinguish smart contracts, as mentioned earlier, and developments aimed at tracking goods (Konstantinidis et al., 2018). It's also worth noting that the blockchain architecture already in place means that data security is guaranteed for the company and customers and can be an important factor for potential customers.

The blockchain contains records of all transactions between participants in a process. Unlike conventional databases, it is considered virtually impossible to change or delete records in a blockchain, but it is still possible to add new ones.

To elucidate the rationale behind this phenomenon, let us closely examine the operationalization process of blockchain technology. Blockchain was originally used in the field of cryptocurrencies and, above all, bitcoin. Therefore, when touching upon the aspects of this technology, we cannot

help but touch upon the process of mining. The so-called cryptographic proof of transaction must be provided by the miner each time he adds a new block to the chain. The block needs to pass through many sets of hash functions in order to acquire it. In the second case, computations are based on an arbitrary-sized piece of data that is converted into a random-length alphanumeric string called a hash. The blockchain requires that the generated hash start with a specific number of zeros in order to improve dependability. What hash a given collection of data would yield cannot be predicted. As a result, the calculation is done several times. Every time a miner adds a new block to the chain, he has to produce the so-called cryptographic proof of transaction. To obtain the block, it must go through several sets of hash functions. In the second scenario, calculations are made using a piece of data of any size that is transformed into a hash, which is an arbitrary-length alphanumeric string. To increase reliability, the blockchain stipulates that the created hash must begin with a predetermined number of zeros. One cannot anticipate what hash a particular set of data would produce. Consequently, the computation is carried out several times.

Chung et al. (2018, p. 3) considers Blockchain as a decentralized ledger system capable of permanently and securely documenting exchanges among participants. Blockchain effectively removes the requirement for intermediaries, by allowing multiple parties to 'share' databases. The decentralized nature of blockchain brings several advantages that can radically change logistics and increase efficiency, provide security and transparency from the beginning to the end of the supply chain. This revolutionary technology provides unique opportunities that can significantly improve logistics processes:

1. Enhanced transparency.

Trust in one of the crucial components in every business, therefore it is important to know how it is conducted in the supply chain, and Lambert (2023) explains:

> The increased openness that blockchain offers in logistics, together with a clear audit trail, is one of its most important benefits. This is made feasible by blockchain technology, which makes it possible to create digital credentials that are impenetrable to fraud and can be quickly verified. This facilitates the tracking of items from manufacture to delivery and helps supply chain managers see any process bottlenecks or delays (para. 1).

2. Enhanced efficiency: Smart contracts may be implemented to overcome issues like fraud, excessive time consumption, and administrative mistakes during document exchange and payments. This would enhance workflow (plainconcepts.com, 2022).

3. Another important aspect is improving security. Blockchain protects cargo and transaction data from unauthorized access and hacking. This is especially important in logistics, where confidentiality and data integrity are crucial.

Blockchain is a distributed, shared ledger that facilitates asset tracking and transaction recording across a network of companies. Anything like a home, vehicle, money, or a plot of land is considered a physical asset. Something akin to intellectual property, such as a patent, copyright, or trademark is an intangible asset. Almost everything of value may be recorded and exchanged on a blockchain network, lowering risk and boosting efficiency for all stakeholders.

According to the Ravindhar Vadapalli smart-contracts are created to do the following functions:

- Only locally and in relatively modest sums, cash is helpful;
- It may take a while for a transaction to be settled;
- The inefficiencies are increased by redundant work, the demand for third-party validation, and/or the involvement of intermediaries.
- Fraud, hacks, and even basic errors increase the cost and complexity of conducting business and put everyone on the network at danger in the case that a central system, like a bank, is compromised.
- Credit card companies have essentially built walled off areas with high entry barriers. The hefty costs of onboarding, which can entail a lot of paperwork and a drawn-out verification procedure, must be covered by merchants.
- Since half of the world's population lacks access to a bank account, they have had to create alternative payment systems in order to conduct transactions. (Vadapalli, 2020)

To solve the problems described above, smart contracts were invented. Simply put, smart contracts are blockchain-stored programs that execute when certain criteria are satisfied. They are usually used to automate the implementation of an agreement, eliminating the need for an intermediary and saving time so that all parties involved may know for sure what will happen right away. They may additionally automate a workflow such that it only advances in response to specific criteria being met (ibm.com, n. d.).

In other words, unlike traditional contracts, which rely on third parties for transaction credibility, smart contracts may promote it amongst contractual parties themselves (Nzuva, 2019).

Therefore, transparency plays important role while conducting engagement between different parties of the chain, as this allows parties to trust each other.

Referring to **plainconcepts.com, (2022)**, one important feature is reliability of smart contract. It is underlined that it can troubleshoot and eliminate mistakes, which saves time and the risk of fraud during transactions. **(para. 2)**

Blockchain is a crucial innovation of the digitalization era, which will be able to simplify, speed up and secure all monetary and non–monetary transactions. The technology is already being used in many leading companies not only from the logistics world, but also in other sectors of the economy. Due to the growing popularity, it makes sense to consider this topic for implementation not only on the example of market giants, but also small and medium-sized businesses that are just starting their way and strengthen their reputation using this technology.

3.2 The use-cases of blockchain in logistics

Walmart

Walmart is an American company, one of the largest representatives of the retail sector, operates more than 10,000 shops worldwide. For 2022, the company's revenue totalled $573 billion.

In 2016, Walmart announced two product traceability projects: mangoes in US shops and pork in Chinese shops. The reason for the need for such a system was that when diseases caused by certain products occur, the time it takes to find the source is measured in days or even weeks. During this time, there is a high probability that whole groups of products will have to be disposed of, even if they have nothing to do with the problem. Obviously, this leads to unnecessary waste.

With the help of IBM's Hyperledger Fabric subsidiary, Walmart has built a blockchain-based system that can trace a product back to the farm where it was grown. As a result, the time it takes to find the source of a product has dropped from an average of a week to 2.2 seconds.

As of 2022, Walmart is tracking 25 products and also, together with IBM they have launched the IBM Food Ledger network, which connects various food suppliers, manufacturers and retailers (HOW WALMART BROUGHT UNPRECEDENTED TRANSPARENCY TO THE FOOD SUPPLY CHAIN WITH HYPERLEDGER FABRIC, 2023).

COX Logistics Group

On April 25, 2020 Track & Trace systems provider MVC Global announced a strategic partnership with logistics company COX Logistics. Together they announced the launch of a "next generation warehouse" in Bahrain. The aim is to exploit the latest technology to distribute food and pharmaceutical products quickly and efficiently throughout the Gulf region.

This warehouse utilizes technologies such as blockchain, internet of things and fintech. Within blockchain, two applications are considered. Firstly, product tracking, i.e. Track & Trace system that records not only the facts of transactions, but also temperature and humidity conditions of storage, which is extremely important for processed products. Secondly, the use of smart contracts can facilitate customs regulation and settlement processes. (Bhargavi, 2020).

Most variations of blockchain applications come from the top down, as in the Walmart example, because they require transforming the entire supply chain. Company X, being only a link in the customer chain, can only be a thought leader. The Track & Trace system being implemented was described above. At the moment, it is based on the interaction of a WMS system and a cloud server, but it is clear that the implementation of blockchain-based tracking is possible in the near future, so Company X can initiate the creation of such systems for its customers, thereby gaining a competitive advantage.

3.3 Advantages and disadvantages of the blockchain

Blockchain is a distributed database. It differs from conventional databases in that the information is not stored on one centralized server but is distributed across different nodes. In this case, the nodes automatically check with each other how much information in each of them is the same and correct. In addition to this advantage, they emphasize fault tolerance: if one of the nodes has an unexpected failure and it deletes information, the system continues to work in the normal mode.

Above all, the blockchain is secure because it is decentralized and cryptographically protected, and it records information about all transactions. This feature eliminates the need for trusted relationships between participants and does not require regulators to exchange information. In addition, the absence of centralized intermediaries reduces transaction costs and the cost of maintaining the relevant infrastructure. For example, McLagan and Wirex analyzed the operating costs of 50 banking organizations and came to a number of conclusions. In particular, optimizing data quality, transparency and internal regulation reduced financial reporting costs by 70%. Simplifying the reconciliation of financial transactions contributed to a 30-50% cost reduction. Moreover, by facilitating shared access to client data, the cost of centralized operations was cut in half. Blockchain technology also helps to speed up various processes by eliminating the need for multiple approvals as well as the absence of time constraints on activities (Kostyukova, 2020). At the same time, blockchain has some drawbacks. Let's list the main ones. As noted earlier, blockchain can reduce transaction costs, but creating a system and implementing it can be costly in and of itself. Moreover, scalability is a limitation due to the size of the blockchain publicity, as the speed of operation can decrease, sometimes significantly (Sokolova, T. et al., 2019). There are also other technological shortcomings, the most notable of which are as follows: - at the user level (botnets delivered via droppers, etc.); - at the network level (DDoS (delivered Denial of Service) hacker attack or distributed denial-of-service assault; it is called Eclipse or information blackout attack, etc.); - effects on blockchain integrity (51% Attack, etc.); - attacks that are applicable to any network technology (deface, phishing, etc.) (Sokolova, T. et al., 2019). Today, the specifics of blockchain functioning are being studied in more and more detail, and the directions of its use are expanding, including logistics activities. European logistics organizations began to show active interest in blockchain in 2017-2018. For instance, many European logistics operators and transportation companies have announced their participation in blockchain testing or have joined relevant alliances. Kuehne + Nagel

International AG is one of the largest transportation and logistics companies in the world. The organization, along with AB InBev, Accenture and APL, has joined a consortium of shipping companies participating in blockchain testing under the supervision of the European Customs Organization. Blockchain technology has made it possible to digitize paper-based processes and overcome various interfaces, which is particularly important in logistics. Thus, the following key findings emerged from the testing: - blockchain's ability to replace paper shipping documents can save hundreds of millions of dollars annually; - blockchain technology accelerates the flow of transportation documents and significantly reduces the need for data entry, reducing errors and the risk of fines; - blockchain technology reduces operational costs and simplifies supply chain audits globally, increasing transparency and security.

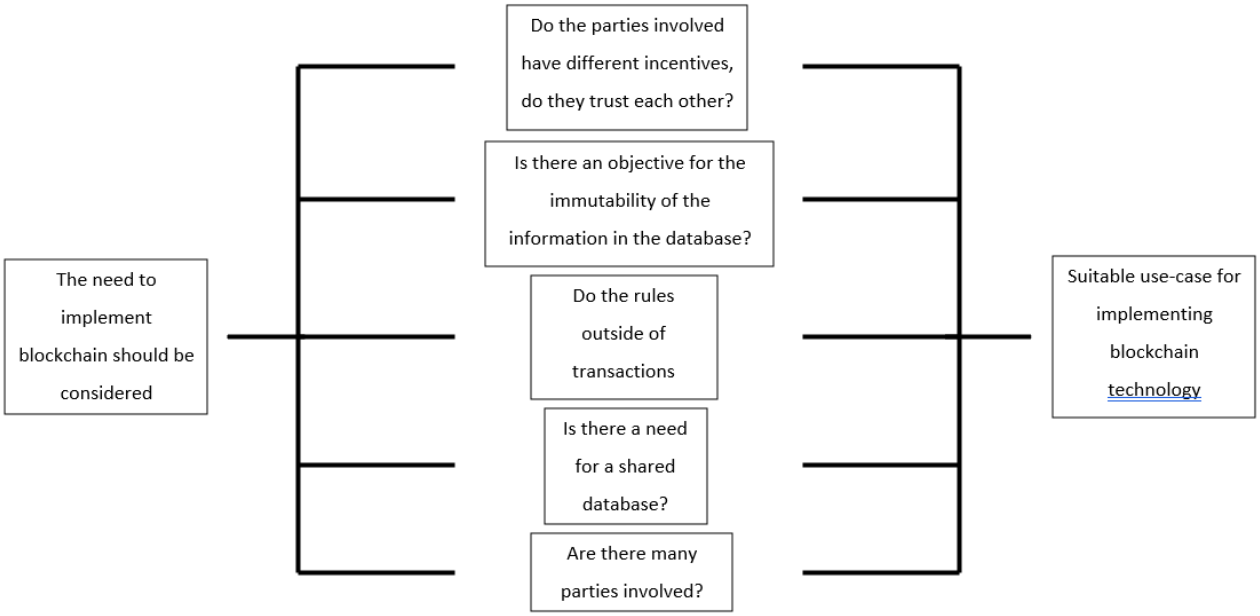

Figure 3. Conditions for blockchain implementation (made by author of the thesis)

If the majority of the conditions above are "Yes", it is worth thinking about implementing blockchain.

The supply chain nowadays consists of many parties. Each one has its own database with data on raw materials, operations, product, because everyone is interested in making a profit. Moreover, this system needs to be monitored and constantly controlled what is happening in it. Each link in the chain is an interval of creating a valuable product or its transportation, which in turn can be

broken down into more subsystems, in which we see a huge number of participants, as in the picture below.

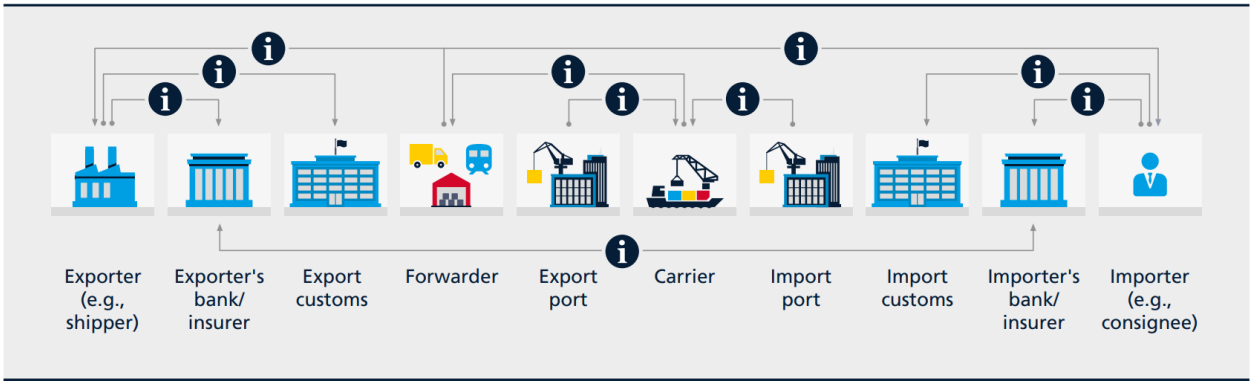

Figure 4. Points of contact between the logistics chain parties involved (DHL, 2018)

In the Figure 4, the letters "i" mark the points of contact between parties - they indicate the exchange of information (documents) to record the change in the status of a certain operation. If information is not recorded, lost, changed, etc., chaos ensues. In the nowadays picture of the supply chain there are certain disadvantages in it shows the following weaknesses:

1. Large number of intermediaries.

From the point of optimization in is necessary to single out freight forwarders who organize transportation, dock the participants, and monitor their further relations.

2. Banks and credit organizations.

They are used as the 3rd party of relations, as the participants do not trust each other, and banks and other credit organizations act as trustees in various transactions.

3. Expensive.

The more participants (intermediaries) in the supply chain, the higher the price of the final product.

4. Standardization

There are many different documentation standards in logistics, and the lack of a single regulation creates difficulties in sharing information between supply chain participants. For example, the U.S. may use the BOL standard to document and track a shipment during transportation. This document contains information about the goods, the consignee and consignor, and information about

the vehicle. (Bill of Lading document, 2023) Whereas China uses the CI standard, Commercial Invoice, to document and estimate the value of goods in international trade. It contains information about the goods, prices, terms of sale and other commercial details. (Shipping to China from the US: Rules, costs, options, n.d.)

4 Blockchain terminology and technology. Principles of decentralization and security

The security of the system is based on power distribution: if there is more computing power under the aggregate control of honest participants in the system than under the control of attackers, then the system is safe. To understand how bitcoin and blockchain work in general, it is necessary to define the basic concepts (Table 1).

Table 1. Basic concepts of building blocks and operations in Blockchain technology

Term	Definition
Hash function	Transformation of an input data array of variable length into an output bit string of a defined length, accomplished through a specific algorithm (Nakamoto, 2008)
Cryptocurrency	There is no precise definition established by legislation as of today. However, it is possible to highlight the main features of cryptocurrency, which will allow to define it: • - Decentralization. Each cryptocurrency does not have a single management body that can issue, control, etc; • - Anonymity of transactions with cryptocurrency. Despite the fact that the system is absolutely transparent and each participant can trace the history of transactions to the zero block, the system is still anonymous, as there is no binding of personal data to the owner's wallet; • - Cryptocurrency is not backed by any guarantees (Khidzev, 2014)
Private key	A cryptographic hash function used as an electronic signature or public address. Represents a numeric-letter sequence (bit string)
Public key	A cryptographic hash function used as an electronic signature or public address. Represents a numeric-letter sequence (bit string). Calculated as the value of some function of the private key
Token	Digital asset
DApp	A decentralized application that has no single point of failure and generates tokens according to cryptographic algorithms
Ethereum	Blockchain platform for creating decentralized applications based on smart contracts
Genesis block	The initial block in the blockchain

Multiple signature	A type of electronic signature that allows multiple users to sign a single document
Off-chain transaction	A transaction that takes place outside the blockchain but is validated in the blockchain at a later date
Peer-to-peer	An overlay computer network, which is based on the equality of participants. In this kind of networks there is no centralized server, which provides network operability, each node in such a network performs the work of a client and a server
SHA-256	A hashing algorithm that allows you to create one-way hash functions
Consensus	Consent for inclusion of a particular blockchain in the blockchain
Node	A full blockchain device that is part of a shared network. It is the basic unit of the network
Smart contracts	Digital contracts that rely on distributed agreement can be used with them; they are usually autonomous through an execution and are resistant to manipulation

Since the first mention of blockchain occurs in Satoshi Nakamoto's work on bitcoin, we will consider the basic principle of this technology on the example of bitcoin.

Blockchain is essentially a chain of transaction blocks, which is built according to the Merkle tree principle. The Merkle tree is a fully binary tree in which hashes from data blocks are stored in its leaf nodes, and hashes from the addition of values in the child nodes are stored in its inner nodes (Kudin, 2017).

The principle of operation is as follows. Each coin in the system is a set of digital sub-scripts, which consists of numbers and digits. When we send our digital asset, we digitally sign the hash of the preceding transaction along with the public key of the further owner, and then attach this information to our coin. In this way, the next owner of the coin can verify all transactions that have occurred with the coin, trace it back to the zero block, and verify that it is real. An example is shown in the Figure 5.

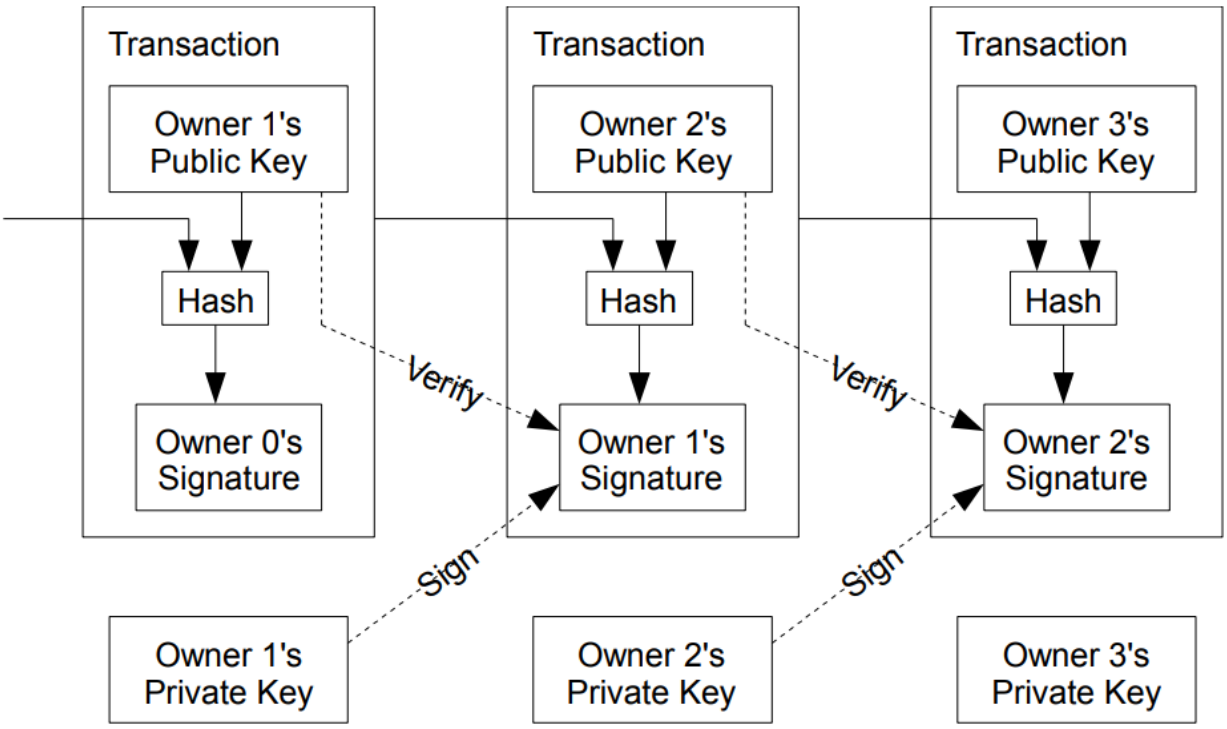

Figure 5. The chain of transactions (Nakatomo, n.d.)

The problem with this system is the so-called "double-spending" situation, which is that the next recipient cannot check how many times the previous owner has sent to someone. The classic solution is to have a third party (trusted person) check each transaction. All banks work according to this principle. During the transaction, the coin is sent to the issuing organization, which checks its authenticity and issues a new one, which is sent to the recipient. Only in this case we can say that we have received a real coin. The main disadvantage is that the whole system depends on the trusted person, as it controls all transactions.

Recipient A must be sure that this coin was not sent by one of the previous owners to another person before the transaction was made to recipient A in the tree of the coin sent to him. In a blockchain system, it is important that only the first transaction is genuine. Usually this would be decided by a trusted person, but to get rid of it, it is necessary to conduct all transactions publicly, without the possibility of concealing any of them, and to be able to agree on the order in which the transactions take place. To do this, the recipient needs proof that for each transaction in the chain, the majority of nodes consider it to be the first.

The description of the solution in Nakamoto's work starts with a timestamp server. The main task of the server is to hash a block of data to which a timestamp should be assigned, and to publish this hash publicly. The timestamp indicates that this data existed at a particular moment, and therefore it was included in the hash of the block. Each new hash in the system includes the hash of the previous hash. Thus, a chain is constructed in which each new link makes all previous links more reliable. An example is shown in Figure 6.

To establish a decentralized overlay timestamp server, it is necessary to employ a "proof-of-work" system akin to Adam Back's Hashcash. (Back, 2002).The main point is to find a value that has a certain number of zero bits at the beginning of the hash. The amount of work done depends exponentially on the number of zeros, but only one hash needs to be computed to verify the value.

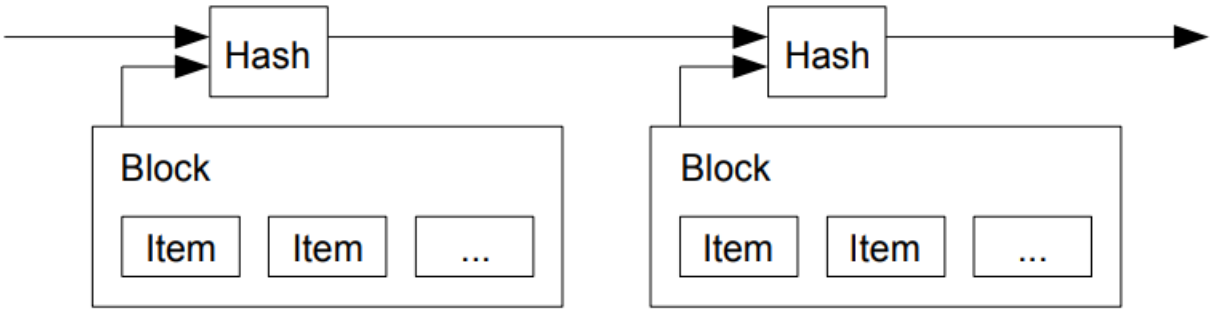

Figure 6. Principle of circuit section operation (Nakatomo, n.d.)

In the case of bitcoin, the search for solutions is done by looping over the value of the iterated additive field in the block. If a block solves a problem, its contents cannot be changed without doing all the work again. For any block except the last one, this will also mean recalculating all subsequent blocks. Figure 7.

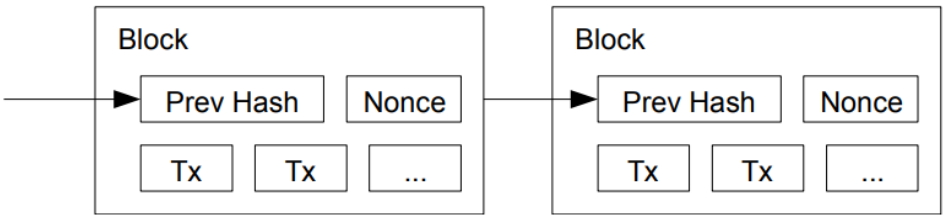

Figure 7. The "proof-of-work" principle (Nakatomo, n.d.)

This principle also helps to address the issue of choosing a version that is approved by the majority. In bitcoin, a single processor has the "voice". A chain of hashes of the longest length will ex-

press the opinion of the majority. It turns out that in a situation where more than 51% of computing power is owned by non-malicious users, a chain of honest blocks will overtake any other chain. If an attacker wants to make a change to a block, he will have to recalculate that block and all subsequent blocks and then generate blocks faster than the honest chain does.

To prevent new blocks from appearing too often or, on the contrary, too slowly, the complexity of the problem to be solved will vary depending on the number of co-created blocks. That is, if too many blocks are created, the complexity of the task increases, and if too few blocks are created, the task becomes easier.

The system works according to the following rules:

1) Each transaction copies to every node after its creation.

2) Nodes combine arrived transactions into a block.

3) Nodes try to find a hash of the block that satisfies the current complexity.

4) Once such a hash is found, this block is sent to the network.

5) Nodes accept the block only if all transactions in it are correct and do not use already spent funds.

6) Nodes express their agreement with the new data by starting work on the next block and using the hash of the previous block as new input data.

Since the longest chain is considered correct, the network members always work on lengthening it. If two versions of the same block enter the system at the same time, it is logical that some users will get one version first and others will get the second. In such a scenario, users start working on their version, keeping the other one if it is continued earlier. The branching disappears as soon as a new block is generated that continues one of the branches, and those nodes that were developing the other network move to it. In addition, new transactions may not always end up with all members, because if enough network members know about these transactions, they will end up in one of the blocks. Then, if a node has not received one of the blocks, when it receives the next one it will request information to fill the apparent gap. The whole blockchain system is built on the interest of the network members in its performance. Thus, to ensure the performance of the network it is necessary to create incentives that will push users to generate new blocks. In fact, the first transaction in a block is a special one. It generates a new coin, which is the property of the block creator. This system rewards honest participants in the network by incentivizing them to keep it running. It also solves the issue of distributing money in this way.

Another type of incentive is the transaction fee. In the case where the amount of money coming into a block is greater than the amount of money that must come out of it, the difference between these numbers is the commission, which is added to the base reward value for the generated block in the first transaction. Later, the commission will be the only type of reward, as the number of coins is usually limited. It has already been said about blockchain platforms that they are generally free to use. To be more precise, Hyperledger Fabric is absolutely free, while Ethereum charges a fee of approximately 3 euro per transaction (*GWEI to EUR Price Converter & Calculator, Live Exchange Rate | CoinBrain*, n.d.).

In addition, this type of incentive will help to reduce the number of unfair actions. If the attacker has more than half of the network's computing power in his hands, it will be more profitable for him to act according to its rules, to generate new blocks, as a consequence of which he will become the owner of more than half of the coins generated by the chain after the beginning of his actions. I.e. in this case he will not just maintain his capital at a constant level by canceling transactions, but will increase his capital by generating new blocks and, as a consequence, creating new coins.

When the last transaction in a coin-chain hits a sufficiently old block, all previous transactions can be deleted to save disk space, and so that the hash of the block cannot be changed, all transactions in it are stored as a Merkle hash tree and only its root is included in the hash of the block. And the size of each block can be reduced by removing unnecessary branches of the tree.

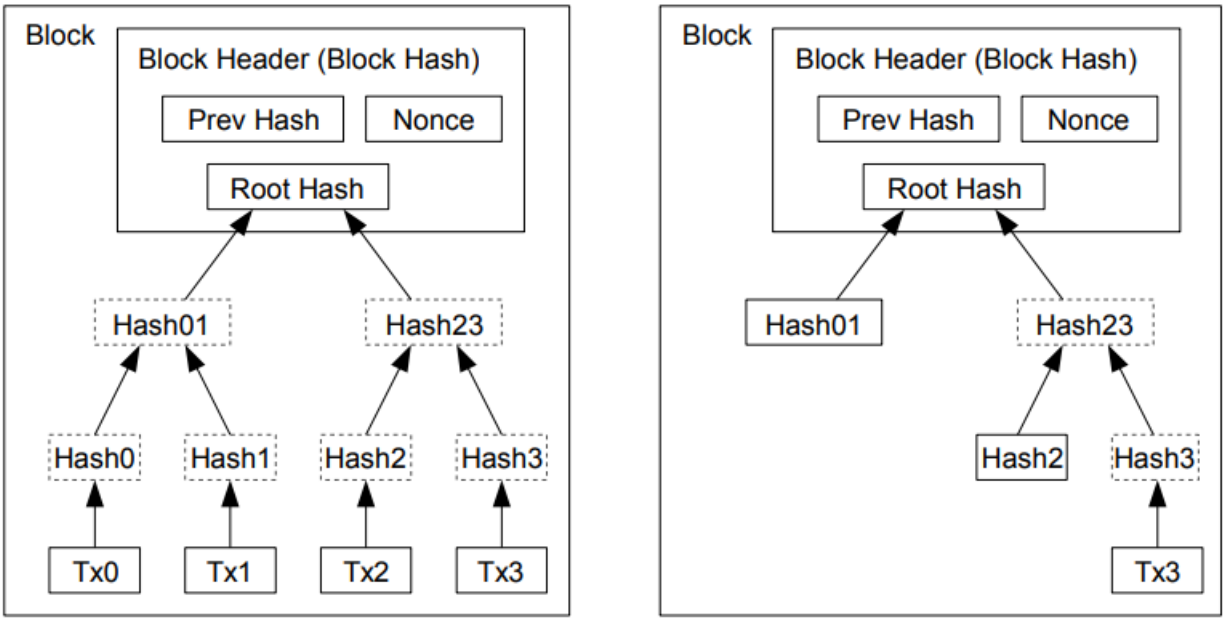

Figure 8. Working principle of disk space saving in Merkle's hash tree (Nakatomo, n.d.)

Transactions can be verified without accessing the full node. For this purpose, it is necessary to store only the block headers of the longest chain of blocks, which was received from other network participants, and to check only the hash subtree of the block of interest. The user cannot verify the transaction himself, but when he receives a reference to the block, he can make sure that this block and all the blocks following it in the chain are accepted and validated. Such a system is called a simplified verification system. The principle of its operation is shown in Figure 8.
This verification method works as long as at least half of the network belongs to "honest" users. Normal nodes can verify transactions themselves, but if an attacker creates the longest chain of blocks, the data in those blocks can fool the simplified verification system. A counterbalance to

this would be to send out alerts from regular peers who receive a "fake" block. Such an alert would force the program client to download the entire block in order to check it for correctness.

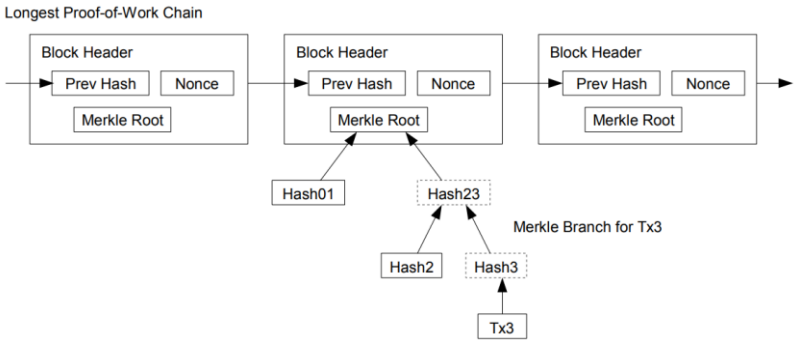

Figure 9. Principle of simplified transaction verification when accessing the longest chain (Nakatomo, n.d.)

It is possible to perform actions with individual coins in the system, but it would be too illogical to create a separate transaction for each penny. Therefore, transactions will function on the principle of pooled and shared amounts, and there will be several inputs and outputs in the transaction it-self. A typical transaction will look like this: it will be one input from a large payment, or several inputs that will summarize several small payments, and no more than two outputs: the first is a payment, and the second, if there is a need, returns the extra money to the sender. A depiction of a typical transaction is shown in Figure 9. The current bank payment system maintains a level of anonymity by providing information only to the participating parties and a trusted third party. Transparent transactions eliminate anonymity if only public keys are tied to a specific person. If, however, the public key is kept unlinked to a specific person, it provides a high level of anonymity. The privacy model is shown in Figure 10.

Further, as a measure to provide an additional measure of anonymity, a new public/private key pair can be created for each transaction. This will help avoid co-signing different payments with

the same sender or recipient. However, again, a transaction with multiple inputs indicates that all of these funds belong to a single sender.

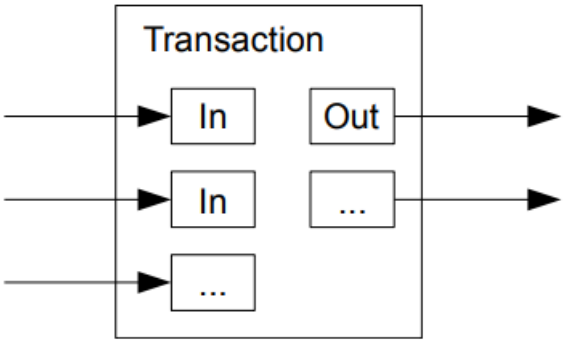

Figure 10. Typical transaction (Nakatomo, n.d.)

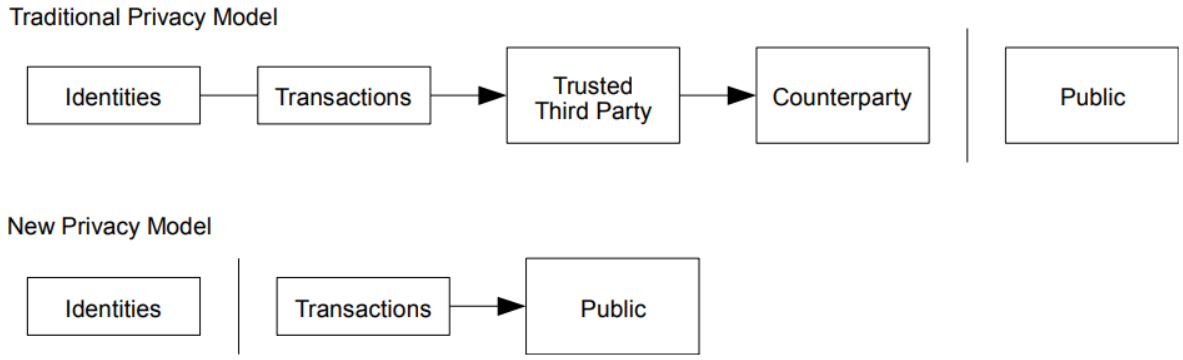

Figure 11. Old and new privacy model (Nakatomo, n.d.)

The last point of Nakamoto's work is to evaluate the system for risks. Suppose that an unscrupulous member of the chain manages to generate a longer chain than the honest members of the chain. Even then, he will not be able to enrich himself infinitely, since the system will not accept such transactions. In such a case, the attacker will only be able to modify some of his transactions to get his money back. Such a situation can be described as binomial random walk. When a block is generated in the chain by honest users, the gap between honest users and the attacker increases by one, while when a block is generated by the attacker, the gap shrinks by one. The attacker has unlimited time, unlimited number of actions, but initially he lags behind the honest participants of the network, because he has to compromise the block of the chain that contained his transaction, plus all subsequent ones.

Blockchain is essentially a database that provides anon-anonymous exchange of validated data, by creating cryptographic hash functions. It is the inherent technical features that blockchain possesses that make it so promising for further research and application in the logistics field.

5 Smart contracts

5.1 Technological review

The original main idea behind bitcoin was to create a system of electronic cash. However, the system is capable of performing other functions that are used in various fields. Satoshi Nakamoto built into the system the functionality to create smart contracts, smart assets, and so on.
Nick Szabo first proposed digital, self-adjusting smart contracts in 1993, but at the time there was not enough economic or communication infrastructure to support their adoption (*Nick Szabo - the Idea of Smart Contracts*, n.d.).

Smart contracts are secure digital agreements that permit the use of terms that depend on decentralized consensus. They usually self-finance through automated execution. The definition is consistent with definitions commonly found among specialists. Because of bitcoin's popularity, several developers have suggested creating "bitcoin 2.0," which would incorporate more sophisticated smart contract technology. Ethereum is the name of the most sophisticated of these systems. (Buterin, 2021) Similar to bitcoin, it uses a blockchain system, but its foundation is a complete Turing contract programming language built on blockchain technology. This feature makes it possible to build and automatically implement complicated contracts. Ethereum's smart contract capabilities enable the precise definition and implementation of financial exchanges, insurance contracts, financial derivatives, and several other types of transactions. Digital services like renting bandwidth, processing power, and digital storage are very simple to put into practice. Proposals have also been made to expand contracts to encompass communication and interaction in the real world. These consist of automated property rentals, earthquake or weather insurance, automobile and property titling, and reputation management. (Buterin, 2021).

There is also discussion on legal matters. A set of agreements between investors, managers, staff, clients, and suppliers characterizes modern organizations. Automating these contracts opens the

possibility of creating "dis-tributed autonomous organizations" (DAOs, commonly known as "decentralized" organizations). Without the need for human intervention, these companies are able to make choices, recruit and dismiss contractors, and purchase and sell goods. Additionally, human groups that use blockchain voting for decision-making can be established. The "Distributed Autonomous Society" (DAS, also sometimes referred to as "decentralized") is the ultimate manifestation of these concepts. Smart contracts have the potential to improve the reliability and affordability of many present government activities. As an illustration, BitCongress is a voting platform built on the blockchain. The use of blockchain in taxation, the federal reserve, intellectual property, universal basic income, real estate records, and other areas are some of the others. (Omohundro, 2014)

It is crucial to note that smart contracts are not simply digital contracts (many of which depend on trusted authority for consensus and execution), nor do they entail artificial intelligence (rather, they are more likely to be robotic).

It is also worth realizing that a blockchain is essentially a database that stores information in cryptographic form. It is capable of transmitting it, but it cannot perform miracles. Each smart contract is written for certain conditions, based on this database and operating on this database. The main application of smart contracts at the moment is the creation of an integrated and automated logistics chain. The use of blockchain technology together with various technical devices will help to significantly reduce costs and shorten the life cycle of goods.

5.2 Utilizing of smart contracts in logistics

In the work of Agafonova A.N. and Permyakova A.A., the following advantages of blockchain implementation are listed:

1. Improving the security of the entire supply chain.
2. Transparency.
3. Simplified access to information. (Agafonova & Permyakova, 2017, p. 182)

The implementation of blockchain technology serves as a safeguard against potential harm caused by malicious actors attempting to manipulate information flow. For instance, any attempt to modify transaction details or deceive the contractual terms is blocked by the system. In the former scenario,

the blockchain rejects false information without majority approval, triggering errors in subsequent blocks. In the latter case, utilizing smart contracts ensures that the system refrains from concluding a transaction until all specified conditions are met in accordance with established protocols.

Considering the frequent transit of the product, often subject to inconsistently enforced transport conditions, a smart contract meticulously outlines all terms, compelling adherence to regulations. The transparency inherent in blockchain, where all transactions are publicly accessible, poses a challenge to hiding information. This transparency allows partners to assess the reliability of suppliers, buyers, and others, providing opportunity to customers to make well-informed decisions by scrutinizing the product's comprehensive history. Each block within the chain stores all pertinent information about a specific transaction, streamlining the retrieval and analysis of data and enhancing error identification.

It is worth adding that the technology will have the greatest effect when it is implemented not in one particular enterprise, but when it is integrated across several companies from the entire supply chain.

At several stages of the supply chain, there is now a lack of openness and an imbalance between agents and principles. In total opposition to the needs of the client, this results in an information gap between the transport protocol and the product's origin: demand and interest in this information (Carter & Rogers, 2008, p. 361). There is now an imbalance between agents and principles and a lack of transparency at many points in the supply chain. This leads to an information gap between the transport protocol and the product's origin, which is completely at odds with the demands of the client: interest in and demand for this data (Lamming et al., 2001). The challenge is to find and implement the right system for pro-transparency and capitalise on its benefits (Carter & Rogers, 2008, p. 361). The difficult part is figuring out how to best promote transparency, put it into the right place, and benefit from its advantages.

Drawing on the research of Everett Rogers (Turner, 2007), for the purposes of this study, we can define blockchain as an innovation. Even though the technology comes from the financial sector, the opportunities for using it in the supply chain, as well as improving its reliability, are very large. Table 2: summarizes the main benefits of using blockchain in logistics.

Table 2. Advantages of using blockchain in logistics

Source	Group	Advantages
(Lee & Whang, 1999)	Relative advantages	Reduction of transaction costs
(Nakatomo, n.d.)		No need for centralised state institutions
(Project Provenance Ltd, 2015)		Open access to information on activities within the supply chain
(Project Provenance Ltd, 2015)		Provides customers with the opportunity to choose sustainable transport systems
(Project Provenance Ltd, 2015)		Provides customers with the opportunity to evaluate a product or supplier before committing to a transaction
(Badzar, 2016, p. 30)	Compatibility	Providing customers with information regarding product origins and freight routes
(Government Office for Science, 2016)		Reducing the likelihood of fraud or receiving counterfeit products
(Government Office for Science, 2016)		Transactions are easier to execute using hashes instead of physical documents
(Project Provenance Ltd, 2015)		Provides monitoring and tracking of transport
(Project Provenance Ltd, 2015)		User-friendly product life-cycle tracking and recycling system
(Project Provenance Ltd, 2015)	Difficulty to use	Effective utilization of WiFi, iBeacons, RFID, NFC, and QR's
(Lee & Whang, 1999)		A platform-based network that exchanges both material and intangible resources
-		Signing up as a user and accessing the network is as easy as using a smartphone
(Rarhi, 2020)		Multi-asset platforms for pubic and private access
(*Nick Szabo - - the Idea of Smart Contracts*, n.d.)	Approbation	The degree of participation and dissemination of information is determined and regulated by the user

(Badzar, 2016, p. 23)		Active participation is not mandatory

Currently, it is very impossible to find out additional information about products or track down their place of origin. Nonetheless, chain participants may discuss and trade information about their products and services on a safe platform thanks to blockchain. Asset tracking is made possible by tagging products or modes of transportation, which creates an object that can be registered in a registry. Coordination between supply chain partners is essential for success. Manufacturers will use a single system to tag products with unique codes that will be hashed and added to the blockchain, allowing for the quality and authenticity of the product to be confirmed. By scanning or re-registering the code, the movement of assets across the supply chain will be documented in the register. The benefit for manufacturers from this investment in a system to tag their goods will be to increase customer loyalty, as customers will consider themselves trustworthy because the full exchange of information indicates that the manufacturer has nothing to hide. It will also help to avoid various public scandals, such as the misrepresentation of the quality of meat products or the presence of dangerous chemicals in toy products.

Recent concerns about the environmental issues that arise from the use of traditional modes of transport have led to the emergence of vehicle options that run on gas or electricity. However, the supply chain is made up of many layers and when a transport is booked with a major logistics service provider, they usually contact a broker who in turn subcontracts to fulfil the order. This means that within the transport chain, the transport may not be performed in accordance with all the environmental requirements that are usually specified in the contract and tend to make the transport more expensive. To ensure the environmental credibility of a vehicle, hashes can be used to get an overview of the lorries, drivers and tracking route. With this information on blockchain, customers will be able to track goods to the first node in the transport chain. This will provide insight into the chosen trans-port route and carrier selection.

Organizations can add a smart contract to the transaction to guarantee that the transport is executed in line with the terms of the contract. If the terms of the contract are not fulfilled, the smart contract's job would be to prevent any payment or payment modification from being made automatically. In addition, the contract stipulates that payment for the products or services will begin

as soon as the requirements are satisfied. The transport contract will be recorded on the blockchain if a condition is not met, and no further action will be conducted until the condition is met or the contract is amended. Transaction costs are high in the present market and will be eliminated or significantly reduced with the implementation of blockchain-based smart contracts, especially for smaller firms. Both the consumer and the transporter will benefit from smart contracts as the former will be able to pay for the agreed-upon amount, which may include insurance, and the latter will be able to ensure that they have gotten the dependable service they sought. Blockchain's near real-time transaction tracking and recoding/auditing capabilities make this feasibleThe function that follows transfers ownership or initiates automatic payment as soon as the delivery is received and recorded in the master register.

Valuable products are transported over time and space in global supply chains together with verification documents in the form of bills of lading or letters of credit. They also consist of several participants who handle or come into contact with the goods being delivered along the route. There is a chance of theft, tampering, and counterfeiting due to the variety of players. Furthermore, a conventional system necessitates confidence between supply chain participants and a centralized entity that oversees and records every transaction (Project Provenance Ltd, 2015). By integrating blockchain technology into the present system, it will be impossible to tamper with or duplicate purchases since information stored on the blockchain cannot be changed, and item authentication will be accomplished by comparing hashes to information stored on the blockchain. It could be wise to choose a different supplier if the current one is unable to provide proof of the item's origin.

In the meantime, supply chains employ a unique coding scheme, typically linked to product labels or barcodes on packaging. Existing software and technologies use QRcodes, RFID, NFC tags, etc. The issue is in the fact that outsiders and maybe even certain insiders cannot access the information linked to these codes. Supply chain participants have to think about expanding their utilization by listing on the blockchain. By scanning a designated tag, users may obtain information on a product, including details about its manufacturing, processing, and transportation, via the blockchain. The client is reassured that the supplier is operating their company and manufacturing in compliance with laws and environmental standards when the tagged items are transformed into intellectual property and added to the blockchain. It is necessary to be aware that the firm may be

questioned if a supplier refuses to provide documentation or certifications on the provenance of its raw materials or production location.

Contracts and insurance documents are usually executed as part of transactions and transport services to guarantee that products are delivered to the correct location, are carried safely, and that ownership and liability are confirmed. In addition to being time-consuming and adding to transaction expenses, waybill checking and control also carries the risk of human mistake. Because blockchain technology is self-executing, a service or delivery just has to be registered in order to be paid for or have ownership transferred. This particular feature has the potential to dissuade individuals from using unauthorized carriers for purposes other than contacting the service provider to handle the transportation. This could happen if there are keys or codes that need to be registered or scanned before unloading. Only the correct key or code can initiate payment for services via blockchain, and if they do not match, the carrier will not receive any compensation for its services.
In addition, current practice allows tracking the dispatch of a parcel through the company's internal tracking system on its homepage. However, the information provided is limited to the timestamp of when the package reaches the logistics service provider's processing system. Registering a package on a blockchain will allow the buyer to follow the movements along the entire supply chain and receive more accurate information on the time of delivery.
Blockchain technology is an intricate system that considers hashing algorithms and the mining process. But it should be seen as a tool, similar to an automobile engine, that may be used in the background of any existing system (Nakatomo, n.d.). Platforms can be custom-designed, for example, to track shipments, based on unique conditions, demands, or requirements. The system's benefit is that any item, real or virtual, may be transformed into a blockchain object and controlled using public and private keys (Project Provenance Ltd, 2015). Keys work similarly to mobile bank accounts or social media profiles, where the user may choose who can access what data and is uniquely recognized by a code. Keys govern the possession, management, and monitoring of assets that are accessible on any mobile device through an app. A public or private key is used for transaction authorization, acceptance, and tracking.

As a seller or customer utilizing blockchain, there are no limitations or duties. You can access the network as a registered participant on a public platform. Because a private blockchain requires a

customized book made to participant specifications, creating one might come at an additional expense to the provider. In order to gather knowledge prior to network integration, several blockchain solution providers provide demonstrations to prospective clients. There is a great chance that they will discover a blockchain solution that satisfies their needs because there are so many active suppliers offering them, mostly for payment systems.

5.3 Limitations and problems of application

1. Insufficient secrecy.

The blockchain system is completely a distributed peer-to-peer registry serving a complete chronology of transaction data. All transaction details, such as the objects being transferred and their number, the accounts involved in the transfer, and the transfer time, are available to everyone. This is necessary in order for each member of the system to be able to determine and confirm ownership, as well as to verify a new transaction (for example, to detect a double spending attack). Thus, insufficient secrecy of operations is an integral component of the blockchain system. Without such a level of openness, the blockchain system would not be able to perform its functions. But this level of openness often becomes a limiting factor for applications that require greater secrecy.

2. Security model.

Blockchain technology uses asymmetric encryption model. In simple words, there are 2 keys: public and private (secret) one.

The data transfer scheme between A and B entities utilizing a public key looks like this:

1. Entity A creates a key pair consisting of a public key and a private key.
2. Entity A shares the public key with Entity B, and this transmission can occur through insecure channels.
3. Entity B encrypts the data using the received public key and sends it to A. Transmission can also take place through insecure channels.
4. Entity A decrypts the information (that was received from entity B) using its private key.

However, when the secret key of the account is obtained by an unauthorized person intentionally, accidentally, by mistake or as a result of data interception, such an account is no longer secured.

When considering areas of blockchain technology implementation, the problems that arise are more down-to-earth. The use of smart contracts cannot be tied to an officially recognised currency (roubles), as they are based on cryptocurrency. Thus, it is a non-trivial task to adapt cryptocurrency settlements to the currently accepted financial statements. Also, there are doubts about the speed of the transaction. Speaking about their automation, there is often a feeling of their instantaneousness. But, in fact, due to the fact that the computers of the chain participants have full copies of the database and any change must be confirmed by all participants, the process can take much longer than in their usual form [Konstantinidis, et al., 2018]. Also, the idea of confronting opportunistic behaviour of participants is based on the assumption that most members of the chain are conscientious. But, if the situation is exactly opposite, chain manipulation is possible. Finally, it is worth noting that, in general, blockchain technologies are not currently subject to legal regulation, and therefore the parties involved have no legal guarantee of their security.

Factors hindering implementation:
- Lack of standardization in the world
In Western Europe, a CMR document is issued, while in the USA it is a land bill of lading. The essence is the same, but at the same time information is recorded in different ways, a different kind of which leads to the problem of unifying documents under a single style.
- Lack of document flow in many countries
Paper and seals are everywhere
- Lack of legislative regulation
- Job cuts
- Skepticism about technology

6 Case study. Implementation of the blockchain in the RX company

In order to apply blockchain technology, a person from IT who understands Solidity was hired to directly create smart contracts. Solidity is an object-oriented, high-level language for implementing smart contracts. (Solidity — Solidity 0.8.23 Documentation, n.d.)

The concept of implementation was the following:

1) Get rack with the QR-code.

2) Scan the QR-code and get the symbols “rack43r”, which will be send to the computer.

3) When a character set is received smart contract put the condition (getting the Rack) in the position “true” which means that the rack has arrived at the store.

4) Then, after receiving the rack, smart contract transfers Phoenix tokens to the sender’s account that will be payment for the rack (the cost is 110,35$).

Smart contract code in the Solidity environment is written below:

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

import "@openzeppelin/contracts/token/ERC20/IERC20.sol";

contract TokenTransferContract {
    // Phoenix token address
    address public phoenixTokenAddress = 0x789f10a6b6d0e4d150f12d1433ee7f5b82eea207;

    // Sender's address
    address public senderAddress =0x9a878c4D1502ABB29b23A3A8cbdAe4e6f67Cb1eb;

    // Recipient's address
    address public recipientAddress =0x7a250d5630B4cF539739dF2C5dAcb4c659F2488D;

    // Flag indicating whether the item "rack43r" has been received
    bool public itemReceived = false;

    // Function to set the flag upon receiving the item
    function setItemReceived() external {
        // Ensure that the function is called by the owner of the sender's address
```

```
        require(msg.sender == senderAddress, "Unauthorized");
        itemReceived = true;
    }

    // Function to transfer tokens upon receiving the item
    function transferTokens() external {
        // Ensure that the item has been received
        require(itemReceived, "Item not received");

        // Get the ERC20 interface for the Phoenix token
        IERC20 phoenixToken = IERC20(0x789f10a6b6d0e4d150f12d1433ee7f5b82eea207);

        // Check the balance of the sender
        require(phoenixToken.balanceOf(0x7a250d5630B4cF539739dF2C5dAcb4c659F2488D) >=
1000000000, "Insufficient funds");

        // Transfer 1,000,000,000 Phoenix tokens to the recipient's address
        phoenixToken.transfer(0x9a878c4D1502ABB29b23A3A8cbdAe4e6f67Cb1eb, 1000000000);
    }
}
```

Furthermore, there is an opportunity to check the transaction with Ethereum scanner using the link: https://etherscan.io/tx/0x119c1e7d2c30f353730ab7bd2170da98c0f448f2b01da19a72e9f52b0247b883.

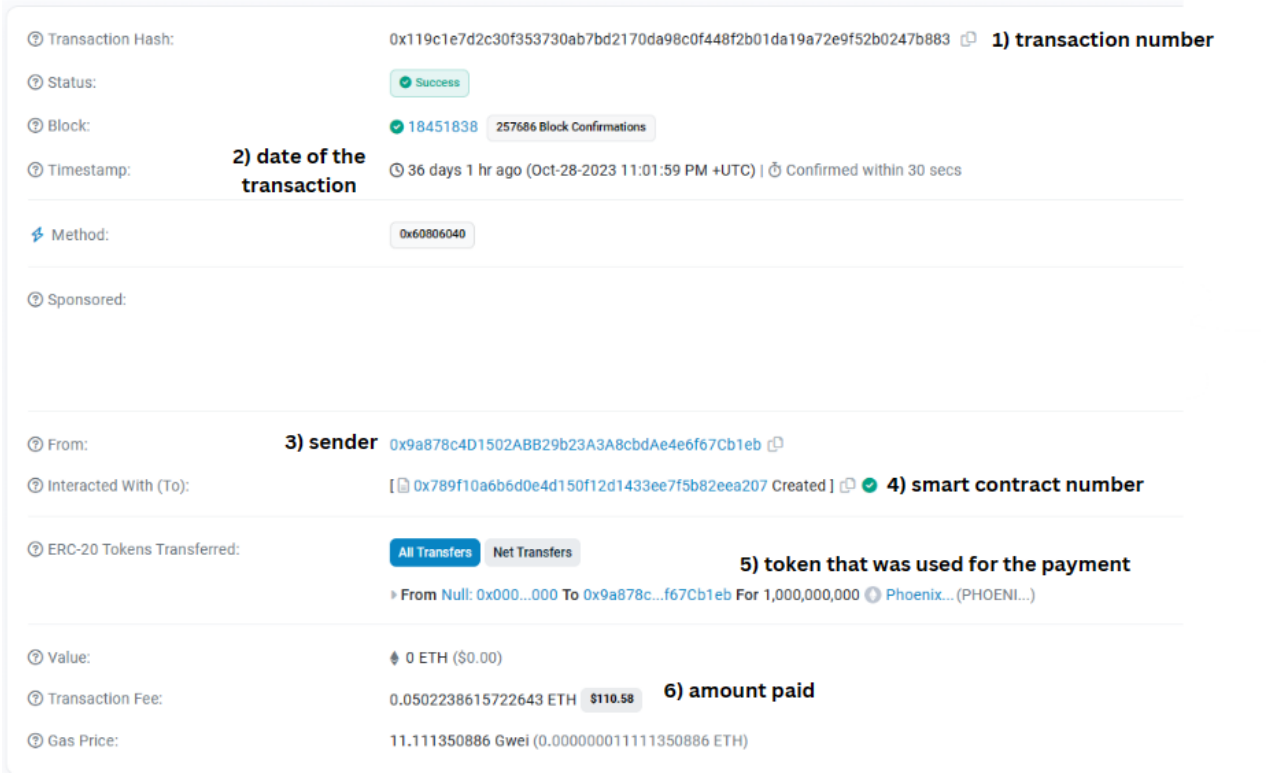

Figure 12. Smart contract completion

From the Picture 1 we can see that smart contract number 0x789f10a6b6d0e4d150f12d1433ee7f5b82eea207 was successfully completed due to condition (getting the rack).

7 PESTLE analysis

- Political prospect:

The results of the study of the legal framework for the use of smart contracts in different jurisdictions provide important information for businesses implementing this technology.

It is important to note the diversity of regulatory approaches in different countries, which emphasizes the difficulty of creating universal regulations in this area.

One significant finding is that many countries are showing interest and commitment to developing legislative instruments that take smart contracts into account. This may be a signal to business that, despite some challenges, greater clarity and stability in the legal area of this technology can be expected in the future.

Awareness of the different levels of recognition of smart contracts is also an important finding. Where they are recognized as binding contracts, businesses can operate with greater confidence in the legality of their use. However, in the context of strict legal restrictions, businesses may face challenges in the implementation process.

- Economical prospect:

The results of the study of economic factors of smart contracts implementation revealed a number of key findings that have a significant impact on the decision of enterprises to adopt this technology.

First of all, the analysis of the development and implementation of smart contracts revealed that the initial costs of their creation and integration into business processes can be significant (chapter 3.3). However, they are seen as an investment in innovation, contributing to the efficiency and competitiveness of the enterprise in the long term.

When it comes to potential economic benefits, the study highlighted that smart contracts have the potential to significantly reduce operational costs. The automation of their execution and the absence of intermediaries can lead to time and cost savings.

Business processes are also identified as an area where smart contracts can bring significant benefits. Improving the efficiency of the business processes involved in contracting and executing contracts can improve the overall productivity of the enterprise.

- Social prospective:

The results of the study of sociocultural aspects of smart contracts implementation revealed important factors affecting the acceptability of this technology in business.

In the context of employee and customer readiness for smart contracts, the level of staff readiness for the new technology was found to be critical. A survey completed by employees (Figure 13, appendix 1) revealed the need for effective educational programs to teach enlightenment in the use

of smart contracts. Also, it was noted that the more transparent and clear the implementation processes are, the higher the level of acceptance of the technology among all stakeholders will be.

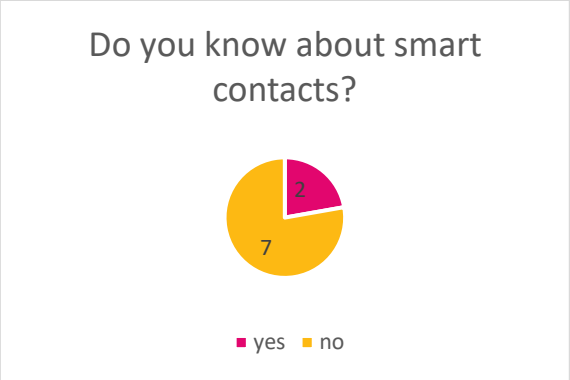

Figure 13. Awareness of smart contracts

An important factor in any business is to meet the sociocultural expectations of users regarding the level of transparency and data management in the business.

The analysis of sociocultural expectations regarding transparency and data management also led to important findings. The study revealed that there is a growing customer demand for transparent business processes and data management. Smart contracts, while providing a high level of transparency and automated data management, are not yet meeting expectations. According to a company manager (link to video in appendix 2), the world is not yet ready for such technology, and smart contracts are a gray area that has no high-profile use cases at the moment and has not yet developed a reputation.

Thus, the results of the study emphasize the importance of not only technical aspects of smart contract implementation, but also of taking socio-cultural factors into account. Successful adaptation of the technology requires not only technical readiness, but also active involvement of employees and customers, as well as compliance with expectations for transparency and data management in modern business.

- Technological prospective:

The results of the study of technological aspects of smart contract implementation highlight current and future trends in blockchain technology and smart contracts, as well as explore opportunities for further business process improvements.

An analysis of current technology trends in blockchain reveals that the technology continues to evolve at a high rate of speed. Enhanced privacy features and new matching mechanisms are also key technological improvements (chapter 5.2).

With regard to smart contracts, trends towards their increased use have been identified. Integration of smart contracts with different platforms and systems is becoming more convenient, which expands the scope of their application. Improvements in smart-contract programming languages, such as Solidity, are also making development easier and promoting more secure code.

One of the key findings is that technological improvements in blockchain and smart contracts are opening up new opportunities to improve business processes. Automation, increased efficiency and the ability to create more complex and flexible smart contracts create an environment conducive to innovation.

The study also identified the potential for further process improvements in smart contracts. This includes the development of new security methods, standardization and better integration with other technology solutions.

- Legal prospective:

The results of the study of legal factors for the implementation of smart contracts have highlighted a number of important aspects concerning legal security and risks in the use of this technology (appendix 2, interview).

The study of possible legal risks and ways to mitigate them also had an important impact on business decisions. Identifying potential risks such as technical failures, misunderstandings in smart contract programs and difficulties in interpreting them is the first step to minimize them. Developing legal strategies and agreements to prevent and resolve disputes also represents an important aspect of risk management.

An important outcome of the study is also to emphasize the need to develop standards and regulatory frameworks for smart contracts to ensure their legal clarity and predictability. This will also help in creating a more favorable environment for business and investment.

Thus, the results of the legal factors study emphasize the importance of developing a clear legal framework for smart contracts as well as actively managing the legal risks in their use.

- Environmental prospective:

The results of the study of environmental factors of smart contracts implementation revealed important aspects related to energy efficiency and sustainability of blockchain technology, as well as the impact of using smart contracts on the environmental sustainability of business processes.

The analysis of the energy efficiency of blockchain technology emphasized the need to find more efficient consensus and mining methods. Trends to move from energy-intensive algorithms to more environmentally sustainable consensus mechanisms are becoming increasingly important. The study also revealed that different blockchain platforms may have different levels of energy consumption, which should be taken into account when choosing a specific platform.

In terms of smart contracts, the study results showed that their use can lead to optimized business processes, which in turn can help reduce overall energy consumption. Automated contract execution and the elimination of intermediaries contributes to a reduction in energy costs, which is a positive factor for the environmental resilience of a business.

Nevertheless, it is important to acknowledge that as technological advancements and the scope of smart contracts broaden, there may be a corresponding rise in overall energy consumption. Thus, it is necessary to consider the balance between the efficiency of business processes and their environmental impact.

8 Achieving objectives and conclusions

Throughout comprehensive research on relevance of smart contract technology in nowadays logistics and RX company especially, the time is not yet come. Even through this technology is revolu-

tionary enough and has several benefits, lack of reputation and use-cases became significant limitations for smart contracts. The reason for this is lack of a legislative framework. However, many initiatives do not start with the state, but with entrepreneurs who act as an engine of social progress. The more often smart contracts are mentioned, the more important this topic will become and the faster it will reach government regulators, who by that time will be able to accumulate experience in using the technology and assess all the risks when creating a legislative framework.

1. What are the potential areas, trends, and applications of blockchain technology in the logistics industry, and what advantages and limitations can be identified?

The potential of blockchain technology in the logistics industry is huge: from improving the visibility of the supply chain and real-time tracking to optimizing cross-border transactions and automating smart contracts. These innovations promise to reduce inefficiency, reduce fraud and optimize the logistics process as a whole. However, issues such as scalability, compatibility, and the need for industry-wide collaboration create limitations. The ongoing trend towards decentralized solutions, the integration of Internet of Things (IoT) devices and the development of blockchain protocols are key areas to keep an eye on, offering the logistics industry opportunities to increase transparency, security, and efficiency.

2. How can blockchain be developed and implemented in a logistics project for a company like RX to optimize and secure logistics processes, and what are the pros and cons of its implementation and effectiveness?

During the application of the blockchain, smart contracts were used on the example of the RX company. Their integration is not the most difficult process, however, in the background of the integration procedure, the most key point was writing the code, as well as the firmware of the QR scanner, from which a signal was sent to the platform that the acceptance of the goods was completed successfully.

The integration of smart contracts into a clothing store provides a number of significant advantages. First of all, the rack purchase process, carried out by scanning a QR code, demonstrates a high level of automation and instant execution of the transaction. This significantly improves the

efficiency of operations, reduces time delays and reduces the risk of human error. The second important aspect is the transparency and trust provided by blockchain technology. A smart contract executed by scanning a QR code creates an immutable record in the blockchain, which becomes available to all participants of the system. This enhances the transparency of business processes and promotes the establishment of trusting relationships between sellers and buyers. Thus, the integration of smart contracts into a clothing store brings benefits in efficiency, accuracy and trust, creating a modern and efficient business environment.

The integration of a smart contract, despite its advantages, is also subject with certain limitations. First of all, the same transparency plays cruel joke with materials supply. since it is not always necessary to announce to the public what has been purchased. It means that all transactions in the blockchain can be tracked at the moment, because there is no separate platform for confidential business transactions. Moreover, the introduction of new technology may require costs for staff training and updating the store's infrastructure. Smart contracts, like any innovative technology, require understanding and support from staff. It is also worth considering that blockchain technology and smart contracts are still developing, and technical problems or imperfections may arise that will require adjustments. This can potentially create challenges in system support and maintenance.

3. What are the risks associated with its implementation and what improvements can be expected in terms of cost-effectiveness?

The introduction of blockchain into logistics involves inevitable risks, including technological difficulties, data privacy issues (the problem is that many sites have open access to all transactions made, although for privacy reasons this is a big risk for many companies) and potential resistance to changes in traditional systems. However, these risks can be mitigated through robust cybersecurity measures, regulatory compliance, and comprehensive training and training programs for stakeholders. As blockchain technology develops, economic efficiency is expected to increase, and increased standardization, protocol optimization and wider adoption will lead to lower implementation and operation costs. The continuous development of blockchain solutions, combined with a proactive approach to risk management, allows the logistics industry to exploit the transforma-

tional potential of this technology, minimizing the problems associated with it. The most significant benefit in terms of cost-effectiveness is exclusion of third parties in business processes. The integration of third parties in the application of smart contracts provides significant advantages for business processes. One of the main advantages is to increase efficiency and accelerate the negotiation of contracts. Thanks to automated execution, smart contracts eliminate the need for intermediaries, reducing the time spent on processing and verifying transactions. The second important aspect is to increase transparency. The exclusion of third parties eliminates the potential risks of conflicts of interest and ambiguous interpretations of the terms of the contract. Thanks to distributed ledger technology, all network participants have access to a common source of information, which promotes transparency and trust between the parties. In addition, excluding third parties reduces transaction costs. Reducing the need for intermediaries leads to a reduction in the costs associated with their participation. It also helps to reduce the likelihood of errors and delays, which ultimately increases the overall efficiency of business processes.

Finally, the use of smart contracts can significantly reduce fraud risks and improve security. Thanks to encryption and the decentralized nature of the blockchain, the system becomes less vulnerable to hacker attacks and interference.

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Appendices

Appendix 1. Questionniare for the stuff

1. Age?
2. Are you familiar with blockchain?
3. Are you acquainted with smart contracts?
4. In the procurement of inventory, is working with documents and delivery notes a frequent task?
5. What are Your responsibilities?
   Would the implementation of smart contracts facilitate your job? (question asked after using the technology / for an accountant)
6. What potential risks do you identify in the adoption of smart contracts, and what factors hinder their widespread usage (areas for growth)?
7. Since the implementation of smart contracting, have you observed an improvement in the efficiency of commodity procurement?
8. How do you define the future of smart contracts?

Appendix 2. Question while interviewing the manager of the company

Name of the interviewer: Nikita Mezenev

Name of the interviewee: Arseniy

Position: Manager, Sales

Questions:

1. What RX does and where it operates?
2. What you knew about smart contracts and blockchain in general before you encountered it in your life?
3. How do you evaluate the effectiveness of the implementation of smart contract technology? Were there any problems during the experiment?
4. What areas of growth do you see in the further application of this technology?
5. Do you see a shift towards the use of electronic document management rather than smart contracts?
6. Could You comment on what procedures you see as necessary to legitimize a smart contract?

Link to the interview: https://youtu.be/6fiygfloSjY