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Adoption of Blockchain Technology in Supply Chain and Logistics

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Abstract This thesis was focused on analyzing the innovative technology "Blockchain" and the potential of blockchain-based applications. The main objectives were to define how blockchain can change the supply chain and logistics industry. The typical challenges in these spheres were considered and the main key features of blockchain that can solve these difficulties were marked. After that the Head of IoT Business Development in Kouvola Innovation Ltd. was interviewed to find out possible challenges or benefits of blockchain-based applications. Considering the current situation in the supply chain and logistics industry, this thesis can empower different businesses to start working with the companies that are creating blockchain-based applications.		
Keywords blockchain, logistics, supply chain, digital ledger, application		

CONTENTS

1. INTRODUCTION

In 2008, Satoshi Nakamoto created a fully distributed digital currency system using Blockchain technology. For several years, this system was unnoticed by the society, but after the breakthrough of Bitcoin, many scientists and developers became interested in the technology that allowed Bitcoin be the best cryptocurrency in the market.

Nowadays, a large amount of people think that Blockchain could be as revolutionary as Internet was. They see many ways to adopt such technology. Therefore, many different applications appear on the market.

One of such applications excited me – an application for logistics and supply chain. The current situation of these industries can be described as challenging. There are many difficulties concerning the transparency, security and visibility of various operations across the supply chain or transportation. Therefore, I decided to study this sphere and find out what benefits blockchain could bring to these industries and which problems solve.

Main objective

The main objective of my thesis is to determine the main benefits of the Blockchain adoption in supply chain and logistics.

To achieve this aim it is necessary to consider the following tasks:

1) Study the basic concepts, metrics and technics of Blockchain technology.
2) Consider the examples of organizations, that have implemented this technology.
3) Examine possible industries for adoption blockchain-based applications
4) Find out the main problems in Supply Chain and logistics industry.
5) Try to employ Blockchain technology to solve these difficulties.
6) Consider the possible adoption of blockchain-based application, created by the Finnish company Kouvola Innovation.

Research methods

The theoretical part will be based on a documentary analysis that includes obtaining information from various types of documents: books, articles, journals, scientific reports and others. Also, I use the observation method in my thesis for better considering the advantages and disadvantages of blockchain technology in terms of its adoption. Moreover, my theoretical part is based on the comparison of different opinions concerning blockchain technology in general. I consider both critics and supporters of blockchain and create my own point of view.

For the empirical part of the thesis, I employ the interview method. I had a conversation with the “Head of IoT business development in Kinno”, Mika Lammi. As a result of both these parts, I was able to define the main benefits of Blockchain adoption.

2. BLOCKCHAIN IN THE DEVELOPING WORLD

Our world is developing every day and especially in the last 40 years, we have faced five disruptive computing paradigms (Fig.1).

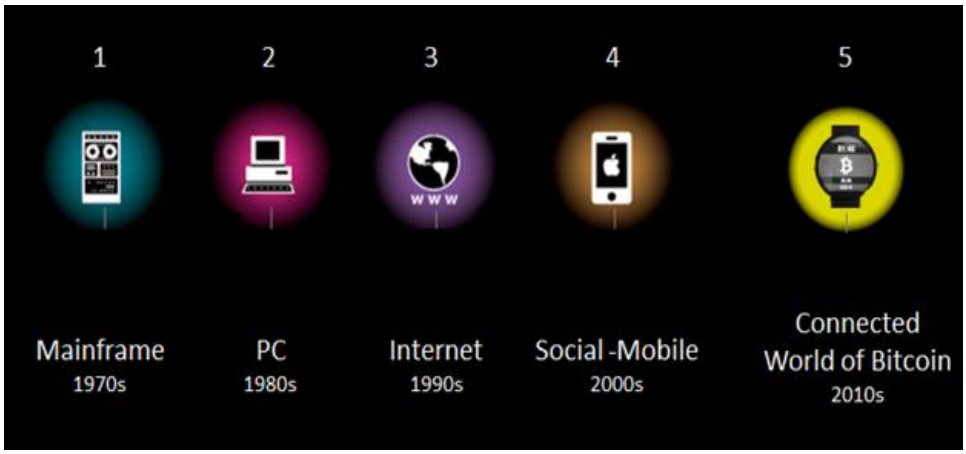

Fig. P-1 Disruptive computing paradigms: Mainframe, PC, Internet, Social-Mobile, Blockchain (Swan, 2015, 12).

The first paradigm is a mainframe paradigm, the second is a PC (personal computer) paradigm, and after that the Internet revolutionized everything. The third were mobile and social networking, and nowadays the Blockchain technology could be the new emerging paradigm. It could be usefully included in the world of multi-device computing as an economic overlay. Internet-of-Things sensors, smartphones, laptops, smart home, smart car, smart city and other innovations could be developed with blockchain. This economy of blockchain is the movement of money, transfer of information and the effective allocation of resources that were enabled by money in the human- and corporate-scale economy. (Swan, 2015, 11-12).

Due to the current widespread global Internet and cellular connectivity, blockchain technology could be deployed much more quickly than any of previous paradigms (Crosby et al., 2016, 8).

Social-mobile services such as Paradigm 4 became one of the biggest part of human socialization with all mobile apps for any businesses. The

same changes the blockchain as Paradigm 5 could bring too. It could bring the ability of value exchange functionality.

“Paradigm 5 functionality could be the experience of a constantly connected, seamless, physical-world, multi-device computing layer, with a Blockchain technology overlay for payments as the Web never had.” (Swan, 2015, 11).

3. WHAT IS BLOCKCHAIN

Blockchain, the technology underlying Bitcoin, is a type of Distributed Ledger Technology that has been defined as a “distributed, shared, encrypted database that serves as an irreversible and incorruptible repository of information” (Wright, 2015, 8-9).

Every 10 minutes, it is constantly growing by adding new blocks to the chain. Miners do it to record the most recent transactions. All blocks are in the Blockchain in a chronological order. Every node has a copy of the Blockchain that is automatically downloaded when the miner enters the Bitcoin network. All information about all transactions ever executed is recorded in the blockchain. (Swan, 2015, 10). Once the information was entered, it could never be deleted or changed. Blockchain is both the network and database, secure and integrate. Blockchain is able to build the transactions based on rules defined mathematically and enforced mechanically. (DTCC, 2016, 6) The main point is that blockchain does not have one definition because of its various dimensions, including technological, operational, legal and regulatory.

One model of understanding blockchain is through comparing it to the new application layer for Internet protocols because blockchain can enable both immediate and long-term economic transactions, and more complicated financial contracts. It can be a layer for transactions of different types of assets, currency or financial contracts. Moreover, a registry and inventory system for recording, tracking, monitoring, and transacting of all assets could be managed with blockchain.

Consequently, Blockchain can be used for any form of asset, including every area of finance, economics, and money. (Swan, 2015, 10).

3.1 Technical concepts

It is important to consider the technical concepts of blockchain to understand the consequence of the various architectures with respect to regulation, security, performance and privacy. There is a variety of different technologies based on Blockchain that were developed to solve various problems. Thus, for different needs there are more or less different available technologies. (Kakavand et al., 2016, 6-7).

Generally, Blockchain is a digital platform that keeps the whole history of all transactions between users across the network in a tamper- and revision-roof manner. Also, Blockchain is a database for providing transactions in digital currency such as Bitcoin and Ethereum networks. All transactions that were created between users or counter-parties are checked by cryptographic algorithms and then grouped into blocks that are added to Blockchain. No one can change the information in blocks because they are chained to each other. Concerning Bitcoin, every node in the network has its own copy of Blockchain, synchronized with other nodes using a peer-to-peer protocol. This demonstrates the uselessness of a central authority and consequently leads to confidence of participants in the integrity of any single entity. (Bitfury Group, 2015, 8). Blockchain enables to process different transactions and securely reach consensus without third parties.

Fundamental technical concepts of Blockchain technology are the following according to Kakavand et al. (2016, 7).

Node. Peer or Node is a computer with the special software that maintains a Blockchain. All nodes are connected to the Blockchain network so they can receive and submit transactions.

Network. It is a result of cooperation of all nodes that run Blockchain software to communicate with each other.

Smart contracts. These are contracts converted into codes to be carried.

Submit transaction. When users submit transactions, they are sent to the nodes on the network who subsequently send them to other nodes.

Transaction Validation. All transactions are cryptographically validated by the nodes on the Blockchain network. Invalid transactions are ignored.

Block. It is a group of transactions collected by nodes into a bundle. To be valid blocks must be formed according to pre-determined set of rules: They must not exceed a maximum size in bytes, contain more than a maximum number of transactions, and must reference to the most recent valid block.

Blockchain. It Is a chain of blocks that is organized by the following system: Each new block is attached to the most recent valid block.

Consensus. It is an agreement of all nodes in the Blockchain. To enable distributed system operation, multiple processes cooperate with each other. Faults in such systems can occur anywhere, that is why they use consensus protocols.

Hash function. It is a one-way function that reflects an input of selectable size to a fixed sized output called hash. Properties of a cryptographic hash function: 1) easy to generate the hash given the input, 2) infeasible to generate the original input given the hash, 3) virtually impossible for two similar inputs to have the same output in a so called “collision”. SHA256 – example of cryptographic hash function.

3.2 Permissioned and permission-less Blockchains

Today, everyone can use any distributed ledgers, supporting for example Bitcoin, to communicate with any individuals. Furthermore, everyone can read from or write to such ledgers, consequently making them appealing for many applications. Nevertheless, there is a number of applications where the counter-parties to transactions want to keep all information about the transaction private, for example, several financial transactions,

exchange of medical records or the shipment of goods. (Kakavand et al., 2016, 8-9).

Permissioned or private Blockchains will likely be in good demand over the coming years, because of their appropriacy and relevancy for a large number of commercial applications. The usage of private Blockchains gives the ability to determine the availability of any participant in the network to keep its information private. (Swan, 2015, 26). (Fig.2)

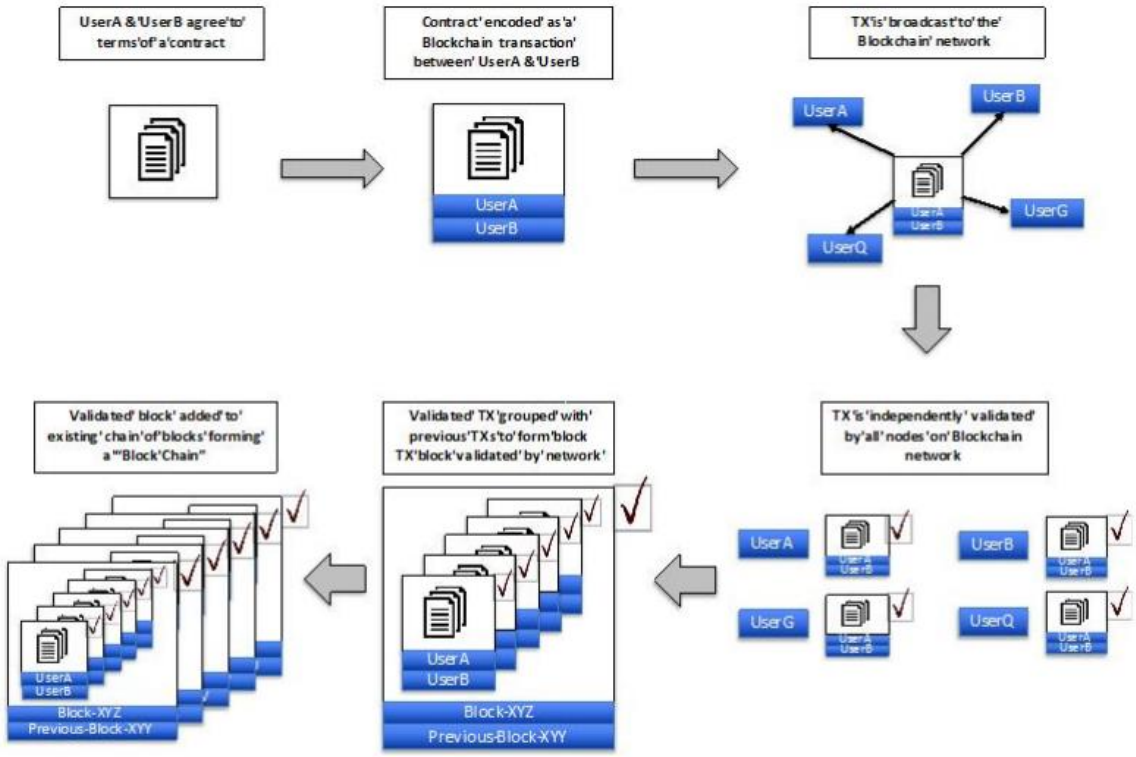

Fig. P-2: An overview of the Blockchain process. (Kakavand et al., 2016, 9).

New participants are always invited to the network. There are various ways of invitation, for example, unanimous agreement, single user invitation or core group acceptance satisfaction of pre-determined set of requirements. (Kakavand et al., 2016, 9).

3.3 Metrics

Blockchain is developing, and many different database technologies and distributed protocols appear. All these technologies are applicable for many different industries and as such require a number of specifications. The main objective of the development of such technologies is improving

blockchains, solving the scalability and throughput capacity of them and ensuring their security, performance and robustness. These areas are being covered by various types of distributed ledger technologies with varying degrees of decentralization. (Crosby et al., 2016, 10-12).

The current and past state of the whole network are stored at a blockchain node. Below are qualitative and quantitative metrics that can evaluate the performance of a blockchain architecture. (Kakavand et al., 2016, 9-11).

1. *Submission Throughput*: It is the maximum number of transaction submissions per second possible/ permitted by each node and by the entire network.
2. *Maximum/Average Validation Throughput:* It is the parameter, that determines the maximum/average transaction processing speed of the network.
3. *Average Transaction Validation Latency:* It is the average period of time that is token to validate the transaction from the time of its submission. This metric determines the period of waiting of the users for their transaction to be validated and placed in a block. Very important is that the block confirmation and notion of validation could be different in every blockchain.
4. *Latency Volatility:* It is a measure of possible variety of the transaction processing time.
5. *Security:* Evaluation of the security system requires a threat model, that is able to define the type and scope of adversaries and attacks on the system. Such threat models could be different in any Blockchain applications. For the security evaluation following analysis are required:
    - Transaction and block immutability
    - Transaction censorship resistance
    - Denial of Service resilience
    - Trust requirement of users and oracles
    - Protocol governance and node membership services
    - Transaction confidentiality and user anonymity

6. *Confidentiality:* It is the ability of nodes to conceal the contents of the transaction or even the identity as having participated in that transaction from other nodes.

7. *Transaction fees:* It is the small fee, that users must pay to the network in order to process transactions or execute smart contracts. These fees cover maintenance costs of the blockchain and provide the protection from frivolous of malicious computational tasks.

8. *Hardware requirements:*

    - Memory/storage: it is a total memory/storage that is required per node
    - Processor: it is an amount of processing resources that are required to validate transactions and blocks.
    - Network usage over time, including throughput and latency requirements
    - Hardware requirements will change as the network scales.

9. *Scalability:*

    - Number of nodes: the increase of the number of nodes leads to the change of system performance
    - Number of transactions: the increase of the number of transaction submission per second leads to the change of system performance.
    - Number of users: the increase of the number of active users submitting transactions leads to the change of system performance
    - Geographic dispersion: the increase of the geographic dispersion of nodes leads to the change of system performance

10. *Validation process:* It is an important factor, that is necessary to determine the performance of the network.

11. *Complexity:* it is a measure of the development, maintenance, and operation complexity of Blockchain infrastructure.

12. *Smart-contract limitations:* The main limitations that can influence on the ability of the code deployed on the blockchain are the smart contract scripting language and the underlying consensus protocols.

4 EXAMPLES OF DIGITAL LEDGER TECHNOLOGY IMPLEMENTATION

Blockchain technology was developed under a digital ledger named Bitcoin by Satoshi Nakamoto and a lot of people think that these two terms are the same. But Blockchain and Bitcoin a totally different. Bitcoin was the first application that utilized blockchain technology, and especially Bitcoin fulfilled the potential of it.

Bitcoin

Bitcoin is an open source, peer-to-peer crypto-currency that was developed by Satoshi Nakamoto in 2008 and launched in 2009. The system is based on public-private key technology and the decentralized clearing of payments to allow quasi-anonymous transactions. Bitcoin is an independent currency and it does not belong to any government or legal entity. It is not possible to exchange bitcoins for gold or other object of utility. Adherents of this system argue that Bitcoin has many features which are able to make it a perfect currency for main merchants and consumers. (Nakamoto, 2008, 1).

For better understanding the functioning of Bitcoin, I studied a typical transaction. Both participants in a payment have a private and a public key. To confirm the ownership of a balance of bitcoin the payer needs its private key. To identify the payee, the payer should use payee's public key, that is open to everyone in the system. For accepting the transaction, the bitcoin software requests all peers on the network to acknowledge the payment is valid. Once the transaction is verified, all other peers are informed that the balance of payer was transferred to the payee. To spend the money, the new owner should repeat this process. (Luther, Olson, 2014, 24).

In Bitcoin system there is no need in a central clearing authority. All transactions are grouped together in a block for authenticating that requires the system to solve a complicated cryptography problem. One by one all peers on the network should complete their "proof-of-work ", and share it with others by adding the transaction to the blockchain – a place for recording all previous payments and transactions. The fact that

all peers can observe the transaction makes it impossible to spend the same balance more than once. (Franco, Pedro, 2014, 27).

The proof-of-work requires the high level of computing power that leads to high costs. But members of this network are able to incur such costs, because of the reward for authentication the transactions. The reward is the ability to have their own newly created bitcoin. This decentralized clearing process is called mining. (Houy, 2016, 62).

Bitcoin has several clear strengths. According to Franco, Pedro (2014,30-32), in comparison with fiat currency or precious metals bitcoin *could not be confiscated*. It also *avoids capital controls and disproportionate taxation*. The one who owns bitcoin can have an access to the funds, as long as one has the ability to connect to the Internet and keeps a copy of the private keys.

There are *no warehousing costs.* It means that there are no additional costs to storing bitcoins except the initial set up and the properly securing a wallet for Bitcoin users.

Bitcoins are *easy to transport*. Everything that is necessary for logging into the system is private keys. They can be saved in storage media (USB flash driver) or uploaded to the cloud.

The insufficiency is *fixed by an algorithm*. Bitcoin documentation provides that any changes in monetary supply of bitcoins can be made in order to unanimously consent of all bitcoin-holders, but the fact is, that the resulting currency could not be called Bitcoin, as it is totally different from the original design. Due to this no central authority can decide to debase it. Critics think that the decision about the changes to the money supply of Bitcoin could be done through a majority decision of people who are not monetary experts. In compare with fiat currencies, very often there is a central bank in commission with the keeping relatively stable value for the currency. (Twenty Second European Conference on Information Systems, 2014, 3-4).

Bitcoin utilizes *cryptographic security*. In contrast with precious metals that require physical security or fiat currency with the institutional security.

Bitcoin provides *automatic record keeping*. When all payments are recorded in the blockchain and records are automatically produced.

Bitcoin is *deflationary,* if take into account its fixed money supply. Further still, the loss of private keys became more widespread for bitcoin-holders and that leads to an actually decreasing money supply. In accordance with economical rules and laws it is well-known that deflationary currency has a harmful influence for the economy, because it increases the burden of depts. That are usually denominated in normal terms. Nevertheless, there are some Bitcoin supporters, such as Austrian School economists, who insist that a fixed monetary supply is not necessarily harmful, as deflation would be produced by technological progress. (Clegg, 2013, 5).

Despite the fact that Bitcoin has several advantages over fiat currencies, it is not without weaknesses. Franco, Pedro (2014, 31-32) state that Bitcoin is an open source; therefore, it can be *easily replicated*, that will give the opportunity to make substitutes of Bitcoin. Critics think that this situation will lead to increase the amount of cryptocurrencies which will compete with each other, whereas that will end hyperinflation and collapse. This view intends that all cryptocurrencies achieve the same level of acceptance. Supporters of Bitcoin respond that cryptocurrencies are subjects to network effects, in view of infrastructure investment, marketing, mind-share and liquidity. Today Bitcoin holds the superiority on the market, but if other currencies were to replace it in future, the network effect would conduce the leading cryptocurrency and lead to gathering the market around it.

Critics argue that Bitcoin is *volatile* and it should not be used as a store of value. In compare with fiat currency, Bitcoin does not have any authorities, such as central banks, to assure everyone in the stability of the value. Therefore, the price of bitcoin could have the self-fulfilling

dynamics where an incident could blame on itself, becoming a huge confidence crisis.

In Bitcoin system *money supply is not under control*. The amount of money can be changed through the open source project, through miners and users agreeing to the change.

Critics argue that by holding bitcoins users could not avoid extra wastes related to inflation, because in the case of inflation the difference in prices of fiat and bitcoins will be *taxable* (Ali, Barrdear et al., 2014, 7). Proponents of Bitcoin appeal, that it concerns most assets, and in any case, bitcoin holders will protect their money from inflationary increase in the money supply of fiat currency with hedge (2014, 3-4).

In compare with fiat currencies, cryptocurrencies do not have a *status of legal means of payment*.

Governments may want to *ban cryptocurrencies*. They could prevent illegal uses of cryptocurrencies and enforce currency control. But it is very difficult task, because of distributed structure of cryptocurrencies. However, the ban for exchanges and payment processors could be realized. (Bradbury, 2014).

Bitcoins have *no physical backing*. Therefore, there is *no intrinsic value* to support them. Bitcoin proponents appeal that gold does not have intrinsic but monetary value too, and furthermore, some supporters of bitcoin argue that the proof-of-work performed by miners is the intrinsic value of it. (2014, 3-4).

The down-trends in the price of bitcoins could be acute, because Bitcoin *does not have a marginal cost of production* to stabilize the price. In contrast with commodities, such as gold, the marginal cost of production acts as a support for price levels.

There is *no deposit insurance* for users of Bitcoin in compare with banks. But supporters of Bitcoin reply that there is no need in them, if the security practices, followed by issuers and services, are verified.

Since the supply of bitcoin follows a predetermined trajectory, change in demand of it causes the fluctuations of bitcoin's purchasing power. In March 2013 there was a fall of exchange rate of bitcoin/dollar, caused by the problems with an updating to the system. On the other hand, such low price pushed the purchasing power of bitcoins up. The speculators were buying bitcoins with the feasible ability to sell them at a higher price. On November 28, 2013, the price has risen to $1132, and after that the price had a decreasing tendency again, perhaps because the speculators were not confident in the future of bitcoin. At the end of May 2014, bitcoin was $631, and today it is trading at $1017. The existence of demand shocks like these influence on the purchasing power of Bitcoin and makes it unpredictably variable. (Nakamoto, 2008, 5).

Although there have been some network problems, Bitcoin has managed to gain a wide acceptance. The market of Bitcoin is developing and, today, users have many ways to obtain and spend bitcoins. One of the ways, as mentioned above, is mining. Due to it, many of the early holders of Bitcoin acquired their profit. However, not every average user can obtain bitcoins by mining because of the high level computer technologies that are required. In order to complete the proof-of-work users need a network of custom-built computers. (Houy, 2016, 61). Nowadays, it has become more common for users to buy bitcoins via an online exchange. There are many exchange services that convert bitcoin to/from a large variety of currencies (USD, EUR, JPY, CAD, GBP, CHF, RUB, AUD, SEK, DKK, HKD, PLN, CNY, SGD, THB, NZD, and NOK), such as BitStamp and Coinbase.

Recent researches (Bonneau, Miller et al., 2015, 113-116) are full of expectations of the possible effects of Bitcoin on the monetary policy of internationally acclaimed currencies. Due to the Quantity Theory of Money, many economists argue that the wide usage of bitcoins could lead to an increase in the velocity of fiat currencies, whereas the necessity of holding them could decrease. Moreover, the result of such an increase in the velocity could be an inflation that will force central

banks to decrease the money supply and consequently implement a tightening of the monetary policy.

On the other hand, there are some economists who see the future of bitcoin as a positive event for the monetary policy of fiat currencies. For example, economists of the Austrian School view the development of Bitcoin as a return to the Gold Standard. (Clegg, 2013, 7).

Finally, it has also been another thought that cryptocurrencies could increase the resilience of the economy. In the case of turmoil or malfunctioning of the existing financial structures, Bitcoin and cryptocurrencies in general could be useful, as they create an alternative payment system. (Nakamoto, 2008, 7-8).

Ethereum

Ethereum is an open Blockchain platform that enables building, executing, and using decentralized applications. It creates applications that automate and facilitate the direct interaction between peers across the network. The same as Bitcoin, Ethereum allows the creation of a payment system without any third-party authorities. Rapid development time, security for applications and the ability of different applications to interact efficiently with each other became very important factors in the context of developing Ethereum. That is why Ethereum began to employ a special programming language – “Turing complete”. It enables to create applications that run on the Ethereum system in different programming languages. Ethereum has high level of security and it relies on a proof-of-work mining. It utilizes Ethereum Virtual Machine “EVM”, where smart contract computations are paid for using a cryptocurrency called Ether. Every node of EVM runs such computations to maintain all operations in the blockchain. (Kakavand et al., 2016, 13).

Due to this process, Ethereum can work with extreme levels of fault tolerance. However, the massive use of synchronized computing across the whole network makes the processes slower.

IBM Open Blockchain and Hyperledger Fabric

IBM OBC was created on the assumption that blockchain technology would be well regarded with many networks that serve and provide different goals. IBM is a part of the Hyperledger Project, a Linux foundation project. The main objective of this project is to promote blockchain technology by identifying and addressing important characteristics for a cross-industry open standard for distributed ledgers. (Cachin, 2016, 2).

The system that is utilized in IBM OBC is self-maintained and does not need any other network requirements. As Ethereum, OBC uses “Turning complete”. (Cachin, 2016, 2).

The Hyperledger Fabric permit many different uses of Blockchain, therefore it allows the creation of distinct levels of permission. Due to the ability to encrypt the transaction, participants can conceal their identity, transaction patterns and terms of confidential contracts from third parties. The Hyperledger Fabric relies on Byzantine Fault Tolerant algorithm to secure consensus in the network, differing from Bitcoin that utilize proof-of-work mining. (Kakavand et al., 2016, 12).

ErisDB / Tendermint

ErisD, similarly to Ethereum, is an open-source blockchain platform for building, testing, maintaining, and operating digital applications. The main difference between these two platforms is that ErisDB allows the creation of both permissioned and permission-less blockchains. This platform was meant to be deployable in many distinct environments. ErisDB supports the EVM, thus any smart contract code written for Ethereum can also execute on an ErisDB blockchain. This platform is aimed to permit easier building of digital applications for users. Moreover, it has developed its own platform, using Tendermint’s consensus protocol. The Tendermint project includes an open source BFT consensus protocol implementation for smart contracts. (Kakavand et al., 2016, 14).

R3CEV

R3CEV is a technology firm, aimed to research, develop and improve the integration of blockchain in the financial sphere and building a financial-grade ledger. This firm expects to ask financial institutions and regulatory bodies to be involved with the creation of a distributed ledger-standard.

4.1 Blockchain and IoT

Blockchain is a revolutionary paradigm for the whole society and the Internet of Things. Probably it can be named as the enabling currency of machine economy. According to Gartner, (2016) there will be 26 billion devices and 1.9$ trillion economies by 2020. Consequently, “Internet of Money” should manage the transactions between all these devices (Omohundro, 2014, 2), and micropayments could develop into a new layer of the economy (Singh, 2014, 1). Connections in M2M (machine-to-machine) sphere are growing faster than any others. A machine economy can provide a fast and efficient decentralized system of handling and allocating resources on a machine scale, just like money economy allows to do it on a human scale.

The visual example of M2M micropayments could be the automatic negotiation “between” connected to each other automobiles on the higher-speed highway. If they are in a hurry, microcompensating road peers on a more relaxed schedule. The next example could be drones, especially coordinating personal air delivery by them with a device-to-device micropayment network. The agricultural sphere could be developed with blockchain likewise. Their sensors can use economic principles to filter out routine data and fulfil the database with the most relevant, depending on the environmental conditions. (Swan, 2015, 13).

Generally, at the most basic level, blockchain technology’s decentralized model of trustless peer-to-peer transactions means intermediary-free transactions. However, the massive shift to this system on a large-scale global basis could mean a totally different operation of humanity in the spheres that cannot yet be foreseen, but where all that system could easily loose its utility. (Swan, 2015, 22).

5 BLOCKCHAIN APPLICATIONS

5.1 Financial markets

Clearing, trading and replacing the intermediary

The settlement of financial assets and the clearing are traditional functions of the banking industry. In the U.S., Canada and Japan, there is a 3-day settlement cycle, and in the EU, Hong Kong and South Korea, this cycle takes two days (Peters et. al., 2015, 26). This one-day difference can bring many risks related to liquidity and credits. That is why in the U.S. the Federal Reserve pressed all stakeholders to act on increasing end-to-end payment speed (Kiviat, 2015-2016, 585-586). Some argue that blockchain does not only move value, but it also integrates several components of the trading-clearing-settlement value chain in an elegant and efficient way (Kiviat, 2015-2016, 569, 587). Therefore, the sphere of clearing and settlement trades is one of the potential applications for blockchain.

Blockchain technology can change the clearing and settlement process by means of decentralization and disintermediation. The use of blockchain could make the settlement cycle les time consuming (Peters et al., 2015, 28). Moreover, back-office costs could be reduced by using Blockchain technology because all reporting, compliance and collateral management can be handled through it (Peters et al., 2015, 28). Also, an important feature in using blockchain is that placed funds will not be allowed to release until each party is satisfied with the actions of the other. It will be useful to add to a transaction a digital signature of a third or even more parties, who play the role in authenticating performance. (Shadab, 2014, 14).

However, there are critics who think that Blockchain is always going to be more expensive than a central clearer because the processing job will be done by a multiple of agents, not by one. This will define such clearing service as not cheap. (Maineli et al., 2015, 11).

Payment systems

Nowadays, all payments are checked and ensured by third party authorities, therefore experts in this industry predict that permissioned blockchains will take a significant part in the payments by 2020. The first bank that decided to introduce Blockchain technology for international payments was Santander UK in June 2016. (Kakavand et al., 2016, 16).

Particularly in the U.S., non-depository financial services such as blockchain payment companies have been traditionally regulated. However, there is a chance that the laws that establish licensing and compliance standards for money transmitters may be enhanced if the amount of blockchain-based systems increases. Still there are several blockchain-based payment providers that may be subject to money services business (MSB) regulations issued by the Department of the Treasury's Financial Crimes Enforcement Network (FinCEN) (Swan, 2015, 22). On the other hand, the EU has a uniform legal framework for regulating electronic money.

Operational risks in financial markets

Clearing intermediaries is applicable to a category of regulated entities called financial market infrastructure (FMI). The Federal Reserve states that FMIs include the system operator that settle or record payments, securities, derivatives or other financial transactions (Walch, 2014, 851-852). Thus, FMIs are regulated. Due to the usage of blockchain technology, there is no need for a trusted intermediary which could present operational risks. Consequently, the blockchain system will lead to the automation of trade clearing or of payment system. (Kakavand et al., 2016, 17).

Smart contracts

Initially, the blockchain was developed to improve cryptocurrencies, but entrepreneurs are now developing a new way of using blockchain – smart contract. It is a contract between parties that is coded and uploaded to the blockchain. The smart contract does not rely on the third party authorities. All processes in dealing with such contracts are

automatically controlled. The clauses of a contract are executed after all parties have accomplished their duties. This function removes all ambiguity regarding the execution of contract conditions concerning the existence of external dependencies. (Swan, 2015, 25).

Smart contracts may make the negotiation process and performance of a contract easier and more efficient. Usually, the interface of a smart contract is clear and it imitates the logic of contractual clauses. The main aim is to secure the contractual processes and reduce the cost related to contracting. (Kakavand et al., 2016, 17-18).

One of the main features of blockchain in smart contract is enabling “trustless” transactions. This type of transaction defines as validated, monitored and bilaterally enforced transactions over a digital network. Smart contracts can incorporate multiple digital signature for necessary approval of participants. If the conditions of a smart contract depend upon real world data, systems called “oracles” can be implemented to monitor and verify this data. (Swan, 2015, 25).

Another potential use of smart contracts is in financial transactions. There are various features of smart contracts that make them appropriate for this sphere. For example, margin could be automatically transferred upon margin calls, and if there is counterparty default, the contract could terminate itself. Due to the “custodial functions” of blockchain, recordkeeping, auditing and custodial functions it will be possible to reduce transactional costs for the parties. (Kakavand et al., 2016, 17-18).

Even if the use of smart contracts may be limited, the use of them may increase the automation of the contractual processes and reduce transactional costs related to them. Smart contract is a replicated form of a real contract in the digital network. (Swan, 2015, 27).

5.2 Other industry applications

Blockchain has the potential to provide not only financial applications but disruptive applications to other industries too.

Real estate industry

Blockchain can be applied to both public and private sectors of the real estate industry. All information concerning land registry records and public records of land ownership can be easily uploaded to blockchain. This opportunity will allow the relevant stakeholders and agencies to have an access to the ownership data. This considerably decreases the amount of disputes and the need in the third party, consequently saving time and cost for the consumers. (Kakavand et al., 2016, 19).

Information about the private sector, such as residential rental agreements between private counterparties, can be uploaded to blockchain. Also, smart contracts can be a good way of improving the real estate industry. This will regulate the workflow of real estate agencies and save resources and time. (Kakavand et al., 2016, 19).

Health care industry

There are various applications of blockchain technology for the health care industry, for example, drug delivery pipeline for the end customer. Throughout this process, drug packages are authenticated, time stamped and placed on blockchain at each delivery point. Therefore, the drug packages can be tracked. Blockchain makes the distribution of medicines transparent and secure because it can prevent the drugs from thefts and reduce the possibility of price manipulation and delivery of expired drugs. (Gilbert, 2016).

Smart Government

The instantaneous and simultaneous access to a database that keeps public records is a considerable benefit for the government agencies. A good example could be identity management. However, there is much space for improvement for blockchain in this sphere, but applications that will be the result of that kind of work will propel the whole sphere to the next level. For example, the placing of passports or drivers' licenses on blockchain can enable different agencies to verify identification in real

time. The Estonian government is experimenting with such management solutions based on blockchain. (Stone, 2016).

Regulatory and taxation applications are also a good example of implementing blockchain technology. Many banks are working on implementing blockchain-based systems. Consequently, if regulators do the same, they could directly and automatically impose restrictions on the execution of transactions. This fact leads to the reduction of regulatory compliance and auditing costs. Financial transactions can also be taxed automatically since the ledger keeps track of transfer of ownership of assets, as each transaction is visible to the relevant tax agencies (Deloitte, 10). This decreases the overhead and the need for various intermediaries in the process (Kakavand et al., 2016, 19).

Foreign Aid is another interesting application for blockchain technology. Foreign aid can be utilized in a more efficient manner using cross-border transfers to reach the targeted zone (Swan, 2015, 61). This fact gives the possibility to avoid corruption and misuse of funds (Kakavand et al., 2016, 19).

Last, but not least, there are voting systems in Smart government. Blockchain technology can help to improve them. By using blockchain, every individual can vote on an anonymized ledger, and all results can be counted and defined without the identity of participants (Swan, 2015, 61). Due to this, the voting environment overhead will be eliminated.

Artificial intelligence

Artificial intelligence is a new area for integration with blockchain. Applications based on blockchain in this sphere will have far-reaching implications in the future. Nowadays, smart contracts work on a “narrow intelligence”, but they can be programmed to accomplish different tasks according to pre-determined rules and conditions. The development of blockchain will lead to the sophistication of the smart contract’s implementation. Integration with artificial intelligence can help nodes on

the blockchain to function on their own in a semi-autonomous way. (Kakavand et al., 2016, 20).

The results of this integration could be following, according to Kakavand et al., (2016, 20-21).

- Negotiations between nodes on the blockchain on asset price discovery.
- Discovering ownership networks of financial assets.
- Blockchain nodes cooperating to optimize household energy consumption within the broader Internet of Things model.

5.3 Applications for Supply Chain and Logistics

Supply chain is defined as the line of various points involved in producing and delivering goods, from the procurement stage to the end customer. Nowadays, the supply chain can consist of various stages and locations. Consequently, it has become more difficult to trace events in the entire chain. Moreover, due to the lack of transparency in the supply chain, buyers and customers cannot be sure in the true value of the products or services. Also, there are several elements related to the supply chain that cannot be tracked, such as environmental incidents. (Dickson, 2016).

It is hard to investigate the accountability of illegal events associated with the supply chain. Because of these challenges, today the world faces following problems of counterfeiting, forced labor and poor conditions in factories.

Blockchain, as an insurer of transparency and security, can be a good solution for fixing supply chains. Even the simplest application of the blockchain technology could bring the supply chain great benefits. Registering the transfer of products on the digital ledger as transactions allows to identify the main data relevant to manage the supply chain.

The main features of blockchain could be very useful for application in the supply chain: (Dickson, 2016)

- Public availability gives the opportunity to track products form the place of origin to the end customer.
- Decentralized structure gives the ability for participation for all parties in the supply chain
- Cryptography-based and immutable nature gives the assurance of security.

To this day, there have been made several efforts to use blockchain for improving Supply Chain Management. IBM is a pioneer in this sphere they have endeavored to streamline the leverage of blockchain in the supply chain. (Dickson, 2016)

Walmart

Walmart is an U.S. retail giant that presented a pilot project of leverage distributed ledger technology to track the origin of pork in China and its production in the U.S. This project was planned to start in the first quarter of 2017 and it will take four months. (Ramamuthy, 2016).

It will be one of the first significant test projects of blockchain technology outside the financial sector. This technology can give the ability to deal with the mistakes and missed deadlines consequently make the supply chain more efficient. In fact, especially that sector is the main target for blockchain-based applications. According to the last data, 42% of companies in retail and manufacturing spheres are planning to spend $5 million on such kind of technology. (Ramamuthy, 2016).

Walmart is going to use the technical platform that was based on IBM's technology developed for Linux Foundation, Hyperledger fabric (Prisco, 2016). This platform was described in the previous chapter.

Everledger

Everledger is a startup that aims to reduce risks and frauds for banks, open marketplaces and ensures. It uses blockchain technology, machine vision, smart contracts and other emerging technologies. This firm wants to make the diamond supply chain more transparent and help to eliminate the forced labor use across Africa. (www.everledger.io).

The platform runs on global, digital ledger that gives the ability to track goods throughout the entire supply chain. Records in blockchain consist of defining characteristics, history and ownership, and all parties in the supply chain can use them anytime. (Dickson, 2016).

Everledger has built a hybrid technical model using private and public blockchains. This allows them to better serve the industry they work in. This firm takes a rightful place in the Hyperledger community, committed to streamlining innovative technologies in the supply chain. (www.everledger.io).

Provenance

Provenance is a London-based company that aims to make the supply chain more transparent by deploying blockchains which make companies more honest in their operations, including the environmental impact on the place of products' origin and by whom they were made. This company is headed by computer science PhD Jessi Baker. She told IBNimes, that they are very concerned with how the data is presented to consumers and they are very focused on the accessibility of that information, and how it is presented, on product or in-store." (Alloson, 2016).

Furthermore, Provenance will use blockchains for eliminating worker exploitation or other poor practices, because the information that is sourced in blockchain ledger could be multifarious. (Dickson, 2016).

There are several problems in the global logistics industry, such as a lack of transparency or a misunderstanding between agents on different layers of the supply chain. Due to this, many challenges concerning transportation protocol and product origin arise (Williams et al., 2015). This is at odds with the customers' interests.

Transparency is considered as a key to a successful business. Sharing information between all parties in the supply chain can improve the relationships between them and make them more efficient (Lamming et al., 2001, 4-10). It was really challenging to find system to establish

transparency before the advent of blockchain. Blockchain can generate transparency and ensure the fulfilment of transport contracts. These are several factors of blockchain features that can be useful for improving logistics industry:

- Opens access to information concerning the activities within the supply chain (Baker et al., 2015).
- Provides customers with the ability to evaluate the product, service, supplier, carrier etc. before making a decision. (Baker et al., 2015).
- Provides customers with the information they want concerning product origins and freight route (Ho-Hyung, 2013).
- Reduces risk in regard to fraud or counterfeit goods (Hancock, 2016, 15).
- Enables monitoring, tracking and tracing transports (Baker et al., 2015).
- Simplifies exchange of goods and payment systems (Nakamoto, 2008, 7).

Unfortunately, the lack of transparency is not the only challenge for logistics. There are also several essential problems that affect to this industry: (Lieber, 2017)

- Organizations do not share all relevant information with other participants, so they choose to protect it from them.
- The large amount of data associated with products or documentation can easily be lost across the entire supply chain.
- None of the parties shares the information concerning the place of origin of an asset to determine quality.

Fortunately, blockchain can solve these problems. According to the recent Expert Insights report of IBM Institute, Blockchain was recognized as a technology that is going to be implemented in various supply chains to consider the benefits in visibility, optimization and forecasting. (Lieber, 2017).

In a large amount of current shipping processes paper is required, which usually causes various costly errors. In blockchain system, all

information concerning shipping processes will be digital, which enables all participants to get the relevant data at any moment. Consequently, this reduce risks and increase the delivery quality. Moreover, it will allow organizations to decrease the amount of waste, spoilage and defects.

Blockchain is useful for logistics by enabling synchronized audit trails between partners and optimizing them in a real time. It will increase trust across the supply chain, consequently simplifying the decision making process on every stage. (Lieber, 2017).

Finally, the permissioned and instantaneous access to data in the digital ledger can allow collaborative forecasting for all parties.

Companies should use blockchain technology to build efficient relationships with their partners, make their business more transparent for customers and avoid numerous errors across the supply chain.

Maersk

Today, 90% of goods in global trade are transported by the shipping industry, but the supply chain is slowed by the complexity and sheer volume of point-to-point communication across a loosely coupled web of land transportation providers, freight forwarders, customs brokers, governments, ports and ocean carriers (Lieber, 2017).

Processing documents and information for a container shipment is estimated to cost more than twice the expenses from the actual physical transportation. IBM and Maersk are addressing this problem with a distributed permission platform accessible by the supply chain ecosystem, designed to exchange event data and handle document workflows. Maersk and IBM are employing blockchain technology to create a global tamper-proof system, to digitize trade workflow and to track shipments end-to-end eliminating frictions including costly point-to-point communications. The collaboration will launch with the potential ability to track millions of container journeys per year and integrate with customs authorities on selected trade lanes. (Armonk, 2017).

In a recent test by Maersk, shipping a single container of flowers from Kenya to the port of Rotterdam resulted in a stack of nearly 200 communications. Using this example, it was examined how blockchain has been implemented to create trust and security in the digitized document workflow and improve the efficiency of global supply chains. (Lieber, 2017).

In the picture below, it is seen that each distinct entity is involved in the transaction: the growers, export authorities, ports, customs and importers (Fig. 3). Shipping from the port of Mombasa requires signatures from three different agencies approving the export, and six documents that describe the origin, chemical treatments quality of the product and customs duties. (Lieber, 2017).

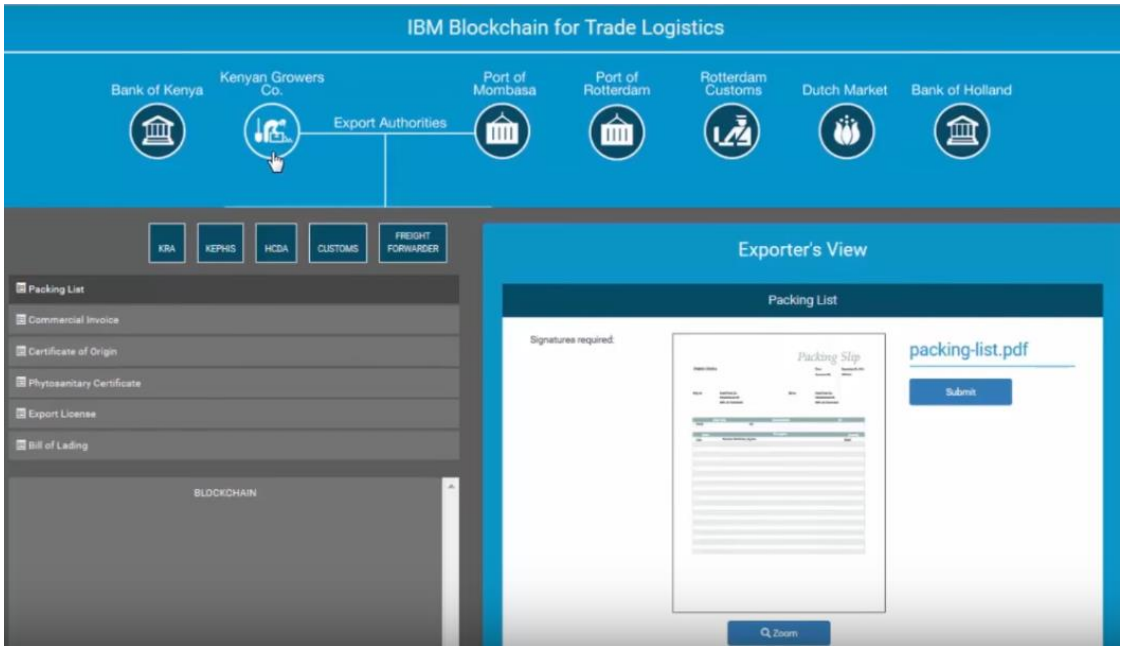

Fig. P-3. IBM Blockchain for Trade logistics (Lieber, 2017).

Firstly, using a PC or a mobile device the canyon farm submits the packing list that becomes visible to all participants. This action initiates a smart contract and export approval workflow between three agencies. As each agency signs, information is updated for all to see. Simultaneously, data about the inspection of the flowers, the sailing of the refrigirated container to pick up by the trucker and the approval from customs is

communicated to the port of Mombasa allowing them to prepare for the container. (Armonk, 2017).

All actions relating to the documents and the physical goods are captured and shared. Especially the information which documents were submitted, when and by whom, where the flowers are and who is in possession of them and the next steps of their journey. Flowers are perishable so it is crucial that there are no delays on missteps. (Lieber, 2017).

Blockchain provides secure data exchange and a temper-proof repository for these documents and shipping events. This system could significantly reduce delays and fraud saving billions of dollars annually and ,according to the WTO, the reduction of barriers within the International supply chain could increase worldwide GDP by almost 5% and the total volume by 15%. (Lieber, 2017).

6 CRITICISM ABOUT BLOCKCHAIN

Nowadays, blockchain has become the technological answer to solve all current problems in different sectors. Indeed, many companies have started to implement it to gain a competitive advantage. Moreover, it does not depend on the industry, all companies from the financial sphere of medicine to aviation want to use blockchain to increase the traceability and transparency in their operations. (Mougayar, 2016, 124-127).

In theory, the blockchain can work, but supply chains are very hard to change and adapt. (Mougayar, 2016, 123). Mougayar thinks, that companies spend years putting supply chains in place and refining them. It is not very easy to insert a new technology inside established supply chain systems because the integration challenges are not to be underestimated.” (Mougayar, 2016, 124-127).

Another researcher in intelligence, strategy and economics Percy Venegas thinks that in order to implement blockchain in industrial context, it is necessary to consider all financial risks of handling a large portfolio of suppliers and increase legal department expertise (Venegas,

2016, 42). He says that currently there is not enough specialists with particular experience in the cryptocurrency space and with broader knowledge of other types of crypto assets. On Venegas's point of view, a company should know more about the blockchain literacy before going into the network.

In their report Gartner Ray Valdes, David Furlonger and Fabio Chesini noted that blockchain as an innovation in the emerging technologies has great potential. They advised to start analyzing businesses to assess potential advantages and disadvantages. (Gartner et al., 2016, 26).

Martha Bennet agrees with Mougayar in that implementing blockchain in a supply chain requires the full cooperation of everyone involved, and this is a very complicated process. (Earls, 2016).

Other researches argue that blockchain absolutely has several strengths, such as access for anyone at any moment, but it still has much room for improvement. Pat Bakey confirms there will be many benefits of applying blockchain, but it cannot fix the flawed relationships between parties in a supply chain. End-to-end processes are too complicated to be solved by a technology. (Earls, 2016).

7 SUMMARY

Blockchain technology has many features and characteristics, that can be useful in today industries. Moreover, it can bring benefits for all parties, especially for customers. Such benefits and key factors can be summed in the following list (Robinson, 2016):

1. Compliance and transparency. These are the most important advantages of blockchain. They can help to eliminate the organizational silos within existing parts of the supply chain and the leadership to understand how to make the supply chain more efficient on different levels.
2. Tracking and Tracing. Due to these features, companies can gain and provide better information concerning product lifecycle, including all types of detailed information.
3. Reduction of errors in auditing and payment processing. Owing to this blockchain characteristic, all payments or

payables can be uploaded in the digital ledger where it will be easily checked and verified.

4. Fraud security. Blockchain is “unhackable”. It decreases the probability of any kind of fraud. Furthermore, it does not work on patches, which makes blockchain the securest in the market of cybersecurity initiatives.
5. Increase of customers’ trust. Blockchain allowing customers to find all necessary information about the origins of the products, way of transportation and packaging, which consequently increasing their trust to the company.
6. Real-time feedback from consumers. Customers can respond to products they have bought or receive in a real time. It can help various parties across the supply chain to analyze their work and to avoid several errors.
7. Better scalability. Blockchain has the ability to help the organizations to develop their business by analyzing the market and responding to possible surges there. Moreover, blockchain does not depend on politics so it inspires companies to expand.

There are many other benefits of blockchain. Yet, the true scope of the blockchain technology is unlimited. It is absolutely a remarkable breakthrough in the history. With the world that becomes more reversible on the IT sphere and mobile devices, blockchain will be a way of improving and connecting the Internet of Things and other industries. (Robinson, 2016).

8 ADOPTION OF BLOCKCHAIN IN LOGISTICS

8.1 SmartLog Project

Nowadays, both the supply chain and logistics industry have several difficulties. One of them is the poor state of standardization and shareability of the operational information. Each company owns its relevant data, and there is a very small amount of organizations that want to share it. This is so because the sharing of information makes planning and resource management much more difficult. This challenge usually leads to inefficiencies in the logistic processes. (Mittwoch, 2017).

In order to solve this problem, many companies try to use different software products. There is a big variety of them, but very few of them can allow companies to communicate with their partners. Most of them are built for one-on-one relationships between ERPs and the company's database, which seems costly. (Dickson, 2016).

Even the larger companies which can cover such costs have their own challenges. For handling world-wide supply chains, these companies need to find independent contractors to cover distant areas. In long-term perspective, this requires expensive systems for integration. (www.smartlog.kinno.fi)

Moreover, the current reality is that data flows associated with cargo are slower than the actual cargo movements. This is so because operational information is usually passed over the phone, email or even fax. Due to this fact, behavioral costs in the supply chain are high.

Here comes SmartLog – the proof of concept project for IoT blockchain solution in logistics industry. (www.smartlog.kinno.fi).

Kouvola Innovation Ltd (Kinno) is piloting this project for the creation a blockchain-based application in order to change the current logistics industry. The new application of SmartLog project is going to be an open-source world-wide solution for every party that is involved in the supply chain. The project is funded by 2.4 million euros from INTERREG Central Baltic. (Ahlman, 2016).

I interviewed Mika Lammi, the Head of IoT Business Development in Kinno. He explained the main data concerning this project.

The entire duration of the project is going to be three years. The launch was on 1 September 2016. According to information on their website the work consists of three stages (www. Kinni.fi/smartlog).

1. Working with the logistics companies in the Baltic region. Sensei LCC is responsible for this stage. The main task is the immediate contact, communication and actual work with the companies that are taking part in this project.

2. The analysis of companies' data that was generated by using a blockchain application. The Tallinn University of Technology is responsible for this stage. The main task is to create a structure of how to analyze the operational data related to container movements across the corridors and find out actual benefits of the use of the blockchain application.
3. Development of the blockchain fabric, application layer and the locator device. Kouvola Innovation Oy is responsible for this stage. The main task is to create the software and hardware tools for both companies and containers to generate the relevant operational information.

Today, Smartlog have finished the ramping-up stage and are now in the first software development cycle. Research hypotheses have been formulated, and an initial batch of pilot companies have been recruited. However, the first indicative results are expected by the end of June 2017. Also they expect the application to have been tested and validated by the end of the project execution period, which ends in the summer of 2019. (www.smartlog.kinno.fi).

For such purposes, SmartLog chose a blockchain-based application because of its ability to share relevant information in a secure and reliable way. (www.smartlog.kinno.fi).

SmartLog wants to create an application that enables companies of all kinds and sizes to communicate and tap into a blockchain in real time where they can find all relevant information related to intermodal transportation throughout the two relevant TEN-T core network corridors in the Baltics, the ScanMed and the North Sea (Ahlman, 2016). The information will be collected from the operational information management systems of different companies, sufficiently anonymized and filtered, and after that added to the blockchain for all participants (www.smartlog.kinno.fi).

Also, SmartLog is going to attach a special device to some containers for comparing their actual movement and information concerning it in blockchain. Information awareness gives the ability to improve the operations, resource management and route optimization planning of the companies. (Lammi, 2016).

One of the main aims of the project is to decrease the duration of the intermodal container movement by at least 3% within the target area.

In general, SmartLog expects that they can achieve total visibility and transparency across the supply chain and create a platform that will connect continent-wide participants of the logistic industry.

SmartLog has many competitors in the market, which are EU funded projects as well. However, they are not going to compete with them or even create a product for the same market. Their task is to fulfil the blockchain potential in logistics by creating the blockchain-based application.

For the actualization of this task, SmartLog has achieved several collaborations. They are connected to the major players in the IoT/blockchain field, as well as the state-of-the-art academic parties (Lammi, 2016). Moreover, IBM, the top five universities and research companies in Finland take big supporting roles. They all have been very excited to be a part of the experiment, and only a very small amount of companies expressed any doubts of the concept. Typically, the operative companies who perform the actual transport are the most receptive, and the ones dealing with information asset management tend to be the most skeptical.

The implementation of the blockchain-application as the host of cargo status information will lead to the appearance of a critical number of users consequently the information will be accumulated very fast and finally the blockchain will become a Big Data Corpus (www.smartlog.kinno.fi). Analyzing such large amount of data is difficult for any analytics platforms, far from human.

The next step for SmartLog is going to be the creation of an artificial intelligence guided marketplace that will increase the analytic and processing activities.

Mika Lammi and the entire team expect this application to be a genuinely innovative game-changer technology which will transform the whole industry in a very profound way.

Arguably, this application could be used to make the transportation processes more transparent, secure and robust. Moreover, if SmartLog and their partners could do it, the results would be immense.

9 CONCLUSION

Blockchain is a technology under Bitcoin's core that possess the key features enabling to solve various current problems in financial and non-financial spheres. This technology faces different ups and downs in the current world. People are divided in two parts: those are truly interested in blockchain-based application and those are skeptical concerning that kind of innovation. Therefore, the adoption of blockchain faces many challenges. The most significant of them, arguably, is the ability of blockchain to displace people from work, but all of us should understand that blockchain is an innovative technology that improves the efficiency in different sectors and enhances globalization in general. Due to this, a large number of financial and non-financial companies invest money in the creation of blockchain-based applications and start to implement them in their business in order to enhance several metrics and performance in general.

Supposedly the adoption of blockchain in the supply chain and logistics is slow at present because of associated risks and some companies appear to be skeptical about this technology, but it is very likely that soon it will earn the confidence of them and will be spread through all industry.

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