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BLOCKCHAIN: FOUNDATIONAL TECHNOLOGY TO CHANGE THE WORLD

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Abstract of Thesis

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Blockchain is a new technology, which has a huge potential for implementation in a variety of industries. It is commonly discussed merely as an underlying technology of the Bitcoin cryptocurrency. However, the areas of the technology implementation are not researched thoroughly and not limited to the financial sector.

The objective of this study is to define the concept of Blockchain, analyse use cases and implications of the technology. An exploratory desk study was conducted in order to describe the Blockchain's history and related concepts. On the basis of the desk research, an analysis of the business value and the technology's principles was made.

The exploratory research approach based on a profound literature examination was chosen. The exploratory approach was found relevant for this study as it enables to conduct a research of technology implementation into supply chain management and the Internet of Things industries. Analyses of the most relevant and valid sources, such as consulting companies' reports, was done in order to collect secondary data for the thesis work. This text provides an examination of Blockchain's implementation areas and possible implications, not concrete suggestions for developing distributed Blockchain-based applications.

The results indicate Blockchain as a foundational, not a disruptive technology, which is to be implemented within the supply chain and Internet of Things. Additionally, the study provides data about economic, technological, social and political implications of Blockchain and the abilities for developing these areas.

Key words: Blockchain, Cryptocurrencies, Internet of Things, Supply chain management

CONTENTS

SYMBOLS AND ABBREVIATIONS

API	Application Programming Interface
DAPP	Decentralized Application
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
EVM	Ethereum Virtual Machine
ICO	Initial Coin Offering
IoT	Internet of Things
PKI	Public Key Infrastructure
SAP	Systems, Applications & Products in Data Processing
SQL	Structured Query Language
P2P	Peer to Peer
XML	Extensible Markup Language

1 INTRODUCTION

The background and motivation of the thesis work are provided first, followed by a description of the study scope and objectives. Lastly, the thesis structure is described.

1.1 Background and Motivation

Today, technologies are an integral part of the world economy. According to McKinsey Global Institute analysis (2013), 12 disruptive technologies will significantly change the situation in the global market by 2025. Their potential economic impact is estimated to be between 14 and 33 trillion US dollars. These 12 high-potential technologies discussed in the Institute's analysis do not include Blockchain. Nonetheless, even though being out of the list, Blockchain might become a dark horse in the competition, because it will influence most of the listed technologies, i.e. Cloud, Internet of Things, and Autonomous cars. Many sources which are dedicated to technology industry have started to share the opinion that Blockchain itself might become one of the most powerful technologies of tomorrow. (TechCrunch 2015.)

Firstly, the technology became well-known in 2008 when it was conceptualized by either an individual or a group of founders of Bitcoin under the name of Satoshi Nakamoto in a research paper titled "Bitcoin: A Peer-to-Peer Electronic Cash System". Blockchain was used as a core component for Bitcoin cryptocurrency. There, the concept of technology was referred to as "block" and "chain". By year 2014, Blockchain had become a term which is referring to new applications of the distributed database. (Kariappa 2015.)

Finally, in 2017 it is discussed that Blockchain is a foundational technology. It has an ability to establish new foundations for both economic and social systems. However, while the influence of the technology is to be enormous, it might take years for Blockchain to be implemented into economic and social infrastructure systems. The adoption process will be smooth and steady, not rapid, because waves of technological and social changes still gain momentum. (Iansiti & Lakhani 2017.)

The motivation of conducting this study is to analyze the Blockchain as a foundational technology, which is already not just a part of Bitcoin, but not yet considered as a “new Internet”. It is somewhere between these two states. This study aims to find the current position of Blockchain at the global technological scene and to discuss possibilities of the technology implementation. Use cases of Blockchain will be discussed in order to understand its applicability in real-life environment.

The second reason why this research is conducted is the researcher’s personal interest in Blockchain. The researcher aims to discover application challenges provided by Blockchain and discuss future perspectives of the technology. Implementation of the technology will cause evolvement of human institutions such as social and economic systems. Following the discussions of the challenges of Blockchain, technological evolution and industry perspective will be considered.

1.2 Research Scope and Objectives

To begin with, the thesis work explores and defines the concept of the Blockchain technology. The study analyzes its principles of work, technical specifications and features of Blockchain, as well as identifies economic, social and technical implication provided by the technology. Moreover, the thesis work provides a brief history of Blockchain and previous similar concepts related to it.

This study specifically analyzes the current level of the Blockchain technology and areas where it is being implemented. The thesis work discovers gaps between the current usage of the technology and the potential of its implementation in various areas. As far as Blockchain can be used in wide range of use cases, from intellectual rights to elections transparency, the thesis work will be narrowed down to several specific cases.

The scope does not include the implementation plan for companies and specific areas. However, implementation challenges are overviewed and the reasons of the Blockchain adaptation are provided for supply chain management and Internet of Things. The researcher’s aim is to analyze the Blockchain technology phenomenon and discuss its possibilities of implementation.

The objective of the thesis is to conduct a research which reviews a relevant role of Blockchain in the global economy and analyzes how the technology might be adopted by specific industries. This study aims to analyze the Blockchain technology phenomenon and understand how it can change the world economy, lives of ordinary people and technologies themselves. Finally, use cases and business value of implementation of Blockchain are provided.

1.3 Research Questions

The following research are presented and described. The questions, which will be answered by this study, are as follows:

1. What are the concept and principles of the Blockchain technology and which essential elements does it include?

This research question is separated into two parts. The first part is targeted to define the concept of Blockchain. The second one helps to consider technological blueprint and understand why it is innovative in modern environment. In order to answer the question, the essentials of Blockchain are discussed.

2. Which industries can potentially benefit from the adoption of the Blockchain technology and how they can do it?

The second research question looks for the business areas for the technology implementation. Areas of application analysis enables to overview practical use cases of Blockchain. Moreover, the outcomes of the technology usage will be described.

3. What are the potential social, economic, political and technological challenges in the implementation of the Blockchain technology?

The aim of this research question is to analyze and point out possible economic, social and technological obstacles, which can be reasoned by Blockchain. The findings are to be researched and described at first. Additionally, the ways to overcome these obstacles will be discussed.

1.4 Research Methodology

This thesis work uses the exploratory research approach based on literature analysis. The research method is chosen due to the freshness of the topic studied. By conducting the thesis work, the concept of Blockchain can be defined. It is also possible to deeply examine the phenomenon of the technology and discuss use cases and implications caused by it. The Blockchain, firstly founded as a basis technology of Bitcoin and referred to as “block chain” (Nakamoto 2008), evolved and has been re-conceptualized in 2014 and requires further research and development.

According to van Wyk (2012, 8), “the main aim of exploratory research is to identify the boundaries of the environment in which the problems, opportunities or situations of interest are likely to reside and to identify the salient factors or variables that might be found there and be of relevance to the research.” Hence, an exploratory research approach based on literature analysis was selected for this thesis work to ensure identification of environmental obstacles and give recommendations for the Blockchain technology usage for supply chain management and Internet of Things. The work defines the Blockchain concept and describes related notions, which grow its potential for implementation in supply chains and Internet of Things. The data used in the thesis research is up to date and covers the research topic.

As the Blockchain technology is novel and it embraces majority of industries, there is no possibility to collect empirical data, due to inability to indicate and reach an appropriate focus group. Thus, all the provided data was collected by conducting a desk research. The used sources were accessed via the electronic library of Lapland University of Applied Sciences, ACM electronic library, Google Scholar and a variety of articles and e-books accessed from the World Web. Qualitative data was used for ensuring research theory drawbacks with descriptions provided by various authors of the literature used.

By conducting the desk research including profound literature analysis, the theoretical basis of this research was formulated. It discussed the concept of

Blockchain and related technologies. Research findings were used for analyzing technology implementation cases and discussing their possible bottlenecks.

1.5 Thesis Structure

The rest of this thesis work is divided into six chapters as follows. In chapter 2, essentials of the Blockchain technology are discussed by providing a brief history of the technology, principles of its work and similar to Blockchain concepts. In chapter 3, the main principles and business value of the technology are presented. Chapter 4 is dedicated to analyze Blockchain as a foundational technology based on use cases in supply chain management and Internet of Things. In chapter 5, implications caused by Blockchain are identified. Chapter 6 draws conclusions on the results of the research and suggests further studies to be conducted.

2 ESSENTIALS OF BLOCKCHAIN TECHNOLOGY

The technical aspects of Blockchain's work are described to start with followed by a review of the history of the technology. Thirdly, the concepts which are similar to Blockchain are defined and discussed. Lastly, the summary of the chapter is provided.

There is a plenty of implementations of the Blockchain technology. The first subchapter discussion on Blockchain describes the oldest and still the most common implementation of this technology in Bitcoin cryptocurrency, as it is essential for understanding the initial concept. Additions to the core technology, which were developed in other Blockchain implementations are discussed in the study. Thus, it is specified in the text which implementation case is considered either Bitcoin's Blockchain or Ethereum's Blockchain.

2.1 Concept and Technical Aspects of Blockchain Work

Before the Blockchain invention, there was no way to manage individual activities over the Internet without centralized control to ensure non repudiation of data. There was no trust between the parties that none of them could change the data for their own profit without agreement with the second party. A group of distributed individuals could not verify transactions without relying on centralized authority. This problem was mostly known as the "Byzantine Generals Problem" (Wright & De Filippi 2015 citing Lamport 1982). It was questioned how distributed computers could make a decision without relying on a central authority, for the network of the computers to be able to defense against an attack from ill-intentioned actors. The problem assumed that the three parts of the Byzantine army are waiting outside an enemy city and planning to assault it. The generals of each division are independent, and to be able to conquer the city, they need to have a common course of action. However, the generals' abilities to communicate with one another are restricted to a messenger service, and there is a traitor who is actively ruining the generals' actions to make a consoled decision by either tricking them to attack before others or missing some relevant data so that there is no opportunity to make united attack (Wright & De Filippi 2015, 5.)

Blockchain uses a probabilistic approach for elaborating a solution for the problem of Byzantine Generals (Nakamoto 2008, 3). Data is moving through a network of computers which increases transparency and reliability. As a result, the ability of potential attackers to corrupt a distributed database with fake data is reduced significantly. The only case to attack is when the attacker can use much more of the computational power than the entire network. The protocols of the Blockchain can ensure that transactions are correct and not double made. (Wright & De Filippi, 2015, 6.)

As it was stated in the introduction chapter, Blockchain was mentioned for the first time in the Bitcoin research paper (Nakamoto, 2008). The definition in 2008: was basic and straightforward, i.e. Blockchain is a technology which runs Bitcoin. However, this definition lacks important details. The Blockchain is a chain of connected blocks that consist of data about transactions. Each block has the hash of the previous block, timestamp and transactional data (Figure 1). When the block is completed with transactions, a new block is created and it contains the same attributes and hash of the previous one.

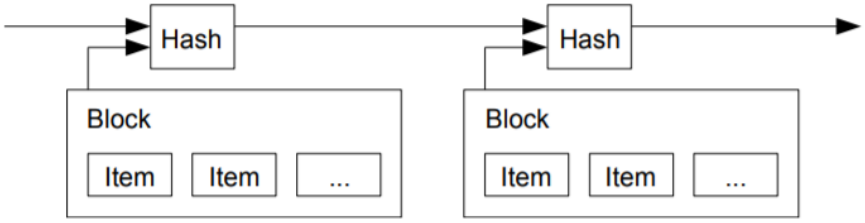

Figure 1. Structured connection of Blockchain's blocks (Nakamoto 2008, 2)

The Blockchain may be described as a chronological database of transactions, which are recorded into blocks and checked by other computers in the Blockchain network. Moreover, each block contains a complex mathematical equation or hash functions, which are proving the integrity and non-repudiation of its data. Each member of the network has a copy of the Blockchain database and the computers are synchronized frequently to make sure that all of them have the original and correct version of shared database.

The copy of Blockchain consists of all transactions happened in the currency. Thus, any node of network can discover a balance of each address at any timeframe. From a random block, there is only one chain can be built to the

initial block. In a case when the block is mined and a few others are created just in several seconds apart, the nodes build onto the block they received first. The first mined block will be included as a part of the main chain, because the chain will be the longest at that moment. However, from the initial block, there might be several chains or forks (Figure 2).

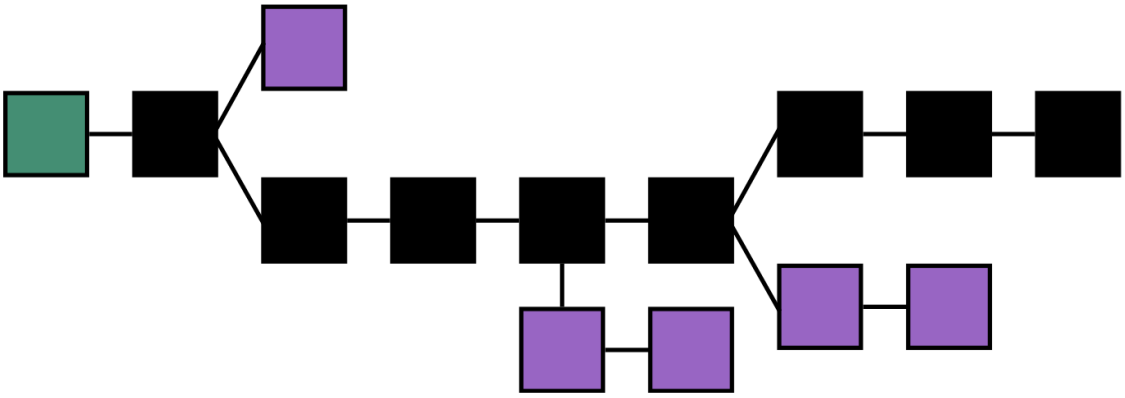

Figure 2. Main and forked chains into Blockchain (Wright & De Filippi 2015, 8)

In Figure 2, the main chain indicated in black has the longest combination of blocks from the genesis or initial block shown in green to the current block. The side blocks or forks illustrated in purple are not related to the main chain. The Blockchain is shared to all the networks members with use of a flood protocol.

Blockchain ensures decentralized, public and encrypted storage of transactions. The process of Blockchain functionality is as follows (Kehril 2016, 9-10):

- User A makes a transaction to User B through his or her client.
- Blockchain miners receive an order on the transaction and they add it to their current mining block.
- One of the miners completes the block faster than others; in other words, the block is mined.
- This new mined block is added as a last mined block in the Blockchain and the copy of Blockchain in broadcasted through the network.

Mining of the block is a process of recording new transactions on a public ledger of approved ones. The ledger of the approved transactions is referred to as Blockchain, because it is a chain of blocks. The Blockchain functionality as a

technology and a system is to approve transaction facts to the network as they take place. Network members use the Blockchain technology to differentiate firstly requested transactions from someone who try to spend coins for the second time, while they have already been spent before. (Kehril 2016, 12.)

To have a new mined block accepted by other network members, miners should complete a Proof of Work including the entire data in the block. The Proof of Work is a consensus mechanism, which requires the condition that specific nodes on the network, referred to as a “miners”, spend computational power to solve mathematical puzzles while other nodes just approve that puzzle solution. (Wright & De Filippi 2015, 6 citing Bonneau 2015.)

In order to motivate miners to spend computational power on mining, the reward system is used. The first miner, who provides the solution of the puzzle, is incentivized by some amount of cryptocurrency or with agreed transaction fees. In Bitcoin’s version of Blockchain, there is a limitation of 10 minutes for mining each new block due to the suggestion that the Blockchain size would be growing 1.2GB per year. (Nakamoto 2008, 4.)

To verify that only correct transactions are added into Blockchain, the network makes a confirmation that the action is valid and has no conflicts with previous transactions. A new block of chain will be added to the end of it only when the members of the network make a decision what the transaction is correct. Consensus within the network is saved through various voting mechanisms, one of which is the Proof of Work. It is dependent on the computational power assigned to the network. (Wright & De Filippi, 2015, 8.)

When a block has been recorded in the Blockchain, it cannot be erased. The transactions of this block are visible and checked by each member of the network. From this moment on, the block is a permanent record of the blockchain and it can be used by network members in order to coordinate an action or prove transaction. (Wright & De Filippi, 2015, 8.)

To change a block, it is required to regenerate all successors and redo the work they contain. It only can be achieved by making a new block containing the same predecessor. This means that Blockchain is highly protected from the

tampering. The most common scheme of proof-of-work is using SHA-256 algorithm and it is also discussed in Bitcoin's research paper by Nakamoto (2008). The target of algorithm is a 256-bit number which is shared by all Bitcoin members. If a lower target is set, it would be complicated and more computational power will be consumed to mine a new block. A valid block is the one which hash value is less than the current hash target. When a new block is produced, it contains acknowledges of the work that was done to generate it. (Kehril 2016, 11.)

2.2 History of Blockchain

In order to understand the concept of Blockchain, similar theoretical and practical approaches are required to be discussed. The technology became widely known in 2008 with the invention of the Bitcoin. However, the used ideas have their roots in the 1980's and 1990's in the 20th century.

According to Pilkington (2015, citing Chaum 1983), the first concept of digital currency was developed and conceptualized relying on central server architecture, the function of which was to avoid double-spending. However, this concept still was failing to have unity of double-spending avoidance, anonymity and centralization. There were a few more concepts in the 1990's. In 1991, a research on cryptographically secured chain of blocks was conducted by Haber and Stornetta. Later in 1996, there was a publication by Anderson, and in 1997 by Doyle. At the same time in late 1990's, Szabo was developing a mechanism for a decentralized digital currency which was named as bit gold.

More than 10 years later, the Bitcoin cryptocurrency was introduced. The centralized system was replaced by a mechanism of consensus, which relies on proof of work (Back et al 2014, 3). The initial Bitcoin technology of Blockchain based on a decentralized system had evolved Chaum's concept with a new vision.

Today, the concept of Blockchain is widely spread, while there are opposite opinions about the technology and even its history. In Nakamoto (2008) white paper, the nouns "block" and "chain" were used separately and, initially, the

technology was named as block chain. However, by 2016 the concept had merged into one word – “Blockchain”.

According to Gupta (2017), there have been five major Blockchain-based inventions in the last ten years. The inventions are briefly discussed below by drawing from Gupta (2017).

- The first major Blockchain-based innovation was Bitcoin, which is a digital currency. Its market capitalization now is accounted between $10–$20 billion dollars. Moreover, Bitcoin is used by millions of people for online and secure payments, also including the banking sector.

- The second invention was the Blockchain itself, which despite of being the hidden technology has allowed Bitcoin to be separated from the currency and used for all types of cooperation. Most major financial institutions are doing Blockchain related research at the moment. Forecasts show that 15% of global banks are going to use Blockchain in 2017.

- The third innovation was named as a “smart contract”. In the second-generation it is called Ethereum. The Ethereum platform develops small programs directly into Blockchain. This allowed financial tools such as loans or bonds to be presented, rather than currency tokens of the bitcoin. The Ethereum market capitalization accounts in 2017 around a billion US dollar, and a plenty of projects are moving to the market.

- The fourth major innovation, the most innovative of the Blockchain thinking, is “proof of stake.” The actual generation of Blockchains is secured by “proof of work” where decisions are made by a group with the largest amount of computing power. These groups are known as “miners” and they control huge data centers to ensure security, by having cryptocurrency payments. Proof of stake systems remove these data centers, and replace them with complex financial tools, with similar or higher security level.

- The fifth major innovation is a Blockchain scaling. At present, in the Blockchain, each member in the network processes every transaction that is really slow. With the use of the scaled Blockchain, there is a possibility to speed up the process without any threats to security. The idea is to find out how many computers are required to validate each transaction and optimize the work process with use of these statistics.

All these innovations were invented during the past 10 years, but the full potential of technology is still hidden and could not be estimated yet. This means that in the next few years, the development of the technology will be continued and some of the Blockchain-based solutions could already become an important part of humans' lives, such as Facebook became a vital part of one billion people just in 13 years.

2.3 Related Concepts

In the previous subchapters, the common comprehension and functions of the Bitcoin vision of Blockchain were discussed. In this subchapter, the concepts and improvements in the Blockchain implementation developed after the Bitcoin's invention will be discussed and defined.

To begin with, a brief timeline of the Blockchain evolution will be presented. In the period of 2008-2010, there was a setting of Bitcoin's role as a digital currency. For example, "The Bitcoin Market" allowed people to exchange fiat money for Bitcoins in October 2009. In February 2011, Bitcoin value reached an important parity with USD as one USD was equal to one Bitcoin. During the next three years until 2014, there was a growth of market capitalization, and as follows, critical mass of companies and technologies realized that Blockchain, the fundamental Bitcoin technology, has its own potential (Insidebitcoins 2014). In December 2013, a vital release occurred, as Vitalik Buterin published his white paper about "Ethereum Project", which is a Blockchain-based platform with an ability to develop decentralized application. (Mann 2016.)

This platform was launched in July 2015 and it caused several major Blockchain changes comparing to Blockchain of Bitcoin. Firstly, Bitcoin and Ethereum are different in their purpose and capability. Bitcoin is focused on tracking the

ownership of digital currency, while Ethereum Blockchain's aim is to run a programming code of any decentralized application, referred to as Dapp. Secondly, instead of mining for Bitcoin, Ethereum uses their own Ether that is not only tradable cryptocurrency, but also payment method of transaction fees for application developers using Ethereum environment. (Bajpai 2017.)

One of the main innovations of Ethereum is the usage of smart contracts. Initially formulated in 1997, it began a transformation from a concept to a real world technology: digital proven contracts where the duration and correctness of contractual conditions go automatically, without human interactions, which significantly reduce possibility of mistake or fraud. (Wright & De Filippi 2015, 10.)

There are cases, when smart contracts prove the correctness of a contractual agreement, which legal states have been fixed into the source code. Parties of the contract are able to manage their relationship more efficiently, with the use of a self-executing tool and reducing the ability to misunderstand contract points because of ambiguity of the words. By relying on a source code, parties are willing to improve contractual performance and think about the agreement's details before execution. Moreover, smart contracts present new codified relationships, which are regulated and powered by the code. However, these relationships are not essentially defined by underlying contractual points or responsibilities. As far as Blockchain allows performance of self-executing transactions, both parties are able to communicate with each other without restrictions and the technical requirement to frequently check predefined contract details. (Wright & De Filippi 2015, 11.)

The most common cases of the smart contract usage today are non-controlled execution of futures and swaps. However, they are also being used for the organization of the goods sale process through the Internet without a centralized control authority. (Wright & De Filippi 2015, 11.)

Moreover, there is the Ethereum Virtual Machine (hereinafter EVM) that is the runtime environment for smart contracts in Ethereum. The EVM is providing security and it executes the code which could not be trusted by computers globally. This project's aim is to prevent Denial-of-Service attacks that are the

common security issues in the cryptocurrency world. EVM is isolated from the Blockchain and has sandbox mode. It means that untrusted code executed inside the EVM could not access the network or database. Additionally, smart contracts have narrow access to other smart contracts. (Ethdocs 2016.)

The Blockchain principle of work makes it impossible to backup system to some state in the history. However, there is an ability to do a side chain or hard fork. According to Bitcoin Glossary (2017), hard fork is “a permanent divergence in the block chain, commonly occurs when non-upgraded nodes can’t validate blocks created by upgraded nodes that follow newer consensus rules”. In other words, a hard fork is a constant splitting from the previous version of Blockchain. The nodes of the previous version of Blockchain would not be accepted by the newest ones. Ethereum did a first cryptocurrency hard-fork in 2016 as a result of a collapse of The DAO project, by splitting Ethereum Classic from the main Blockchain. The Bitcoin hard-fork in August 2017 was caused by technical changes of block size in order to boost Bitcoin's transaction capacity.

2.4 Summary

The Blockchain is a relatively young technology, which was firstly conceptualized about ten years ago as a part of Bitcoin cryptocurrency. It has been only in the last years that it has become the global phenomenon as an independent technology and revolutionary discovery, such as the Internet invention was. From historical point of view, Blockchain is a mix of algorithms and concepts, which was theoretically developed in the 1980’s and 1990’s and practically applied 10-20 years later. From the technological point of view, Blockchain applies the best cryptographic algorithms and solves some critical issues, such as double-spending problem and third parties’ participation in transactions by relying on decentralization and validation of actions by network members, referred to as mining.

Despite of being a well-known technology, there were several of other inventions besides Bitcoin’s Blockchains, which brought some important updates to the Blockchain technology. Ethereum’s Blockchain has introduced the platform for Blockchain-based solutions development and implemented

smart contracts to the technology, which made it more flexible and variable by enabled predefining conditions on the program. Thus, the Blockchain technology can be adapted in many industries and solutions and significantly change them by providing transparency, absence of a third-party and secure P2P connections.

3 MAIN PRINCIPLES AND BUSINESS VALUE OF BLOCKCHAIN TECHNOLOGY

Started as a technology that ensures cryptocurrency maintenance, Blockchain has evolved significantly during its relatively short history. After the application of smart contracts in 2014, the technology was reconsidered by public and named as Blockchain 2.0. The innovation was in the broadening of possibilities of usage. If Bitcoin's Blockchain was a subject of interest for financial industries, the Blockchain 2.0 became interesting for non-financial either, because the smart contracts are able to radically automatize processes in various industries, which can change the way the Blockchain technology might be used.

As Tapscott (2016) defined in his book "Blockchain Revolution", there are seven principles of the Blockchain technology as follows:

- Networked Integrity
- Distributed Power
- Value as Incentive
- Security
- Privacy
- Rights Preserved
- Inclusion

Discussion and description of each of these principles will be followed with related use cases. Moreover, business value of each implementation will be discovered and explained.

3.1 Networked Integrity

The first principle of the Blockchain technology stated by Tapscott (2016) is one of the most important. Trustworthiness of the network is defined by its structure and technical aspects and not relies on external factors. Network integrity is

created by each action of nodes and due to distributed database, it is not owned by one main member. Oppositely, it is owned, ensured and traced by every network member. They can deliver value straight to the second party and have no doubts on partner's honesty because the system provides integrity. The main expectations of honesty such as realizing agreed conditions, respect second party interests and transparency of actions are encoded in a program code and could not be manipulated or affected without both parties agreement. Even if one of the nodes will decide to ruin the agreements, it would be traced over the Blockchain network and have negative reputational, financial and other impacts for the fraud party. (Tapscott 2016, 45.)

The problem solved by Blockchain's networked integrity principle is described below. In the previous time, before cryptocurrencies invention and Blockchain usage, people could not pay to someone directly. The obstacle of direct payments is known as double-spending and it was already discussed before. There is always an opportunity to spend a specific amount of digital money through the Internet twice, as a confirmation of payment and charging the money takes a few business days. For empowering direct payments, there is a need for a third party or centralized money transfer solution, such as Western Union or online payment service PayPal. As it was stated, confirmation of payment takes several days or even weeks, depending on parts of the world and amount of intermediaries that are involved into the transaction chain from one party to another. (Tapscott 2016, 46.)

Blockchain provides an opportunity to avoid third parties' participation in straight payment between two parties. The guarantee of avoiding double-spending is for sure provided within the solution. To make it real, the consensus mechanism is used. By merging various concepts and theories, such as decentralized structure of database, storing data as blocks in a chain form and applying encryption algorithms, it became possible. Due to the public availability of Blockchain, it is possible to trace actions that are done in the network. No transactions can be hidden and, therefore, cryptocurrencies are even can be considered as more transparent for transactions than cash currency. (Tapscott 2016, 48-49.)

Not only intermediaries are absent in Blockchain-based payment, but also misunderstanding and conflicts between parties became more transparent and hence more solvable. The human factor or personal interest is also eliminated from direct payments as possible fail factors.

Various projects are being developed today, which are using networked integrity principle. Both of financial and non-financial cases of implementation can be found. However, there are many opportunities to develop new solutions. Several operating solutions are listed and described below.

Medici (Kelleher 2014) is a stock market which is using Blockchain 2.0 functionality to implement counterparties. It is aimed to create a stock exchange of securities. Counterparty is a protocol which is using smart contract to execute traditional financial tools. The smart contract is simplifying, ensuring or controlling the contract details correctness. It makes useless to have an assistance of intermediaries, e.g. broker or bank. (Crosby, Nachiappan, Pattanayak, Verma & Kalyanaraman 2015, 14.)

Augur (2016) is a decentralized prediction market that will allow users to forecast events and be rewarded for it. Ethereum Blockchain is a basis of the platform. It can be used as a distributed oracle system, supporting various smart contracts to submit questions and by answering discover the real world with no trust or support of any person or organization. (Crosby, Nachiappan, Pattanayak, Verma & Kalyanaraman 2015, 14.)

The ability to avoid interaction with third party and do actions safely is a huge change and challenge for society and industries. There were no any similar forms of exchange data or value before. This means that new opportunities for creation new businesses, society organization forms and business platforms have appeared. Trust between parties is an essential condition to ensure digital economy and system for reliable mass collaboration. (Tapscott, 2016.)

3.2 Distributed Power

The second principle that was described by Tapscott (2016) is Distributed Power. It states that the power of network is spit through it by peer-to-peer

connection and there is no centralized authority place. No member can damage or break the system. If one or a few nodes are disconnected from the major network, the system will continue its maintenance. There is only one opportunity to damage network or overwrite Blockchain and, as it was discussed before, it is known as the attack of 51%, as it requires majority of network to approve the Blockchain changes. (Tapscott 2016, 49.)

By Blockchain's Distributed Power principle the problem of data access was solved. In systems with centralized control, such as social networks or governmental databases, there is the ability to access and use private data without user's knowledge about it. The accessed data might be analyzed, shared, sold, or stolen, while the owner of the data has no warning about the action occurred. (Tapscott 2016, 49.)

However, by Blockchain's Distributed Power principle this kind of shared access to confidential information is restricted by a user. With the use of distribution of database, the system ensures its defense from centralized hacking, which can be used for centralized database. The structure of distributed database is also used by widely-known volunteer network BitTorrent: as long as there are members in the network, it is alive. (Tapscott 2016, 49.)

From a business value point of view, distributed principle is profitable for users hiding from governmental control or law jurisdiction. It can have advantages and disadvantages at the same time. As an example, both political dissidents and drug dealers can be secured when using a distributed solution. Even though Blockchain's distributed structure just provides an opportunity for anonymity, this is a society's moral challenge on how to use it in a right way. (Tapscott 2016, 50.)

The principle of distributed power and distribution itself is used in plenty of Blockchain-based solutions already. Most of all, e-government and distributed storage solutions are developed.

For example, Storj (2014) is using Blockchain for P2P distribution of cloud storage. The platform allows users to store and share documents without a requirement to have a third-party as a data provider. Thus, it is possible to

share not occupied internet bandwidth and empty storage space in users' devices. To store large files, there is a fee in return for the storage space, which is based on Bitcoin. (Crosby, Nachiappan, Pattanayak, Verma & Kalyanaraman 2015, 17.)

Stampery (2015) is providing a Blockchain-based solution of documents' certification. It ensures certifying of data up to exabytes volumes and it is based on the most popular Blockchain of Ethereum and Bitcoin. Advocating companies are using Stampery's service as a low-cost solution for documents certification. Stampery has integration with Estonian e-Residency IDs, which is vital for global adoption of that kind of services. (Crosby, Nachiappan, Pattanayak, Verma & Kalyanaraman 2015, 15.)

Decentralization of a platform allows eliminating common data failures, and accordingly increases security, privacy and control of data. Storj as a P2P solution struggles to stimulate members to actively participate in the network to keep it working. Storj can time to time with means of cryptography validate the integrity and availability of data, and provide rewarding fees to members who maintain the file. In such a case, Bitcoin-based returns serve as stimulation and payment while a Blockchain is used as storage for a file's metadata. (Crosby, Nachiappan, Pattanayak, Verma & Kalyanaraman 2015, 17.)

The distributed power principle is significant for society and governments. Distributed Blockchain solution can enable realization of new business models as well as disrupt the most vexing social issues (Tapscott, 2016). Additionally, there is an ability to ensure citizens' rights to control the government power and even provide the real opportunity for society to control it.

3.3 Value as Incentive

According to Tapscott (2016), there is Value as Incentive principle of Blockchain. The meaning of this principle is correlated with the Game Theory and considered as a win-win situation for all active parties of the network. Blockchain is based on rewarding the nodes that develop and ensure the maintenance of the system. Thus, the miners of the Blockchain systems receive the tokens of the platform they are mining for. (Tapscott 2016, 50.)

Value as Incentive solves the inequality issue. When the Internet was invented, corporations empowered with the rights over the networks gained much more values for themselves than they should. Financial institutions used the networks to achieve their own goals and citizens could not compete with them. Data mining was profitable for banks, but not for customers, whose data was unsecured and stolen. (Tapscott 2016, 51.)

Applying the Game Theory in the Blockchain concept, it is possible to achieve equality in nodes relations in the network and provide value for all parties. The requirement of the consensus mechanism merged with rewarding in tokens monetary reward for mining data, makes the process of verification of transaction profitable for miners. Thus, many mining farms were developed at the moment as the business model which brings monetary benefit. However, other users are also satisfied and provided with unique service. All parties have their own benefits and continue using the system and keep it alive. (Tapscott 2016, 51.)

The implementations of value as the incentive principle of Blockchain are being developed today. It is mostly common in alternative energy generation and distribution. There is a New York based ongoing experiment called Brooklyn Microgrid (2012) on building solar energy aggregation system by using Blockchain. The connected devices have identities and ranks based on their history records. Local citizens are able to purchase power easier and rely on trusted devices, which have already proved their solar production. All parties that use the system make their benefit, one party gets financial reward, another finds the trusted local provider of solar energy. (Brooklyn Microgrid 2012.)

There are great opportunities for this principle to find more implementations and being adapted to various industries and use cases. The platform, empowered by Blockchain is able to financially stimulate people and even devices to contribute into the network and ensure its stability. A huge variety of implementation can be considered, starting from P2P solar network finishing with developers' community, which stimulates best contributors. (Tapscott, 2016, 53.)

3.4 Security

The fourth principle of Blockchain that was empathized by Tapscott (2016) is Security. Measures of its protection are defined by the Blockchain's structure and have no single point of failure. Additionally, confidentiality, authenticity and nonrepudiation of activities are ensured. The usage of cryptography in the network is a must condition. Inappropriate behavior in the network is not supported by the community and restricted with isolation of address from the network. (Tapscott 2016, 54.)

There are several issues, which are solved by the Blockchain's security principle, such as hacking, identity theft, phishing, fraud, and malware. Before Blockchain invention, the Internet was developed not enough in a way to secure users and financial transactions. Weak and common passwords used by the majority of the Internet users did not provide required level of data protection. Means of data protection, access control and identity verification are not responsive and still can be hacked. In order to send money straightforward between two parties, there is a need in hack-proofed solutions. (Tapscott 2016, 54.)

The Blockchain principle of security allows solving the problems described above. First of all, public key infrastructure (hereinafter PKI) is used for ensuring the systems security. PKI is a form of "asymmetric" cryptography, which is based on the two keys for encryption and decryption. Users of Blockchain hold hashed keys to their addresses or wallets and they are able to access them by imputing the private key. Additionally, the Bitcoin's Blockchain is using SHA-256 encrypting algorithm which can be hacked just in a theory assumption, due to the complexness of the encryption. Finally, the chain structure of Blockchain provides extra security of data as it becomes more secure during the time because of its length. (Tapscott 2016, 54-55.)

One of the industries which are highly interested in the Blockchain's security is insurance industry. There is already a developed solution for them. Everledger (2015) is a Blockchain-based startup which provides reduction of risks for financial institutions, insurers and marketplaces. The permanent ledger of a

diamond certification and transaction history is created by the company with use of Blockchain. The properties of each diamond such as height, width, depth, and weight are encrypted and registered in the ledger. Insurance companies, law agencies and owners can verify diamonds via the platform. The startup provides a smart, secure and easy way to use web service's application programming interface or API for accessing data about a diamond and creation/reading/changing cases by insurance companies on diamonds. (Crosby, Nachiappan, Pattanayak, Verma & Kalyanaraman 2015, 14.)

The security principle of Blockchain can be considered as the major one as it is the main characteristic provided by the technology today. In the world where digital warning can collapse many areas of the human life, the Blockchain's transparency and security are able to ensure stability and development of global economy and specific industries. (Tapscott 2016, 55.)

3.5 Privacy

The fifth principle of Blockchain stated by Tapscott (2016) is privacy. Users should have an option to control the data they are sharing with the system. Most of Web services do not request the user's ID copy, but in order to do registration on the platform and become a member, one needs to share the name, email and other confidential data. Moreover, there is an absence of trust to the platforms, as there are no tools to trace on how the information is used. However, the privacy can be settled into the system architecture by changing the way of user's verification and data required to do it. (Tapscott 2016, 56.)

In free and democratic societies, an individual's privacy is a basic human right, which should be respected. However, the Internet is based on centralized solutions, which are collecting, analyzing and sharing users' confidential data without notifying them about it. There is a problem of lack of tools and services over the Internet to use them privately, without providing sensitive information. Additionally, by storing information on centralized server, the abilities of hackers to achieve data are increased. For example, there is a case of Ashley Madison dating service, which was hacked in 2015 and all of users' data was stolen. In the stolen databases, name and governmental email of former British prime-

minister Tony Blair were found, but there is no email verification on the site (Bolton 2015). In summary, there are two major privacy issues in the Internet: collecting and using personal data without proper permission and inability of services to provide adequate security measures against centralized hacks. (Tapscott 2016, 56-57.)

The usage of Blockchain is going to fix the problems discussed above. The Blockchain does not require confidential data to operate. No email, name or any other personal information is collected. Hence, due to the Blockchain structure, it allows and ensures privacy and anonymity of users. In addition, the identification and verification layers are divided from the transactional layer (Tapscott, 2016). During the process of transaction, there is no reference to identity, but there is a reference to authorization of the address and verification of transaction. It is uncommon scheme of service usage, as most of the services are based on a personal verification, such as credit cards usage, phone numbers, and social networks.

Monero (2014) is a Blockchain-based cryptocurrency forked from Bytecoin and focusing on privacy, distribution and scalability. The user is provided with secure and untraceable mean of payment. Unlike other cryptocurrencies, Monero rebuilt Bitcoin’s Blockchain with different algorithms and achieved more features. For example, despite of the public ledger of Bitcoin, Monero hides publicly available balance of an address and no one can trace transactions. Moreover, the platform uses stealth address on public ledger and by this provides more confidentiality to users. (Monero 2014.)

The Blockchain principle of privacy provides a new way of organizing the systems and reorganizes the way of personal identity shared over the Internet. The users receive the tools to realize their human rights. The application of this principle is going to change the society and corporates significantly in a way of a better transparency and integrity. It is a switch from big data to private (Tapscott 2016, 59.)

3.6 Rights Preserved

The principle of Right Preserved that was discussed by Tapscott (2016, 60) means that ownership rights should be transparent and prosecute. Personal freedoms are admitted and esteemed. All humans are born with a set of inherent rights, which should be protected where it is possible.

The problem with the current state of rights is that there is lack of efficiency in execution. The Internet is efficient in sharing data. News, art, music, photos, videos and tons of content are shared daily. However, the licensing of an author's content is primitive. The content maker still needs to find an intermediary to share his or her data. For sure, it makes the content receiving process complicated, pricing unclear and licensing meaningless, as there is no clear way of how to trace the execution of intellectual rights. Finally, there is an issue with the free reproduction of content or digital piracy. (Tapscott 2016, 60.)

In order to solve the above problems, the Right Preserved Blockchain's principle can be applied. The Blockchain can be used to verify the ownership and define the conditions of how to spread the content by applying smart contracts. The creator receives the reliable tool for content sharing without the need of a middleman and with the ability to clearly state responsibilities of sides. Other users can support artists or producers straight and request citation or rights to use the media for their own purposes. By cryptographical tools of technology, it is possible to prove ownership and preserve records without censoring it that is also important. (Tapscott 2016, 61.)

There are a few implementations of Blockchain for rights regulation. BlockNotary (2015) is an application for iOS, which enables users to provide proof of existence of any kind of digital content, such as images, documents, or videos with support of TestNet3 or Bitcoin networks. (Crosby, Nachiappan, Pattanayak, Verma & Kalyanaraman 2015, 15.)

Dot Blockchain Media (2016) is a Blockchain implementation for expression media rights into the files. The owners of music are able to control the transparency of rights where it is required.

The right field is an excellent opportunity for Blockchain, which can make a difference by providing a detailed and distributed ledger containing the data about the intellectual rights. Moreover, the usage of smart contracts can add an ability to define the rights ownership information and the royalty share. Finally, there is an ability to develop a new understanding of right management systems (Tapscott, 2016), which would have both social and economic and probably political impact.

3.7 Inclusion

According to Tapscott (2016), there is the Inclusion principle of Blockchain. It states that economy is the most effective in case when it works for everyone needs. The conditions of participating in the global economy should be lowered, which is possible to be achieved by establishing distributed platform businesses and not just redistributed capitalism. (Tapscott, 2016, 63.)

The problem that is solved by this principle is described below. When the Internet was invented, it was discussed as a communication tool, which could bring prosperity to many entrepreneurs with a lack of starting capital. In some ways, it provided new opportunities for fresh ideas to be realized. However, there is much more space for further growth. Most financial institutions have user-friendly solutions with mobile payments and touchless payments, but all of them have the same basis with intermediaries between consumer and provider of service. The transaction fees ruin all of the benefits of user-friendly solutions. (Tapscott 2016, 63.)

Blockchain can increase effectiveness and provide new opportunities for fresh incomers. By having minimalistic requirements for Blockchain, when no personal data is required, it is possible to reinforce the global economy. Elimination of transaction fees, lowering the barriers for business operations, such as opening a bank account, investing or gaining investments can dramatically change the global economy. However, technical limitations of the Internet bandwidth can play a significant role and slow down the process.

A few of the solutions based on inclusion principle are already existing in the market. As an example, there is Augur, which is a decentralized prediction

market that will allow users to forecast events and be rewarded for it. Ethereum Blockchain is a basis of the platform. It can be used as a distributed oracle system, supporting various smart contracts to submit questions and by answering them, discover the real world with no trust or support of any person or organization.

The principle of Inclusion can significantly change the way people live. There is an opportunity to end social, economic and racial hegemony and various discriminations (Tapscott, 2016). The lowering of the barriers will include multiple areas and cases, such as elimination of inequality based on political views, the way of a person's life, preferences among others. The process of changes will take decades, but it was already started and, therefore, humanity has abilities to boost it. (Tapscott 2016, 65.)

4 BLOCKCHAIN AS A FOUNDATIONAL TECHNOLOGY AND USE CASES

According to Iansiti and Lakhani (2017), Blockchain is not a disruptive technology, but foundational. Disruptive is a technology, which creates in a relatively short period of time a new market by provision of new values, which completely transform existing marketplace. A foundational technology is also establishing markets and business models, but the adaptation and development of them can take decades. Thus, the effect of Blockchain adaptation will be significant, and social, economic and political systems will be affected.

Today, the Blockchain is the subject of many research and investments. Kashyap, Davies, Shipman, Nicolacakis & Grafinkel (2017, 12) stated that "funding in Blockchain companies increased 79% year-over-year in 2016 to US$450 million". Moreover, the amount and diversity of various blockchain projects are increasing. The most likely business use cases of Blockchain, as seen by 55% of respondents, is in Payments Infrastructure, followed by Fund Transfer Infrastructure (50%), and Digital Identity Management with 46% (Kashyap, Davies, Shipman, Nicolacakis & Grafinkel 2017).

Additionally, Ethereum's and other modifications of Blockchain have provided a new vision of this technology and made it interesting for many industries. Despite the similarities between implementations, there are some differences in a level of the Blockchain's innovations, starting with no innovation and finishing with entire new Blockchain systems being built (Figure 3).

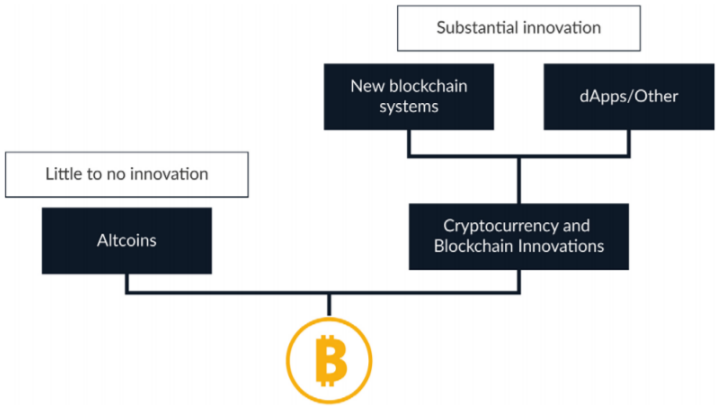

Figure 3. Innovation diversity of Blockchain applications (Hileman & Rauchs 2017, 15)

The leading tech companies are representing their solutions based on the technology and fintech companies are researching on possibilities of its implementation known as dApps. Lastly, during the 2017 the cryptocurrencies market was disrupted and capitalization of them multiplied more than six times as is shown in Figure 4 (Coin Dance 2017).

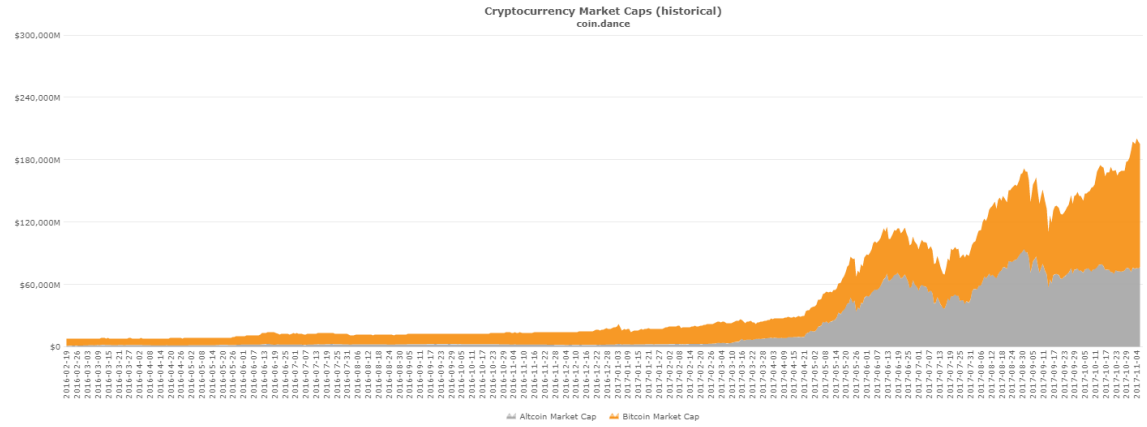

Figure 4. Cryptocurrency Market Capitalization (Coin dance 2017)

Consequently, investments in cryptocurrencies go viral, which allows the Blockchain solutions to gain their investments even without support of tech leading companies and provide solutions to various industries, which will ensure the Blockchain as a foundational technology.

4.1 Supply Chain Management

One of the most discussed areas of Blockchain implementation is supply chain management. In a nutshell, the supply chain evolution has four steps referred to as Four Industrial Revolutions. First of all, steam and water power were implemented into production in 19th century, which is known as First Industrial Revolution. Secondly, electrification gave an impulse to evolve in first half of 20th century and switch from analog to digital technologies in second half of the century, which is known as Third Industrial Revolution. Finally, modern state of technologies is referred to as Fourth Industrial Revolution. According to PWC partners' summary on supply chain digitization (Schrauf & Berttram 2016, 7), "Industry 4.0 is about companies orienting themselves to the customer through e-commerce, digital marketing, social media, and the customer experience". They conclude that all together, recent technologies are enabling to build new

business models, which also means total rebuilding of supply chains. The reasons are simple as the development of a supply chain is expected to bring major economic benefits. (Schrauf & Berttram 2016, 7.)

It is common today to run enterprise resource planning (hereinafter ERP) applications, such as SAP for supply chain management. Most of the processes of production are analyzed already for over decades and standardized for better performance of each of them. However, the visibility and abilities to manage the processes are quite limited from functionality point of view. As an invention of Industry 4.0, Blockchain can be considered as a technology able to provide significant new abilities for supply chain management.

In order to understand how Blockchain can be utilized in supply chains, major challenges of them should be discussed. According to Lierow, Herzog and Oest (2017) article on Blockchain in supply chains, the biggest challenges are luck of transparency because of missing crucial data, high percentage of bureaucracy, absence of interoperability, and insufficient data of goods' lifecycle or transportation steps. Moreover, there are gaps between companies, which use different ERP systems. The systems of electronic data interchange (EDI) and XML messaging are used now in order to access information. However, they have their own limitations and unable to provide full functionality of interchange required. (Brody 2017.)

As Brody (2017) emphasizes, two transformations of supply chains have occurred recently. First of all, supply chains are no more common networks of original equipment manufacturers and suppliers, but ecosystems. They contain goods delivered by multiple parties working collectively. Secondly, the networks are more flexible now as product lifecycles are shorter and periods of growth and fault are more intense than used to be before. However, the update of supply chains does not change the technologies that are used. That is why the Blockchain-based solutions can fulfil the market space in supply chains. (Brody 2017.)

The Blockchain, due to its structure is able to overcome challenges of supply chain management and improve it. The transparency and security provided by the technology will make it possible to track production and transportation

processes. As Blockchain is a distributed ledger, the problem of scamming one party on another will be solved. There is a possibility to create platforms of businesses to exchange required information, which was not possible with old technologies. The absence of intermediaries between companies will cut operational costs and speed up delivery time. (Brody 2017.)

The Blockchain technology is required by supply chains, because it allows everyone who needs it to check each step of manufacturing or delivery of good. In addition, the technology can provide scalability to supply chains, starting from overall manufacturing process and finishing with particular step or moment. It is much simpler comparing to previous solution, which is limited on depth of interchange of data and required to use side software for it. (Brody 2017.)

Despite of advantages of Blockchain, there is some skepticism on it. The Research Director at ARC Advisory Group Harry Forbes (2017 cited by Banker 2017) identifies the following possible obstacles, which can prevent the successful adoption of technology for supply chains:

- Developers of the technology's software are rare and expensive to be hired as they headhunted by Fintech startup firms.

- Lack of network members who already use or tend to use Blockchain in logistics. As it is a fresh solution, which is just gaining its popularity, it is not common yet, but as soon as new companies will join the network, the value of it will be growing proportionally.

- Huge companies will likely need their supply chain partners to join new network. However, there is absence of important standards. Further, a few organizations will push their standards while none of them will achieve the required scale yet.

- "Miners" nodes are validating the data addition to the Blockchain. With cryptocurrencies, this process usually takes several minutes depending on complexity of the blocks. While for some supply chain processes, reducing operating time might be crucial.

Due to the freshness of the Blockchain technology, it is still not very common to use it in supply chain management. However, there are some different use cases and applications which were already developed.

To begin with, IBM has developed a service to build and test Blockchain in a secure cloud and trace valuable elements through complex supply chains (Nash 2016). The Everledger was a first company to run the Blockchain with aim to have more transparency in diamonds supply chain by record its movement from mines to jewelry stores (Crosby, Nachiappan, Pattanayak, Verma & Kalyanaraman 2015, 14).

One of Blockchain's adapters is London-based Provenance, which is also improving transparency across the supply chain from the initial manufacturer to the final customer. Both Bitcoin- and Ethereum-based blockchains are available to be used and provide more transparency to firms in their way of product manufacturing. Usage of Blockchain allows going in deep and indicating if the environmental impact was estimated, find the place and manufacturer of goods and the way they were created. The startup does its business socially responsible and ensures no slavery or exploitation was done during the process of the goods production, which is ensured by the Blockchain technology. (Dickson 2017).

BlockVerify is going to use Blockchain's transparency to fight against a product's reproduction (Dickson 2017). Notably, they will care on counterfeiting of drugs, which is counted to have a high impact on economic side and the silently take hundreds of thousands of lives annually. The company goal is to simplify medicine authenticity's process of verification in a way as QR code scanning occurs. By tracing any product's ID on the Blockchain it would be easy to verify ownership or access manufacturing data. (Dickson 2017.)

The Blockchain will potentially evolve the supply chain and become a foundational technology, which transformed manufacturing, marketing and goods selling processed. By having transparency, traceability and security of Blockchain into the supply chain, it can begin a long process of transforming an economy and making it trustful by providing openness as a new key factor and preventing doubtable practices implementation.

4.2 Internet of Things

As it was previously stated, it is an era of Forth Technological Revolution or digitization today. One of the basement concepts in terms of future vision is an Internet of Things. IoT is a network of interconnected physical devices or sensors, which are able to collect, analyze and reuse data from physical world. The costs of technology, which consists of devices with Wi-Fi support, are going down enabling interconnection or Internet of Things. Business Intelligence suggests (Figure 5) that number of connected devices would be growing in a geometric proportion from 6.6 billion in 2016 up to 22.5 billion in 2021. (Newman 2017.)

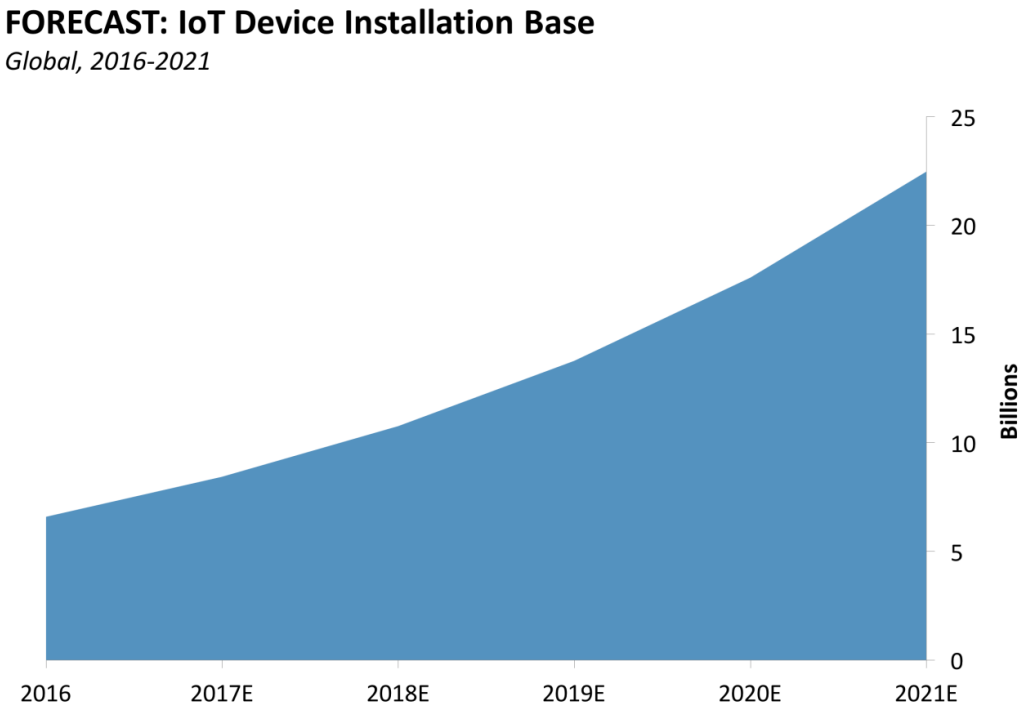

Figure 5. IoT Device Installation base forecast (Newman 2017 refers to BI Intelligence Estimates and Business Insider Global IoT Executive Survey 2016)

Tapscott (2016) states in his book “Blockchain revolution” that the Internet of Everything is already enabled by the Ledger of Everything. It means, that by mixing IoT and Blockchain there is an ability to build the connected rounded system, which is distributed, self-learning or machine learning automated and secured. This allows employment of systems, which was never used before due to technological inability to build them. (Tapscott 2016.)

To begin with, the current state of Internet of Things and its challenges should be discussed. IoT is going to gain $5 trillion over the next 5 years (Newman 2017) and increase number of connected devices as it was written above. However, there are security, connectivity, compatibility and a few other issues in front of IoT.

Internet of Things solutions require technology which is scalable, secure and operates in a predictable way. Beginning with security, it is a serious concern for IoT due to the ability of hacking network's devices easily. Sensors, smart fridges, medicine infusion pumps and other similar devices are weakly protected and can be hacked, thus the data would be compromised. Additionally, the number of devices in the networks is continuously growing and there are possibilities to manipulate one node of the network to spread the virus software forward and infect the whole infrastructure. (Banafa 2017.)

From the connectivity perspective, the ability to connect many devices in one network is an issue as well. Centralized solutions are sufficient for current state of IoT, while it will be ineffective when number of devices multiplies a few more times. Supporting centralized systems for billions of devices will not be economically justified. In addition to electricity costs of servers' maintenance, it will include the costs of IT support, which should be scaled. The more devices will be connected, the less effective will be the centralized point of access solutions. It means that there will be a request on decentralized network systems and P2P communications (Banafa 2017.)

Compatibility of network nodes is also a critical challenge to be faced by Internet of Things. Having various systems included into the network will make it reasonable to develop software to unify the connecting process by one interface. Protocols and standards are also different for the companies which raise a question of developing technology standards that are supported by all members of the network. As Banafa (2017) emphasizes, querying unformatted data will be a problem as there are SQL and NoSQL types of databases used nowadays. (Banafa 2017.)

However, Blockchain can be used in order to solve these issues. The technology enables to verify connected devices with relevant data and program

them to ensure specific actions to be done under defined situation (Tapscott, 2016). Connectivity and compatibility issues can be solved by tracing software versions or unified interface with protocols applied for the Blockchain's network. Moreover, Tapscott (2016) states that technology companies realize the potential of Blockchain and agree that it is essential for achieving full potential of IoT. In addition, the new business models, such as providing each node's computational power, are enabled to be built by combining Blockchain and IoT. By connecting securely with use of public/private keys, users of IoT network can manage privacy themselves instead of using centralized rules. For manufactures, Blockchain-based IoT means that they can transfer maintenance, access and other responsibilities to community of self-supporting devices.

According to Tapscott (2016), there are nine features of Ledger of Everything, i.e. a mix of IoT and Blockchain. They are as follows:

- Resilient or self-troubleshooting with no single point of failure due to decentralized network structure
- Robust with an ability to contain billions of nodes and transactions
- Real-time with a 24/7 availability and smooth data flow
- Responsive, allowing to respond to changing conditions
- Radically openness, continuously developing and ability to update network with new input
- Renewable, i.e. multiple aimed, reused and recycled
- Reductive with optimized costs and increased efficiency
- Revenue-generating, providing opportunities to new business models
- Reliable, ensuring data integrity and trustworthiness of nodes.

However, even Blockchain has vulnerabilities, such as 51% attack. As Blockchain is based on consensus mechanism of actions approval, the network

may be hacked if the attackers manipulate 51% or majority of network nodes. However, the scalability of IoT plays for Blockchain in that case, because that attack is mostly impossible. The ability to manipulate billions of devices is just a theory assumption.

There are already some solutions developed on the cross of IoT and Blockchain. They belong to logistics, asset lifecycles, infrastructure management and supply chains.

One of these solutions is Chain of Things (2017), which integrates Blockchain and IoT hardware and solves mentioned above IoT issues, such as security and interoperability. The startup states their mission as to find the best use cases of Blockchain and IoT, which are providing valuable benefits to industry, states or individuals. Moreover, their topics of research include solar power generation proofing and shipping via Blockchain powered IoT.

As another example of cross of IoT and Blockchain solution, Filament can be discussed. The solution aims to interconnect industrial infrastructure with the Blockchain. They provide hardware and software platform to connect machines. By connecting machineries, the costs might be cut, efficiency raised and new markets developed. The startup is building Blockchain-based IoT networks for energy, mining, construction, manufacturing, agriculture, transportation and smart cities industries. (Tapscott 2017, 153.)

Overall, the Blockchain merge with IoT will be a huge opportunity for both technologies and industries, which will implement into their businesses such kind of solutions. Decentralization of Blockchain will bring to IoT security, scalability opportunities, financial benefit as well as efficiency growth and ability to trace history and easy verify actions.

5 IMPLICATIONS CAUSED BY BLOCKCHAIN

While Blockchain is an invention, which is already changing people's lives in a better way, it has some vital challenges to be faced. As Blockchain is a foundational technology, it might take a long time for the global adaptation and usage. However, the changes will not be limited by specific areas but cover all industries. As Iansiti and Lakhani (2017) emphasize, there are two dimensions to measure the effect caused by technology: novelty and complexity. The more novel is the technology, the more time and effort will be required in order to make it common. Complexity is represented by the number and structure of the parties included to operate and produce final value. Depending on the area of implementation, complexity and novelty of Blockchain adaptation will be different. If a financial institution can easily use well-developed Blockchain-based cryptocurrencies, such as Ripple or Bitcoin, then adaptation in governmental services brings specific issues. General implementation of the Blockchain technology into various industries will evolve economics, technologies and society as well. The next three subchapters will discuss changes and implications for each of these areas.

5.1 Economic Implications

Today, there are certain risks and challenges to be faced by the global economy. A few of the risks are as follows: absence of new markets for developing economies, nature of investments and their transparency, as well as insecure capital accounting, which prevents global economic growth (Spence 2016). Allegedly, there are many more obstacles and threats, but these specific ones could be managed and partly or completely solved by implementation of Blockchain. Economic implications caused by Blockchain can be divided into two groups, i.e. use cases of the technology in finance and overall effects by the Blockchain implementation into various industries.

First of all, the financial industry implications would be discussed. During the human history, there have been several stages in financial relations between people. Each of the periods brought about a new way of measuring goods and establishing trade relationships, or economy. Started with natural exchange of

goods for ancient people, continued with gold and silver coins for people in Middle Ages and gold supported banknotes in 19th century, old financial systems are deep in history due to new requirements faced. Modern financial system was established about a hundred years ago with Federal Reserve System creation by signing Federal Reserve act in 1913, as a solution of inability to gain enough gold to ensure currencies.

Today, the solution of a hundred years ago problem does not fulfill the modern surroundings. As Parker (2011) emphasizes, merchants' transaction fee is normally 1-3%, while it might grow to 5% in some cases. Moreover, the time of transaction to be completed is about 30 days (Parker 2011). The system of intermediaries is used, which makes the process of value exchange complex, unclear and expensive. According to Tapscott (2016), the basis of the financial system is including powerful intermediaries that unite capital and impact and often manipulate on monopoly economics mechanism. That organizes the system workflow, but also slows it down, makes extra costs, and creates more benefits for themselves. Due to their monopoly position, many parties have no stimulation to develop their products, improve efficiency, working on the customer and user experience. (Tapscott 2016.)

As Tapscott (2016, 71-73) states, there are six reasons, why the Blockchain technology will bust finance monopolies and evolve the industry. The reasons are discussed below.

The first reason is attestation. Never before it was possible to transact and communicate straight between two parties, when they have no trust to each one. From now on, it is possible to verify identity and ensure trustworthy connection without any financial intermediary. Additionally, there is a new possibility to ensure trust by using the Blockchain. Technology can verify the identity and trustworthy of any party via analyzing transaction history, recorded in the public ledger, rating based on reviews, and other additional options. (Tapscott 2016, 71.)

The second reason is cost. The network of Blockchain continuously tracks and records P2P values transactions by unceasingly updating public ledger. If financial institutions acquire that functionality, they could save up to $20 billion

by reducing infrastructure costs attributable to cross-border payments without significant changes of their business model (Belinky, Rennick & Veitch, 2015). By sharp reducing of costs, banks could offer private and public customers greater opportunities: higher amount of financial services, new markets, and investment opportunities in developing economies. This would benefit not only banks, but entrepreneurs around the world. A lower level of access brings about more opportunities and even establishes new markets. (Tapscott 2016, 71.)

Speed is the third reason of financial monopolies to be busted by the Blockchain technology. In average, money transfers and trades on stock exchanges need three days to be completed in the modern system (Tapscott 2016, 71 citing Leising 2015). SWIFT or Visa networks facing the same issues and their delay on payments cause troubles for businesses. The Blockchain solutions are able to take payments in ten minutes as Bitcoin or even in three-four seconds as Ripple (2012) cryptocurrency do. For sure, the usage of system, which is operating and confirming transactions closely in live time, can significantly change the economy by freeing up capital, which is staying in transition process nowadays. (Tapscott 2016, 71-72.)

Risk Management is the other reason, because adaptation of the Blockchain technology is able to smooth some of financial risks. Firstly, the settlement risk, which is accounting trade bounce back effect, can be decreased. Secondly, there is the risk of failing the deal by second party or counterparty risk. Finally, there is systemic risk, which is summing up all of outstanding second party risks. The Blockchain can totally eliminate most of the risks related to counterparty trust. Accountants could research transaction history of inner works of a party at any time and analyze the operations that were done. Integrity and non-repudiation of transactions will decrease the risk of high-level managers who use imperfection of the financial system in order to hide their inefficiency or manipulations. (Tapscott 2016, 72.)

The fifth reason is referred to as Value Innovation. The Blockchain was initially introduced as an underlying technology of Bitcoin, but not other financial assets. However, because of the open code of the technology, there are lots of similar projects based on Blockchain, which are known as altcoins. They can be used

for different aims than Bitcoin do, such as leverage the Bitcoin or Ethereum Blockchain's length and transactions volume to create side projects or so-called sidechains. There is ability for sidechains to be "colored" in order to symbolize specific physical or digital asset, such as stock shares, gas tankers, loan or currency. The communication between sidechain and main Blockchain is going through a two-way peg, which is a cryptographic tool to transfer assets without intermediaries. Major financial institutions are actively developing and even already using Blockchain solutions as they could replace traditional centralized exchanges and provide new opportunities. (Tapscott 2016, 72-73.)

The final reason is Open Source. Today, the financial institutions are based on the technologies, which could be changed soon and be followed with significant economic issues as updating business model. Changes of the technologies are difficult to be made, because they should be compatible with previous and future versions and even with different platforms. Open source basis of Blockchain allows continuously developing, evolving, testing and improving the system when the consensus in the network is achieved. (Tapscott 2016, 73.)

As Tapscott (2016, 73) emphasize, "These Blockchain benefits of attestation, lower costs, quick transactions, minimization of risks, innovation of value and reusability can transform not only payments. Industries of investment banking, audit, risk management, retail banking and many others can also use pros of Blockchain for their purposes."

As it was discussed above, Blockchain effect on the global economy is not limited to the financial sector. Other opportunities of Blockchain implementation are also required to be researched with an aim of finding economic implications. As Tapscott (2016) emphasizes, with the Blockchain technology, the possibilities for Dapps are almost unlimited, because of new opportunities provided to reach a new level.

To begin with, Blockchain-based solutions require tokens to run the network. Despite of the method chosen to launch the platform, such as Ethereum Dapp, fork from other cryptocurrency or establishing of a new platform there is a possibility to do initial coin offer (hereinafter ICO). ICO is a way of crowdfunding with use of cryptocurrency tokens. When the platform is launched and amount

of tokens is announced, the platform can offer coins to a public. By purchasing some amount of tokens, everybody can support the project and help the platform to gain the startup capital. As a form of crowdfunding, ICO is a Blockchain invention, which is already changing a way of investing and gaining capital. However, there are plenty of bottlenecks for these events. ICOs can appear as scams, or part of pump and dump mechanism. Additionally, no regulation regarding ICOs was developed yet, but plenty of countries are actively developing such documents. Nevertheless, ICO is a new way of crowdfunding, which will change global economy landscape by lowering the requirements for startups to be launched. (Tapscott 2016.)

Next, business models could be dramatically changed by the Blockchain. As it was discussed before, the technology provides transparency, security and quick verification. These benefits can be used in various industries in order to remove unnecessary processes in supply chain and provide services straight to the customers securely and with minimum transaction fees. Tapscott (2016) discusses the decentralized business platforms development, such as Airbnb. It is a Dapp, which is hosting a set of smart contracts that stores data on a home-listings blockchain (Tapscott 2016). It would allow solving Airbnb current issues, with apartment owner's frauds, building trust between the network members and optimizing insurances rates for good rated owners.

The transparency property could be used to simplify analysis of counterparties and resource planning. Moreover, the Blockchain infrastructure means creation of new business models for supporting the network. As an example, there are so-called mining farms in China and around the world, which earns by providing computational power for the network. Brooklyn Microgrid solar project was just a beginning of sharing devices and computational power (Brooklyn Microgrid 2012). The more Blockchain-based solutions will appear, the more infrastructures they will require. Thus, the evolution of computation power sharing business model will be done achieved.

Finally, the copyright issues could be solved by creating new solutions. The music royalties and other intellectual properties control has always been complex, and in the era of the Internet it has become even more complicated,

because of the digital piracy rise and damaging the transparency of the royalty fees provided to artists and content providers. This field is an opportunity for Blockchain, which can make a difference by providing a detailed and distributed ledger containing the data about the intellectual properties. Moreover, the usage of smart contracts can add an ability to define the rights, ownership information and the royalty share. Overall, the implementation of Blockchain will disrupt the process of content providing and licensing, which will evolve existing market of media and provide space for growth of decentralized solutions.

5.2 Technological Implications

The concept of Blockchain is totally relies on the distributed network. In opposite, most of the solutions at the moment are built on the centralized databases. Thus, there is not enough infrastructural capacity for mass extension of the Blockchain technology. It seems as the biggest challenge, as well as the biggest opportunity.

In the report conducted by Shah et al. (2016), there are four waves of anticipated Blockchain deployments defined: information sharing during 2016-2019, data solutions 2017-2025, critical infrastructure 2020-2030 and fully decentralized systems with unknown dates. First two waves could not be considered as ones to completely change infrastructure, while the third could do. By 2020, major market participants will be more or less familiar and integrated with their local Blockchain solutions. This will allow eliminating global centralized authorities, which manage administrative functions. However, the process of elimination requires much larger computational capacities, than local Blockchain solutions, even if it was built for transnational corporates. In order to complete elimination, the existing assets, transaction and payment infrastructure would be replaced (Shah et al. 2016). Finally, other market participants would be forced to implement Blockchain infrastructure. The way of transformation is also visible from the concept of Blockchain. As the technology requires a significant amount of computational power, the manufacture of hardware for mining will be growing. This might lead to changes in the hardware market in a way of a higher variety of choice and lower prices.

Thinking about industries of Blockchain applications, the technology could also make some changes in them. As the Blockchain adaptation will lead to transparency, elimination of third parties and workflow optimization, it might be forecasted that optimization technological changes would occur in supply chain and manufacturing, as well as in other workflow processes. The devices, required in them, will be useless for corporates. They might be sold or upgraded and transformed into mining machines.

5.3 Social and Political Implications

Society and politics are going to be completely changed by application of Blockchain. According to the principles that were discussed in chapter 3, the Blockchain implementation will lead to significant changes in social life and political systems.

To begin with, the current state and obstacles of society and political institutes will be described. Society, while having a huge step forward done during last century in democracy development, personal freedom and smoothing inequality, is still facing critical issues. Poor social institutions work, censorship in social media, lack of access to the education in developing counties are just the most known of them. Political system is also suffering from the lack of management tools and crystal transparency of government. Trust to the election tool is broken in some authoritarian countries, as well as corruption still can be operated elsewhere.

The Blockchain technology could not solve all of the mentioned problems, but it could start a transformation and empowerment of services to improve current systems. Networked Integrity principle, discussed in section 3.1, is one to establish trust between two parties without any middleman. In a nutshell, there is an ability to build much more decentralized platforms such as Airbnb or Uber. The last two are already disrupted hotels and taxi industries. With use of Blockchain, there are opportunities to establish similar platforms for private healthcare, education and many other services. Last but not least, all of these services will be secured by technology structure and publicly opened for modification, rating and reviews, as distributed public ledger forms Blockchain.

An important topic to discuss is sharing. The global society has carsharing, flatsharing and even foodsharing startups today. All of them lack security and ability to predefine conditions. However, Blockchain could easily solve these issues, upgrade existence and provide basis for new projects development. Ability to securely share resources and services will significantly change the way people live and produce and consume products and services. A business model of ecologically-friendly recycling and power generation could be realized and become profitable due to distributional network and elimination of extra transactions that were allowed by Blockchain implementation. There are hidden abilities to indirectly impact on such important problems as global warming, poverty and hunger as well.

Human rights execution, real opportunity to ensure privacy over the Internet and lowering obstacles for entrepreneurship can be ensured by transparency provided with Blockchain. Human rights activists could trace actions via distributed ledger and ensure execution of them, being secured against the repudiation of data. Citizens could escape from Big Brother eye by using general, non-personalized accounts. For entrepreneurs, there are new perspectives appear, as barriers to establish own business could be eliminated or simplified. By having ability to launch crowdfunding via ICO, quickly open bank account for business, securely and with minimum or even no documents provided, more people could try themselves as entrepreneurs, which will change labor market. Moreover, it could evolve many monopolized markets, because new players will take their market shares from the market leaders.

Furthermore, Blockchain could ensure freedom of speech and right for announcing the information publicly without censorship. Wikileaks was just the first step for public sharing of vital information. On the crossover of Tor private browsing environment and Blockchain, a secure, transparent and trusted source of news for the world or specific regions can appear. Authoritarian regime as a governmental model will likely lose its power and provide freedom and equality to people worldwide.

In view of political landscape, it should be also prepared for new conditions and rules. Blockchain integrated with smart contracts will completely change

governmental services. Corruption would be decreased dramatically, as the political system became transparent and traceable, which makes it hardly possible to use top-ranked positions for personal financial benefit. Democracy institutions could receive the tool to track and validate the actions performed.

The election process would be also changed in a way of more transparency. A Blockchain-based system of accounting of presidential election could provide the most accurate results and solve the problem of usage of administrative methods to manipulate elections exodus.

As an example of an established Blockchain-based political project, digital government of Estonia republic can be discussed. Blockchain solutions are widely used in various governmental and social services, such as national health, judicial, legislative, security and commercial systems (E-Estonia 2017). Estonians can vote, manage tax forms, apply for social compensations and access public services virtually. Health information is aggregated from diversity of sources and form single record for each citizen, which is owned by him or her. Privacy settings allow restricting access to the data for other people and controlling access to their health data to specific doctors or family members, if necessarily. All these services are secured by the Blockchain-based solutions.

Moreover, Estonia is the first state in the world to provide a national digital identity worldwide. It can be issued to anyone and allows accessing Estonia’s public e-services. The opportunities provided are impressive. With use of e-Residency of Estonia, anyone is able to remotely establish and manage business in Estonia, get access to trusted network of financial services. This crossover of governmental support and Blockchain empowered solutions could build completely new type of business ecosystem, which is a game-changing for worldwide, not just for one state.

6 CONCLUSIONS

Today, Blockchain is an infant technology, although it has already done a few steps in its development and global recognition. Initially, the technology was conceptualized as an underlying principle of Bitcoin cryptocurrency in 2008. However, Blockchain is based on theoretical and practical concepts and implementations which were developed in the 1980's and 1990's. Thus, Blockchain is a result of several decades of continuous work by cryptographers, algorithm's researchers and computer scientists. The technology is mainly used for fueling secure digital payments. On the other hand, the foundational technology has a huge potential to change almost all of the major areas of human lives.

In this thesis work, a desk research of Blockchain was carried out, which includes analyses of technology's principles, use cases and caused by it implications. The concept and historical background of the technology are defined in order to provide a basis for further discussions. Additionally, historical research and concept definition allowed to understand the subject matter of the research clearly and distant the technology from common forms of implementation as a cryptocurrencies basis. Moreover, the concept of smart contract related to the Blockchain and upgrades of the basic technology, such as Ethereum platform were analyzed.

The main principles of the Blockchain were described and business value of each of them was discussed. Additionally, discussions of some use cases of startups, which apply these principles, were provided. According to the findings, Blockchain can be used for more than just financial services and provide solutions to various issues.

As the study's use cases, the implementations of Blockchain into the supply chain management and Internet of Things industries were analyzed. The current states of industries and obstacles they are facing were provided. It was found out that Blockchain implementation could solve current issues faced by these industries.

Supply chain management could benefit from the Blockchain implementation, because it will make the processes transparent, which causes elimination of unnecessary intermediaries, simplification of the chain and, as it follows, financial savings. Moreover, transparency provided by the technology could allow the improvement of old and development of new services for supply chain consumers.

For the Internet of Things, Blockchain implementation can also provide important outcomes. There will be accessible possibilities of secure and traceable scalability of connected devices network. New types of systems could be organized. Traceability of the network increases analytical capabilities, which could lead to more efficient maintenance and cheap support of the network. However, these findings could be significantly enlarged and Blockchain integration into use cases industries could provide even more benefits than discussed in this thesis work. The implications caused by the Blockchain are also analyzed. They are grouped into economic, technological, social and political implications.

Economic implications are massive and diverse. On the one hand, the transparency of Blockchain could allow saving resources by optimization of the systems. On the other hand, plenty of new economic opportunities appeared, such as ICO for crowdfunding the projects, Blockchain-driven business models and lowering the barriers for entrepreneurship by simplifying the process and access to resources.

Technological implications could also change the industries and impact on technological processes significantly. The development of mining equipment and its price changes are predictable. The leading players in industries would start to update their equipment in a few years and the rest of the market will be forced to do the same.

Social and political implications of the Blockchain implementation are notable and vital. New forms of communication will be developed, which could cause extension of freedom of speech and improve the work of social institutions. Governmental censorship could be eliminated, causing democratization of national regimes. Thus, the inequality between people from various continents,

cultures and background could be smoothed. The education will be accessible for bigger amount of people, especially in developing countries. The political institutions will be reformed in order to be more efficient and transparent.

The research scope of this Bachelor level thesis work was narrowed down to define and analyze implementation possibilities of the Blockchain technology and its impacts on humans' lives. The technology has a huge potential for development and application. Depending on the area of its implementation, Blockchain could solve some obstacles faced and evolve the core processes. Each of industries earlier or later will face the changes caused by the Blockchain. There is no technological and economic reason to force the development, as it is a foundational, not a disruptive technology. Therefore, there are plenty of opportunities to companies' and industries' representatives to use this thesis work as an introduction point to a distributed future powered by the Blockchain. This work may also serve as a starting point for further research with a wider scope than in this thesis work.

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