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BLOCKCHAIN – AN OPPORTUNITY FOR DEVELOPING NEW BUSINESS MODELS

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Abstract: Over the last years, the blockchain technology has attracted the attention of both business users and IT specialists. In essence, blockchain or a chain of blocks is a distributed and decentralized database replicated across the multiple nodes of a network. Until recently blockchain has been associated mainly with cryptocurrencies, but nowadays it is revealing its serious potential as a means of replacing the business models that facilitate the operations of business organisations and the communication between them. The utilisation of the advantages provided by blockchain, however, requires their appropriate interpretations within the framework of business processes. With reference to this, the article analyses some of the main concepts and mechanisms of this technology. Special attention is paid to the interrelation of blockchain and distributed ledger (DLT) technologies, hashing of transactions and data management through consensus as well as the so called “smart contracts”. A parallel is made between the capabilities of public and private blockchain. Based on this, the study defines the fundamental blockchain characteristics and the advantages resulting from them. It is suggested that the blockchain technology offers a solution to the primary problem of trust between people in the context of global communication and ensures better transparency, reliability and security of data and business processes. In addition, the author outlines certain potential technical and business risk that have to be taken into consideration in the process of data transfer with reference to blockchain.

Key words: blockchain, distributed ledger, decentralized application (DApp), smart contract.

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Introduction

The blockchain technology – associated until recently mainly with crypto currencies – is promising today revolutionary changes in the social and economic infrastructure and is helping to find solutions to numerous problems in the spheres of business, government, health care, education and legislation to name just a few. Kandaswamy and Furlonger (2018), analysts from Garner, the consulting company, define it as the new paradigm that facilitates the business and communication between people. The interested towards this technology is increasing mainly due to breach of trust in the Internet and online operations: everyday there are discussions about unauthorized use and compromise of shared information, including personal details and financial data. Therefore, it seems that the blockchain technology will be the driving force of the next generation Internet, namely the decentralized Internet or Web3.

According to research, conducted by Gartner, however, despite the interest towards this technology, only 1% of the surveyed companies actually use it (Technews.bg, 2018). The widespread use of an innovative technology and the exploitation of its benefits pose the need for serious changes in the business models and business processes of its users, as well as in their information systems and IT infrastructures. Otherwise, it remains an abstract opportunity that is not put to actual use. This, however, requires a sound foundation, namely users should be very well aware of the concepts behind this technology. With reference to this, the ***purpose*** of the author is to outline some of the main ideas and mechanisms of blockchain technology and its capabilities to improve the business models and processes of its users. At the same time, some advantages and potential problems of applying the technology will be identified and discussed.

1. Blockchain – DLT relationship

The term “blockchain” (chain of blocks) is used as a modern word with promises for innovations. Nevertheless, it can be said that users are not familiar enough with the mechanisms of the technology. It should be noted that, often, the "blockchain" concept is linked to crypto currencies or is used as an umbrella term describing a number of related technologies, including the Distributed Ledger Technology (DLT). For this reason we will try to clarify some technical aspects of both technologies and their interconnection.

First, it should be emphasized that blockchain is a technology which appeared before bitcoin and the other crypto currencies and is not invariably related to them. Therefore, it is not correct to transfer the concerns for cryptocurrencies of some users to the blockchain technology because it only creates the infrastructure for their design and use. Technically, blockchains can exist without the cryptocurrencies but it is a fact that the increased interest towards them attracted attention towards this technology.

In informatics blockchain is associated with cryptography and data structures. It is based on the so called ***“hash tree”,*** which is also known as ***Merkle tree***. This data structure was patented back in 1979 by Ralph Merkle (see Merkle, 1979). It is used for verifying and managing the amount of data transferred between computer systems. It guarantees that sent data is not false or altered during transfer. In other words, Merkle three is used for supporting data integrity of networks.

In 1991, Merkle tree was used for developing the so called ***“secured chain of blocks”***. This is a series of records where every record is linked to the previous one by a cryptographic hash function. Lafaille (2018) points out that this marks the beginning of the blockchain technology. In 2008, the legendary Satoshi Nakamoto developed the chain of blocks concept based on DLT and it has become the backbone of the bitcoin technology (see

Nakamoto, 2008). Actually, bitcoin is the first widely used application of blockchains.

Nowadays, the terms “blockchain” and “distributed ledger” are often used together and interchangeably but there are differences in their origin. As Brakeville and Perepa (2018) point out, DLT is a type of database that is shared and synchronized between the nodese of a distributed network, i.e. this is a distributed database. Transactions referring to exchanging data or assets, for example, are registered between in it between the network participants. Each node stores an identical copy of the register and updates it independently from the other nodes. The changes are constructed separately by each node but before they are written in the register the network participants must reach a ***consensus***, i.e. the changes must be approved by all of them or the majority of them. To achieve consensus the network participants must reach an agreement as of changes in register. It is done automatically with a consensus algorithm (protocol). Bitcoin networks, for example, use Proof of Work protocol (PoW) to reach consensus when new blocks have to be added, i.e. for “digging out” cryptocurrency. When consensus is reached, the updated register copy is stored in all network nodes. This guarantees the storage of identical register copies in all network nodes.

With reference to this, it is important to determine the differences between DLT and traditional databases. Web – based databases are usually centralized structures, i.e. they have one management centre. They have a client – server architecture (Figure 1) and are stored on server(s). In case the server fails, the databases cannot be accessed. To read and modify them, users must have rights to do so. Most databases support information which relevant to a specific time, i.e. screenshot of the data. Database control is centralized, it is carried out by a database administrator who gives access rights, ensures the data security and reliability, etc. In other words, users depend on the database administrator. Database administrators (or other users with enough rights) could damage or corrupt the stored data, limit the access of other users, etc. In certain cases, this causes serious problems.

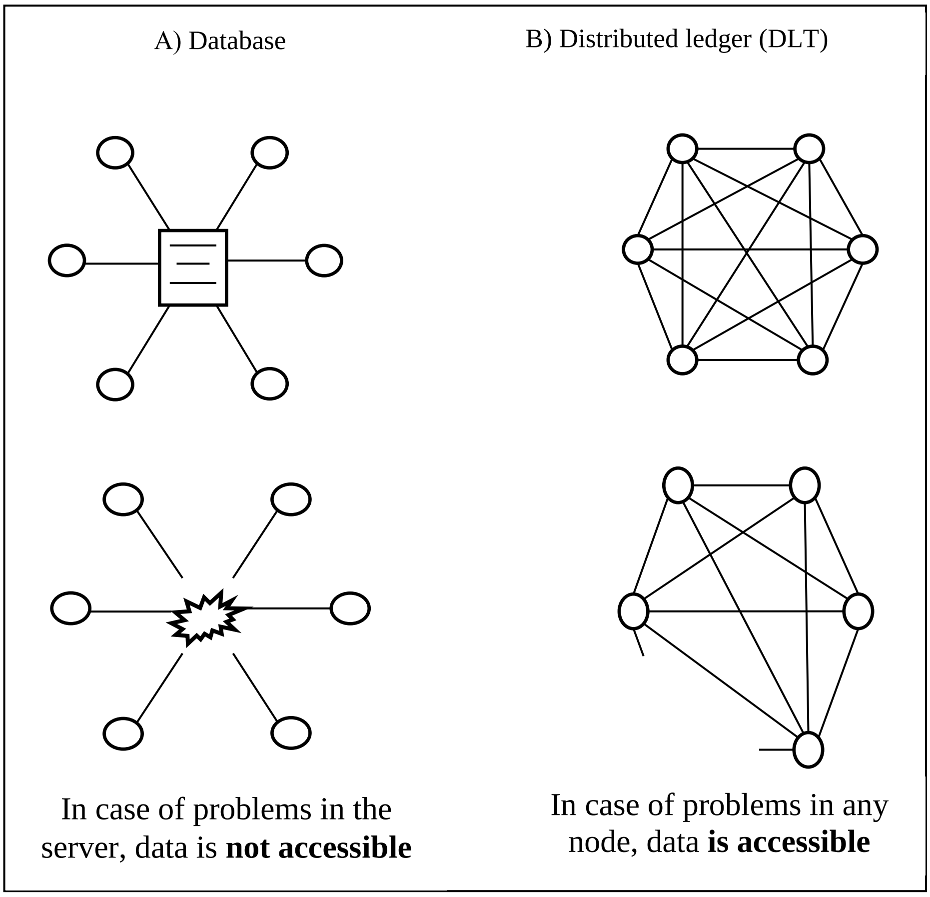

Figure 1. Traditional database and distributed ledger

DLT has peer-to-peer (P2P) architecture. The participants have equal rights and exchange information without a server (Figure 1.B). Each user can create and add new elements and all participants work together to guarantee the safety and reliability of information. If one or more nodes of the P2P network fail, the data remains accessible. With reference to management, DLT is a completely or partially (de)centralized structure, i.e. it is managed by all network participants or authorized nodes. The control and responsibility for data is shared and is done by achieving consensus. One of the main advantages of DLT is avoiding the above- mentioned risks of centralized database administration. In addition to supporting current updated data, distributed ledgers hold history data records about previous state and changes done by network participants.

Blockchain is the functioning distributed ledger and for many years it has been its only form, which has led to the interchangeable use of the two terms. However, new alternatives to the blockchain (and respectively new cryptocurrencies) have appeared in recent years. This has resulted in higher speed of transaction processing, improved security and lower costs. For example, the NANO (RaiBlocks) cryptocurrency is based on block lattice. This can guarantee approximately 7,000 transactions per second compared to 3 – 4 ones done with bitcoin (Gvili, 2018). Iota and Hashgraph utilize a Directed Acyclic Graph (DAG) and permit 500 – 800 and over 250,000 transactions per second respectively (Schueffel, 2018). But because there is still not sufficient experience, it is early to conclude whether these data structures are better than the blockchain technology and whether they will be its long-term alternative. Therefore, they are not dealt with in this publication.

With reference to this, it can be concluded that the scope of DLT is broader than that of the blockchain technology. The distributed ledger provides to its user a technology for data access, storage and distribution. The responsibility for maintaining DLT is shared among all network participants (nodes) that vote to reach consensus about its current state. Blockchain is only one of the possible forms distributed ledger can take. This is a data structure, which allows for organizing the distributed data by guaranteeing its integrity and confidentiality. DLT, however, supports the utilization of other types of data structures.

2. Main blockchain mechanisms

Blockchain is a related list of blocks, which contain different information (not only cryptocurrency transactions). It allows for adding new data organized in blocks. Changing or deleting data, which is already entered in the data chain is impossible.

Hashing plays a key role in building and maintaining the chain of block. With this cryptographic hash function based on a mathematical algorithm, input data of arbitrary size is transformed into an output string of fixed size, also called hash, hash value or hash signature. The cryptographic hash function has the following characteristics:

- The hash value is easily generated;
- Decrypting, i.e. recreating the initial input data, based on the hash, is impossible;
- It is impossible to generate one hash value for different input data, i.e. there is lack of collision.

There are different cryptographic functions. For example, the bitcoin blockchain uses SHA-256 (Secure Hash Algorithm 256-bit), which generates 256 – bit (32 byte) hash value. It is usually represented as a sixteen-digit number, consisting of 64 digits. Every change, even the smallest one, in the input data leads to changes in the hash value. Figure 2 shows the hash values under SHA-256 of several spelling versions of "blockchain".

The block has a header and a body. The body includes the transactions. Their number depends on the size of both the block and the transactions. For example, the average size of a block in bitcoin chains is approximately 1MB and it can contain more than 500 transactions (see www.blockchaininfo, 2018).

The block header consists of:

- The header hash value of the previous block (parent block);
- Timestamp showing the current time after January 1^{st} 1970 in seconds;
- Merkle hash root, which is built by recursive hashing of pairs of transactions and in this way summarizes the hash values of all transactions in the block (Figure 3).

Blockchain	0bf5b3c53e2da83eafd74b401d7b16c4c4a3dd4fa292f81ef491734fe19c42c8
Blockchain	e6c5e23a451f292eff31cb44edc2c89394fbfc5d9d25a85fabde02a4c0a4db90
Blockchain	625da44e4eaf58d61cf048d168aa6f5e492dea166d8bb54ec06c30de07db57e1
blockchain	ef7797e13d3a75526946a3bcf00daec9fc9c9c4d51ddc7cc5df888f74dd434d1
BC	768921a22b8e190c2cfafeb0688f0d58a5f76ee4c7fb369758a208c7ba5e9acb
#blockchain	86edce3cbbd8ac6968c3c854cfe8d25d8ee6be2df52b4beab7622879ac848108

Figure 2. Examples of blockchain values (generated from http://www.xorbin.com/tools/sha256-hash-calculator)

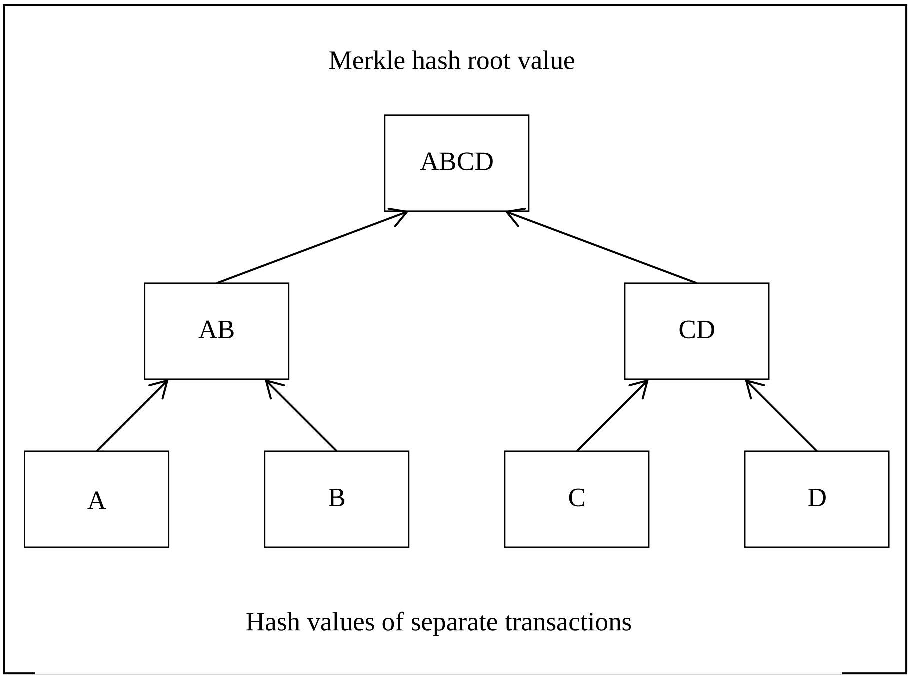

Figure 3. Hashing of the Merkle tree of a block with 4 transactions

Each block uses the hash of the previous block to form its own hash and this is its unique identification in the chain. This means that when a single transaction is changed or added in a particular block, it hash value has to be changed and the entire chain after it has to be reconstructed. The facts that a copy of the blockchain is stored on multiple computers in the network and every change requires consensus make this task (for now!) impossible. Therefore, it may be appropriate to use the technology for registering events, processing transactions, managing records and tracking assets to mention a few.

The evolution of blockchain is related to developing ***decentralized applications*** (dapp, dApp, DAPP or DApp) for automation of business processes and data processing. DApp are becoming the new paradigm of programming and are setting new challenges to software engineers. According to Raval, (2016) it is possible to utilize them more extensively in the web applications, which are very popular nowadays.

Actually, the decentralized applications are similar to the traditional web applications. Their front – end part is developed in the same way but instead of working with databases, they work with blockchain, i.e. encrypted data. Their back – end part is executed in P2P networks instead of by servers. According to the authors of a “white” paper on the subject, DApp must be open source and operate autonomously. In addition, there must not be centralized control on DApp, respectively it must not be proprietary (Johnston et al., 2015). The application can be adapted if necessary but all changes must be approved by consensus by users. Therefore, it must be very well – designed and as well debugged as possible, before being launched. The decentralized applications differ significantly from other traditional software applications, which are offered to users very soon after being developed and have a shorter development cycle.

One of the simplest forms of DApp, which is widely – used in blockchain, is the so called “***smart contracts”***. The concept was developed by Szabo (1996), but has been implemented in blockchain. The smart contract is essentially a code that is executed upon the occurrence of a condition or combination of conditions. It is used to ensure that a transaction can be carried out simultaneously with other transactions, which arise from and are related to it. According to Voshmgir and Kalinov (2017) the term “smart contract” is not very good and misleading to a certain extent. The “smartness” of the smart contract depends on the knowledge and skills of the people who have written the particular code, i.e. it remains dependable on the human factor. It must be clarified, however, that it is not a legal contract and is not legally binding for those who utilize it.

Due to the different method of organizing data, the chain of blocks does not have access to external information. However, the external environment often undergoes changes that must be registered by smart contracts. These changes can include, for example, changes in stock exchange quotations, payment terms and conditions, climatic conditions or occurrence of events such as receiving payments or making deliveries. Smart contracts receive information from the external environment through an ***oracle.*** This is a software application, an agent that is external to the blockchain. It transmits outside information to the smart contract and initiates it when a set of predefined external conditions happens. In other words, the oracle guarantees the communication between the smart contract and the external environment.

The smart contracts have good perspectives in the fields of finances, logistics, insurance, administrative services, education, copyright, etc. For example, if two participants in a deal do not know each other they need one or some intermediaries who will guarantee the transactions, i.e. a notary, lawyer, bank or the government to mention a few. The sale of a car or immovable property can become a debt, an expensive and risky process (in case the intermediary or partner is dishonest). The role of the intermediary can also be played by the smart contract. If the real estate register is based on blockchain, the smart contract can be used for transferring funds, paying taxes and fees, transferring property rights or carrying out any other transaction during the selling or buying of property. The question, however, is whether there are legal barriers to the realization of this process in blockchain and whether clients will trust the technology.

Based on analysis of the main mechanisms of the blockchain and DLT, we can summarize the ***fundamental characteristics*** of blockchain technology as follows:

- Distributed and decentralized architecture of the data and applications based on P2P;
- Necessity of consensus for adding data and changing the programmes, including the smart contracts;
- Hashing of transactions and links between blocks of a chain;
- Data immutability – once stored, data it cannot be changed.

3. Public and private blockchains

An important aspect of transforming business processes for work in blockchain is selecting the appropriate blockchain version. With regard to their ownership, blockchains can be classified as public and private (Buterin, 2015). Examples of public blockchain platforms include the ones used by the cryptocurrencies such as Bitcoin, Ethereum, Litecoin. They are "open", i.e. they have an open source code and do not require special access rights, i.e. any user can join the chain, download the code and run it on their device thus become a node. The current versions of public blockchains use mainly the Proof of Work (PoW) protocol and any user can take part in the vote for achieving consensus, transaction validation and distributed ledger support. Transactions are transparent (i.e. anyone can see them), but their owner may remain anonymous or use a nickname. Everyone can send a transaction in the chain and it can be added after being validated. In the users' business processes, blockchain can play the role of an intermediary in transactions by guaranteeing their security and reliability, which are based on data immutability. It is not surprising, that this form of blockchain originated particularly from the financial sphere.

A main advantage for public blockchain users is the low price because it is not necessary to invest funds for developing infrastructure, maintaining and administering servers. However, appropriate decentralized applications need to be developed to automate business processes. The disadvantage of these blockchains is the fact that large computer resources are generally needed to support a multi-node infrastructure. In order to achieve consensus, every participant has to solve a complex cryptographic problem, i.e. to provide a proof of work. Another potential problem for business users may also be the "openness" of the public blockchain because most business processes require confidentiality of transaction data and participants.

Private blockchains are owned by a single organization or a consortium of organizations. Examples of private blockchains include Multichain, Corda and EWF (operating in the financial sector and energy industry respectively) to mention a few. These blockchains are “closed” and not every Internet user can join them and add transactions because the access is administered by the owner. For this reason, they are called permissioned blockchains. The right to read transactions may be public or limited by the owner. Pre-defined network nodes participate in the consensus process, i.e. there is representative democracy. This speeds up the validation of transactions and generally reduces their value.

A major advantage and, at the same time, a drawback of private blockchains is that they are more flexible than public ones. It can be said that the private blockchain is only partially decentralized. The blockchain owner can change the rules, cancel, and change transactions. This is, in principle, contrary to the basic concepts of blockchain. The fundamental features outlined earlier are partially implemented but this is needed in some business processes. For example, the government should have access and control over certain public registers such as the business, land and property and public procurement registers to mention a few. Actually, it would not give up on its control over these registers.

4. Advantages and potential risks of blockchains

The characteristics and mechanisms of blockchain lead to a number of benefits for the business processes and data of users (Hooper, 2018; Treagust, 2017):

- **Security**. It is due to several factors, i.e. the hashing of data in the blocks, the links in the chain, the reached consensus regarding new blocks. This, along with the storage of multiple copies, makes it virtually impossible to change sensitive data. The risk of fraud and unauthorized access is significantly reduced.
- **Reliability.** It is based on DLT and support of chain copies in all network nodes. A problem in a particular device cannot affect the executed processes.
- **Transparency and tracking**. It is determined by the unchangeability of data, storage of multiple copies and need of consensus. Data is available to all participants who can track the movement of goods and financial resources, for example, as well as any changes in them over time.
- **Trust**. In blockchain trust is decentralized and is supported by all participants. According to Voshmgir and Kalinov (2017), blockchain supports "trustless trust". This means that without trusting any of the participants, users can trust the results from the processing of data.
- **Higher efficiency and lower price.** Blockchain is a highly automated, secure, and reliable system that reduces the need for intermediaries such as banks, notaries or the state in business processes and this leads to their acceleration. The fact that blockchains are based on DLT and hashing reduces labour costs regarding data security and data archiving.

Based on the above-mentioned advantages, blockchains provide opportunities for improving business processes in a number of ways. This is done by accelerating and simplifying, increasing the degree of automation, reducing the number of intermediaries and paperwork, providing opportunities for audits and data tracking, minimizing the risks of fraud and errors, reducing transactions processing time, implementing innovative payment instruments, relying on democratic decision – making, etc.

However, in order to make the right decisions regarding the adaptation of their business processes to blockchain, users must also be aware of the risks. For the purposes of the study they are divided into two groups, i.e. technology – related and business – related risks.

The technology – related risks involve problems with the reliability of P2P and DLT architectures, algorithms, protocols and blockchain software. According to authors such as Pang (2017), there are concerns regarding blockchain security. The distributed architecture and high number of nodes minimize the risk of successful hacker attacks. Nevertheless, these threats exist. The truth is that there are many attempts of breaking the blockchain systems used by the cryptocurrencies because of their increased value. However, so far, most of the attacks have been directed towards service platforms based on cryptocurrencies rather than towards their blockchain. It is assumed that the quantum computer can hack even multi – node public blockchains. On the other hand, however, it can be used for protecting similar systems by developing and utilizing of more efficient cryptographic algorithms. The oracle, a service external to blockchain, could also be the target of attacks with the purpose of failing or changing the work of a particular smart contract.

The specialists from Forrester question data immutability – a term, which is not correctly used according to them (CIO, 2018). They claim that the chain of blocks can be reconstructed in case of unwanted events, something that can easily happen in a private blockchain with limited nodes or a branched blockchain. Actually, this has already been done in the Ethereum blockchain in order to neutralize a hacker attack.

The fact that blockchain is a comparatively new technology should not also be underestimated. There is still not enough experience in the field but mainly there are not well – prepared specialists who can develop and support the blockchain infrastructure, identify and solve problems, and develop DApps, smart contracts and oracles. Mechanisms for integration with the legacy systems as well as different public and private blockchain systems are needed for the realization of efficient business processes.

However, practice shows that the technology – related risks of switching to any new technology are understandable and sooner or later solutions for their elimination will be found. Solving the above-mentioned problems associated with blockchain as well as many other yet unknown ones are responsibility of the IT specialists.

Business – related risks refer to the fundamental characteristics of the blockchain technology and their interpretation in the field of user business processes. Detailed knowledge of these attributes is important for finding solutions for reengineering the business processes when they are to be transferred to the blockchain. For example, the possibility for tracking transactions (even only their metadata) and securing their transparency is not an appropriate solution for all business processes. According to Forrester, „…for most companies, transparency is more a curse than a blessing…“ (CIO, 2018). In many cases, it is necessary to protect the confidentiality of information about clients, the deals they are involved in and their transactions. This is a requirement, for example, in banks and FinTech companies. It is also necessary to take into account the requirements of the data protection directives such as the European General Data Protection Regulation (GDPR).

When switching to blockchain-based business processes, it is necessary to interpret correctly concepts such as “smart contract” and “complete trust”, which often accompany the term “blockchain” in the media. As already mentioned, smart contracts are not legal documents – they are software applications which are created by people and perform the tasks they are designed to complete. Trust is based on cryptographic algorithms and software and their proper functioning. Consequently, the human factor cannot be completely avoided.

Adaptation of business processes for blockchain should be in line with the existing legal regulations. Lawyers have already started to deal with these aspects of the technology, mainly due to cryptocurrencies, and probably certain legislation changes will be made in the near future. For example, it is necessary to find answers to certain questions: who takes responsibility in case users suffer losses due to mistakes in the public blockchains or smart contracts; how can regulatory authorities receive information from blockchains in case of crime suspicions without breach of data about or belonging to other users; can blockchain information (for example, about ownership of certain assets) be used as evidence and can it be used as a legal document (for example, a notarial deed); can users request deletion of their data in blockchains; is cryptocurrency a legal payment instrument; etc.

Conclusion

Whether the expectations for blockchain and DLT technologies are realistic or whether the promised changes will be ubiquitous and will change “dramatically” our world will be revealed in the future. Nevertheless, the interest of the technological giants in these technologies is a fact. Numerous startup companies are making efforts to establish themselves on the market by developing blockchain and DLT applications for different activities in different spheres – from global payment systems to downloading music and scientific research; from selling valuable objects and works of art to producing organic products. This proves the enormous potential of the blockchain technology and the fact that it is developing extremely rapidly. Consumers, in turn, have to decide when to invest in it and which of the existing solutions, platforms and blockchain service providers to trust. It is very likely that those who are late to transform their business processes for the blockchain technology and to start benefiting from its advantages lose their competitiveness. Nevertheless, tt has to be remembered that using blockchain as infrastructure for data storage and executing business processes may involve certain risks, which are characteristic of the early stages of every new technology launch, namely customer and user mistrust, legal barriers, lack of experience and compatibility problems with other technologies. Therefore, decisions to switch to blockchain must be based on a careful analysis of the mechanisms, advantages and risks of the technology, and the opportunities for integrating them into the organization's business processes.

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- Font – Times New Roman, size 14 pt, line spacing 1,5 lines;
- Page size – A4, 29–31 lines and 60–65 characters per line;
- Line spacing 1,5 lines (at least 22 pt);
- Margins – Top – 2.54 cm; Bottom – 2.54 cm; Left – 3.17 cm; Right – 3.17 cm;
- Page numbers – bottom right;
- Footnotes – size 10 pt;

4. Layout:

- Title of article title; name, scientific degree and scientific title of author – font: Times New Roman, 14 pt, capital letters, Bold – centered;

- Employer and address of place of employment; contact telephone(s) and e-mail – Times new Roman, 14 pt, capital letters, Bold – centered.

- Abstract – up to 30 lines; Key words – from three to five;

- **JEL** classification code for papers in Economics (http://ideas.repec.org/j/index.html);

- Introduction – it should be from half a page to a page long. It should state the main ideas and/or objectives of the study and justify the relevance of the discussed issue.

- The main body of the paper – it should contain discussion questions, an outline of the study and research findings/main conclusions; bibliographical citation and additional notes, explanations and comments written in the footnotes.

- Conclusion – it should provide a summary of the main research points supported by sufficient arguments.

- References – authors should list first references written in Cyrillic alphabet, then references written in Latin alphabet.

- Graphs and figures – Word 2003 or Power Point; the tables, graphs and figures must be embedded in the text (to facilitate language correction and English translation); Font for numbers and inside text – Times New Roman, 12 pt;

- Formulae must be created with Equation Editor;

5. Citation guidelines:

When citing sources, authors should observe the requirements of **APA Style**. More information can be found at: https://www.uni-svishtov.bg/default.asp?page=page&id=71#jan2017, or: http://owl.english.purdue.edu/owl/resource/560/01/

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