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Blockchain Technology and its utilization in Finnish companies

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Abstract

Blockchain technology created a fair amount of hype in recent years, resulting in a myriad of cryptocurrencies and promises of a new trustless economy. As students of Business Information Technology at JAMK we were interested in the ways that blockchain could transform the way data is handled. The goal for the thesis was to find out the relevance of blockchain technology from the point of view of Finnish companies.

The research was conducted with qualitative methods focusing on the current and future use-cases of blockchain technology in companies around Finland. Also included in the research is an overall assessment on the need for raising awareness of the technology as well as the need for blockchain-related expertise. The research material was collected from existing literature on the subject and semi-structured interviews with individuals from related companies. The data was analyzed deductively with thematic analysis.

The findings indicated that blockchain technology is a significant actor in distributed system architectures because it acts as a solution to many existing problems encountered in various industries such as finance and logistics. Implementing blockchain technology can, in specific cases, allow for more efficient and secure processes by replacing the work done by trusted intermediaries. In some companies blockchain technology was already in use, but in most cases applications were in development.

Based on the findings, blockchain technology offers considerable benefits to companies in specific industries, although it isn't essential in every situation. The technology still faces challenges that need to be addressed, but at the moment it is the most promising format for systems utilizing distributed ledger technology.

Keywords/tags (subjects)
Blockchain technology, blockchain applications, blockchain adoption

Miscellaneous (confidential information)

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Työn nimi
Lohkoketjuteknologia ja sen hyödyntäminen suomalaisissa yrityksissä

Tutkinto-ohjelma
Tietojenkäsittelyn tutkinto-ohjelma

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Tommi Hakala
Jarkko Immonen

Toimeksiantaja(t)

Tiivistelmä

Lohkoketjuteknologia keräsi viime vuosina paljon huomiota mullistavien lupausten sekä lukuisten kryptovaluuttojen myötä. Tietojenkäsittelyn opiskelijoina JAMK:ssa olimme kiinnostuneita siitä, miten lohkoketjuteknologia pystyisi muuttamaan tapaa, millä käsittelemme informaatiota. Tutkimuksen tarkoituksena oli selvittää lohkoketjuteknologian olennaisuus suomalaisten yritysten näkökulmasta.

Opinnäytetyön tutkimusosuus toteutettiin kvalitatiivisin menetelmin. Tutkimuksessa kartoitettiin lohkoketjuteknologian tämänhetkisiä ja tulevaisuuden käyttökohteita suomalaisissa yrityksissä. Tutkimus sisältää myös tietoa teknologian tietoisuuden ja asiantuntijuuden tarpeesta. Aineisto kerättiin kirjallisuudesta sekä puolistrukturoiduista haastatteluista yrityksissä työskentelevien henkilöiden kanssa. Aineisto analysoitiin teorialähtöisesti teemoittelemalla.

Tulokset osoittivat, että lohkoketjuteknologia on merkittävä tekijä hajautetuissa järjestelmissä. Teknologia auttaa ratkaisemaan eri aloilla, kuten taloudessa sekä logistiikassa todettuja ongelmia. Tarkemmin ottaen, lohkoketjuteknologian implementointi voi tietyissä tilanteissa tehostaa prosesseja sekä tehdä niistä turvallisempia, koska teknologian ansiosta voidaan karsia tarpeettomia välikäsiä. Lohkoketjuteknologia oli jo käytössä joissain haastattelemissamme yrityksissä, sekä osassa yrityksistä käyttöönotto oli kehitysvaiheessa.

Tulosten perusteella lohkoketjuteknologia tarjoaa merkittäviä hyötyjä tiettyjen alojen yrityksille, vaikkakaan se ei sovi kaikkiin tapauksiin. Teknologialla on edelleen haasteensa, mutta tällä hetkellä se on lupaavin vaihtoehto hajautettujen tilikirjojen teknologioista.

Avainsanat (asiasanat)
Lohkoketjuteknologia, lohkoketjusovellukset, lohkoketjuadoptio

Muut tiedot (salassa pidettävät liitteet)

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Terms

Block	An individual block in a chain of blocks, containing transaction information added to the Blockchain.
Blockchain	A growing list of blocks linked together using cryptography.
Consensus	A state between participants in a blockchain, where everyone agrees on the status of the ledger.
Consensus protocol	A mechanism in blockchain which ensures the validity and authenticity of transactions.
Consortium	An association of two or more organizations to achieve a common goal.
Cryptocurrency	A digital currency whose ownership is managed by a blockchain.
Cryptography	A method of protecting information and communications through the use of code.
Distributed ledger	A shared database spread across various geographies, sites or institutions.
Fork	A split in a blockchain network, where a new version of the blockchain is created from the existing one.
Hash	Function used to convert arbitrary data sizes to fixed-size values.

Internet of Things	Devices around the world are connected to a network collecting and sharing data, without requiring human interaction.
Mining	Computational work by which transaction records are added to certain blockchains.
Node	A point in the network where a message can be created, received or transmitted.
P2P	Peer-to-peer. A network of computer systems that share data between the network, without the need of a central server.
PKI	Public Key Infrastructure. A technology for authenticating users and devices in the digital networks.
Smart contract	A computer protocol that digitally facilitates, verifies or enforces the performance of a contract, without third parties.

1 Blockchain - A Technology Transforming Industries

Blockchain technology has seen a relatively large surge in popularity since its inception in 2008, when an anonymous internet user known as Satoshi Nakamoto proposed to the world a new way of transferring value without relying on existing financial institutions. The protocol in question is known as Bitcoin, an open source digital currency that exists on a vast network of geographically distributed devices, accessible to anyone with an internet connection. (Nakamoto 2008.)

Seemingly countless new digital assets (cryptocurrencies) built upon blockchain technology have since appeared on the markets, many of them claiming to fundamentally transform the way that several industries such as finance operate. At the heart of these claims is the vision that by utilizing blockchain technology, various intermediaries of the world become obsolete, paving the way for direct person-to-person or business-to-business interactions. With intermediaries out of the picture, efficiency is set to increase and costs of doing business are expected to go down. (CoinMarketCap 2020; Johansson, Eerola, Innanen & Viitala 2019.)

The benefits created by blockchain technology are universal, reaching far to other industries besides its origins in finance. The strive to utilize this technology already spans across sectors such as supply chains, healthcare, identity management, energy production and copyright management among many others. By replacing traditional systems with a single distributed database accessible to all parties, it creates much needed improvements to their operation. (Johansson et al. 2019.)

In recent years a big hype boom was seen in the industry, when around the turn of the year 2018 cryptocurrencies achieved their all-time peak in overall market capitalization. This brought cryptocurrencies to everyone’s attention for a brief moment. However, since then the hype has died off and actual use cases have begun to appear on the technology to utilize it in various scenarios. (CoinMarketCap 2020; Johansson et al. 2019.) So where does the technology stand with companies in Finland today?

By diving deeper into the operation of Blockchain technology, this thesis seeks out to assess the feasibility of its use as a disruptive new technology. This is done by conducting comprehensive theoretical research on the subject, and then mirroring findings by interviewing companies about different aspects of Blockchain technology such as its strengths, weaknesses and use-cases. Research on the subject is needed because as of yet, there is a very limited amount of research done on the subject. Specifically, research on emerging use cases, blockchain-related employment opportunities, the need for education as well as the future significance of Blockchain technology.

This study is conducted by ourselves, the researchers, emerging from our own interest in the subject. With years of experience in observing blockchain technology mainly in the form of cryptocurrencies, the thirst to further understand the technology and its possibilities exists in our minds. And as students of Bachelor's Degree Programme in Business Information Technology in JAMK University of Applied Sciences, a notable impact can be expected to be made by blockchain technology in the field we study, so the technology is worth studying for us.

This thesis consists of six main chapters and their subchapters. The relevant terms used in this study are explained in a section after the contents. The structure is illustrated in the Figure 1.

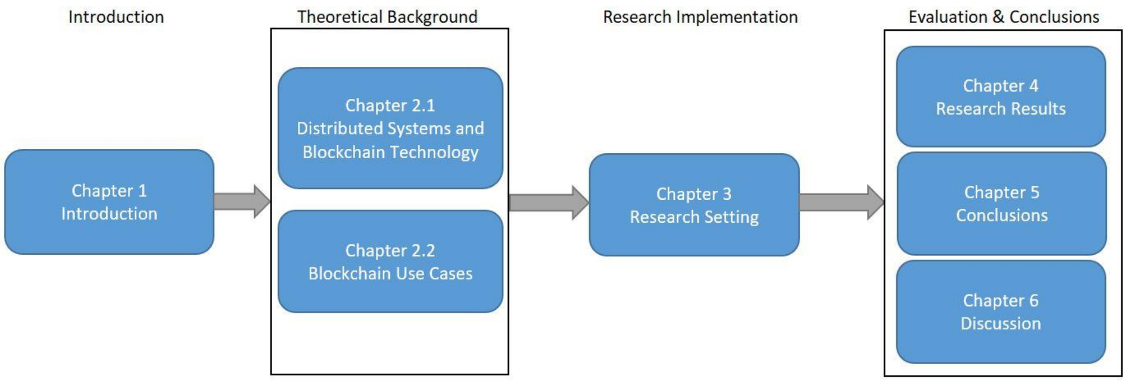

Figure 1. Thesis structure

2 Blockchain Technology

This chapter builds the theoretical background for this research. It explains the basics for understanding how distributed systems and blockchain technology work, and what are the advantages and challenges for them. It also goes through different blockchain applications and use cases exist.

2.1 Distributed Systems and Blockchain Technology

Blockchain technology at its core is built upon a distributed system architecture. A good way to determine if a system is distributed or not, is to find a single point of failure, be it a database, a login component or a user registry. If the system can be terminated by compromising even one of these components, it does not qualify as a distributed system, but is instead referred to as a centralized system. These systems are depicted in Figure 2. Distributed systems, however, do not rely on a central authority to maintain databases or guard safety. Instead, a copy of the system database is available in an open cloud for all participants who are eager to independently maintain the system. These participants then work together according to rules set by the protocol on which they are operating and compare their versions together in a process of voting uninterruptedly. (Drescher 2017.)

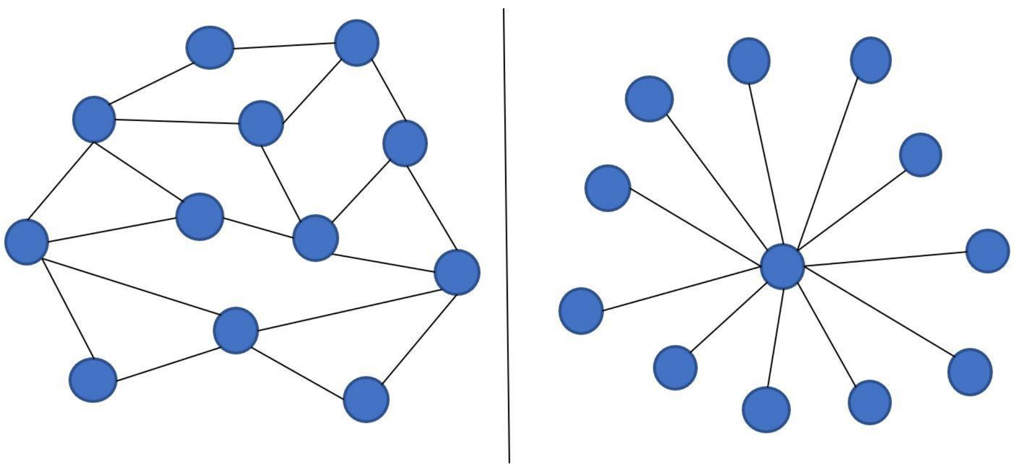

Figure 2. Distributed (left) vs. centralized (right) system architecture (Drescher 2017.)

Compared to a centralized system, distributed systems have certain key advantages that make them valuable. One of them is the ability to grow naturally. The computing power of the whole system is increased for each additional computer connected to it. The costs of creating, maintaining, and operating systems like this is lower than operating supercomputers with the same capabilities. A distributed system also has higher reliability when compared to a centralized system. The network can continue operating even if individual machines crash, since the system does not have a single point of failure. If an element ends up failing, the remaining elements take over. (Drescher 2017.)

However, distributed systems come with their own set of challenges that need to be addressed. Some of them emerge from the fact that the computers that form a distributed system need to successfully communicate with each other. This requires a communication protocol and the sending, receiving and processing of messages. And since the system doesn't have a central entity to coordinate the members, the coordination must be done by the members themselves. These are challenging to create and require cost effort and computing power that cannot be spent on genuine computing tasks. (Drescher 2017.)

The Network communication also requires a medium, which is responsible for transferring information between the entities known as nodes. Networks have their own challenges that impact the communication and coordination between computers in a distributed system. Without a network to work on, distributed systems cannot exist. Security concerns are implied as well when sending information through a network. Untrustworthy entities are able to misuse the network to gain access and exploit information. The less restrictions there are to access a network, the higher the security concerns are for a distributed system. (Drescher 2017)

The operation of peer-to-peer networks

Nodes are essentially either a redistribution center for information, or a start- or end-point for communication. The strict definition of a node depends on the specific network and protocol layer on which it is operating. In essence, a node can be any kind of active device including a computer, printer or phone, as long as it is connected to the Internet and possesses an IP-address. In the blockchain environment nodes have the role of supporting the network by maintaining copies of the blockchain data and in some cases processing transactions. All blockchains have their own nodes that perform different tasks in order to keep the network running. Nodes are essential components in maintaining a peer-to-peer network. (Johansson et al. 2019.)

Peer-to-peer networks refer to certain kinds of distributed systems. These systems may still use aspects of centralization within them, such as maintaining central nodes to help connect peers to each other or performing identification of nodes. Peer-to-peer systems that are centralized typically use a **hybrid** architecture, illustrated in Figure 3. In a purely distributed Peer-to-peer system, like the one Bitcoin operates on, nodes make their computational resources such as network band-with, processing power and storage capacity available for use to other network participants without a central coordinator. As supporters of the network, nodes act as both consumers and suppliers of resources. This kind of Peer-to-Peer activity has been used outside of blockchain technology as well, to power up use cases such as the distribution of content, file sharing and privacy protection. (Drescher 2017.)

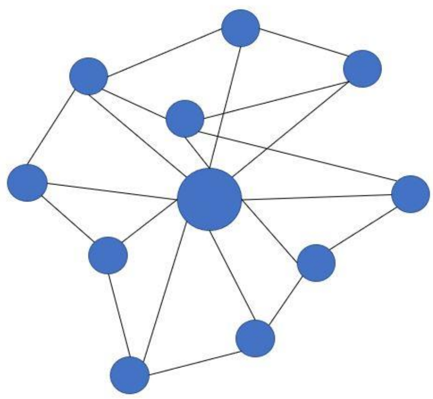

Figure 3. System architecture with an established central component within a distributed system (Drescher 2017.)

Blockchain is a powerful companion to Peer-to-peer systems because it can be used for achieving and maintaining the integrity of the system in a manner that does not require a centralized middleman. In the case of Bitcoin, this means transacting with contractual partners directly, instead of having transactions going through trusted intermediaries. The term “blockchain” refers to a data structure that allows the creation of a shared digital ledger that contains a list of transactions. Cryptography is then used for a distributed network of computers to participate and manipulate the digital ledger securely without intermediaries or central authorities controlling the network. Therefore, the potential implications and benefits of such a technology extend to economic, political, humanitarian and scientific fields. (Neittaanmäki 2016; Drescher 2017.)

However, it is important to note that blockchain is only one form of the Distributed Ledger Technology (DLT), where data is stored in a specific format. Generally, the term “distributed ledger” refers to a type of database distributed across a network. So, a blockchain is always considered as a distributed ledger, but not every distributed ledger utilizes the blockchain data format. (Chowdhury, Ferdous, Biswas, Chowdhury, Kayes, Alazab & Watters 2019.)

The nodes supporting the peer-to-peer system have equal rights and roles within the network. One such important role on the Bitcoin network is processing transactions, also known as updating the ledger. This process happens through the **consensus protocol,** which ensures that new transactions that are added to the blockchain are valid and ordered. Consensus protocols are very important in securing the integrity and trustworthiness of distributed blockchains. Different blockchain platforms are focused on different kinds of applications, which create distinct security needs. This means that differing projects will opt for specific consensus protocols, which cater to the projects’ specific needs. Generally speaking, public blockchains such as Bitcoin achieve consensus among a large amount of untrusted nodes by using computational work, while sacrificing transaction throughput and finality. A closer look at some of the most popular consensus models reveals the tradeoffs inhibiting them. (Drescher 2017.)

In order for new transactions to be added to the blockchain, Full Nodes must perform computational work, which is known as **Proof-of-Work**. On the Bitcoin network, nodes must find a certain hash value that is smaller than a number set by the difficulty level of the network. This difficulty level is controlled in a dynamic fashion by the protocol layer of Bitcoin, which makes sure that one block is produced approximately once every ten minutes. A Node that manages to successfully find the correct hash adds the produced block to the blockchain and claims a reward for its work. This process of finding a winning hash value through computational work and getting a reward for it is also referred to as mining. Proof-of-work is currently the most popular consensus method, as it allows the blockchain to be updated in a frequent and reliable way across the numerous nodes found all over the globe. While Bitcoin's consensus method of Proof-of-Work scales to thousands of participants (nodes) on the network, it inhibits serious drawbacks such as low transaction rates, high latencies and an immense energy usage due to the amount of energy used on its computational work. This places some limits on its usecases. (Baliga 2017.)

Proof-of-Stake is a type of consensus method that is designed to overcome some of the disadvantages present in Proof-of-Work algorithms, specifically the high energy usage due to mining. Instead of using computational work to validate the network, Proof-of-Stake algorithms involve staking a user's virtual currency to purchase proportionate block creation chances.

Nodes in a blockchain network are often categorized into defined groups, which have their own responsibilities. For example in Bitcoin, they can be categorized into two groups, Full Nodes and Partial Nodes. A Full Node contains a complete list of all transactions that have been made on the specific blockchain the Full Node is operating on. On the Bitcoin Blockchain, a Full Node would comprise of all the blocks that have been processed on the network since 2009 to present day. When Full Nodes are connected to the network, the complete list of blocks is copied to them, making it practically impossible to destroy all the copies of the blockchain. As long as even one of the Full Nodes retains its records of the blockchain, the network on that node remains untouched and can be further copied by adding to it other Full Nodes. A Partial Node could only contain blocks processed during the last few months or blocks within an even smaller time-frame. (Johansson et al. 2019.)

Blocks on the Bitcoin Blockchain

Blockchains are made up of a chain of blocks containing information about transactions that have been made on the network. The information within blocks can refer to token transfers on the Blockchain or any manner of data exchange. A block is divided into two distinct parts, the header and the body, as depicted in Figure 4. Transactions reside within the body part of the block, while the header acts as a link to the previous transaction by containing the identifier of the previous block and a timestamp of when the block was published to the blockchain network. (Ali, Vecchio, Pincheira, Dolui, Antonelli & Rehmani 2018.)

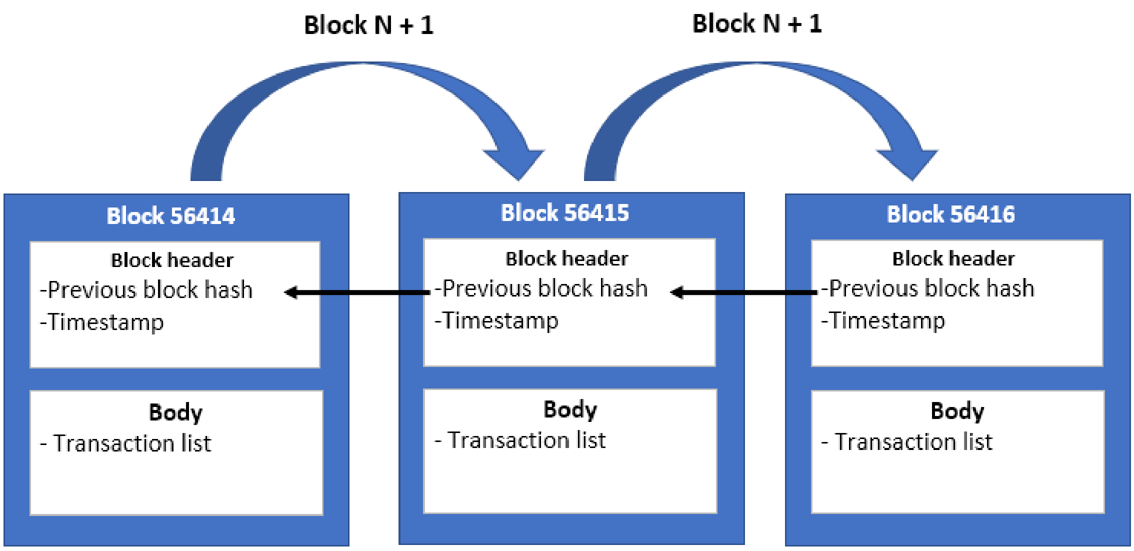

Figure 4. A blockchain consisting of a sequence of blocks (Liang 2020.)

A genesis block, which has no parent block, refers to the first block on the chain. All subsequent blocks are linked to the genesis block by having its cryptographic hash within the identifier. Because the blocks are structured in this way, the blockchain achieves its immutability and makes it hard for attackers to take control of. For example, if a hacker tried to change the transaction information of a former block, the identifier of the block would cease to be valid, and all the following block identifiers would also be rendered invalid. For a hacker to successfully modify the chain of blocks, they would have to modify all headers in all the ensuing blocks, while having the modification occur in the majority of the nodes in the network in order for all the nodes to reach consensus on the modified blockchain. (Ali et al. 2018.)

Hashing

Hash values are one of the most important base technologies underlying blockchain. They can be considered as unique identifiers, just as fingerprints identify people uniquely or as IP-addresses identify computers. The need for hashing within peer-to-peer distributed systems comes from dealing with a massive number of transaction information occurring on the blockchain which needs to be identified uniquely and compared as efficiently as possible. (Drescher 2017.)

Hash functions are computer programs that serve the purpose of transforming input data of any size into a fixed length hash value. Cryptographic hash functions are one group of hash functions that create an equivalent of a digital fingerprint for any kind of information. This specific group of hash functions inhibits qualities such as rapidly providing hash values for any kind of data, being pseudorandom and being deterministic. (Drescher 2017.)

Different blockchain types

Blockchains can be broadly classified to two groups; Public (permissionless) blockchains and private (permissioned) blockchains. Public blockchains like Bitcoin and Ethereum do not restrict access to any specific users. Therefore, anyone is allowed to allocate their resources such as computing power to support the network. This helps with decentralization as the barriers of entry to the network are very low. On public blockchains updating the mutual blockchain requires the majority of participating nodes to support the update. This means that no single node can by itself alter the blockchain. (Catalini & Tucker 2018.) Public blockchains are preferred in a situation where multiple parties do not trust each other but still want to transact and interact with one another. (Drescher 2017.)

Public blockchains often leverage pseudonymity in their operation, which means that addresses in the blockchain network are not directly linked to individuals. However, singular addresses can still be held accountable for transactions and they can be tracked. (Ali et al. 2018.) For this reason, blockchain projects such as Zcash exist, to offer additional protection for transactions. In these networks all personal and transaction data can be entirely confidential, so that the sender, receiver or the transaction amount are never revealed to other parties. (Electronic Coin Company 2020.) But this means that it compromises transparency in the network, which many other blockchain projects base their work on.

Typically, the source code of public blockchains is public, which means that its users and developers are free to create a fork from one version of the blockchain. The entire codebase can be forked, including the complete history of transactions, which means that the new blockchain can be set to a state existing previously. In many cases of cryptocurrencies, this has already happened, including Bitcoin and Ethereum. The reasons for creating a fork in a blockchain can be various, for example attempts to modify the incentives of the blockchains system, or disagreements in the technical or administrative solutions in the network. So, in theory, every public blockchain is in constant threat of competing forks of the blockchain, that might achieve superiority and seize the users from the original network. (Catalini & Tucker 2018.)

Private blockchains, known as permissioned blockchains as well, allocate some network participants with more control than others. For example, a private blockchain could allow certain trusted nodes with the ability to write data, while other participants are only allowed to read the data. In some cases, trusted nodes hold all the power to maintain the blockchain and can be considered centralized as opposed to decentralized blockchains. (Catalini & Tucker 2018.)

Private blockchains are well fit for single enterprise solutions and they are commonly used as a synchronized distributed database as a means to keep track of the flow of data between different departments or entities. As private blockchains are centralized to trusted nodes, they do not necessarily need transaction fees or a currency to operate. Private blockchains can be altered by their operators much more easily than public blockchains, because the trusted nodes hold more control. (Ali et al. 2018.)

However, the lack of fully decentralized confirmation in the network is a vulnerability for the private blockchain. The network can more easily be exposed to tinkering, if a node falls into the hands of malicious actor. Using a private blockchain also requires trusting a third party or governing authority to confirm the occurring transactions. (Catalini & Gans 2018.)

One of the most common consensus mechanisms in private blockchains, of which different variations are used, is known as Byzantine Fault Tolerance (BFT). BFT is used to prevent fail states in the system, that are created by a faulty node sending false information into the network. Other nodes in the system need to achieve consensus in identifying the faulty node and decide whether it is to be removed from the system. BFT is a good fit for real-time systems, including even systems like air traffic control, that require low latencies to work. For example, in Hyperledger Fabric, there exists support for two consensus models: Practical Byzantine Fault Tolerance (PBFT) and it’s further developed model SIEVE. (Syed, Alzahrani, Jan, Sidiqqui, Nadeem & Alghamdi 2019).

In some applications, private blockchains are used together with public blockchains, to create a tiered structure for the network. In these cases, there can exist multiple private blockchains that work together with a public blockchain network, as depicted in Figure 5. The private networks can work in complete privacy, only to provide certain data to the public chain through requester nodes to be viewed. This has been researched to be used for example in the environment of Internet of Things. (Ali et al. 2018.)

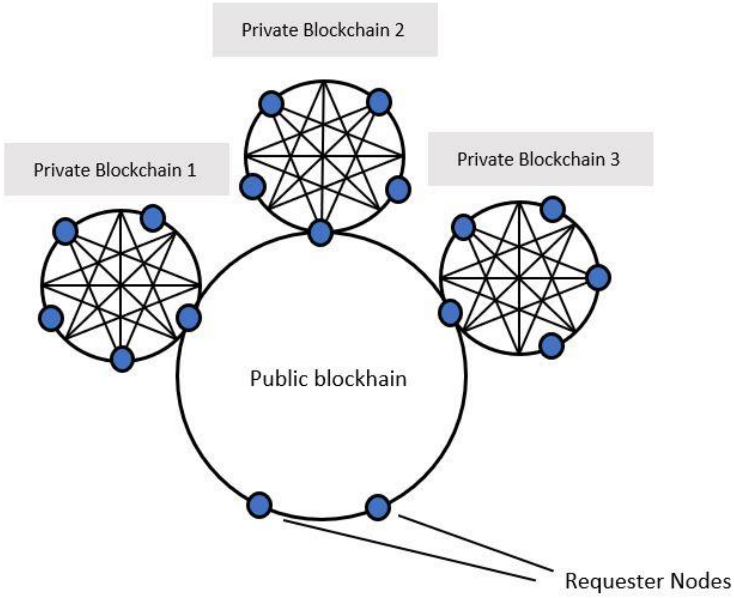

Figure 5. Tiered blockchain system architecture (Ali et al. 2018.)

Decentralized Applications

Building decentralized applications on top of Bitcoin's protocol is very difficult. While the protocol started as a means to transfer value from one individual to another, its fundamental limitations made it non-viable to do more complex tasks such as manage a decentralized reputation system. What Bitcoin did bring to the table, however, was the fundamental breakthrough of Blockchain Technology, which allowed its users to agree on the state of a public ownership database without middlemen. On Bitcoin's protocol, this ownership was limited to money. (Buterin 2014.)

To overcome the limitations of Bitcoin and to explore new use cases for blockchain technology, a new protocol had to be developed. In 2014, an individual named Vitalik Buterin released a whitepaper for a project called **Ethereum**. In it is described a "Next-Generation Generalized Smart Contract and Decentralized Application Platform", which is able to create self-governing corporations or applications operating on the blockchain without any centralized authority. These applications are able to autonomously manage funds and resources by using self-enforcing **Smart Contracts**. How Ethereum manages to do this is by having an abstract foundational layer containing a blockchain with a built-in

Turing-complete programming language. Anyone is then allowed to utilize Ethereum by creating their own decentralized applications and Smart Contracts with their own set of rules for ownership and transaction formats. (Buterin 2014.)

Applications that can be created on top of Ethereum come in three different categories. Firstly, there are financial applications that give users powerful tools to manage and enter into contracts by using their money. Sub-currencies, hedging contracts, wills, saving wallets and even employment contracts are included in this category. Secondly, semi-financial applications that involve money but also include a non-monetary function. An example of this is self-enforcing bounties for solutions to computational challenges, essentially meaning that when a bounty for a computational problem is completed, the application will pay the individual that completed the bounty by itself. Thirdly, Ethereum supports applications without a built-in financial function such as online voting or decentralized governance. (Ethereum Whitepaper)

Smart contracts are applications that can be programmed to manage transactions within a blockchain. What makes smart contracts different from traditional economic contracts is the fact that while traditional contracts are controlled by centralized parties, smart contracts in fact do not require middlemen to authorize transactions as they are run fully digitally on decentralized blockchains. (Ali et al. 2018.)

Benefits of blockchain

Through the technical characteristics blockchains, they offer different benefits to distributed systems. Here are gathered some key elements, that make the blockchain a valuable asset for use:

All new entries to a blockchain are confirmed by peers through decentralized consensus so the blockchain can’t be censored and is nearly impossible to be tampered with. Also, all previously recorded data in the blockchain is **immutable**, and can only be compromised if an attacker would gain control of majority of the nodes involved in the network. (Ali et al. 2018.)

By being highly **transparent**, blockchain technology seeks to solve related problems that exist in current systems. One of these is data falsification, which blockchain aims to prevent by having all transactions be traceable and verifiable by any peer in the network. A copy of the blockchain is held by all the peers and they have access to the timestamped transaction records (Ali et al. 2018). The transparency with blockchain's verification systems also tries to make double-spending impossible for a user through ordinary means (Tran & Levin 2017). And as every peer contains the exact copy of the ledger records, any faults or data leakages in the network can be detected. This happens through decentralized consensus, and data leakages can be handled by using the copy stored in other blockchain peers. (Ali et al. 2018.)

Using blockchain creates a **democratic and trustless environment** removing the need for third party intermediaries to validate and authorize transactions. Nodes in the network engage in transactions directly with each other, and every participant gets a say in forming the true course of events in the network, resulting in a leaderless democracy of devices. (Mattila, Seppälä & Holmström 2016.) Each peer has the same replica of the ledger, which updates simultaneously as changes are entered in one copy. This results in transactions records of the values and assets exchanged being permanently entered in all ledgers securely and verifiably. (Iansiti & Lakhani 2017.)

Challenges of blockchain

Not every blockchain shares the same set of challenges because of the unique composition of different mechanisms in them and the use they are designed for. Certain applications of blockchain have developed solutions to specific problems to some extent, but they haven't yet gained enough recognition to stand out beside the major known applications. Mentioned here are some of the most common challenges known to popular blockchains, that are seen as notable halts to the advancement of the technology:

Energy efficiency has not been a priority in the computer engineering field, and some domains are faced with possible major issues regarding **power consumption and wasted resources**. Blockchains that perform mining similar to Bitcoin with its Proof-of-Work require huge amounts of energy to compute and verify transactions securely and with trust. For the mining to be efficient, the amount of wasted resources needs to be decreased. Alternatively, different consensus mechanisms can be utilized for more efficient operation. (Yli-huumo, Ko, Choi, Park & Smolander 2016.)

Depending on the used consensus mechanism to achieve consistency in a blockchain, confirming transactions require longer times, **limiting scalability**. Currently the confirmation rate of Bitcoin is approximately 7 transactions per second, which falls behind greatly when compared to VISA or MasterCard that both have the capacity to process tens of thousands of transactions per second. Highest transaction rate currently in the major cryptocurrencies is held by Ripple, which with its consensus mechanism claims to be able to consistently handle 1,500 transactions per second. In the future, if blockchain solutions are to be used by tens of millions of people, especially in contexts that require high processing speeds, scalability and throughput, they need to be able to handle the amount of transactions made. (Yli-huumo et al. 2017; Baliga 2017.)

One of the key components to the mass adoption of blockchain is its **usability**. The value and information represented on a blockchain needs to be moved between different parties for the purpose of commerce and utility. If this only happens to a limited degree because of inaccessibility, the mainstream adoption of blockchain can’t be achieved. As blockchain transactions are immutable, users must have high confidence in occurring transactions. It is also essential that supporting tools are developed for users to help in analyzing the blockchain networks. (Yli-huumo et al. 2017; Blockchain Usability Report 2019.)

For blockchain technology to be a valid option in regulated markets, it needs to address existing **legal and regulatory requirements**. A good example is the EU’s GDPR, which requires personal data to be freely accessible across Member States and ensure the integrity and confidentiality of that data. It also assumes that all personal data points have a data controller. Each use-case of blockchain has its own specific technical design and governance, so compatibility with GDPR cannot be generalized. However, private and private blockchains are generally easier to be designed to match the data protection laws.

This is because the participants of the network are known to each other, which allows for example contractual relationships that enable the allocation of responsibility. (Finck 2019.)

The growing interest in blockchain networks has increased the amount of identified **security vulnerabilities**. One of the most known ones is the 51% attack, which means that attackers have control over majority of the network's mining hash rate and are able to manipulate the blockchain. This manipulation can include actions such as preventing other miners from completing blocks, blocking other users' transactions and reversing sent transactions. (Double-spending 2019.) The trustworthiness of a blockchain is based on most of the system's computational power being controlled by honest nodes. The attack is especially critical for small peer-to-peer systems with limited computational power, where controlling the majority is more easily achieved. (Yli-huumo et al. 2017.)

Forwarding information in a distributed peer-to-peer system to all elements in the system requires time, and not all peers are up to date at the same time. Exploiting this can lead to transferring ownership and making the same transaction more than once, resulting in double spending. Blockchains are built to verify each transaction so that double-spending doesn't happen. However, through the 51% attack for example in bitcoin, the attacker would be able to make transactions to their wallet multiple times by reversing the blockchain ledger to a state where the initial transactions had never occurred. (Drescher 2017; Double-spending 2019.)

2.2 Blockchain Use cases

IoT

Blockchain technology in Internet of Things, together with smart contracts, aims to provide autonomous systems that work with minimum deliberate human interaction. This allows the system to exchange data as well as pay and get paid for resources that they consume and provide. As an inherently decentralized system with entities that have no shared trust, blockchain seems a valid option. However, the smart contracts and the sensors that provide the data for the contracts, both need to be trusted. (Ali et al. 2018.)

Current IoT platforms are based on a centralized model, where a central high-end server is in charge of providing services like data handling, coordination and authorization. Increasing the number of devices communicating with each other over the Internet continuously increases the requirements for the servers. Weaknesses of a centralized model consist of security, data privacy, and the trust inherently included in using centralized servers. A blockchain-based decentralized IoT framework addresses these weaknesses, and offers other potential benefits such as resilience, adaptability, fault tolerance and reduced maintenance costs. (Ali et al. 2018; Wüst & Gervais 2018.)

IoTeX is one of the blockchain based projects that focuses on privacy, scalability and speed in IoT. Its architecture utilizes many hierarchically arranged blockchains that run concurrently and interoperate to maximize the scalability and privacy to work efficiently in this environment. Privacy actualizes in the network through different protocols that allow confidential transactions so that anyone in the network can't view their details. (IoTeX 2018.)

Some of the use cases of IoTeX mentioned for the IoT consist of shared economies, smart homes and identity management. For example in shared economies some of the claimed benefits of IoTeX are: the deposits being settled by smart contracts without having to trust companies, the economy being run by the community with shared things realizing their own value and mission autonomously, and the user's data being kept safe in the blockchain with privacy protection. (IoTeX 2018.)

IOTA is a distributed ledger project focused on utilizing the technology to offer solutions to IoT through feeless microtransactions and data integrity for machines. It's distributed ledger "Tangle" consists of a stream of individual transactions entangled together instead of transactions grouped into blocks and stored in sequential chains. Instead of being a blockchain, the Tangle is a Directed Acyclic Graph which doesn't have transaction fees and fixed limits on the amount of transactions that can be confirmed per second. The throughput grows together with the amount of activity in the network. In order to make a transaction, the validation for that transactions are earned by validating two previous transactions made in the network. (What is IOTA? 2019.)

Currently IOTA is involved in industries such as Mobility & Automotive, Global trade & Supply chains, Industrial IoT, eHealth and Smart energy, but ultimately it seeks to applied in the Internet of Everything. As an example, for Industrial IoT, IOTA offers a solution for machine to machine communication, payments, and immutable data storage required in smart factories. This is provided by the distributed ledger's scalable, lightweight, and zero-fee communication and transaction protocol. (What is IOTA? 2019.)

Finance (and Transfer of Value)

Finance and value transfer have long been one of the main use cases at the forefront of blockchain technology. It has brought up a new-found excitement for the future of money, but it has also come with a new set of challenges.

If properly implemented, blockchain technology can introduce substantial technical benefits over traditional systems in finance for individuals and businesses alike. For individuals, benefits include increased security, extra privacy and greater control of their own financial assets. Businesses can benefit by eliminating the risk of charge back fraud, a considerable decrease in payment processing fees and the fact that payments can be easily accepted from anywhere on the globe. With the use of blockchain technology, existing systems of value transfer between payment processing companies or individuals can be greatly improved as well. For example, a reduction of the settlement time between banks can be reduced from several days to mere seconds. Different blockchain projects focus on different kind of usecases regarding finance and value transfer. Some are focused exclusively on Peer-to-peer value transfer while others center their protocols around interbank payment systems. (Mattila 2016.)

There are a couple of different blockchain technology projects, cryptocurrencies, worth mentioning when talking about finance and protocols aiming to improve traditional systems of value transfer. While Bitcoin itself started out as a means to transfer value fully digitally and in a decentralized fashion (Nakamoto 2008), its technical limitations especially in transaction speeds and costs have hindered its ability to act as an efficient transfer of value protocol and gain substantial adoption. Therefore, its main focus has later shifted to acting as a decentralized store of value. New solutions utilizing blockchain for efficient value transfer are emerging, however.

One such project in the sector of finance that aims to provide a global distributed settlement network which allows the communication of blockchain and traditional banking systems is Ripple. One of its core focuses is to enable financial institutions to send funds across borders instantly, reliably and cost-efficiently (Ripple Official Website). Ripple also has its own cryptocurrency, XRP, which can be used as an intermediate currency for facilitating transactions. It is useful in this regard because of its instant and low-cost transactions. Essentially, banks and credit unions can use Ripple's blockchain for transfers outside their own institution while at the same time retaining their own banking systems. Some banks such as Accenture and UBS have used Ripple's protocol (Koch & Pieters 2017). Ripple's usecase of blockchain technology does not remove trust from banking systems, it simply helps attempts to bring the slow, traditional banking system up to today's standards with faster and more efficient settlements. (Wust & Gervais 2018.) The project is also owned by a private company, Ripple, and thus should not be confused with decentralization.

In the past, blockchain technology projects with the aim of facilitating trustless P2P cryptocurrency transactions have had some technical limitations that have hindered their ability of acting as a real-world digital currency. For a decentralized digital currency to function reliably, it should be scalable for a high volume of transactions, its fees should be very low or even non-existant and its transaction speeds should be virtually instantaneous. On top of that the protocol should most importantly be secure from a myriad of different attack vectors. In 2015 Colin LeMahieu released a whitepaper for a feeless distributed cryptocurrency protocol, Nano, with the aim to address these issues. Nano uses a "block-lattice" structure, essentially enabling each account running on the protocol to have its own blockchain. This helps the protocol with scaling, as the transactions can happen asynchronously, in P2P fashion. (LeMahieu 2015.)

Instead of mining as its consensus method, Nano uses an Open Representative Voting system, allowing every account to freely delegate their voting weight (amount of Nano on the account) to Principal Representatives (Nodes that vote together on the validity of transactions). The upsides of this kind of consensus system include extremely lightweight block sizes allowing for instant transactions, significantly less energy use than PoW and stronger decentralization due to the low cost of producing consensus on the protocol. (What is Nano?)

Supply Chains

Blockchain technology can bring massive improvements to supply networks by providing detailed and immutable supply chain records to companies and consumers. More detailed information about products and services can be provided, and ultimately every step of the production process would be transparent. This would enhance product safety and allow consumers to specify their product criteria. (Mattila 2016.)

Instead of having to maintain their own individual production models and local product data, companies involved in a supply chain could store their information in a distributed blockchain database tied to the corresponding products and components. This way all the data would be always verifiable and authentic, and file versioning would be in sync for everyone involved. (Mattila 2016.)

In Supply Chain Management (SCM), the flow of materials and services required in manufacturing a product is managed, which includes storage and production cycles from its production to consumption. Typically, this means multiple companies interacting and trading globally on a given supply chain. Because of the complexity, costs of managing inventory, processes and failure detection are particularly high. Several blockchain solutions have emerged to improve the efficiency of the supply chain management. Traditionally SCM comes down to planning and communication, where the future demand is estimated based on past and current demand. The information is vulnerable to being late in responding to changes, delays and errors. Companies are in charge of deciding when to release products, and customers indirectly steer the demand. (Wüst & Gervais 2018.)

Demand chain management puts the customer’s interests as the core of the chain, which allows great flexibility in that stakeholders have real-time visibility of the consumer’s demand. Opposed to SCM, all parties in the demand chain are closely connected within a network and companies are required to have complete and accurate picture of the market to make optimal production decisions. Stakeholders in DCM can actively query the state of the chain management to achieve this. Some companies claim blockchain technology to pave the way for demand chains in the future. (Wüst & Gervais 2018.)

One of the blockchain projects that offers a solution to logistics in supply chain management is VeChain. It leverages blockchain with IoT technology to enable participants to record core data arising from transportation. IoT devices equipped with a VeChain ID, keep track of the entire logistics process by being deployed in the product itself, the transportation vehicle, and the warehouses used to store the products. Temperature, humidity and location data is recorded constantly to ensure the authenticity and validity of the data. (Solution – Logistics Solution 2019.)

The collected data is stored in the blockchain to ensure the immutability of the information. Through accessible APIs, enterprises are able to upload and observe different product and business data. In VeChain, the standards for the generated data will be set by a third-party organization DNV GL, which provides risk management and quality assurance worldwide in different industries. Together with the customers they seek to identify emerging problems and ensure the authenticity and reliability of the data. (Solution – Logistics Solution 2019.)

Other Emerging Use cases

As blockchain technology can essentially eliminate the need for trusted middlemen, many different kinds of use cases and applications become possible.

Some companies or organizations adopting blockchain technology may benefit from lower operational costs, while others may find benefit from increased security, the immutability of their databases or better transparency.

Counterfeit products represent an issue that is estimated to account for at least 1.8 billion dollars globally. Not being absolutely certain of the origin of a product can also present ethical issues, as is the case with blood diamonds mined in Africa, for example. **Fraud prevention** is something that can be potentially achieved with the help of blockchain technology. As products can have their unique identifiers stored on a blockchain, one can be certain that the information regarding the product is trustworthy and correct. (Honkanen 2017.)

Blockchain technology has a potential use case in managing **copyrights** in a new distributed way. For this example, let's consider a music streaming service. Instead of paying royalties and fees to middlemen, listeners could directly connect with artists, paying with microtransactions for each song listened. (Honkanen 2017.) In the case of SOUNDAC, one of the blockchain platforms created for managing royalty payments, the music data is registered to the SOUNDAC system with the defined split of royalties. Then the music is added to a streaming service available to be streamed, through which it automatically pays the appropriate royalties to the copyright holders with each stream of a song. (How It Works 2020.)

As renewable energy is becoming more commonplace worldwide, new solutions using blockchain technology are also emerging. **Energy** production, -usage, –transfer and –trade could all benefit from the increased transparency that blockchain technology brings. For example, a distributed marketplace for energy may be beneficial when looking at the market for solar energy. As the usage of solar energy grows, households using solar panels may find that their energy production outweighs their energy usage. Therefore, with the use of blockchain technology, households could freely trade with each other on a distributed energy marketplace. (Honkanen 2017.)

Blockchain technology has already been utilized in **charity** by ensuring that donations to catastrophic sites make their way to the people they are intending to reach. In refugee camps, a digital ration card with deposited money can be monitored in real time. Blockchain benefits to charity are greater transparency and tamper-proof donations. (Honkanen 2017.)

The utilization of blockchain technology within **healthcare** systems is considered to be in its early stages. Companies and even some governments are, however, already interested in the potential benefits that come along with using blockchain technology. Such potential benefits include greater security when handling, storing or transferring sensitive patient information and lower operational costs. Furthermore, blockchain technology could be used to help with research involving medical records, where there have been challenges with patient privacy and information security. Healthcare systems often rely on a single point, a centralized cloud database, which failure would cripple the whole system (Ismail, Materwala & Zeadally 2019). As the technology is fairly new, there are many challenges involving implementation. (Honkanen 2017.)

Estonia is currently paving the way for blockchain adoption in this field, as there exists a country wide system, e-Health Record, which collects data from different healthcare providers into a unified blockchain database. Users can access this database, and all their related data from different providers, through a single file. By utilizing blockchain, it ensures that the data is immutable, and non-authorized entities are unable to access the data. (E-estonia 2020.)

Blockchain technology adoption

The adoption of new technologies is a process that can take decades to fully come to fruition. Looking back at the early development of TCP/IP protocols, parallels to blockchain technology development can be drawn when it comes to adoption. Traditional telecommunications and computing sectors initially had their doubts of TCP/IP ever being able to establish powerful data connections on a secure and scalable system. It took TCP/IP over 30 years to go through its phases of adoption. From single use, localized use, substitution and transformation to ultimately reshaping the way the world works. This is not to say that the path to adoption for blockchain technology will be exactly the same, but that similar phases can possibly be anticipated. (Iansiti & Lakhani 2017.)

Different consortiums have been established by companies to develop unified applications for the distributed ledger technology and blockchain. In certain fields efficient operation requires that companies have a common practice in a technology. As blockchain technology is a possible solution to different existing problems shared among the companies, it is worth developing in union. The consortiums can then work together with companies, legislators or governments to dictate common standards and build the needed infrastructure for the technology. (Johansson et al. 2019.)

One of the popular projects developed to facilitate mainstream commercial adoption for blockchain technology is called Hyperledger. It is an open-source platform designed for easy development and interoperability of blockchain applications. Started in 2015 by the Linux Foundation, with 17 collaborative companies, the project has been growing since, currently with hundreds of member companies. Hyperledger includes significant members such as IBM, Intel, SAP and Fujitsu among many others. Together they strive to advance blockchain technology and make it accessible for cross-industry use in business. (Gupta 2017.)

Corda is also a wider known blockchain project developed by a consortium, the R3. After being introduced in 2016, over 300 partner companies have taken part in its development. It is designed to offer a consistent decentralized database for use in different industries with mutually distrusted nodes. It utilizes tools such as smart contracts and identity management systems to provide a trusted and secure environment for all parties to operate in. (Hearn & Brown 2019.)

3 Research Design

This chapter goes through the research process and defines how it is executed. In this chapter the research questions, scope, used research methods, and the reliability of the research are described.

3.1 Research Objectives and Questions

The subject of Blockchain technologies was chosen for this thesis, because we believe it to be a prominent technology in the near future. Blockchain technology is fairly new and its use cases and implementations have not yet been properly researched. The research consists of both the business and technical aspects, as they are both relevant in the study of blockchain implementations. The focus is, however, shifted towards the business-side. The final aspects of our research were decided after discussing it with our instructor, who has experience with the subject closely. The aim is to gather useful knowledge for anyone interested in the technology.

Currently not much research has been done on the implementations of Blockchain technology in Finland, and the technology itself is fairly unknown to many. The technology is slowly getting attention, and Blockchain related courses are being worked on in universities, including JAMK. This is a good time to offer our input and help spread knowledge on the subject. Not having sufficient research on the technology may lead to hindrance in its development and adoption.

This research seeks to provide an understanding of blockchain technology and its current and future state in Finland. Students, schools, institutions and other individuals can benefit from this research in getting a depiction of the technology and its state in the research area. This allows them to allocate resources as they see fit in order to meet the potential demand that this technology may introduce.

Research questions:

Research question 1:

What is Blockchain technology?

Research question 2:

What is the current state of Blockchain technology within companies in Finland?

Research question 3:

What kind of future plans do companies in Finland have regarding blockchain technology?

The objective of RQ 1, is to provide a comprehensive theoretical overview to the basis of Blockchain technology, as well as the context for RQ 2 and RQ 3. The scope of the theoretical overview covers use-cases, fundamentals of distributed systems, examples of blockchain-related projects as well as the benefits and challenges of the technology. Technical aspects of blockchain technology are covered only on a surface level, to provide a basic understanding of how blockchains work. Specific technicalities such as code snippets are not included in the scope of the research. Cryptocurrency distribution methods are also not included in the scope. In our view, these aspects are not integral in order to understand the basics of Blockchain technology.

RQ 2 aims to provide information about what kind of concrete plans or implementations companies in Finland have for blockchain technology as well as describe the overall demand of blockchain-related expertise. In addition, this question covers aspects such as the strengths and weaknesses of the technology from the perspective of the companies utilizing it. The scope of RQ 2 does not cover in-depth technical aspects, as our focus is on the overall utilization of the technology. RQ 3 dives into the future of Blockchain technology by answering questions relating to where the technology is headed and what kind of potential use-cases the technology could facilitate. In addition, the timeframe for potential Blockchain Technology adoption is considered in this research question. The scope for this research question only includes the aforementioned RQ 3 objectives. Only Finnish companies are included in the overall scope of RQ 2 and RQ 3 because we specifically wanted information on blockchain-related adoption in Finland.

3.2 Research Methods

The research method used in this paper is the qualitative method. Qualitative research attends to the contextual richness, and it enables the study of different kinds of people and what they think, under different circumstances. The basis for choosing the qualitative method, is that it seeks to gain a deep insight and understanding into the topic. Qualitative research represents the views and perspectives of the study's participants, emerging from the real-world setting. (Yin 2016.)

In qualitative research, the relevant data can be collected from four different data collection methods: interviewing, observing, collecting and examining, and feeling (Yin 2016). In this research in-depth interviews with people are used, which are optimal for collecting data on individual's personal histories, perspectives and experiences. In this study, it is also important that the research method offers responses that are rich and explanatory in nature and cannot be anticipated by the researcher. (Mack, Woodsong, MacQueen, Guest & Namey 2015.) Collecting and examining documents is used to collect existing information related to the study topic, and to gain contextual information to complement the field work (Yin 2016).

The data in qualitative research is commonly analyzed through five phases. This includes compiling, disassembling, reassembling, interpreting and concluding. In the compiling phase, all the data collected is orderly arranged into a database. In the next phases, disassembling and reassembling, the collected data is first labeled into smaller fragments known as codes and then constructed into themes. In the fourth phase, interpreting, the reassembled data is formed into a new database after which, in the final phase, conclusions are drawn based on the entire chain of analysis. (Yin 2016.)

Creating concepts and theories based on the research can be inductive or deductive. Inductive approaches let the data lead to concepts and deductive approaches let existing concepts lead to the definition of relevant data to be collected. With deductive approach the fieldwork is started with relevant concepts based on the literature we have reviewed before the interviews, rather than waiting for them to emerge only from the interviews. This way we can apply initial concepts and theories for example on the existing applications on Blockchain technology, and let it help guide the nature of our interviews with each company. (Yin 2016.)

Studies may yield more value if their findings and conclusions have implications that can be applied to other studies and situations. Qualitative studies have the possibility to be analytically generalizable or transferable. Transferability involves a more modest claim compared to analytic generalization, as transferability acknowledges the uniqueness of local conditions in a qualitative study. Rather than making direct conclusions, transferability can create working hypotheses at a conceptual higher level than the specific findings or conditions of the study. They embrace ideas or concepts that are similar to existing data related to the subject to determine congruence between them and strengthen the credibility. These working hypotheses can be used for new studies that continue to produce findings in support of the original hypotheses. In this case due to the localized nature of the study and the uniqueness of the interviewees, it is considered to be transferable to similar cases. (Yin 2016.)

3.3 Data collection method

The appropriate way to collect data from companies for this study, is to do interviews with their personnel relevant to the subject. Qualitative methods tend to be more flexible, so they allow more spontaneity and adaptation of the interaction between the interviewer and the participants. With more open-ended questions responses are more elaborate and greater in detail, and the interviewers are able to respond to what the participants say by tailoring subsequent questioning. (Mack et al. 2015.)

In qualitative interviews, the relationship between the researcher and the participant is not scripted. There is no strictly specified list of questionnaires to be asked from the participant, however an interview guide with pre-defined questions can be used as an effective way to help guide the interview and make sure of each of the key topics are covered. Because of the difficult nature of fully open-ended interviews, a semi-structured method is preferable to us. (Yin 2016.)

With semi-structured interviews, substantive questions are asked, that may be tailored for each kind of participant. Conducted similarly to a conversation, semi-structured interviews consist of closed- and open-ended questions blended together, often with follow-up why or how questions. Some of the strengths that justify the use of this method are, that we seek to know independent thoughts of each participant, and we are examining a somewhat unknown territory, where maximum latitude is needed in spotting useful leads into possible new subjects. (Newcomer, Hatry & Wholey 2015.) Data collected from interviews are used to answer RQ 2 and RQ 3.

The theoretical basis for the thesis is built with the method of collecting and examining documents. This means compiling and accumulating objects related to the study. (Yin 2016.) As is typical of the qualitative research method, any material can be used to solve research questions, and all written material can be referenced (Kananen 2017, 90). In this study we utilize reliable articles and books on blockchain technology to map out the technological background and its meaning to different industries, which we use to answer RQ 1. This material was collected from digital libraries such as IEEE Xplore.

3.4 Research execution

The literature on blockchain technology and its different applications was gathered simultaneously, when the overall structure of the theoretical background was being formed. The objective was to create a comprehensive layout of what the technology is and what it can offer for distributed systems. The literature utilized in this study consisted mostly of scientific articles and research focused on different parts of the technology.

The representatives for the companies to be interviewed were sought from companies in Finland that work closely with IT-department, and which based on our literature research might have familiarity with blockchain technology. Different databases, search engines and our instructor were utilized to scour possible companies to be interviewed, and we picked the ones which seemed the most interesting. The chosen interviews were also planned to cover multiple different fields of industry.

The companies, or specific individuals related to them, were contacted through emails and/or phone calls, to seek an interview to represent the company's field of industry in the study of blockchain technology. The marketing material prepared for our research, including the interview questions, was sent to the interviewees to inform the participants fully of the research. First, the researchers and the subject of research were introduced, and then proposal of participation was put forward. To ensure the credibility of our research, already existing knowledge on the subject was required from person to be interviewed. If the company was interested in participating in the research, the interview was set up when suitable.

The ethicality of the research was based on transparency with the interviewees. The subject and objective were told to the participants as it stood at the moment. The participants were informed that the interview was performed anonymously and their name or the company they work for was not to be mentioned in the results of the research. If they had any questions towards our research, those concerns were answered truthfully.

A structural list of questions (appendix 1) was formed for the interviews based on what we wanted to know from the companies, reflecting on the information gathered from literature. This was made to make the interview easier for us and the interviewee, so that the subjects of the questions were known beforehand to both parties. The interviews were conducted from December 2019 to August 2020. They took place virtually in communication tools such as Skype or Zoom depending on the preferred option. The interviews were recorded through the program’s internal recording.

Transcriptions of the interviews were made shortly after the interviews. The information was decompressed carefully, which took its own time to perform. During the transcription, the names of the interviewee and the company were anonymized and only the field of industry which the company operates in was reserved. Analysis of the research data was done in conjunction with data collection to find out whether a point had been achieved, where new interviews no longer brought additional insights into the research. Also, the analysis helped to further refine the structure and execution of the following interviews.

The reliability of the research was based on the quality of the interviews and the objective handling of the analysis of the results. To ensure the best results from the interviews, the interviews were conducted so that in each situation the questions were aimed towards the current company in question and potential in-depth follow up questions were asked towards their field to gain full comprehension of the answers. The objective handling of the results was based on confronting the gathered information as it was, avoiding any personal opinions. Also, the most weight was put on answers with a clear objective standpoint, opposed to answers that could be interpreted as clearly personal opinions.

To analyze all the theoretical documents as well as the transcribed interviews, a software called ATLAS.ti cloud was used to compile and organize the data. The data was then coded into smaller fragments, which were reassembled into themes. Based on the thematized data collection, it was possible to interpret the data in order to draw informed conclusions. A cloud-based tool for the analysis was preferred, as there were two of us conducting the research simultaneously at different locations.

4 Research Results

This chapter presents the interviewee backgrounds as well as the findings of the research based on the data analysis from the interviews. The research findings are categorized based on the interview questions (Appendix 1) into three main themes:

Blockchain Technology Use Cases & Challenges,

Employment & Educational Situation,

The Time Frame for Significant Blockchain Technology Adoption.

4.1 Interviewee backgrounds

The interviews consisted of seven different individuals, each from different companies. The companies represented are mainly focused on developing and offering software or entire systems, to service customers in different fields. Depicted in Table 1 is a summary of the interviewees’ background information followed by a short introduction to each company and interviewee.

Table 1. Interviewee backgrounds

Interviewee	Industry	Role	Industry experience (years)	Blockchain experience (years)
A	Finance	Leading Technical Strategist	20	5
B	IT	Leader of Blockchain department	19	5
C	IT	Founder and CEO	7	7
D	IT	Solution Architect	1	4
E	IT	Doctorand	7	7
F	IT	Developer	13	3
G	Logistics	Leader of IT Development	15	3

Company/Interviewee A

A company in the financial sector, offering services such as banking and wealth management. The interviewee works as a leading technical strategist in a group focused on emerging technologies and has acquired over two decades of experience in distributed technologies, of which five years have been spent working in relation to Blockchain Technology.

Company/Interviewee B

A digital services and software company with clients in multiple industries such as banking, logistics, media and energy. The interviewee works as a leader in a department that heavily focuses on Blockchain Technology and is also a group leader in an innovation department which is focused on development related to fields such as Enhanced Reality and Blockchain. The interviewee has been involved in Blockchain Technology since 2015.

Company/Interviewee C

An IT company that develops and works with the decentralized technologies underlying blockchains and other distributed protocols. The interviewee is the CEO and founder of the company and is mainly responsible for sales but is also involved in product strategy and technology strategy. The interviewee has been working in relation to Blockchain Technology since 2013.

Company/Interviewee D

An IT company that offers IT Service Management solutions for clients in public administrations, financial institutions and the industrial sector. The interviewee works as a solution architect in the company and has been involved in Blockchain Technology roughly since the year 2016, having studied it through multiple universities.

Company/Interviewee E

An individual with a Master of Physics degree in the process of completing a Doctor of Information Technology degree focused on cryptocurrency and Blockchain Technology. In this case the interviewee is not directly involved with any company at the time of writing but can offer valuable insights relating to Blockchain Technology due to the experience they have acquired working and being involved with various companies since 2013.

Company/Interviewee F

An IT company focused on building, maintaining and advising on distributed computer systems on a well-known cloud-based service network. The interviewee works as a developer and has been involved in Blockchain Technology roughly since 2017, having worked with various blockchain-based startups.

Company/Interviewee G

A cargo carrier company. The Interviewee is mainly responsible for IT-related development projects and has been in his current position for three years. The interviewee has over a decade’s worth of experience in various cargo-related development projects.

4.2 Blockchain Technology Use Cases & Challenges

This section covers the current use cases (currently in use or in active development) and potential, future use cases that came up in the interviews. The technology benefits are included in the description of use cases, as both complement each other. In addition, the challenges and risks associated with the technology and its use cases are explored. Important findings based on interview questions 1-5 (Appendix 1) are presented in this section.

Use cases

A major use case currently in production use in Finland is the digital housing trade platform DIAS. According to Interviewee A, the need for a digitalized housing platform came when a change in Finnish law required share certificates to become digital. This forced the participants of the industry to work together to solve the problem. Thus, a blockchain-based solution was proposed, and a prototype was developed with Corda technology to digitalize the housing trade process. DIAS utilizes Blockchain Technology in a closed environment to store data in a distributed fashion between banks that are participants in a housing trade. In other words, the key benefit of Blockchain Technology is that information that used to be centralized in various locations can now be accessed in a distributed fashion, increasing efficiency, security and flexibility. (dias.fi, FAQ, 2020)

Interviewee A also describes a similar use case focused on stock exchange. Namely, a blockchain-based solution that enables digitalized company shareholders to trade stocks fully digitally: “Traditionally, stock trade systems involve numerous intermediaries such as clearing and settlement services and marketplaces. These services by themselves are already complicated but combined together, they are extremely complicated. With Blockchain Technology, it was possible to implement a trading platform with zero intermediaries.” In practice, this means that an individual could head straight to a company’s website and purchase its shares. The settlement of the trade is handled directly on a bank’s interface, which simplifies the entire process significantly for all parties. According to interviewee A, a similar solution which gets rid of complicated components is applicable to any kind of trading activity, be it value, token or contract transferring from one party to another.

In the case of interviewee D, the company already has live products on blockchain technology, and they have been composing new ideas of applications and services for the technology to be used in the future. They have chosen to utilize Hyperledger as a platform for their applications. The developed products are sold to other companies wanting to adopt this new technology, of which one of them is a solution for a logistics ecosystem. The company is keen on learning more about the technology and developing new solutions from it.

Blockchain-based digital identity is another use case that can be leveraged to simplify otherwise complicated processes. According to interviewee B, a digital identity has to do with not only authentication, but also with providing digital evidence relating to an individual or a company. Interviewee B says that various banks and government services in Finland are involved with a project that aims to leverage digital identity in order to more efficiently and securely provide licenses and certificates to individuals. “While the role of Blockchain Technology in distributed identity networks is minimal, it is crucial in providing trust. Blockchain Technology operates as a Public Key Infrastructure, making it clear who has written which claims on an identity network.” Interviewee B says that one of the biggest benefits of a distributed identity network is the fact that it can be integrated and utilized in other systems as well, meaning that separate identity networks will not have to be built for systems for value transfer or other processes. Instead, a more public identity infrastructure can be used. Other key benefits include scalability, fairer competition and more dynamic roadmaps.

Interviewee C sees that the use cases for Blockchain Technology are quite restricted. According to interviewee C, many companies have attempted to use Blockchain Technology in different ways: “Some simply use it wrong and eventually stop using it. Enterprise companies are aware of Blockchain Technology and are experimenting with its use cases or trying to integrate it into their products.” Interviewee C goes on to say that on an EU-level, there are starting to be projects leveraging Blockchain Technology. Interviewee C thinks that value transfer is a clear use case which works even today, while not being extremely convenient. “Blockchain Technology can provide proof of something happening at some point at time. We are focused on distributed computation and storage.” Interviewee C describes the main benefit of Blockchain Technology as another layer of trust.

In Logistics, Blockchain Technology can also add trust to supply chains, which carry information, money and products. Interviewee D says that companies can differentiate themselves from competition by leveraging a blockchain-based solution, as with the already developed logistics solution. According to interviewee D, supply chains are currently fragmented into different pieces, where each participant provides their own fragments of information into the supply chain. With Blockchain Technology the supply chain becomes more transparent, from the ordering process all the way to delivery. Interviewee D believes that Logistics is one of the major use cases of Blockchain Technology alongside Finance, as it not only provides transparency but also speeds up logistical processes. Some manual processes are also able to be left out, namely information that an individual must enter into a database regarding an item on a supply chain. Interviewee D says that this process is intended to become automated in the entire supply chain, increasing efficiency and lowering the risk of human error.

Interviewee G also sees the potential of using Blockchain Technology to digitalize processes in the logistics industry. In fact, interviewee G believes that the logistics industry is currently in a time of transition in which old, paper-backed supply chains are moving towards a more open and digitalized form. According to interviewee G, Blockchain Technology will play a key role in bringing trustable traceability to entire supply chains. “In my view, Blockchain Technology will be in high demand especially in situations where many countries are involved in a logistical process. In these situations, one cannot rely on local authorities to identify individuals or companies. Blockchain Technology can add transparency in a way that all actors know exactly who they are working with and that the logistical information is verifiably valid on all parts of the supply chain.”

Challenges and Risks

The challenges and risks reported by the various companies interviewed can roughly be categorized into technical challenges and limitations, business challenges and (miscellaneous) challenges. It is important to note that the challenges vary depending on what kind of use cases different companies are pursuing. For example, a company with a main focus of developing a blockchain-based identity system will encounter entirely different challenges as opposed to a company that is focused on decentralized file storage.

As for the technical challenges, interviewees were somewhat split on their opinions regarding how challenging it was to work with Blockchain Technology on a technical level. Interviewee C finds blockchains somewhat limiting because of performance bottlenecks and costs associated with consensus mechanisms. According to Interviewee C, the biggest challenge, however, is designing a user interface that while being decentralized, is at the same time intuitive to use for anyone. As an example, if a user is in control of their own cryptocurrency, they must hold the private keys to that data themselves. Storing large amounts of cryptocurrency can be very difficult for the average person and, on the other hand, having it stored on an exchange poses its own security risks such as hacking.

Interviewee D says that the relatively new blockchain-based technologies such as Hyperledger and Solidity are not as stable as programming languages for example. They may change significantly between version releases which makes it challenging for developers to commit to them, as there is no standard as of yet for the technology. Interviewee F points out that development at the moment is horrendous as the development tools are still at very early stages. On the other hand, Interviewee F mentions that the tools are constantly improving, and new, alternative options are being made available for use. Interviewee E finds blockchain scalability to be one of the biggest limiting factors in the cryptocurrency space. As an example, the amount of transactions the Bitcoin network is able to process in one second (TPS) is far too low compared to the required TPS of a global currency. Other blockchain-based protocols can perform better in this regard, according to Interviewee E.

Interviewee G believes that there is a challenge in combining private blockchains together. The need for combining blockchains comes from requiring consensus on a global level, which, in the case of logistics, means that air carriers, land carriers and other operators must be working together. This, according to Interviewee G is a major challenge but at the same time it is very much needed. At the same time, there are not many working blockchain-based systems as of yet. Interviewee G believes that it is likely for companies to fail first, before finding the right approaches.

According to Interviewee A, even though the technologies being used are at very early stages, issues that have popped up have been solvable. Interviewee A and B believe that the real challenges are in the business side of things. Namely, the challenges are related to figuring out how to lead and organize an ecosystem that has distributed elements in it. According to Interviewee A, the key challenges are as follows:

How to make sure the network stays stable and functional?

Who owns and uses power on the network?

How to incentivize businesses to join this type of network?

Interviewee A goes on to say that what makes it more challenging is the fact that there are no existing models on how to build systems like these, because of how new the technology itself is. This can evoke fear due to the uncertainty, which creates barriers for the adoption of the technology as mentioned by interviewee D. Interviewee B also finds incentivizing different parties to join a distributed ecosystem to be the most challenging part. Companies need to be able to see the benefits of joining a blockchain-based distributed ecosystem.

There are some other challenges as well. According to Interviewee E, the energy consumption of some cryptocurrencies such as Ethereum and Bitcoin is problematic. This has to do with the consensus mechanisms of these cryptocurrencies, which requires a massive amount of energy. Switching the consensus mechanism to a Proof of Stake-mechanism would mitigate these issues to a large extent. Interviewee E also mentions the risks associated with smart contracts. “If the code is faulty and can be exploited, who will be responsible?”. Interviewee A considers the lack of responsibility to be a problem as well. According to them, purely open source networks will be difficult to regulate and thus their legal status is questionable. According to Interviewee A, the distributed networks must inhibit mechanisms that prevent the possibility of misuse because otherwise they will be not be compatible with business activity.

Interviewee D points out the issues that concern the image of blockchain technology. According to Interviewee D, blockchain technology is easily thought to be merely one of its original use cases, cryptocurrency: “This, of course, does not represent the whole truth, as blockchain technology can be applied to many other use cases as well. Scams involving some cryptocurrencies have also tainted the reputation of the technology as a whole.”

4.3 Employment & educational situation

This section explores the current and future employment situation in Finland in relation to Blockchain technology. Explored as well is the potential need for blockchain-related education. Important findings based on interview questions 6-7 (Appendix 1) are presented in this section.

Employment

Interviewee A states that at the moment (05/2020) job opportunities related to Blockchain Technology are still quite slim as the space is still so new. However, according to Interviewee A, it is only a matter of time before the world starts to fully embrace distributed blockchain-based technologies. “It is important to understand how to make distributed systems legal and operable for business activity. Once one understands these things, finding a job should not be difficult.” Interviewee B is of the opinion that more job opportunities will surely be available in the future but claims that it is difficult to predict exactly when the job market will start to increase.

Interviewee C thinks that in Finland, job opportunities related to Blockchain Technology are currently few and far between. “In total, there are perhaps 5-6 open positions of which half are related to stocks and trading platforms. On the software side, only a couple of companies may have open positions.” Interviewee C also raises the point that more people are often hired when cryptocurrency prices rise and are let go when prices fall. “On a longer timescale, job opportunities have surely grown from 2013 to this day. Today there are more opportunities”. Interviewee D on the other hand believes that the employment situation is good. “Our company sees Blockchain Technology as a prominent future technology alongside Artificial Intelligence and Data Analytics. Job offerings will grow, which is a positive thing for students."

Interviewee E recalls that some banks and software companies in Finland have been looking for blockchain experts. According to Interviewee E, we may have already passed the point of the largest amount of interest in Blockchain Technology. But, on the other hand, Interviewee E thinks that the technology still needs five to ten years to mature. "I am sure there will be open positions related to Blockchain Technology in the future as well." Interviewee F says that there are very little open positions, but at the same time the amount of blockchain experts is quite low. "If you are at the right place at the right time, you may find yourself a job." According to Interviewee F, the amount of open positions has remained the same for some time now and only a handful of companies are operating in the field.

Interviewee G says that blockchain-based services are mostly acquired from the outside, rather than developed within the company itself, so the available job offerings are locally quite limited. The company has received multiple offers in recent years for a blockchain solution for their needs. Logistical systems as a whole will be needing blockchain experts at some point in time, according to Interviewee G. The time frame for this is unknown. Interviewee G believes that logistics as an industry requires accomplished references before taking the leap to integrate a new technology into existing systems. Moreover, there seem to be multiple choices for a blockchain based logistics system.

Education

All of the companies interviewed were of the opinion that at the minimum, general awareness of Blockchain Technology should be increased. Most companies also added that universities should offer at least some introductory courses related it. Interviewee A argues that there will be a substantial need for awareness and education based on their opinion that complex older technologies will no longer be worthwhile to develop. Instead, as solutions based on distributed systems become more common, knowledge on how to develop and operate these systems will be needed.

Interviewee B raises the point that education within universities should not only focus on the technical side of things, but a focus of equal importance should also be placed on the juridical, administrative side of Blockchain Technology. According to them, both are needed in order to accomplish anything meaningful at all. Interviewee C admits that while awareness and education in universities should both be increased, it is difficult to determine what exactly should be taught. Information and best practices become outdated fairly quickly, as blockchain technology space has grown fairly rapidly within the last few years. Nevertheless, Interviewee C believes that universities should have courses available for students to get a basic understanding of the subject.

Interviewee D is of the opinion that education related to Blockchain Technology should be substantially increased not only in higher level bachelor’s and master’s degrees, but also on some level in vocational schools that offer education in information and communication technology. According to Interviewee D, awareness in relevant businesses should also be increased, and that webinars aimed at accomplishing this can enable people to start developing products with blockchain in mind. Interviewee E thinks that educational courses of different varieties should be available for students through universities and online courses. Introductory courses should be available, as well as courses focused on a deep dive into technical aspects such as programming. The need for awareness within relevant companies is also there. Interviewee F sees the need for increasing awareness and education within universities, but also adds that no one really knows if Blockchain Technology will still be important in the future.

Interviewee G believes that skills relating to Blockchain Technology will be needed in the future, which means that education and awareness are important aspects as well. “Building awareness should be done on a practical level, so that people can have a general idea about the subject and they can trust the experts that are in charge of the technical details.”

4.4 The Time Frame for Significant Blockchain Technology Adoption

This section explores the future significance of Blockchain technology and includes some speculation on the time frame for Blockchain technology adoption. Important findings based on interview questions 8-9 (Appendix 1) are presented in this section.

According to Interviewee A, older technical solutions (in finance) will be around for quite some time. They will, however, be upgraded in a way so that they can become participant nodes in a newer type of network involving Distributed Technology and Blockchain Technology. Interviewee A also thinks that in a period of five years, older technical solutions that are not based on distributed technologies will no longer be produced. “It will take approximately two years to develop technical and governing models [based on Blockchain Technology]. A turning point will be reached within three to five years from now, after which the pace of new development will most likely be very rapid.”

Interviewee B finds it useful to explain his thoughts on the matter using Gartner’s Hype Cycle (depicted in Figure 6), which is a graphic representation that depicts the adoption cycles and maturity of emerging technologies. According to Interviewee B, we are now in the phase depicted as the Trough of Disillusionment. “If you think about what has happened already, I believe that in the year 2015 we were in the Innovation Trigger-phase and in 2017-2018 we were in the Peak of Inflated Expectations-phase. For us, the aforementioned phase showed itself in a way that people were extremely interested in learning about Blockchain Technology. No one really understood what it was all about but little by little, people started to realize that it is something other than traditional databases or techno-anarchism.” Interviewee B goes on further to say that within the last two years people have understood that Blockchain Technology is not applicable to absolutely everything but that at the same time we still do not know all of the potential use cases. This is the reasoning why Interviewee B places us in the Trough of Disillusionment.

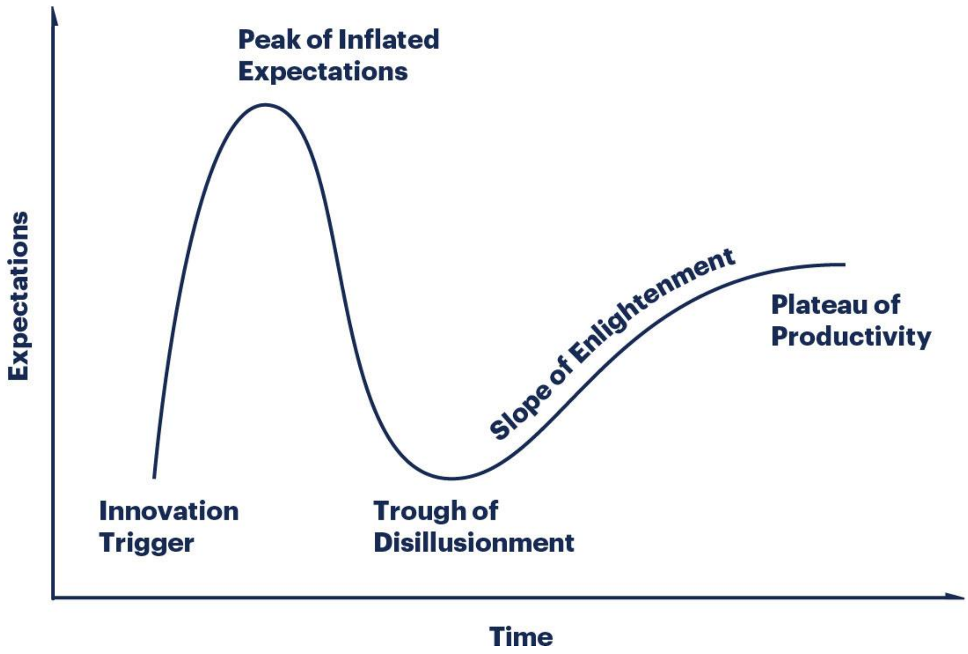

Figure 6. Gartner Hype Cycle (Gartner 2020.)

From Interviewee C's point of view, we are in a very early stage of adoption (in finance) concerning Blockchain Technology. Interviewee C believes that at some point in time we will eventually shift to a situation where we have global [blockchain-based] currencies that no single entity has full control over. "It just makes more sense for everyone. It requires, however, that powerful countries give up some of their power and then on the other hand, less powerful countries gain some power. The time frame for this to happen depends largely on what is happening in our world globally, as in, the more there is instability, the more use there would be for a global currency. It would take several financial cycles, though. In 30 years' time I think central banks could have their own currencies." Interviewee C goes on to say that even though a cryptocurrency might gain a lot of adoption, it could still be a tiny fraction of the global supply of money.

Interviewee D says that Blockchain Technology is already in active use, but that further adoption of it in general depends on various factors such as: industry, strategy, the internal understanding of the technology and attitudes. "Blockchain Technology has to become a mainstream technology for it to become more common. This will take a long time, but perhaps in the year 2030 it could become mainstream. It depends largely on how companies develop products based on blockchain and how they are able to gain visibility and trustworthiness through these products." On the other hand, Interviewee D mentions the negative things such as some outright scam cryptocurrencies that hurt the reputation of the entire Blockchain Technology space. "People can easily associate the whole industry with these cryptocurrencies and not realize all the other things that can be done with this technology."

Interviewee E thinks that blockchains and distributed ledgers are still so new at the moment that it will take perhaps five to ten years before the technology becomes commonplace. "Banks are very interested, once scalability issues as fixed." Interviewee D has a similar point of view: "In the financial sector some banks are already using the technology on some level, but I don't see it becoming commonplace at least for a couple of years."

Interviewee G says that within the year 2021, integration with Blockchain Technology will begin on logistical processes. Currently the company has several ongoing pilot programs to determine the best approaches. Finding blockchain-based solutions relating to keeping track of flyers, on the other hand, may take several years. Generally, the pace of development relating to Blockchain Technology is rapidly increasing, according to Interviewee G. "If we had had this interview a year ago, most of the ongoing [blockchain-based] activity would not have existed yet."

5 Conclusions

This chapter summarizes the results and presents the conclusions to each of the research themes. This includes discussing the different implementations of blockchain technology that emerge from the research results, as well as describing the overall state of the technology in Finland and where it is heading.

To briefly summarize the theory section of this study, blockchain technology is a tool for keeping track of information on a digital ledger. In essence, it enables the recording and tracking of information in a distributed fashion, meaning that it is not centrally controlled by any one entity. While there are many kinds of blockchains, a common characteristic found in most of them is the use of a consensus mechanism. Consensus in the case of blockchains is essentially a set of rules that all users of a particular blockchain have agreed upon. These rules are important to establish because of the distributed nature of blockchains. Consensus mechanisms establish the security and reliability of a blockchain, while making sure that information recorded on the blockchain is trustworthy and valid.

The distributed nature of recording and storing information opens up interesting use-cases for the technology. Services and systems that rely on trusted intermediaries to validate or process information in exchange for a fee can potentially be replaced with a blockchain-based solution, which can handle these tasks more securely, efficiently and reliably. It is important to note, as seen in our interviews, that blockchain technology has yet to mature to a stage where it can reliably be deployed to replace most existing systems. In most cases, a technical standard has not yet been established, as the technology itself is relatively new. On a second note, the implementation of blockchain technology is not applicable to all systems, meaning that not all products stand to benefit from it. On the contrary, implementing blockchain technology to a product that operates as it should in a centralized fashion can hinder performance and introduce unnecessary complexity.

Depicted in Table 2 are the main conclusions briefly presented based on our interview findings. The table covers each of the themes derived from our interview questions (Appendix 1). Following the table, conclusions, including use cases, are explored in more detail.

Table 2. Conclusions regarding the Blockchain technology situation

Utilization (interviewed companies)	Key Benefits	Key Challenges
In use: 2 companies In development: 3 companies Not in use: 2 companies Key industries: -Finance -Logistics -IT -Identity	Efficiency Security Flexibility Transparency Integration Scalability Fairer competition Trust Immutability Differentiation from competition Traceability	Technical challenges: Scalability Restrictions of consensus mechanisms Development tools Energy consumption of cryptocurrencies Private blockchain compatibility Business challenges: Lack of existing models Defining ownership and use of power Incentivizing businesses Network misuse
Employment Situation	**Need for Education**	**Adoption Time Frame**
Employment possibilities are currently sparse, but a handful of positions are available for dedicated specialists. The situtation is expected to improve, if blockchain technology gains more adoption.	There is a growing need for education, especially in universities, where there should be a variety of basic and technical courses. Awareness should be increased for relevant personnel in specific blockchain-impacted industries.	The overall consensus was, that in 5 to 10 years, blockchain technology is expected to gain major adoption in certain industries.

Overall, there seems to be a considerable amount of knowledge relating to blockchain technology in Finland, further demonstrated by the fact that one of the frontier applications of the technology is already implemented. The digital housing trade platform, DIAS, is one of the few currently in use systems that utilizes blockchain technology. In most of the companies interviewed, the technology is seen as a significant actor in the near future offering trust and removing additional steps from current processes. In these cases, the adoption of the technology is still in the research and development stage. The individuals interviewed were eager to talk about the subject, which radiates positivity and accumulates even stronger interest in the technology.

The current main use cases of the technology identified from the interviews involve trading shares and stocks. The push to digitalize these systems has made distributed ledgers and blockchain technology an essential tool to provide the working environment for these systems. This also goes for logistics and identity management, where outdated means of handling and sharing data still exists, even in traditional paper form. This supports the information gathered from existing literature on the subject, and the same points in the different use cases were seen in the answers.

Generally, blockchain technology can introduce major benefits to industries that have for a long time operated with a myriad of intermediaries, each of them adding further complexity to how the industries operate. Removing intermediaries out of the equation and replacing them with the cryptographic trust that comes with blockchain technology can make industries more efficient and reliable on a disruptive scale. Developing a blockchain solution, however, is no easy feat as it often requires the cooperation of many companies. Of the companies with use-cases currently deployed or in development, most believed that cooperation with various players in the industry was needed in order to develop a blockchain solution.

In the case of supply chains and logistics the outdated methods of handling data were brought up in the interviews. The fragmentation of the supply chain creates errors and slows the overall operation of the chain. This creates a need for a more transparent and efficient distributed system to work on, to which blockchain technology is a valid solution. With it, the processes in the supply chain could be automated, and all actors and information on the chain could be made verifiable. Regarding the adoption in this field, two of the companies interviewed were developing blockchain solutions for it. One of the companies was already close to deploying a product with distributed ledger technology, with a high probability of it being blockchain based, while the other had developed one as a commission for another company.

The most common industry mentioned in the interviews for the use of blockchain technology was finance. Currently the only major in use application utilizing blockchain technology in Finland was the digital housing trade platform, DIAS, in which multiple companies are taking part in. The technology allows for distribution of data, to which each participant has access to from various locations. Regarding trading overall, blockchain technology offers individuals the ability to purchase shares directly from companies without any intermediaries in the process, simplifying it noticeably.

Digital identity management was brought up as well as a significant use case for the blockchain technology. Through utilizing blockchain as a Public Key Infrastructure, additional trust can be provided when authenticating individuals or companies digitally. The network would eventually integrate into other systems as well, so separate identity networks would be no longer needed. This way ultimately a way of global identification could be provided efficiently and securely.

On the contrary to the several benefits offered by blockchain technology, certain challenges and risks underlay the use of the technology in some areas of application. One of the main challenges identified from the interviews addresses the usability of blockchain related systems. The user interface in these systems needs to be simple to use for anyone, despite the complicated nature of technology itself. In the case cryptocurrencies users are responsible for their own wallets, holding private keys to access them if no third party is established to do so. On the developer side, the development tools are still on a primitive level with insufficient standards, which can cause uncertainty in committing to specific blockchains.

Understanding the business side of blockchain is also essential in creating working environments for blockchain technology. The network needs to stay stable and functional, the distribution of power has to be established and incentives for using the network defined. As there is next to no existing models on building a system on this technology, some elements need to be figured out from the start. This has halted or caused some attempts to fail, when trying to create a new system on blockchain technology. But these failures are required to ultimately create a refined system that can operate successfully.

Blockchain technology also has an apparent issue with its image, as its reputation has suffered due to a large amount of scams and pyramid schemes involving some cryptocurrencies. Companies and individuals may still have these associations in mind which can cause them to doubt the legitimacy of the technology as a whole. This is a barrier which can be alleviated with the help of proper education on the technology.

When dealing with a large system with multiple operators, combining different blockchains also introduces its own problems. If the participants still have their own networks in use, they need to be able to communicate with each other and share data to a common network. These are still largely in development, but they are believed to be essential if global utilization of blockchain technology is integrated into the systems.

In the sphere of cryptocurrencies, scalability was mentioned in the interviews as one of the main struggles of blockchain technology. For a wide adoption of a cryptocurrency, huge amounts of transactions need to be processed continuously. Newer protocols have appeared, but they still require further development. The energy consumption of the consensus mechanism in use also must be taken into account. In addition, the lack of regulation and responsibility in these open networks brings its own challenges to their operation.

Regarding the employment situation of blockchain technology, the highest demand is seen to be had in the future, when the technology has established a more stable role in industries. At the moment, work opportunities are mainly seen in roles of a few dedicated experts in bigger companies, who deeply understand the technology. If the technology lives up to be an essential future technology, the job offerings will greatly increase. This is to be seen especially in software companies that create blockchain-based solutions for other companies to acquire. These solutions are already being offered to major companies, as is confirmed by one of our interviewees.

Offering education and increasing the awareness on blockchain technology is seen positively and even encouraged by the companies. It is still somewhat unclear on which parts of the technology the actual education should be focused, but the educational level of universities is commonly agreed as the proper place to offer it. The available courses should range from very basic knowledge on the subject to in-depth technical operation of the technology. In some universities in Finland, it is already offered to some extent, but continuous education needs actual usage of the technology at its side. Potential is also seen in offering some level of education already in vocational schools specialized in information and communication technologies.

Raising overall awareness in relevant companies on the subject is not seen as redundant, but the content of the teachings should be on a very basic level, so anyone can gain an understanding of the technology. As in many cases the technology works in the background and might not be seen to a common worker, in-depth technical information on the technology would be most likely pointless to teach. The importance of understanding the juridical and administrative sides of utilizing the technology is also important in the development of new products, which could be based on this technology.

Based on the results of our interviews, Blockchain technology looks to be one of the more promising distributed technologies, as it is currently already in its early stages of actual adoption. The rate of adoption does depend on the industry in question but nevertheless, most interviewees believed that within five to ten years blockchain technology will be mature enough to encourage significant amounts of adoption as a trusted cryptographic backbone in various industries ranging from logistics and finance to identity-based use-cases. Overall, it can be concluded that after the initial hype period of blockchain, we are slowly beginning to see the development and deployment of blockchain-based solutions in the aforementioned industries. Time will tell if blockchain technology will become the new standard of digitized trust. At the moment it certainly is one of the best candidates for its role.

A global blockchain-based cryptocurrency is, however, harder for ordinary people to adopt. The most popular transfer-of-value cryptocurrencies are slower and more expensive to transact with compared to existing fiat-based solutions such as PayPal or Venmo. In addition to this, the user of a decentralized cryptocurrency is responsible for storing their cryptocurrency safely, as banks do not facilitate these services. Looking into the future, the demand for cryptocurrencies depends largely on the stability of existing financial systems. If traditional financial systems become unreliable or unusable for whatever reason, cryptocurrencies may be an option for storing value in a situation like this. In this case, cryptocurrencies should look to tackle challenges such as user experience and scalability. It is important to note that decentralized cryptocurrencies also inhibit the inherent tradeoff of wildly fluctuating prices. As the price of a scarce cryptocurrency such as Bitcoin is driven largely by speculative demand, its value will never be as stable as the value of government-controlled fiat currencies. For individuals looking to transact with cryptocurrencies, this is a serious drawback which looks to be a difficult challenge to overcome in the future.

6 Discussion

In this chapter the results of the research are reflected and its contribution to academic research is discussed. It also points out the successes and limitations of the research, possible future research and development, and the overall meaning of this research.

6.1 Reflection on the results of the research

The purpose of this study was to gain a deeper understanding of blockchain technology and gather information on the current and future state and applications of the technology in related companies. In addition to ourselves, this study would benefit all interested parties in assembling useful information on the subject. The data on the utilization of the technology in companies was gathered through interviews with individuals in each chosen company. As there hasn't been much research into the actual adoption of this technology in companies in Finland, the benefits of this study would justify the conduction of this research. Notable information was obtained on concrete applications in use today, as well as prominent use cases for the future.

Considering each of the research questions set for this research, we found suitable answers to each of them. Regarding Research Question 1, **"What is blockchain technology?"** the theoretical background was collected to gain a basic understanding of blockchain technology and how it appears in different industries. This consists of a collection of its technical aspects, as well as a summary of the benefits and challenges underlying the technology. Also included is a view to the existing use-cases in different industries.

Regarding Research Question 2, "**What is the current state of Blockchain technology within companies in Finland?**", valuable information was gained about several topics such as current use cases, the employment situation and the need for education. What we found through our interviews, was that in many cases, Blockchain technology was indeed already in use or in active development, and its utilization brought companies benefits such as increased efficiency, transparency and security. The major beneficiaries of the technology were industries such as finance, logistics and identity management. These industries were found to rely on a large number of intermediaries to verify and track information. In its essence, Blockchain technology has the potential to replace these fragmented and, in many cases, outdated, processes with cryptographic trust. Currently, there are still various challenges, both technical and non-technical, regarding the use of the technology. As the technology is currently in the very early stages of adoption, open jobs are limited, but a handful of positions are available for dedicated experts. Regarding education and awareness, it can be concluded that universities should at the very least offer some courses on the basics of the technology and that awareness of the technology should be increased in relevant industries.

To Research Question 3, **"What kind of future plans do companies in Finland have regarding blockchain technology?"**, the results presented different views depending on the industry in question. In some of the cases blockchain applications were in development, to be deployed in the future. Blockchain technology acts as a solution to emerging changes in industries, regarding for example data management and sharing. Overall, a consensus among the interviews was that the technology is expected to gain major adoption in the next 5 to 10 years. Naturally, this also affects the employment and educational situation, that goes along with the demand for the technology as a whole.

Other recent research papers on blockchain applications in most cases focus on a specific industry. The findings considering same industries share many similarities, but they often go deeper into the singular case in question. The most valuable results of this research differing from others are the ones dealing with employment and education, which have not been a focus of research in the sphere of blockchain. Our research also gives a broader sense of the use of blockchain technology in various industries, including information on brand new projects which are still in development and might not have been mentioned before in other studies.

The information and statements gathered on blockchain technology in the theoretical background were in many aspects verified in the interviews. The same benefits and challenges of the technology are still identified in the use cases of the technology, as well as the expectations for future use. However, the interviews offered much more detailed case-by-case information on the use cases, and an understanding into the background of why this technology is utilized. Often blockchain technology is not the starting point of development, but it is seen as a solution to an already emerging change in some operational aspect of a company.

Our research questions, while sufficient, proved to be a bit problematic in the sense that differentiating "future plans" (RQ 3) from current use cases (RQ 2) was not always so clear. For example, a company could be in the very early stages of designing a blockchain-based solution, having perhaps only a simple prototype at its current stage. The company could be years away from releasing a finished product, so categorizing the project simply into a "future plan" or "current use case" was challenging.

The data from companies was gathered through semi-structured interviews, which turned out as a suitable way achieve the objective of this study. Having an already laid out structure for the interview made the process effective, although the interview guide turned out relatively detailed in the end. Certain aspects were mandatory for our research, but depending on the nature of the company interviewed, additional further questions were asked. Some of the interviewees differed notably from the others, so some aspects of the interview had to be tailored specifically for them, though the main interview questions (appendix 1) remained the same. Often through a little bit of background research into the company, we could find interesting articles or posts mentioning the use of blockchain technology, which then could be brought up in the interview. We also had to do a fair bit of background research relating to how industries such as finance and logistics currently operate. This was needed in order to properly understand the context of the interviews and how blockchain technology could potentially help resolve some of the issues that inhibit these industries.

Some of the interviewees appeared inspired by the subject, as the utilization of blockchain technology was a kind of personal mission for them. A few individuals with decades of experience with decentralized networks seemed clearly enthusiastic on the matter of solving problems in the existing systems. Such knowledge and experience in the field can act as a trailblazer for other people involved and the overall advancement of distributed systems.

In the context of offering information strictly for our own benefit, the research was well beyond sufficient. Huge amounts of knowledge on blockchain technology itself was gained, as well as information on the current situation of the technology in Finland. It was surprising how much involvement there was in relation to the technology that we were not aware of before the study. Even with the still questionable characteristics, the technology appears as a major actor in the field, when dealing with distributed systems architectures.

6.2 Reliability of the results

The reliability of this research depends much on the honesty of the interviewees. If the interviewed companies and personnel were further investigated in advance, a more reliable base for the chosen interviews could have been achieved. However, in our case, this would have required too much effort in the scope of this research. The interviews provided us with data that stood both against and for the technology, so it supports the aspect of reliability, as the answers were not biased on a single point of view. It is also noteworthy to mention that while our research was conducted to be as objective as possible, it is in the realm of possibilities that our own inherent biases could potentially influence the interpretation of the gathered results.

In many of the interviews, the subject was personal to the interviewee as they directly worked with the technology in question. Much of the interview questions focused on the survey of actual use cases and utilization of the technology, so direct personal feelings and views were not sought after in those cases. However, some of our questions were focused on those personal viewpoints. This combination ensures that the results carry objective weight to them, as well as introducing individual thoughts on the subject.

The interviews were done in a single take in varying durations from 15 to 40 minutes, so the results rely also on the interviewees ability to memorize and tell the answers to each question. The interview spans over many different aspects of blockchain technology so perfect and complete answers cannot be expected for each question as the interviewee might forget to mention something. The results overall can be considered to cover the main points in each of the question's target territory.

Because we wanted to interview people who had experience with the technology, the companies chosen for the study were mainly ones with existing professionals on the subject. Companies with no relation to blockchain technology were not considered for the research, as they would not contribute to our study, which mainly focused on the use of blockchain technology. It could be argued that our research emphasized more optimistic views on the subject, as companies with a pessimistic or negative take were not directly represented in this study.

As the interviews conducted for this study consisted of a relatively small sampling of seven interviews, the results cannot be fully generalized. However, saturation was already noticed in the answers of companies with a similar setting in certain areas of questions, so same findings started to repeat. But because of the fact that not every field of industry was represented, or had only one representative in this study, this study cannot claim to completely represent the state of the technology in Finland. The results can be transferrable to other similar studies and compared with their results. Considering the results of our study and the theoretical research done for this research, many similar points were seen. The results were enough for us and the scope of our research, and they already offered significant insights into the state of blockchain technology in the research area.

6.3 Further research

As we only scratched the surface with the number of interviews conducted in this research, further research into blockchain technology as a whole would certainly be useful. More information and perspectives can surely be gathered on this subject as there are companies and individuals who were not represented in this study. Moreover, the technology is changing and developing fast, so noticeable leaps in certain aspects can happen in a matter of a few years. This research also did not cover clear negative standpoints on the technology, where for example the failures would be brought up. This would also increase the transferability of this research, as the results could be compared and verified for further credibility.

Further research could be conducted regarding specific industry fields, gaining in depth information on the applications existing in that area. For example, a detailed look at one of the prominent use cases that came up in our interviews, identity management, would be a viable topic for further research. Also, identifying what types of blockchains are utilized in certain fields could help in focusing education on those cases. Different use cases of the technology differ considerably from each other, so through a universal research on the subject it's hard to gain a deep enough understanding on a singular case.

Detailed research on the impacts of a successful blockchain implementation could also be explored. While there are not so many implementations of the technology as of now, in the future it could be worthwhile to study the effects that blockchain has on industries and society. How much could blockchain affect the amount of labor needed and what are its implications on society as a whole?

An interesting subject for future research would also be to map out different instances of distributed ledger technology besides blockchain technology. In our interviews other potential DLT methods were mentioned, as well as in our literature research we came across the case of IOTA, which utilizes Direct Acyclic Graph. Other types of DLT such as Hashgraph and Distributed Hash Table seem to be less utilized, but more research could be done to determine the relevancy and potential real-world applications of these technologies in Finland.

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Appendices

Appendix 1. Interview guide (in Finnish)

Osa 1 – Haastateltavan tausta

1. Missä roolissa työskentelet yrityksessä?
2. Kuinka kauan olet työskennellyt nykyisessä roolissasi?
3. Kuinka kauan olet työskennellyt tämänhetkisen alan työtehtävissä?
4. Mikä on koulutustasosi?
5. Miten tutustuit lohkoketjuteknologiaan?

Osa 2 – Aihepiirikysymykset

1. Kuinka lohkoketjuteknologian yleistyminen näkyy yrityksessäsi/alallasi?
2. Miten lohkoketjuteknologiaa hyödynnetään yrityksessäsi/alallasi?
3. Millaisia sovelluskohteita lohkoketjuteknologialle on yrityksessäsi/alallasi?
4. Onko lohkoketjuteknologiaan liittyen esiintynyt ongelmakohtia tai riskejä? Millaisia?
5. Millaisia tulevaisuuden suunnitelmia yritykselläsi on lohkoketjuteknologian hyödyntämiselle?
6. Millainen työllisyyden tilanne alallasi on lohkoketjuteknologiaan liittyen? Miten ajattelet työtarjonnan kehittyvän tulevaisuudessa?
7. Pitäisikö lohkoketjuteknologiaan liittyvää opetusta/tietoisuutta lisätä? Miten sitä pitäisi lisätä?
8. Kuinka merkittävässä roolissa koet lohkoketjuteknologian olevan tulevaisuudessa? Miksi?
9. Osaatko arvioida millä aikavälillä lohkoketjuteknologian käyttöönotto tapahtuisi alallasi?