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BLOCKCHAIN - HISTORY, FEATURES AND MAIN AREAS OF APPLICATION[3]

SUMMARY:

Blockchain technology is viewed as one of the breakthrough information technologies of our time. More than 8 years of history of this technology inextricably links with the history of the digital currency Bitcoin, created by the mysterious Satoshi Nakamoto. Since the first users connected to the Bitcoin network, the perception of blockchain technology has evolved, as a base technology that can be used not only to create other cryptocurrencies than Bitcoin. The emergence of Ethereum, Bitcoin-independent blockchain network, designed by 19-year-old Vitalika Buterina, was also important, for new functional possibilities it offered - smart contracts. The Blockchain, which we know today, very intensely and effectively uses known cryptographic concepts such as one-way hash functions, asymmetrical cryptography or time stamping. With automated consensus mechanisms between blockchain network members, no trusted third party is required to process transactions, whilst intelligent contracts have extended the scope of blockchain technology applications far beyond cryptocurrency transfer. Companies and institutions around the world have discovered the innovative potential of blockchain technology's unique features and are now improving their processes via blockchain technology. The above examples of applications improve the quality of life of ordinary people.

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1. BACKGROUND

The history of blockchain technology inextricably links with the history of the digital currency known as Bitcoin and Satoshi Nakamoto, its shady developer. It is hard to believe that the true identity of the inventor of one of the most revolutionary technologies of our time has been unknown, even though this person (or persons), under a pseudonym, actively participated in the development of the source code of Bitcoin software for over 2 years.

It is difficult to say exactly since when Satoshi Nakamoto worked on the concept and technical solutions of Bitcoin. Amidst speculation and guestimate, in one of his posts[4] published on the discussion group on cryptography, Nakamoto suggests that he was developing elements of the solution already in 2007. 18 August 2008 saw the registration of bitcoin.org, considered to harbinger the establishment of the Bitcoin network. Registration took place through anonymousspeech.com, for anonymous registration of domains, nonetheless it is Satoshi that is widely recognized the first domain owner. On 31 October 2008 Nakamoto published "The White Paper", "Bitcoin: A Peerto-Peer Electronic Cash System[5]", a highlight in the history of Bitcoin, which showed blockchain technology to the world.

The subsequent developments followed. Once the Bitcoin project was registered on SourceForge.net[6]on 9 November 2008, the initial Bitcoin block (the so-called Genesis Block)

[4] http://satoshi.nakamotoinstitute.org/emails/cryptography/15/ [accessed on 28.05.2017].
[5] https://bitcoin.org/bitcoin.pdf [accessed on 28.05.2017].
[6] SourceForge.net is a free Open Source project management and control system that allows one to store and version the source code of these projects and make it available on request.

came into existence ("dug out") on 3 January 2009. Next, on 9 January, the first stable version of Bitcoin software, marked 0.1, was released, and on 12 January, the first cryptocurrency transfer transaction was completed: 10 Bitcoins (Satoshi sent them to Hal Finney - a known activist in the cryptographic environment). Thus more than 8 years of the history of Bitcoin and blockchain technology commenced, which is recognized as a revolution tantamount to the go-ahead of global Internet. To this day many things have happened regarding the Bitcoin network and quoting all these events, often unimaginable from today's perspective (such as paying 10,000 Bitcoins for one pizza), goes beyond the object of the present paper. However, the story is so interesting that for sure it is worth to review it, be it in general.

Also important to note are events related to the evolution of the perception of blockchain technology as a base technology, which can be used not only to create cryptocurrencies other than Bitcoin. A special mention must be given to a completely new, Bitcoin-independent blockchain network called Ethereum. This time the author has been identified. Vitalik Buterin, 23, with his family emigrated from Russia to Canada at the age of 6, where as a talented mathematician and programmer scored significant successes already as a teenager (for instance bronze medal at the International IT Olympics 2012[7]).

Vitalik embarked on a journey with cryptocurrencies in 2011, when he first came into contact with Bitcoin. Since then he has been actively involved in the community developing Bitcoin software, contributing articles on Bitcoin and co-creating one of the first cryptocurrency (Bitcoin Magazine) magazines, which made him an expert in cryptocurrency and blockchain technology. In 2013, at the age of 19, he dropped out of university and began to travel around the world, taking part in the development of open source software (open source) related to cryptocurrencies. The travel and projects infused him with an idea for a completely new kind of blockchain network, which it described in late 2013[8]. According to this concept, Vitalik announced the launch of the Ethereum project on 23 January 2014 and started to develop software for a new blockchain network, which would offer new functionalities unavailable in Bitcoin. The main functional revolution brought by Ethereum consisted in "programming" blockchain, that is taking recourse of functionalities / scripts that perform virtually any calculations or store data, called "smart contracts". which remained unchanged after joining blockchain and continued to operate as originally programmed. Vitalik viewed the Ethereum

[7] http://www.ioi2012.org/competition/results-2/ [accessed on 28.05.2017]
[8] http://www.the-blockchain.com/docs/Ethereum_white_paper-a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf [access: 28.05.2017]

network as something more than a registry recording cryptographic transactions, the plan was to build a "world computer" - a platform for the creation of distributed applications drawing from the benefits of blockchain technology, on which they would be embedded. Ultimately, the Ethereum network was launched on 30 July 2015 and since then it has been developed as the second largest open blockchain, whose area of application has gone far beyond cryptocurrency transfer.

2. THE ESSENCE

No doubt, both Bitcoin and Ethereum are prototypes of other solutions, which are now intensively developing and evolving. Knowledge of the basic mechanisms of operation of both these networks paves the way to understand also other modern solutions defined as blockchain technologies or more widely technologies of distributed registers.

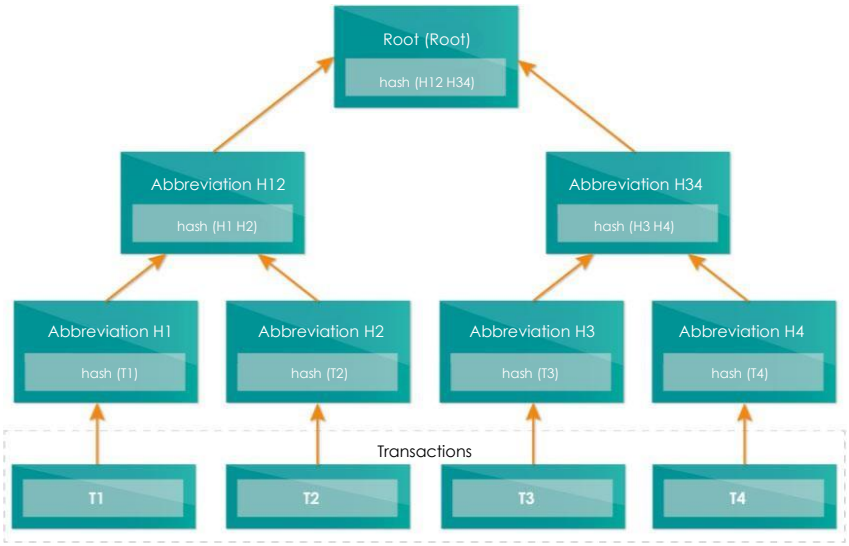
2.1 Blockchain robustly and effectively leverages existing cryptographic concepts. The first is the creation of unique and unambiguous 'fingerprints' of data via one-way hash functions (so-called 'hashings'). These functions have been known and used in IT for over 27 years[9] to calculate a short signature (the so-called "hash") for the input data. With the input of any digital document, photo or other information, or even entire big data sets, the hash function calculates the "abbreviation" of this data, which will be:

- collision-proof - two different data sets will not give the same abbreviation and no data set may be generated with the same abbreviation as the specific set of data;
- one-way, irreversible - the original message may not be reproduced based on its abbreviation.

Both these features of the data abbreviation calculated via hashing functions quickly identify digital data and verify their integrity. The point is that even the slightest change in the source data, even if only one bit is changed, causes the calculated hash to differ from the shortcut of the source data. This basic cryptographic mechanism running on a single data portion can be used multiple times to ensure the integrity of entire data files, for which the abbreviations of individual components of the set are calculated independently, and then, by hierarchically calculating the abbreviations, we obtain one hash at the end identifying the entire set of data.

[9] The first algorithms of the "MD" family of abbreviations used for many years appeared as early as 1989 and were created by Ronald Rivest (https://en.wikipedia.org/wiki/Ron_Rivest).

This approach is used in blockchain, where individual transactions are hashed separately, and the entire set of transactions packed in the block is represented by a tree of abbreviations (invented in 1979 by Ralph Merkle[10]), whereby not only data substitution may be identified in a single transaction, but also any attempt to exchange the entire transaction for another. The diagram of the creation of the abbreviation tree is best illustrated on the diagram:



2.2 The second important component of blockchain technology, asymmetric cryptography, ensures information exchange, or even encryption of information exchanged between two parties, without the parties having to agree on one common security key. Asymmetric cryptography helps users open a secure website (HTTPS) or digitally sign e-mail or electronic documents. Certificates and digital signatures based on this type of cryptography are common today and any detailed information about them is easy to come across. It is worth to know the differences between these commonly known solutions and the use of asymmetric cryptography mechanism in blockchain technology. First, asymmetric cryptography in blockchain is used for each transaction, it the basis for blockchain to operate. Each blockchain network participant interacting with other network participants uses his or her private key to sign transactions he or she sends and the public keys of the addressees of those transactions. Moreover, there is no "key certification" of network users in public blockchain networks such as Bitcoin or Ethereum, anyone can generate their own pair of keys and immediately become a fully-fledged participant in the exchange of goods within the selected blockchain network.

[10] https://pl.wikipedia.org/wiki/Drzewo_hash [accessed on 28.05.2017]

2.3 Time stamping makes the third element from the world of cryptography adapted by blockchain technology. Time in a blockchain network is synchronized between network participants (nodes), both transactions and blocks themselves are time-stamped. This allows all objects and events in blockchain to be placed very precisely on a synchronized timeline and together form a reliable, chronologically arranged history.

2.4 Further pillars providing unique blockchain functional features are consensus mechanisms and smart contracts.

The consensus mechanism is, in short, a mechanism for approving transactions and attaching new blocks to the chain, performed by the blockchain network node software. In traditional solutions, in order to confirm certain events (validate transactions), a trusted third party must be established, which collects all data enabling it to decide which version of events presented by participants in the process will be deemed valid. In blockchain, the need for such a trusted third party has been eliminated and replaced by an agreement made automatically between network nodes, called consensus. Two main types of consensus mechanisms may be identified. The first one is the so-called "Nakamoto consensus", which consists in carrying out a kind of lottery for each new block and selecting a leader-node that will be able to propose a new block to join the chain, and once it has been approved by other nodes, receive remuneration for adding this block. The best known implementation of this type of consensus is represented by the so-called "proof of work" used in Bitcoin or Ethereum. The second type of consensus is based on the classical algorithm of Byzantine generals used in distributed networks and involves the network nodes voting rounds to obtain consensus[11]. Consensus of this type is used very often in closed blockchain networks, which do not use economic incentives for nodes joining the network.

Smart contracts, most often referred to by their original English name as "smart contracts", were described by Nick Szabo[12], cryptographer, over 20 years ago.

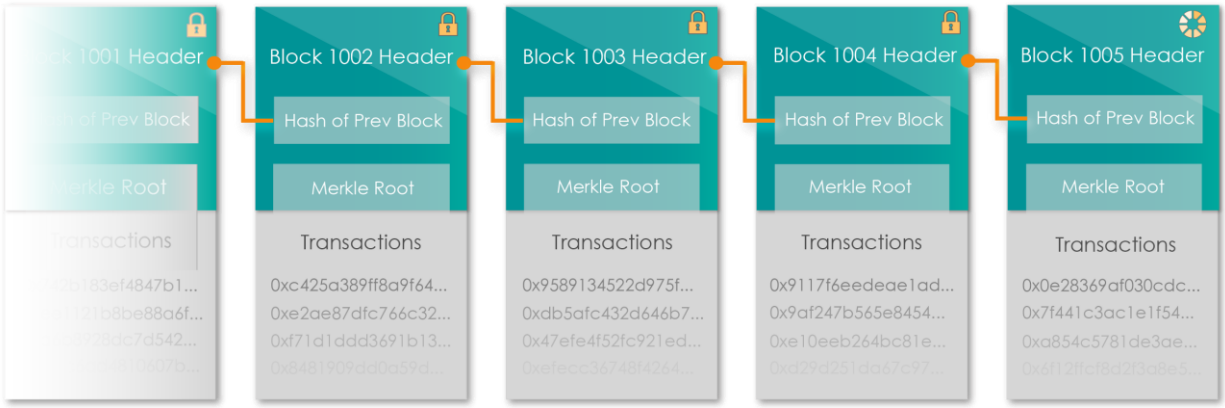
The concept developed by Szabo was implemented in a very limited form already in the Bitcoin network, but only Vitalik Buterin fully actualized it in the Ethereum network, which deploys smart contracts. These specialized programs, residing in the blockchain network as autonomous agents, are responsible for performing additional operations recorded in their programming code when processing transactions. Thanks to intelligent contracts, blockchain

[11] https://pl.wikipedia.org/wiki/Problem_bizantyjskich_genera%C5%82%C3%B3w [accessed on 28.05.2017]
[12] https://en.wikipedia.org/wiki/Nick_Szabo [accessed on: 28.05.2017]

network gets additional functional capabilities, for much more complicated processing than just the transfer of basic cryptocurrency of the relevant network. Smart contract can both define completely new, previously unknown cryptocurrencies with virtually any functionality, but it can also become a carrier or storage of non-financial digital values and digital representation of material values. This flexible blockchain functionality from smart contracts is today a great promise of brand new, truly innovative blockchain-based solutions.

Both consensus mechanisms and smart contracts are so extensive and so interesting that they undoubtedly deserve separate and more in-depth studies to be published in subsequent issues of the quarterly 'Człowiek w Cyberprzestrzeni'.

2.5 Combining the components described so far: hashing functions, shortcut trees, asymmetrical cryptography, time stamping, consensus mechanism and intelligent contracts into one whole, yields blockchain technology as we know it now.



Before examining specific cases of blockchain use, it is essential to realize that systems based on this technology form unchanging, time-stamped entries in a distributed database for individual transactions. Accordingly, each transaction and the corresponding data record are easily and unequivocally identifiable. This distributed database has neither a distinguished central node, nor any "super-controller", so blockchain does not have a single point of failure. Additionally, the consensus mechanism and continuous verification of records by nodes protect the transaction system against double use of the same token/script/value (double-spent[13]), thus preventing fraud, abuse and other types of manipulation on the transaction data.

[13] https://en.wikipedia.org/wiki/Double-spending [accessed on 28.05.2017]

Based on the features of blockchain technology in pursuit of verification whether this technology has a chance to improve the quality of life of ordinary people, it is worth looking at selected projects currently underway in the world.

3. BLOCKCHAIN AND THE SUPPLY CHAIN OF GOODS

This technology appears to naturally support recording facts and events as transactions in blockchain. Most of us use GPS (Global Positioning System) as a useful way of navigation[14]in our daily operations. Assuming that the location data was placed in the blockchain, we would receive an undeniable record of our route. No one, from the moment of writing, would be able to modify the available trace of geolocation. Time stamping natural for blockchain reveals the route of the object correlated with the time of checkpoint recording. As soon as the object of interest may be "marked" in an unambiguous way, a tool emerges for reliable and credible tracking of goods. Tracking and tracing throughout the supply chain plays an important role in high-value items such as luxury goods, pharmaceuticals, cosmetics and electronics. Each time a physical element changes its position over time (for instance by changing its suppliers), the digital token is transferred in parallel so that the real supply chain is accurately reflected by the transaction chain at blockchain level. This materially reduces abuse during distribution processes and facilitates responses as soon as after the anomaly has been detected.

The undeniable traceability of the origin and route of goods is only the first and fairly obvious case of use. For many goods, such as food and pharmaceuticals, the conditions under which they were transported are more important than the route itself, and not infrequently any delays during transport. This is where IoT[15] (Internet of Things) comes in handy. Thanks to sensors capable of communicating with the Internet, and thus with blockchain, parameters such as temperature or humidity during transport can be additionally measured and recorded, and such measurements can also be placed together with the location of control points as blockchain transactions[16]. Records can be made autonomously and the stored values are unmodifiable, which, given the transparency of data reading, provides an effective verification tool for the recipient of goods and in fact the end customer. Already today in the systems operating under of the above model, the customer receives a mobile application. Respectively, it may scan the

[14] http://www.gps.gov/ [accessed on: 28.05.2017]
[15] https://en.wikipedia.org/wiki/Internet_of_things [accessed on: 28.05.2017]
[16] http://blulog.eu/pl/ accessed on: 28.05.2017]

barcode of goods to verify its origin and trace the route travelled and the conditions under which the goods were transported. In pursuing this approach, suppliers are able both to guarantee a high quality of the goods and to provide the customer with reliable evidence of high quality standards throughout the supply chain. Thus, it receives a correspondingly higher remuneration for the goods delivered. For example, fish delivered from Indonesia from specific fishing grounds to exclusive English restaurants get a price several times higher thanks to the documentation in blockchain of both the exact place of origin and the route of their delivery[17].

4. IDENTIFICATION AND AUTHENTICITY OF GOODS

Confirmed authenticity of goods is a feature that many counterparties care about. For confirmation of origin, a good example are luxury goods such as diamonds. The origin of a stone, if known, can stop insurance fraud and sift real diamonds away from synthetic or "gore" diamonds or those from conflict zones. Fake paper-based certificates obscure the origin of diamonds. The year 2015 saw an initiative emerge to create a global register of diamonds based on blockchain records. More than 40 properties of stones are used, including colour and transparency, to create an identifier for each diamond. This information becomes a certificate protecting the origin of the jewels, from the mine to the ring. Everledger has digitised more than one million diamonds and is working with many companies, including Barclays[18].

As anyone can imagine, confirmation of a characteristic such as authenticity becomes valid not only for rare and valuable goods, but also for virtually the whole world of digital goods[19].

Through increasingly integrated systems, the exchange of these goods, particularly in digital form, is becoming easy, common and virtually unrestricted, but also vulnerable to manipulation, counterfeiting and cyber-attacks. In many situations it is the confirmation of the authenticity of electronic data and documents that plays an important role. The trend with the use of undeniable confirmation in blockchain can be seen even in such IT giants as Microsoft. Recently, the company has introduced an add-on to MS Office package, which uses blockchain networks (Bitcoin and Ethereum) to save a document identifier that is a one-way abbreviation

[17] https://www.provenance.org/tracking_tuna_on_the_blockchain [accessed on 28.05.2017]
[18] http://www.wired.co.uk/article/blockchain-conflict-diamonds-everledger [accessed on: 28.05.2017]
[19] https://stampery.com/ [accessed on: 28.05.2017]

of this document[20]. This identifier stored in blockchain allows the recipient of this document to verify whether the document is authentic.

The ease of use and certainty of records cause that more and more state registers and document circulation systems reach for solutions based on blockchain. A telling example is the new strategy for Dubai, which assumes that by 2020, all tasks within the state administration will have given up the use of paper in favour of electronic documents verified within the blockchain network [21].

The authorities of the United Arab Emirates believe that such modernization will not only bring real savings in the costs of state administration, but will also optimise service of citizens' affairs and access to public services.

5. BLOCKCHAIN IN PRODUCTION AND DISTRIBUTION IN THE ENERGY SECTOR

New energy initiatives, such as domestic energy production and social solar energy, fill in the gaps in electricity supply worldwide. The opinions are emerging that, in energy terms, households should become real prosumers, not just consumers, as is currently the case. The prosumer combines both energy consumption and energy production. By way of illustration, solar panels connected to the Internet via technologies offered by newly established companies such as Filament, enable the connection of traditional electronic devices to the Internet[22]. Generated with IoT sensors, anonymous energy certificates can be sold to a prospective user of solar energy in the energy network[23].

Sure, energy companies also see benefits, for they will be able to significantly optimise the flows in the power grid and thus minimise energy losses during transmission.

[20] https://www.microsoft.com/reallifecode/2017/04/10/stampery-blockchain-add-microsoft-office/ [accessed on: 28.05.2017]
[21] http://gulfnews.com/news/uae/government/dubai-launches-blockchain-strategy-to-become-paperless-by-2020-1.1907790 [accessed on: 28.05.2017]
[22] https://filament.com/ [accessed on 28.05.2017]
[23] https://solarcoin.org/en/front-page/ [accessed on 28.05.2017]

6. DIGITAL IDENTITY MANAGEMENT

The above blockchain-based system applications had a common feature in the form of anonymity of users. No user's identity must be provided to verify the authenticity of goods, their transfer or energy transmission. Nonetheless, if we can create unambiguous digital identifiers for the things around us, why not clearly define the personal identity and record it into blockchain?

Authentic identification should be easily accessible to those who need it, and a publicly distributed database such as blockchain can be convenient to this end. Identity is in many cases confirmed information about personal identity and what others know about a person (which in many cases proves more genuine than what one says about oneself). Accordingly, newly emerging systems may confirm the identity in cyberspace, without storing data on the servers of a trusted third party (be it a bank). With the confirmable information and available documents, the system will create appropriate entries in blockchain[24, 25].

7. CONFIRMATION OF PROPRIETARY RIGHTS

Blockchain technology also makes it possible to confirm that an item or good belongs undeniably to a particular person and stores that information in a permanent and unchanging manner. This offers enormous opportunities as regards diverse property rights registers. By way of illustration, the so-called proof-of-existence may confirm the authorship of any kind of document (paper-based, photographic or audio/video[26]).

This simple method allows anyone to store the cryptographic abbreviation of any document in blockchain, which confirms that the digital good data existed when the block was added to the string. The author's name or unique identifier inserted in the document will mark a strong link between the good and the owner. If no one proves to have or know this particular good (file or work) before the date recorded in the blockchain transaction, the author should be able to assert his rights under these records. In the USA, there are already known precedents, where an entry of a transaction in blockchain was considered court evidence[27]. This opens a

[24] https://shocard.com/ [accessed on: 28.05.2017]
[25] https://www.sovrin.org/ [accessed on: 28.05.2017]
[26] https://proofofexistence.com/ [accessed on: 28.05.2017]
[27]https://www.blockcrushr.com/vermont-state-legislature-will-begin-accept-blockchain-evidence-admissiblecourt [accessed on: 28.05.2017]

field for activities about notarial confirmation of documents and property deeds (for example land).

8 MEDICAL DATA SECURITY

Safeguarding both ownership and authenticity proves even more critical and desirable when sensitive data are involved – such us medical data (test records, research results, consent forms, etc.)[28]. If during the process someone has doubts about the authenticity of the data they are in contact with, they can check whether their information is authentic, using the original data abbreviations stored in blockchain.

9. BLOCKCHAIN AND FINANCIAL SOLUTIONS

Many issues, such as high transfer costs, limited methods of money distribution, limited possibilities of promoting one's own brand, limited ways of dealing with money, etc. resulted in blockchain being able to present its strengths in the area of FinTech solutions in a particularly clear way. Even traditional financial institutions have recognised the huge potential of blockchain technology for innovation in financial services. Transfers and currency exchange are probably the most developed areas of blockchain applications, as they rely on the basic mechanisms of this technology. A number of large financial institutions, including many of the world's largest banks, have already initiated research and conceptual work to explore the real potential of blockchain, [29] for example on fast interbank transfers. Blockchain enables secure and secure direct exchange of financial assets between two network users ("peer-to-peer"), this being its great advantage over traditional solutions, which cannot do without a trusted third party to settle transactions. By eliminating intermediaries, blockchain can enable cheap and instant crossborder transfers and thus increase the spending power of money trading. Loans in the alternative system cryptocurrency form a very common trend today.

[28] https://www.wired.com/2017/02/moving-patient-data-messy-blockchain-help/ [accessed on 28.05.2017] [28] http://socialracemedia.com/jpmorgan-tests-blockchain-for-loan-streamlining/ [accessed on 28.05.2017] https://www.credit-suisse.com/pl/en/about-us/media/news/articles/media-releases/2016/09/en/blockchaindemonstration-shows-potential-loan-market-improvements.html [accessed on 28.05.2017]
http://www.reuters.com/article/us-banks-blockchain-idUSKCN0RF24M20150915 [accessed on: 28.05.2017]
[29] http://socialracemedia.com/jpmorgan-tests-blockchain-for-loan-streamlining/ [accessed on: 28.05.2017] https://www.credit-suisse.com/pl/en/about-us/media/news/articles/media-releases/2016/09/en/blockchain-demonstration-shows-potential-loan-market-improvements.html [accessed on: 28.05.2017]
http://www.reuters.com/article/us-banks-blockchain-idUSKCN0RF24M20150915 [accessed on: 28.05.2017]

10. CROWD FUNDING AND REMUNERATION FOR AUTHORS

A specific and interesting case of direct exchange based on the blockchain network is illustrated by the systems of creating content, such us blogs or books, where each participant accesses appropriate shares/grants in the form of cryptocurrencies (tokens), depending on the contribution to the publication. Next, these contributions translate directly into the share of profits that a publication will generate in a dedicated e-learning system. The better the material is, the more people read it and the higher the "gain" is automatically transferred by smart-contractors to the authors. In the United States, such a model has been introduced at several universities. Reading is free of charge and the author scores points, which then translate into course credits and additional bonuses as part of the university's activities. Needless to say, there are also commercial applications of this model, where the reader pays cryptocurrency for access to the authors' publication.

11. ELECTRONIC VOTE (E-VOTING)

For many people, electronic voting, particularly via the Internet, is a non-debatable issue. The system is so important that people do not wish to entrust the whole voting process to an IT system. The existing electronic voting systems reveal serious design flaws. Due to the use of centralised voting centres, a single supplier controls the database and system outputs and provides the tools to monitor the system. The absence of open, independent verification of input data makes it difficult for such a centralised system to gain the credibility required by voters and election organisers. Blockchain can act as a secure, undeniable database to record votes and audit results in a credible and reliable way. In both public and[30] corporate[31] voting with the use of blockchain, research and design activities and significant investments can be seen all over the world. In the area of electronic public elections, Estonia's success was a breakthrough: it has been the first country in the world to introduce Internet voting using a blockchain-based

[30] http://www.zdnet.com/article/australia-post-details-plan-to-use-blockchain-for-voting/ http://e-vox.org/balta-installs-e-voxnarada/ [accessed on: 28.05.2017]

[31] https://bitcoinmagazine.com/articles/russia-s-national-settlement-depository-successfully-tests-blockchainbased-e-voting-system-1464198071/ [accessed on: 28.05.2017]
http://bravenewcoin.com/news/new-blockchain-e-voting-service-complements-abu-dhabi-economic-vision/ [accessed on: 28.05.2017]

system[32]. As the Estonian example shows, thanks to the use of blockchain voting system becomes more resistant to fraud, more transparent and much more accessible, thus expanding the possibilities of real participation of voters in the electoral act.

12. SUMMARY

The cases of using blockchain technology cited in the article, which have a genuine impact on boosting corporate effectiveness and improving the quality of life of ordinary people, are only a small portion of the possibilities offered by blockchain. Thanks to better understanding of this technology and its innovative potential more and more practical applications are in a pipeline. Blockchain is a type of technology often referred to as "enabler" or "changer", in other words many difficult or even unsolvable problems of yesterday become realistically simple today.

It is also worth noting that blockchain introduces a very important new aspect to the Internet - direct economic relations between network members. Including the ability to confirm the authenticity of physical or digital goods and identity of individuals, we get a completely new, hitherto unknown tool - "Internet of Value".

[32] http://business.nasdaq.com/marketinsite/2017/Is-Blockchain-the-Answer-to-E-voting-Nasdaq-BelievesSo.html [accessed on 28.05.2017]