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Abstract: Crypto technologies present a challenge for the field of logistics, which is associated with the change of stereotypes in the management of logistics processes. It is practically another stage of development connected with a wide range of logistics processes, resulting in the creation of new paradigms that bring increased efficiency and improved process quality. The understanding of crypto technologies is generally associated primarily with cryptocurrencies. However, the presented knowledge is wrong and very misleading. Crypto technologies are not only cryptocurrencies. Crypto technologies, in connection with logistics, represent this field's future direction. This statement is also underlined by the current trend aimed at the development of digitisation. The paper presents the issue of the relationship between crypto-technologies and logistics. The effort will be to point out that crypto technologies are not only Blockchain, but Blockchain is the base on which crypto technologies are built, thus bringing benefits to the field of logistics and supporting its development.

1 Introduction

Logistics needs to ensure the maximal possible efficiency, reliability, and safety of its processes for its functioning. Several methods and technologies meet these requirements, and in the last period, it has been possible to monitor the potential for significant application of Blockchain technology and other crypto technologies.

Crypto technologies have a huge and, so far, unused potential, which can gradually minimise even the main problems in logistics, such as order delays, damage of goods, mistakes and multiple data entries [1]. In connection with the field of logistics, crypto technologies can be characterised as innovative technologies [2] with key potential for developing logistics in the future. The gradual application of crypto technologies in logistics can increase the effective implementation of logistics processes [3]. Specifically, crypto technologies can provide indisputable and immutable proof of the origin of raw materials, products, and their sale to the final customer. This can potentially increase customer confidence in the product and gain financial benefit for the producer by protecting their intellectual property rights [4].

So far, in most cases, the use of crypto technologies in connection with logistics has focused exclusively on Blockchain [5]. On the one hand, this approach is logical because blockchain technology is key to the functioning of crypto technologies. On the other hand, however, the full potential of crypto technologies available in logistics is not used this way. The application of Blockchain is visible in connection with transport logistics chains using container transport [6], within intra-company transport systems [7], reverse logistics [8] or most often in the field of supply chains [9,10].

However, crypto technologies represent a challenge for logistics in searching for other possibilities for their practical application within various logistics processes. In addition to Blockchain, it is also necessary to consider other crypto technologies based on decentralised applications (dApps), Non-fungible tokens (NFT), cryptocurrencies or WEB 3.0. The first signs of the use of other crypto technologies in the field of logistics can be monitored, for example, in the use of smart contracts [11,12] that are based on dApps. Smart contracts can be effectively used again, e.g. within supply chains [13,14]. Similarly, NFTs are starting to be used in connection with logistics in the energy field.

Based on the above examples, the implementation of crypto technologies in logistics is progressing very slowly. One reason for this is that many logistics experts do not realise the potential of crypto technologies. The paper aims

to present the issue of crypto technologies from the point of view of logistics and indicate possible areas for their potential use.

2 Crypto technologies

Crypto technologies are a term that has been appearing increasingly lately and used in various contexts. From the point of view of searching for the meaning of what this term denotes, it is necessary to mention the year 2008, which represents a kind of imaginary turning point and a change in the understanding of its meaning. Until 2008, it would have been possible to define crypto technology as a technology whose active use and functioning were based on various cryptographic tools, protocols, and methods. After 2008, however, crypto technology has been chiefly understood as Blockchain and related technologies such as

cryptocurrencies, decentralised applications, smart contracts, or other technologies associated with blockchain. 2008 was a turning point regarding the perception of crypto technologies because it introduced and described the principle of the first successful cryptocurrency, Bitcoin. The author of the allowlist describing Bitcoin acted under the pseudonym Satoshi Nakamoto.

However, blockchain technology was not created in 2008. Its existence in connection with informatics was known quite a long time ago. However, in connection with cryptocurrencies, blockchain was reborn, became widely known, especially among the broad professional and scientific public, and began to develop further (Figure 1). Currently, blockchain is considered a technology of the future, which can significantly change the functioning of our society and will affect many areas.
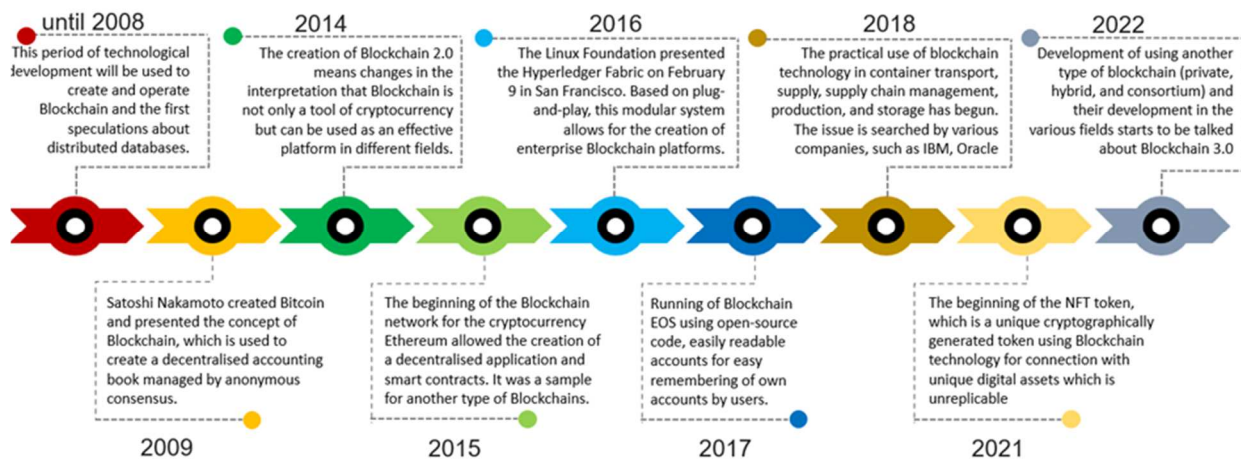

Figure 1 Overview of Blockchain Technology Development

As already mentioned, crypto technologies are not only Blockchain. These are the technologies that Blockchain uses for its operation. We currently know five technologies

that can be labelled crypto-technologies (Figure. 2) and are directly connected to blockchain technology. The link means that Blockchain is a prerequisite for their operation.
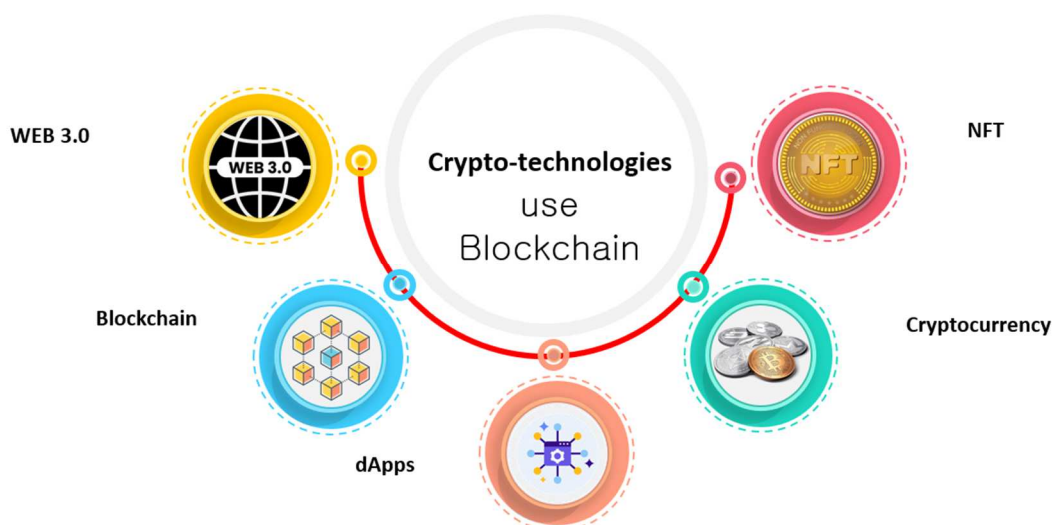

Figure 2 Overview of Crypto technologies

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Crypto technologies were generally believed to be a highly speculative means of achieving a high financial commission and profit. They are often seen as technologies for a specific group of users - enthusiasts who are the only ones who understand them and know how to use them. However, these technologies are largely unknown and difficult to understand in everyday life and for ordinary people.

But this opinion is wildly inaccurate and wrong. Crypto technologies represent a tool that, in the future, can significantly impact various areas of our society. Regarding its functioning and future development, logistics must pay adequate attention to the issue of crypto-technologies and gradually implement them into its functioning.

However, crypto technologies must be looked at in a completely different way from the point of view of logistics. Their perception must be realised regarding their potential benefits for the functioning of logistics processes. For logistics, crypto technologies cannot only be synonymous with decentralised finance. On the contrary, decentralisation is not a condition for their use. Crypto technologies represent a technology with high potential for the field of logistics, which, if used correctly, will bring a competitive advantage and significantly improve the functioning of logistics processes. The first pioneering efforts using crypto technologies have already been completed in logistics. Progress in their use continues. For it to be successful and effective, it is necessary to know crypto technologies from the point of view of logistics and its processes.

2.1 Blockchain

It is possible to define Blockchain as a particular type of distributed database that was initially exclusively decentralised, but nowadays, there are also variants in a centralised form. It is a continually expanding database that stores records and protects them against modification and alteration.

Applying this technology does not directly belong to crypto technologies (Blockchain does not mean that cryptography must automatically be used). However, its use as an accounting book database for the functioning of cryptocurrencies, for example, when cryptographic methods are used to ensure the immutability of entries and confirm their authenticity, makes it a full-fledged crypto technology. The principle of Blockchain is relatively simple (Figure 3).
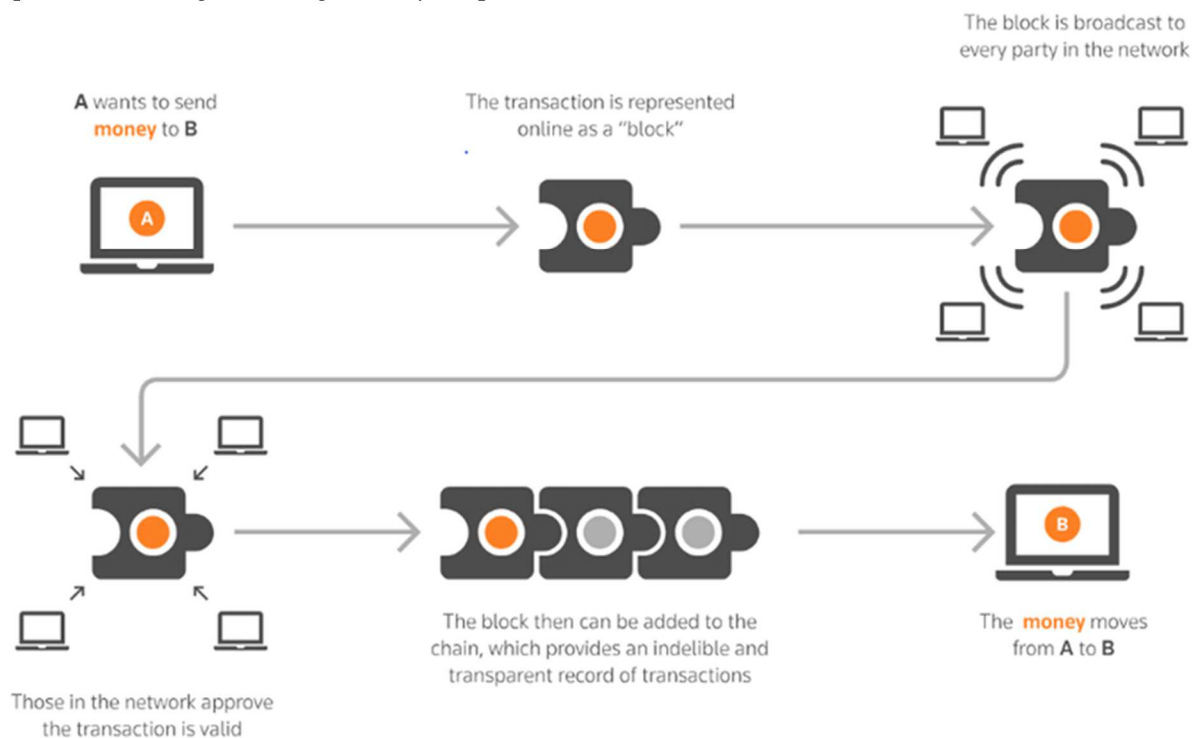

Figure 3 One of the working principles of blockchain technology [15]

As mentioned, the Blockchain used in logistics does not have to be fully decentralised. This means that its users, owners of full nodes, must be known. However, this variant of Blockchain does not decrease the possibilities of this technology in logistics; on the contrary, it enables its full use within processes where participants must know each other and communicate. Blockchain is increasing due to its generally known possibilities and advantages (Figure 4), which have application potential for logistics.
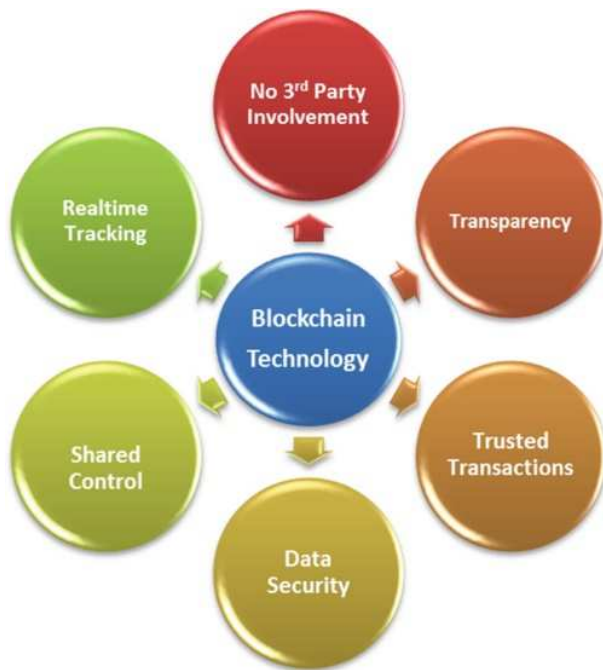
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Figure 4 Blockchain advantages and potentials [16]

The benefits of blockchain technology for logistics can be classified into three basic levels. The first is the "High" level, a significant advantage. This benefit is characterised by increased efficiency, acceleration of processes, or expansion of the capacity of provided services and processes. The second level is "Middle". These are cases when the application of Blockchain will bring a change to the implementation of logistics processes; it will be reflected in their efficiency, reliability, and security. However, the benefit in that case is not so drastic, but it is important and makes sense to use. The third level is represented by "Low". This is the lowest level that will manifest itself only in certain specific situations, and the impact of Blockchain is not so significant or crucial. The use of Blockchain within this level should be considered in terms of investment, operating costs, and benefits. Based on the mentioned assessment, it is thus possible to evaluate the contribution of blockchain technology to logistics activities (Table 1).

Table 1 Importance of Blockchain for the selected logistical activities

	Traceability	Data Security	Transparency	Quality	Realtime Monitoring	Service	Trusted Transactions
Supply Chain	High	Middle	High	Middle	Low	Low	High
Warehousing	High	Low	Low	Low	High	Middle	Low
Productions	High	Low	Middle	High	High	Middle	Low
Transport	High	High	Low	Middle	High	Low	High
Manipulation	Middle	Low	Low	High	Middle	Low	Low
Planning	Low	Middle	High	Low	Low	High	Middle

2.2 Non-fungible tokens

In crypto technology, a token is a coin (which may have its name) of a digital currency that does not have its Blockchain. Generally, a token is a carrier of value, and we consider tokens interchangeable. Fungibility means that if we have one specific token with some value, we can exchange it for another identical token with the same value. Therefore, the token is often called a "digital coin." The token can be divisible into smaller units.

However, with the development of crypto-technologies and blockchain technology, a unique token was created, characterised by its incommutability and indivisibility. The name non-fungible token (NFT) was used for this token type.

NFT was primarily created and used to verify and prove the originality of digital content. Its initial application focused on digital creation, such as graphics, audio, and video. Over time, however, the application possibilities begin to be further developed and explored. NFT is finding more and more new application areas, including logistics. NFT represents a massive potential for the field of logistics

(Table 2). Active use can significantly increase logistics processes' quality and reliability. In the future, NFTs could thus become essential to various products and services and participate in managing multiple logistics chains. It would be, for example, about guaranteeing the originality of products, proving the right to service and additional services, and enabling the improvement of quality and safety in the distribution of food and other commodities.

In logistics, recording most NFTs within private blockchains seems logical, where access will be regulated and controlled. On the other hand, however, for example, by verifying the originality of products, it is also possible to use decentralised public Blockchains from the point of view of availability.

The principle of operation of NFT is quite simple. It is based on a record of ownership of digital media based on the Blockchain. The entry contains a link to the relevant digital medium. However, this digital medium does not reside directly on the Blockchain. However, the application possibilities of NFT are no longer limited to graphics and multimedia. For example, it is possible to mention one of the key areas of logistics, namely supply chain (Figure 5).
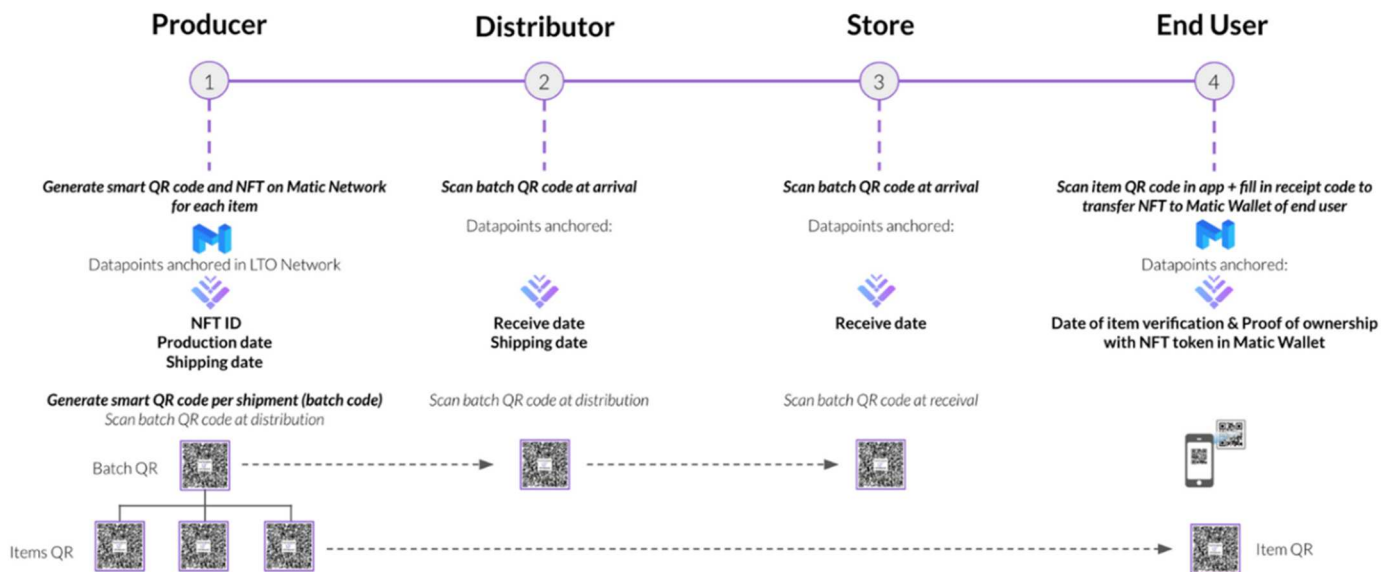
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Figure 5 Tracing a supply chain with NFT and QR codes in the Matic Network functions on TO Network [17]

The application possibilities of NFT in logistics relate to criteria such as originality, quality, safety, transparency, and traceability. These are parameters that directly affect several logistics areas (Table 2).

Table 2 Possibilities of NFT use for the selected logistics activities

	Originality	Quality	Security	Transparency	Traceability
Supply Chain	yes	yes	yes	yes	yes
Warehousing	--	-	yes	yes	yes
Productions	yes	yes	-	yes	-
Transport	-	yes	yes	yes	yes
Manipulation	-	-	-	yes	yes
Planning	-	yes	yes	yes	-

2.3 Cryptocurrencies

Cryptocurrencies are a technology that rediscovered the Blockchain, significantly starting and accelerating the issue of crypto technologies. Nowadays, cryptocurrencies are mentioned more and more often, and they are not only a means of interest for technology fans who see the future of a functional and independent financial sector.

Logistics, from the point of view of its further development, cannot overlook the issue of cryptocurrencies and must be prepared for their acceptance as part of financial flows and payments. A specific deficiency causing problems with accepting cryptocurrencies, not only in logistics, can currently be their high volatility and possible limitations in the speed and amount of realised payments. However, these facts cannot be a reason for their rejection.

In the future, modern logistics must actively prepare to accept cryptocurrencies as full-fledged financial means for realising payments. The main emphasis must be placed on their selection. At the same time, their key criteria must be considered (Table 3). The selection of a cryptocurrency for logistics needs must reflect parameters such as the speed of transactions (Figure 6), public acceptance and trust of the public, their expansion, quality of the used Blockchain and, of course, the rate of inflation.

Based on the mentioned criteria, it will be possible to implement selected cryptocurrencies into the logistics portfolio. However, the implementation of cryptocurrencies cannot be realised massively in terms of acceptance of a broad spectrum of cryptocurrencies; on the contrary, the selection must be narrowly limited from the beginning to one or two cryptocurrencies, which would be supplemented by one stablecoin. This way, it will be possible to use cryptocurrencies effectively, and logistics processes will not be threatened. Also critical is an approach to logistics for cryptocurrencies. It is possible to talk about an alternative that is a full-fledged supplement to existing currencies. At the same time, it is necessary to decide at what level cryptocurrencies will be used, whether all types of payments from customers will be realised through them, or whether their acceptance will only be realised in connection with specific logistic processes. However, it is necessary to approach all the mentioned questions on a highly individual basis.

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Table 3 Cryptocurrencies criteria selection for logistics needs

	Bitcoin	Ether	XRP	Cardano	Solana	Tether	Shiba Inu
Transaction speed	1	2	4	3	5	3-5*	3
Acceptance by public	5	4	2	3	3	4	1
Expansion	5	5	4	3	4	5	2
Blockchain	5	5	5	4	4	3-5*	2
Inflation	1	3	3	2	3	4	4
Decentralisation	5	5	2	3	5	1	5

(1 – low level of criterion, 2 – below-average level of criterion, 3 – middle level of criterion, 4 – above-average level of criterion, 5 – high level of criterion)
* According to the type of Blockchain

Another factor that significantly supports the implementation and use of cryptocurrencies in the field of logistics is the gradual acceptance of cryptocurrencies by large payment and financial companies. These companies are gradually making cryptocurrencies more accessible as part of regular payments and financial transactions, which significantly simplifies the use of cryptocurrencies in the field of logistics.
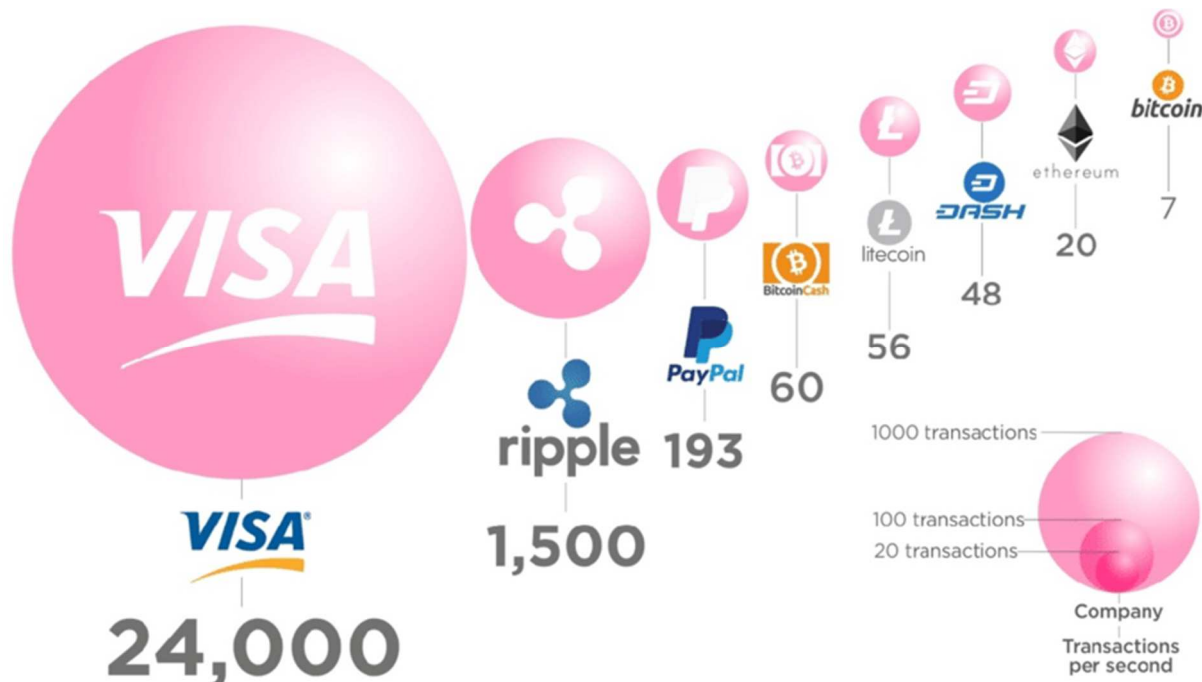

Figure 6 Cryptocurrencies transaction speeds compared to Visa and PayPal (2018) [18]

Therefore, for the successful implementation of cryptocurrencies into logistics processes, the conditions of transaction speed and financial operations must also be met. Implementing cryptocurrencies without ensuring a sufficient transaction speed would not be efficient and could be slightly problematic in terms of logistics. However, this condition is no longer such a problem nowadays because there are crypto technological solutions that can fully ensure and reliably implement the mentioned requirement (Figure 7).

These and similar technological solutions must negotiate various barriers, for example, in legislation. They must find and build their position within the financial market, while compliance with applicable legislation is necessary. At the same time, they must be accepted by the subjects of the logistics chain, they must win their trust in terms of reliability, and at the same time, it will be necessary to implement them in the environment of logistics systems. The implementation assumes they can realise financial operations without problems in full or limited mode. However, the development in cryptocurrencies is huge, so the solution to these questions can be implemented soon. Cryptocurrencies, as a dynamic field, bring new challenges and opportunities for the field of logistics, to which it must respond. Otherwise, there would be a risk that logistics does not use the opportunity and possibilities that implementing cryptocurrencies in logistics processes can bring.

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Figure 7 Example of using the XRP cryptocurrency for the realisation of financial operations [19]

2.4 Web 3.0

WEB 3.0 is a label associated with the future of the Internet. This is practically its next stage of development, which will be based primarily on the use of crypto technologies and the semantic web. It is the integration of several information technologies into one unit, the purpose of which is the verification of digital content, decentralisation, and machine processing of a wide range of information to increase the total efficiency of the Internet. WEB 3.0 will bring more efficient browsing, the possibility of targeted and relevant advertising, and customer support improvement.

In logistics, WEB 3.0 represents development in communication, information technology support, changes in classic business models, and the possibility of the coordination of logistics processes and their management. Its implementation in logistics processes will also use artificial intelligence tools.

Currently, the supply chain is one of the first fields of logistics where WEB 3.0 could be successfully implemented (Figure 8).

Figure 8 Benefits of Web3.0 in logistics and supply chain [20]

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Although at first glance, it may seem that the benefits of WEB 3.0 are repeated with most of the benefits of individual crypto technologies, this is not the case (Figure 9). WEB 3.0 must be understood from the point of view of logistics as an integrating unit that combines the mentioned crypto technologies with other information technologies into one integrated unit. This increases their use and, at the same time, creates new possibilities that will be of great benefit not only to the field of logistics. Specifically, it will significantly increase logistics chain transparency and support their members' trust. WEB 3.0 will enable effective management of products and services. It will contribute substantially to updating information on the progress of logistics processes in real-time.

Figure 9 Impact of WEB 3.0 on logistics [20]

Web 3.0 has the potential for use in several areas of logistics (Table 4). It can be presented in the form of intelligent moves, which, based on the definition of various conditions, can activate multiple processes and actions, significantly accelerating and automating the entire process. On the other hand, WEB 3.0 will provide permission access within logistics, achieving control over access to information. This means the information will be accessible only to the circle of persons. Other benefits include simplified control of the Peek-A-Boo service for customers. In this way, the implementation of some operations becomes simple and convenient. At the same time, customers will have access to shared documents and a permanent communication connection, contributing to the speed-up and efficiency of logistics processes.

Table 4 Possibilities of WEB 3.0 use in logistics

	Smart Moves	Permissioned Access	Peek-A-Boo for Customers	Shared records	Staying Connected
Customer service	no	yes	yes	yes	yes
Order fulfilment	yes	yes	yes	yes	yes
Service and service parts	yes	yes	yes	yes	yes
Supply and purchase	yes	yes	yes	yes	yes
Good transportation	yes	no	no	yes	no
Reverse logistics	yes	no	no	yes	no
Storage	no	yes	no	yes	no

The development of WEB 3.0 is still in the initial phase. However, it is possible to say that its potential in the field of logistics is huge. However, it should be remembered that the development of the WEB 3.0 area will stimulate the growth of other regions, such as information technology or business information systems.

2.5 Decentralized applications

Decentralized applications (dApps), a crypto technology, began to be used only in connection with Blockchain 2.0. With its deployment, Blockchain technology began to be viewed as a broad-spectrum tool with much wider possibilities of use than just an "account book" for the needs of various cryptocurrencies. Decentralised applications represent one of the youngest crypto technologies.

Although the name decentralised applications evokes their similarity to applications used in a wide range of smart devices, this is not the case. The principle of decentralised applications is based on smart contracts. They are digital

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applications (programs) that run on Blockchains, not centralised servers. All information that dApps contain is cryptographically protected. Smart contracts are made up

of predefined rules (conditions), which, if met, will carry out the operation or operations the contract is supposed to realise (Figure 10).
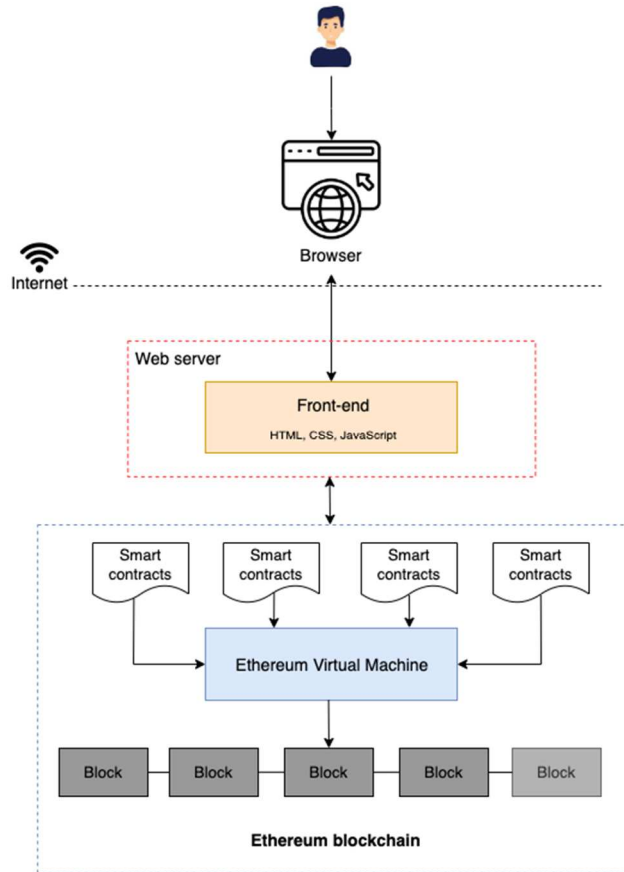

Figure 10 Architecture Of Decentralized Applications (dApps) [21]

Decentralised applications or the idea of their operation represents a chance for logistics to automate various processes, primarily management and decision-making. It is possible to use private centralised or decentralised types of Blockchain. However, the purpose for which dApps will be used depends on the purpose. It is necessary to realise that the public decentralised Blockchain in connection with dApps may have certain disadvantages. For example, the stored information will be available practically to anyone,

and it would not be desirable in specific logistics processes (non-guarantee of discretion). On the contrary, some processes have no problem with this. That is why it is necessary to analyse the deployment of dApps within logistics processes and then decide what type of Blockchain will be used. Table 5 presents an example of a comparison of the kind of Blockchain for the application of dApps within selected areas of logistics.

Table 4 Comparison of Blockchain types for the application of dApps in the selected fields of logistics

	A centralised type of Blockchain			Decentralised type of Blockchain		
	High discreteness	Limited availability	Suitability	Low discreteness	Unlimited availability	Suitability
Supply chain	advantage	advantage	yes	disadvantage	advantage	no
Customer service	advantage	neutral	yes	neutral	advantage	yes/no *
Advertising	disadvantage	disadvantage	no	advantage	advantage	yes
Public relation	neutral	disadvantage	no	neutral	advantage	yes
Transport	advantage	advantage	yes	disadvantage	advantage	no
Automatisation	neutral	yes/no*	yes	neutral	advantage	yes

* need to be considered according to the specific situation

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One big area where decentralised applications have potential for logistics is their product life cycle management implementation. However, the use of this technology requires further long-term research, which will aim to identify potential risks and opportunities (Figure 11).
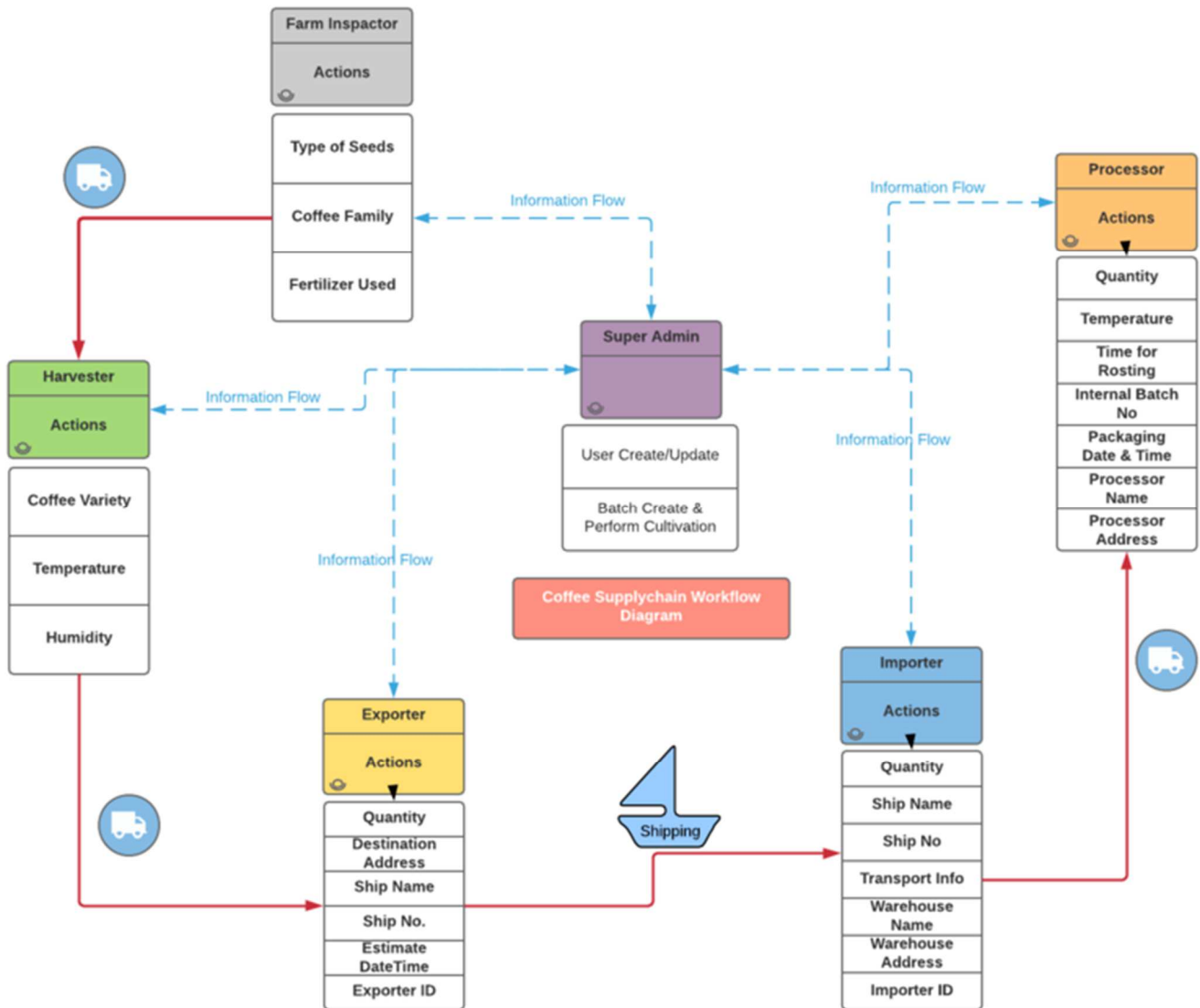

Figure 11 Ethereum-Based Supply Chain Dapp [22]

3   Conclusion

Nowadays, crypto technologies are no longer exclusively associated with cryptocurrencies. On the contrary, more and more areas are beginning to realise their potential and possibilities. One reason for such a change in perception is that their application primarily brings greater transparency and security.

Logistics is one of the dynamic fields that are characterised by an open approach to implementing new technologies to increase their activities. In connection with the growing trend of automation and extensive digital transformation aimed at managing and operating logistics processes, crypto technologies are becoming highly attractive for widespread acceptance within the mentioned activities. Crypto technologies can bring a certain level of decentralisation to logistics in connection with trust among the individual links of the logistics chain. At the same time, it is necessary to emphasise that implementing cryptocurrencies in logistics and process management is a challenge for logistics experts, especially for the current understanding of the usual standards for solving logistical issues. It can be said that based on the current knowledge of cryptocurrency ideas and ways of their implementation in logistics, application areas of logistics and logistics processes, it is possible to move towards increasing the efficiency and, finally, the quality of processes as essential cost items within logistics solutions. In conclusion, it is necessary to highlight the effort to digitise logistics processes, which is currently preferred in almost all

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application areas of logistics. But as it was mentioned in the presented paper, the possibility of implementing and designing a way of realisation of a possible connection of logistics and crypto technologies is an excellent potential in the field of digitisation of logistics processes with an emphasis on managerial efficiency solutions of logistics processes with a focus on process performance and logistics cost-effectiveness.

Crypto technologies present the future of digital technology and logistics. One of the reasons that helps their promotion is the high level of efficiency and safety in their use. Crypto-technologies' development has been carried out exclusively on a general level, which was then gradually adapted to individual areas, including logistics. However, this trend will change progressively.

In the future, crypto technologies development will be more targeted and narrowly focused on specific areas where they will be deployed. Their principle will continue to be based on blockchain. However, development in the field of blockchain will progress to meet the relevant requirements for the creation of blocks in terms of speed, capacity and access to the required information. Based on the above-mentioned expected development, it is possible to expect new crypto-technologies in the future, which, e.g. in conjunction with WEB 3.0 and artificial intelligence, will significantly change and push the boundaries of logistics process possibilities.

Acknowledgements

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