YRKESHÖGSKOLAN NOVIA

How Can Blockchain Technology Support Component Traceability in Wärtsilä

Case: Wärtsilä Field Service

Rickard Svartgrund

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EXAMENSARBETE

Författare: Rickard Svartgrund
Utbildning och ort: Produktionsekonomi, Vasa
Handledare: Tommy Rodas och Måns Granholm, Wärtsilä
Mikael Ehrs, Yrkeshögskolan Novia

Titel: Hur kan blockkedje teknologin understöda komponent spårbarhet inom Wärtsilä
Fall: Wärtsilä Field Services

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Abstrakt

Detta arbete beställdes av Wärtsiläs Product Lifecycle Management avdelning i Vasa, Finland. Wärtsiläs grundades år 1834 som ett lokalt sågverk. Idag är Wärtsilä en global ledare inom smarta teknologier och kompletta livscykel lösningar för energi och den marina marknaden. Wärtsiläs omsättning för 2018 uppgick till 5,17 miljarder euro.

Målet för detta examensarbete var att undersöka om och hur blockkedje teknologin kunde förbättra och göra spårbarheten smidigare med tanke på komponent spårbarhet inom Wärtsilä jämfört med traditionella databas system. Syftet var också att studera nuvarande sätt att hantera spårbarhet inom Wärtsilä och peka ut begränsande områden och visualisera luckor i nuvarande system.

Som resultat så har en bredare förståelse för vad blockkedje teknologin är och vad som kan åstadkommas med den erhållits för både mig och mina handledare. Kontakter har även skapats till experter inom blockkedje området och ett förslag på hur man kan gå vidare med att tackla komponent spårbarhets problemet har givits.

Språk: Engelska Nyckelord: Blockkedja, spårbarhet, komponent

BACHELOR'S THESIS

Author: Rickard Svartgrund
Degree Programme: Industrial Management
Supervisor(s): Tommy Rodas and Måns Granholm, Wärtsilä
Mikael Ehrs, Novia University of Applied Sciences

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Abstract

This thesis was commissioned by Wärtsiläs Product Lifecycle Management Department in Vaasa, Finland. Wärtsilä was established in 1834 as a local sawmill. Today Wärtsilä is a global leader in smart technologies and complete lifecycle solutions for the marine and energy markets. In 2018, Wärtsilä's net sales totaled EUR 5.17 billion.

The aim of this thesis was to investigate if and how blockchain technology could improve and make traceability leaner with regards to component traceability within Wärtsilä compared to a traditional database concept. The purpose was also to study the current way of handling traceability within Wärtsilä and pinpoint the pain areas and visualize the gaps in current systems.

As a result, a broader understanding on what blockchain technology is and what can be accomplished by using it has been given to both me and my supervisors. Contacts have been made to experts in the field and a suggestion on how to proceed with tackling the component traceability issue has been given.

Language: English Key words: blockchain, traceability, component

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List of Abbreviations

ERP = Enterprise Resource Planning, management systems of core business processes.

UII = Unique Item Identifier, formatted data that consists of several characters, contains product information.

P2P = Peer-to-peer networks, a computer network of connected nodes who don't communicate through the standard client-server model.

BaaS = Blockchain as a Service, a blockchain provided by one company for one or more other companies.

SAP = Systems, Applications & Products in Data Processing, their main product is an ERP system for managing business operations and customer relations.

WAMS = Warehouse Activity Management System, a system for keeping track of components within field service.

1 Introduction

This chapter will present an overview the background of this thesis, as well as discuss the problem area and purpose. Thereafter the delimitations and confidentiality of the paper are discussed. Finally, a disposition is presented to give a better understanding of the composition of the paper.

1.1 Background

The concept of blockchain technology was first introduced in October 2008 as part of the digital currency bitcoin. This blockchain was published by a person who goes under the pseudonym name of Satoshi Nakamoto, whose true identity has not yet been revealed. Ever since the launch of the first blockchain the topic has been of great interest for both private persons and companies around the world. (Twesige, 2015, p. 1)

The original idea of blockchain was born out of the financial crisis in 2008. The base idea was to change the idea of how we handle our money, how the ownership of money is managed. The money system as it was in 2008 and still is today is centralized, you put your money and trust in the banks and the government, if they fail, you fail. In the case of blockchain however, all is decentralized, meaning you put your money and trust on the blockchain that is spread over millions of computers, which doesn't allow any single entity to be the only controller. This makes it way much harder for corruption, theft, and loss.

Not only is there the possibility that blockchain technology could reinvent every category of monetary markets, payments, financial services, and economics, but it might also offer similar reconfiguration possibilities to all industries, and even more broadly, to nearly all areas of human endeavor. The blockchain is fundamentally a new paradigm for organizing activity with less friction and more efficiency, and at a much greater scale than current paradigms. (Swan, 2015, p. 27)

The supply chain of components within Wärtsilä is getting longer and longer all the time, components are produced simultaneously in different parts of the world and they all need to meet the same standards no matter where they are produced. This creates a bunch of challenges when it comes to traceability, when for example the parts fail to meet quality demands or when a part brakes it is very important to find not only the cause of the problem but also what other parts might be affected by the failure or quality problems.

1.2 Problem Area Defined

Due to the fact that current systems for traceability within Wärtsilä and specifically field service is not optimized for the current needs of usage. The problem as of today seems to be the lack of traceability of components, which leads to problems when components need to be changed, reclaimed or fixed in various ways. There seems to be a lot of data available but it is all unstructured and difficult to use, the data is scattered across many different systems and these systems are not in sync with each other. Each component has a unique serial number stamped on to it during manufacturing, this serial number can however not be easily accessed through the current database, thus leading to difficulties in tracking specific components service history, current location, manufacturing place etc.

Previous efforts of improving the traceability of components within field service have been done, none of them including blockchain technology.

1.3 Purpose

The purpose of this thesis is to create a concept for how the blockchain technology could improve the component traceability throughout Wärtsiläs organization and specifically Field Services and post-installation assemblies, investigate if and how blockchain technology specifically could improve and make traceability leaner with regards to component traceability within Wärtsilä compared to traditional centralized database concept. It is also to study the current way of handling traceability within Wärtsilä and pinpoint the pain areas and visualize the gaps in the current systems and propose on a conceptual level how traceability should be handled within Wärtsilä including logical next steps. Another thing that should also be investigated is in which context and in which areas blockchain would be superior to traditional database systems.

A Proof of Concept is a rather small exercise to test the feasibility of a certain idea or method. The proof of concept may or may not be complete. The main purpose is to demonstrate a theory or a certain concept and to verify that it can be achieved in development. The main purpose of this work is not to look at the physical parts of traceability, such as physical markings etc. even though these will be mentioned briefly, but more to look at the software part and the system as a whole. (Singaram & Jain, 2018)

1.4 Delimitation

Wärtsilä ordered this thesis to get an understanding of how the blockchain technology could be implemented in their current systems, or what kind of new approaches there is to look at.

This thesis main purpose will be investigating how the technology of blockchain could be implemented within the area of field service since that is where the lack of traceability is the most obvious.

1.5 Confidentiality

This work includes sensitive information that must not be shared outside of Wärtsilä.

1.6 Disposition

The first chapter of this paper has given the reader a brief introduction to the background of both the blockchain technology and component traceability within Wärtsilä. It also includes the purpose, problem area, delimitation, and confidentiality.

The second chapter contains an explanation of what Wärtsilä is, where it started and what it looks like today. Company segments and field service is also included.

The third chapter contains the theoretical background for this thesis, it involves the theory that stands behind blockchain, as well as some theoretical background of component traceability.

The fourth chapter contains the methodology that was used to come in front with the results. This chapter includes the interviews that were done, and the methods used to reach the result.

The fifth chapter contains the results of this thesis.

The sixth chapter will discuss the completed thesis. Theory, methods and results will be reviewed as well as some proposal for further research and final conclusion will be made.

2 Wärtsilä in Brief

Wärtsilä was established in 1834 as a local sawmill in the municipality of Tohmajärvi, Finland. Since then Wärtsilä has changed markets many times. Today Wärtsilä is a global leader in smart technologies and complete lifecycle solutions for the marine and energy markets. By emphasizing sustainable innovation, total efficiency and data analytics, Wärtsilä maximizes the environmental and economic performance of the vessels and power plants of its customers. In 2018, Wärtsilä's net sales totaled EUR 5.17 billion with approximately 18,000 employees. The company has operations in over 200 locations in more than 80 countries around the world. (Wärtsilä, 2019b) (Wärtsilä, 2019a)

2.1 Company segments

Wärtsilä was earlier divided into three separate businesses, there was Marine Solutions, Energy Solutions, and Services. As of now though Wärtsilä is divided into only two segments, as *Service*s has been integrated into *Marine Solutions* and *Energy Solutions*. All of these segments have different purposes and goals. *Marine Solutions* offers powering and operating of seaborne transportation vehicles, propulsion solutions and also maintenance agreements and ship designs. *Energy Solutions* is in the business of designing and building power plants for utilities and industry use, this consists of solar plants, internal combustion engines as well as LNG terminals. *Services* purpose is to offer lifecycle improvements through the whole lifespan of Wärtsiläs installations through spare parts and on-field assemblies, both in the Marine and Energy segment. When looking at the net sales by the business chart (figure 1) one can see that Services stands for almost half of all net sales as of 2017. (Wärtsilä, 2019a)

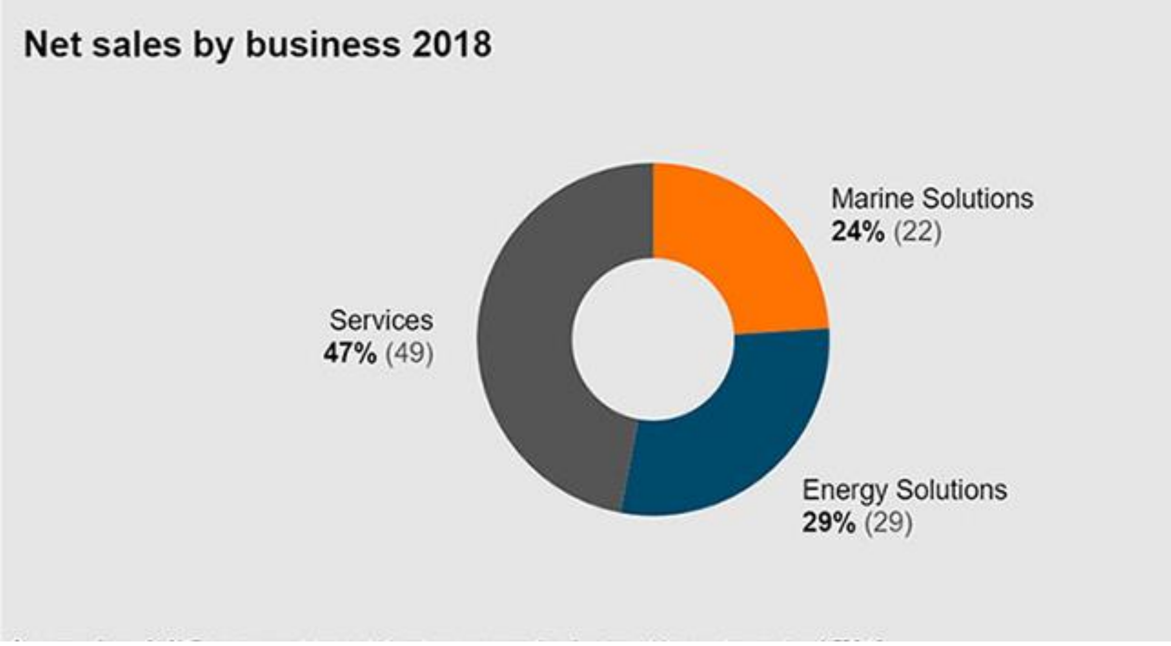

Figure 1 Net sales by business

2.2 Field Services

Field services is a segment within services that's purpose is to offer and perform high-quality on-site support throughout the lifecycle of the installations. There are over 4500 field services professionals spread all around the world in 70 countries in order to serve the

customer as fast as possible. As one can understand it is no easy task keeping track of everything in such a huge network of both people and components. In Figure 2, one can see the extent of the service network offered by Wärtsilä, it is also worth mentioning that Wärtsiläs network is the most extensive in the industry. (Wärtsilä, 2019c)

Figure 2 Field Service locations

Field services are divided into three different areas, these are:

- **Global Field Services**, is responsible for securing the way of working throughout the different Business lines and Areas. The Global Field Services team consists of participants from all Business Lines and Areas and is led by Field Services PSS in line with the agreed Shared Business Operations responsibilities.

- **Business line Field Services**, is responsible for global Field Services expertise, know-how, and superintendent level support, through a pool of highly skilled engineers and selected specialized support workshops.

- **Service Unit Field Services**, are responsible to provide all Field Services activities (utilizing available competent resources and assets, tools and workshops facilities, etc.) in their geographical area according to market requirements. One Area Field Services General Manager per Area is the link between the Service Unit Field Services and the Global Field Services. (Björknäs, 2019)

The stakeholder or the parties benefiting from this work is actually all three of these in one way or another. Because this topic is so big it interacts with **Service Unit** through scanning and reporting the traceability data, **Business Line** needs to be aboard in order to know how to use the data and interact with it effectively and **Global Field Services** needs to know how to utilize the data collected in a way that supports the other areas.

3 Theory

This chapter consists of the theoretical framework that is the foundation of this thesis. The chapter will begin by explaining the theory of blockchain.

3.1 Blockchain theory

The blockchain is a purely distributed peer-to-peer system of ledgers that utilizes a software unit, which negotiates the informational content of ordered and connected blocks of data together with cryptographic and security technologies in order to achieve and maintain its integrity. (Drescher, 2017, p. 35)

To more easily understand the function behind a blockchain, let's compare it to a physical book. Each page in the book is filled with a lot of transactions that have been distributed, this is called a "block". Each and all of these pages are glued together in the book in a specific matter and every x seconds there is another page created, time-stamped and given a specific serial number, thereafter it is glued into the book in the right place. The glue is what links these pages or "blocks" together, making them into a "chain" of pages of blocks. The serial number on the page is what makes every page unique and every adjacent page is locked together through the serial numbers of those pages. So, in order to alter one of the transactions on one page, one would need to rip out that page and every subsequent page, fill up the page with new transactions and a new serial number and glue every page back into the book. Since a new page is created every x seconds and the users of the book always consider the book with the most pages to be the only true book, one would need to work faster than the rest of the users combined, making it literally impossible to change, therefore it makes the blockchain secure. (Jansson & Petersen, 2017, p. 2)

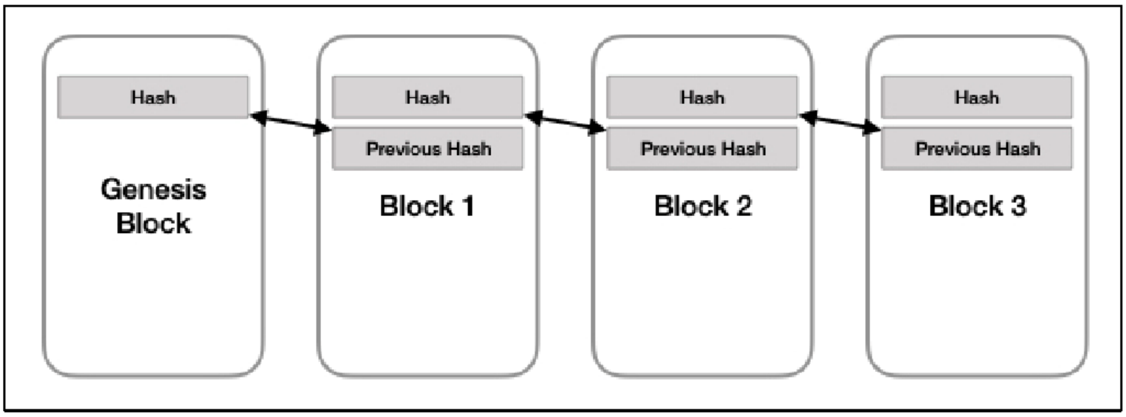

Figure 3 The blockchain ledger

The result is a network where individuals can transact without the need of a third party, everyone can view all the transactions that have happened on the blockchain which ensures that everyone agrees upon the current chain.

On the bitcoin blockchain, everything is connected through different computers all running an algorithm that is securing the network this is called “nodes”. These nodes can be placed anywhere in the world, the reward these get for ensuring the network is safe is cryptocurrency coins that in this case is called bitcoin. These coins hold a certain value, as determined by supply and demand. (Laurence, 2017, p. 12)

The information on a blockchain is crowd-sourced, which means it is open to anyone who wants to add inputs or material to the chain. This enables corporations or conflicted actors to cooperate because no sole organization has control of the information. Once a transaction is made on the blockchain the system encrypts it and sends it out to all other nodes on the network. In the case of supply chains, this transaction contains barcodes, RFID tags, QR-Codes or whatever they choose to use to represent the physical items. After all nodes agree that a block is legitimate, the block is added to the ledger. This ledger then serves as the new foundation for the next block. Because all nodes verify every other nodes transaction it makes the system resistant to fraud. This means that the greater the number of nodes involved, verifying the other nodes transactions, the more secure the system gets. That makes it ideal for larger supply chains with many parties. (Bateman, 2015)

One important thing that the blockchain aims to solve is the trust issue. Trust in business is the expectation that other parties will be honest, considerate, accountable and transparent.

- **Honesty**, all parties involved in business must be truthful, accurate and complete in communications.

- **Consideration**, parties will operate in good faith. This requires a genuine respect for interests, desires, or feelings of others.

- **Accountability**, means making clear commitments to stakeholders and abiding by them. No playing the blame game, no passing the buck.

- **Transparency**, when it comes to pertinent information companies needs to be open and not be hiding something.

  (Tapscott, 2016, s. 10)

Because of the general lack of trust towards other parties involved in business today we have involved third parties, not only to vouch for strangers but also to maintain transaction records and perform the business transaction that powers online commerce. In the world of blockchain however, we lay our trust in the network and even the objects on it. A global ledger can build a more open and trustworthy world with less fraud and people or organizations going behind others backs. (Tapscott, 2016, s. 11)

3.1.1 Distributed ledger

A distributed ledger is a type of data structure that is spread over a number of computer mechanisms that generally is in different geographical locations. The distributed ledger technology generally consists of blockchain technology and smart-contracts. Although DLT existed before blockchain, blockchain distinguishes itself from the older DLTs through time-stamped transactions, peer-to-peer (P2P) networks, encryption, and new consensus algorithms.

Sahdev et al. (2019) mean that a distributed ledger generally consists of three components.

- A data model that captures the current state of the ledger.

- A language of transactions in order to change the ledger state.

- A protocol to create consensus among participants around which transactions will be accepted, and in what order, by the ledger.

(Sahdev, et al., 2019)

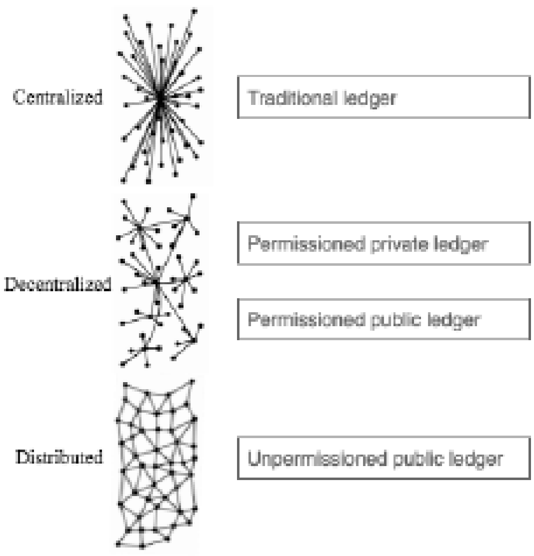

Figure 4 Different ledgers

In Figure 4, one can see how different kinds of ledgers work, the degree of centralization depends on the type of ledger, the unpermissioned ledger, like the Bitcoin blockchain being the most decentralized ledger, followed by permissioned public ledger, the permissioned private ledger, and the centralized ledger. One thing to also consider with these ledgers is that the more towards the distributed way they go, the more expensive they get to build and maintain, but they also get a lot more secure at the same time.

3.1.2 Smart Contracts

Smart contracts were first introduced in 1996 by Nick Szabo. The general definition is a data protocol that is used to promote, verify or claim negotiations of legal contracts. Smart contracts are simple computer programs that execute predetermined negotiations when specific conditions in the system are fulfilled. Smart contracts provide the language of transactions that allow the ledger state to be modified. Users can facilitate the exchange and transfer of anything of value, e.g. shares, money, content or property. (Sahdev, et al., 2019)

Smart contracts are immutable and cannot be updated to newer versions, the only way to update a smart contract is to delete the older version. Removing a smart contract does not affect the blockchain it is built upon. (Andreas & Gavin, 2018)

3.1.3 Peer-to-peer

Historically most programs use a central server or different centralized servers. This means that if one user is to send a message to another user, the request is first sent to the server, the server then directs the message to the right user. P2P networks first got popular with Napster and later in the torrent world, it consists of a network of computers who is directly connected to each other without the need for a centralized server. (Sahdev, et al., 2019). This meant, that before the blockchain technology it was not possible to prevent double spending of digital cash. It required a trusted third party, like a bank to mediate because digital cash could be copied. (Rituparna, et al., 2017, pp. 1431-1435)

P2P-networks is generally seen as more secure than centralized networks because they don’t have one single point of attack. In a server-based network, there is a risk of the whole network being at risk if the central server is attacked. (Sahdev, et al., 2019)

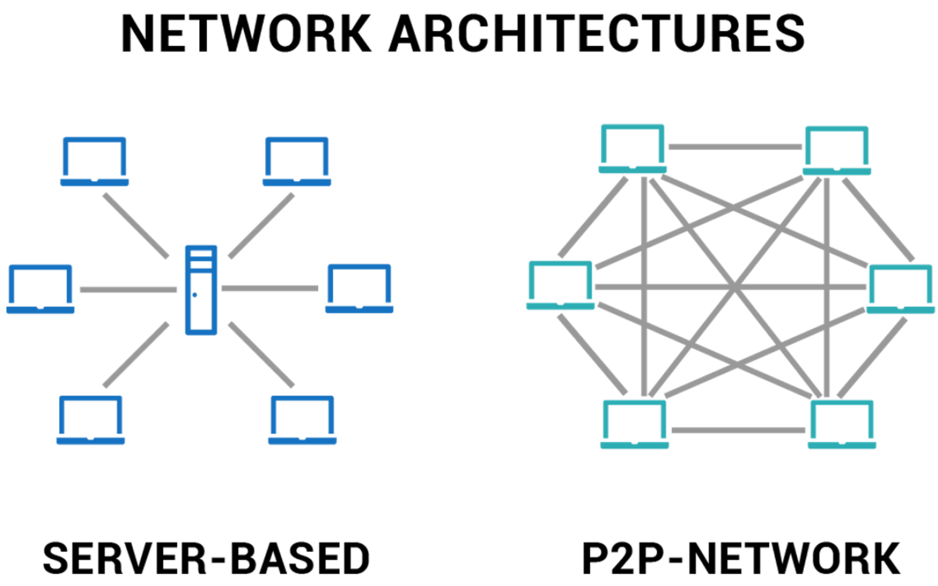

Figure 5 Network architecture, server-based vs P2P-networks.

3.1.4 Challenges

The blockchain technology is still only an infant technology when compared to other technologies that have been around for a long time. The problem with blockchain is that theoretically, it is a very good idea, but practically it is very complex, expensive and relatively unstable. In order to fully utilize a technology, you first need to understand why you need it and why it brings value to the problem. This has been a problem within the blockchain space for the past years, a lot of money has been invested but no good concrete results have been achieved, at least not yet. (Higginson, et al., 2019)

According to (Higginson, et al., 2019) the solution seems to be to use the theory of Occam's razor, also known as the law of parsimony. This theory is a problem-solving principle that states that solutions are more likely to be correct than complex. This essentially means that when faced with a problem or decision you should choose the easiest or simplest way out. If applying this theory to blockchain you should only choose to implement blockchain if it is the simplest solution available, this says quite a bit since the blockchain has proven to be quite complicated. Conceptually the blockchain technology has the ability to revolutionize the process in industries, the problem thus far has been that the blockchain technologies of today have not yet been run at a significant application of scale. Another obstacle we face thus far is the lack of standardization, this is causing problems when enterprises are trying to integrate blockchain into existing systems and collaborate with others. (Higginson, et al., 2019)

Blockchain has also become some sort of solve it all, meaning it is seen as the solution to all technical problems that a company is faced with. In theory, the blockchain can work, but supply chains are very hard to change and adapt. Companies spend years making supply chains work. It is not an easy task to insert a new technology inside established supply chain systems because the integration challenges are not to be underestimated. (Mougayar, 2016, pp. 124-127)

3.2 Component Traceability

According to IEEE Standard Directory of Electrical & Electronical terms "tracking" refers to the process of following a moving object or a variable input quantity, using a servomechanism. The term "traceability" on the other hand means the ability to trace a component at any time, this means where it is, its current status and where it has been in the past. (Gao, et al., p. 1)

The ability to track and trace components is crucial or almost vital in supply chain management, traceability affects product safety, supply chain efficiency, on-time deliveries, customer management and controlling costs. Companies often fail to realize the effect of missing out on good traceability and therefore can't justify the investments needed for improving it. (Bateman, 2015)

The ISO 9000:2000 definition of traceability is "The ability to trace the history, application or location of that which is under consideration"

There are several types of traceability involved in the tracking of components. One type of traceability is the tracing of a component's behavior, this is done in one of two ways, either internal or external. The internal tracking of components is done through sensors and different kinds of measuring equipment's, this is also where IoT- devices come into play. The external type of tracking a component is done through visually and physically examining the component. The other type of traceability and the one that is interesting in this study is the traceability of a products physical location and its history. This is currently something that Wärtsilä lacks, at least outside the walls of the factories. (Gao, et al., u.d., p. 403)

The need for component traceability doesn't really surface until something goes wrong, track-and-trace solutions not only aid in recalling and or changing components, they also help stop unnecessary recalls. If one engine component fails because of manufacturing faults it is crucial to know what other components originate from the same supplier and batch, so that they can be changed prior to breaking. In the case of not knowing where the problem originates from, it can get really expensive, really fast.

In 2008, a salmonella outbreak sparked the recall of tomatoes across much of North America. Unfortunately, the outbreak was later attributed to jalapeno and Serrano peppers, not tomatoes. The total loss as a result of the recalls was estimated to be over $200 million. If a good traceability system would have been in place at that time the need for these recalls wouldn't have been necessary. (Matthews, et al., 2014, p. 5)

3.2.1 Challenges

The key challenges in component traceability, with or without the blockchain is that all component vendors would have to be part of it. This means that every single supplier to Wärtsilä and to Wärtsiläs suppliers must be incorporated in the same system.

Another problem Wärtsilä is facing is the rough environments components must withstand, this imposes several challenges in the tracking of the components. Physical markings and data codes get worn out over time as a result of wear and tear, heat and other factors.

Another problem that we face is the link between the physical and the digital world, this means that while collecting the information in the physical world there needs to be a solution that enables a seamless transmission to the digital world. This means that in order for this to work, one must be able to effectively seal the object and authenticate them uniquely over time. One possible solution to this is using IoT sensors to capture the data, blockchain to store it and the world wide web to connect them together. The problem is that the sensors, blockchain and the communication between them need to be secure, authenticated and certified at all times. (Deloitte, 2017, p. 19)

3.3 Internet-of-Things

Internet of Things (IoT) as a term was first introduced about 20 years ago. The term was coined by a Kevin Ashton in the context of Supply Chain Management (SCM) as he was working on a research project to explore ways to improve business performance through linking the Radio Frequency Identification (RFID) technology to the internet. The term is a general concept about linking physical objects who communicate with each other and through the internet to attain certain goals. IoT has the potential to improve the operation and decrease the costs through its flexibility and scalability. (Abubaker, et al., 2017). The primary goal of IoT is to secure a global network infrastructure to more easily be able to exchange goods, services, and information. (Mengru, 2018)

There are many definitions of IoT, but no real unity has been achieved yet, almost everyone though, is convinced that there are four main components at play, these are:

- **Sensors**, these are often embedded into the thing itself and scans different elements, either about the things internal or external factors.

- **Processor**, to interpret and do something useful with the data that the sensors collect, there needs to be some kind of data power. This can be located in the thing itself, in a close by hub or in the cloud.

- **Network**, the network can be used for controlling, reporting or collecting of data from other things of the internet, it must be in some aspect important to the things function.

- **Actuator**, it is through the actuators the things can change the physical reality, not all things have these though. (Sundström, 2016, pp. 9-10)

3.3.1 IoT & Blockchain

As of now, there exists an increasing trend of trust towards modern IoT-technology in supply chain management. Through new innovations such as RFID, sensors, and barcodes an item can be tracked in real time all the way from manufacturing to delivery to the customer and beyond. The trust of the system can be questioned as the information in the supply chain is spread among the participants, the centralized organization can become too powerful in possession of this data that could result in information asymmetry between supplier and customer. It can become a vulnerable target for bribery. An example can be that the administration of the organization can be bribed to change valuable information and thus the system can no longer be trusted. (Feng, 2017)

Blockchain enables a solution for identity management. Blockchain has the capacity to be used in combination with supply chains to register who executes what orders. That also opens up the possibility of registering time and place for saved actions. When the information then later is saved within the blockchain it is practically unchangeable. Other participating suppliers can then track and trace deliveries from their origin to their current position. This increases the trust among the participating suppliers. (Kshetri, 2018)

3.4 Artificial Intelligence

Artificial Intelligence is the ability of a computer to perform tasks commonly associated with intelligent beings, or in other words, humans. It all boils down to how close or how well a computer can imitate or go beyond, when compared to human intelligence. What this means is how well a computer can understand what is said to it, and depending on the input it gets, come to certain conclusions or results. (Kulkarni & Joshi, 2015, pp. 1-6)

There are several levels of AI. These levels range all the way from a computer understanding that if your input is X then the output should be Y, to a computer that can correlate, understand and act on the data or input it is given in an intelligent way, just like a human. Making an AI is just like growing up, in order for an AI to know how to act in certain scenarios it first needs to be learned how to act, just like a child growing up, it doesn't know everything from the start, but it learns as it goes. (Kulkarni & Joshi, 2015, pp. 1-6)

One example of AI is IBM Watson, which was originally developed as a question answering machine to answer questions on the quiz show Jeopardy. IBM Watson is currently used in Wärtsilä through the "Spare Part Explorer" tool. Which is a a tool to search on structured and unstructured data, across many sources, to reduce the time needed for the technical spare parts identification. In addition, the target is to reduce the percentage of total requests going to Tech ID and reduce average response time on Tech ID's, thus increasing customer satisfaction and hit rates. A screenshot of the Spare Part Explorer can be seen in Figure 6. (Lehtonen, 2018)

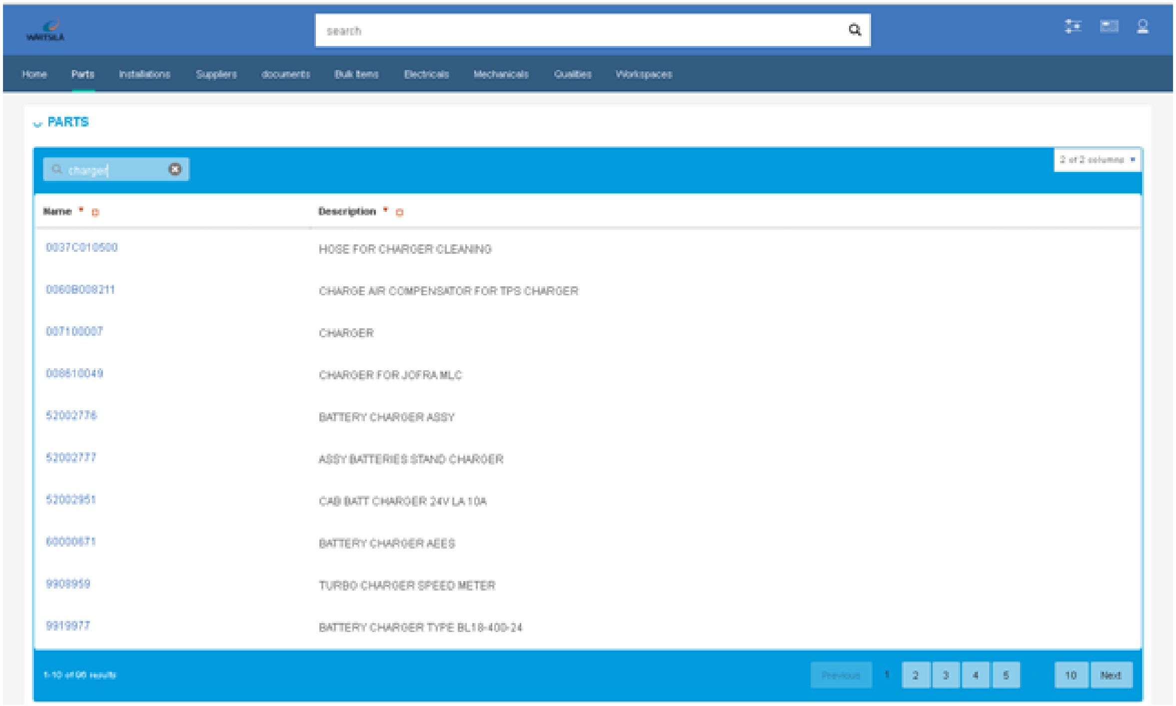

Figure 6 Spare Part Explorer

3.5 Available solutions

There are currently many service providers that either provide Blockchain as a Service or provide public blockchains that individuals and/or companies can join if they so choose. BaaS is a cloud-based service provided by one developing company to a company in need of the service. This allows the receiving company to build, host and use their own blockchain apps, smart contracts while the provider of the blockchain manages all backend development.

This may solve the problem of lack of competence within any ordinary company when an external “blockchain expert” can develop the software and customize it to one's needs. (Behnke, 2018)

As previously stated there are plenty of different blockchain providers out there, some more serious than others and some larger and some smaller. I will discuss a few of these that I deem most relevant to this case.

3.5.1 Ethereum

The biggest public blockchain so far is still Bitcoin, followed by Ethereum. Ethereum is a platform that extends the concept of bitcoin to provide the possibility for running decentralized applications known as DApps. These applications can be made to run any kind of transactions or agreements between users while taking advantage of the secure blockchain ledger and without having a corrupt central authority that may manipulate the records. (Ray, 2018). Bitcoin uses only proof-of-work as a way of keeping the network secure and validating new blocks. PoW is essentially a computer solving an advanced cryptographic puzzle algorithm, the solution is then later stored in the block as proof that the miner has performed the solving process. Ethereum, on the other hand, is transitioning to a proof-of-stake approach for achieving consensus. Proof-of-stake is another approach to achieving consensus within the network, in this network the creator of the next block is chosen by various combinations of random selection, wealth and age. That means that the nodes that choose to validate blocks must all contribute a stake of their own wealth in order to be chosen as a block creator. In figure 6 one can see a screenshot of the Ethereum Wallet that is used to send coins and tokens across the network, it can also be used to deploy smart contracts and interact with them. (Buterin, 2013)

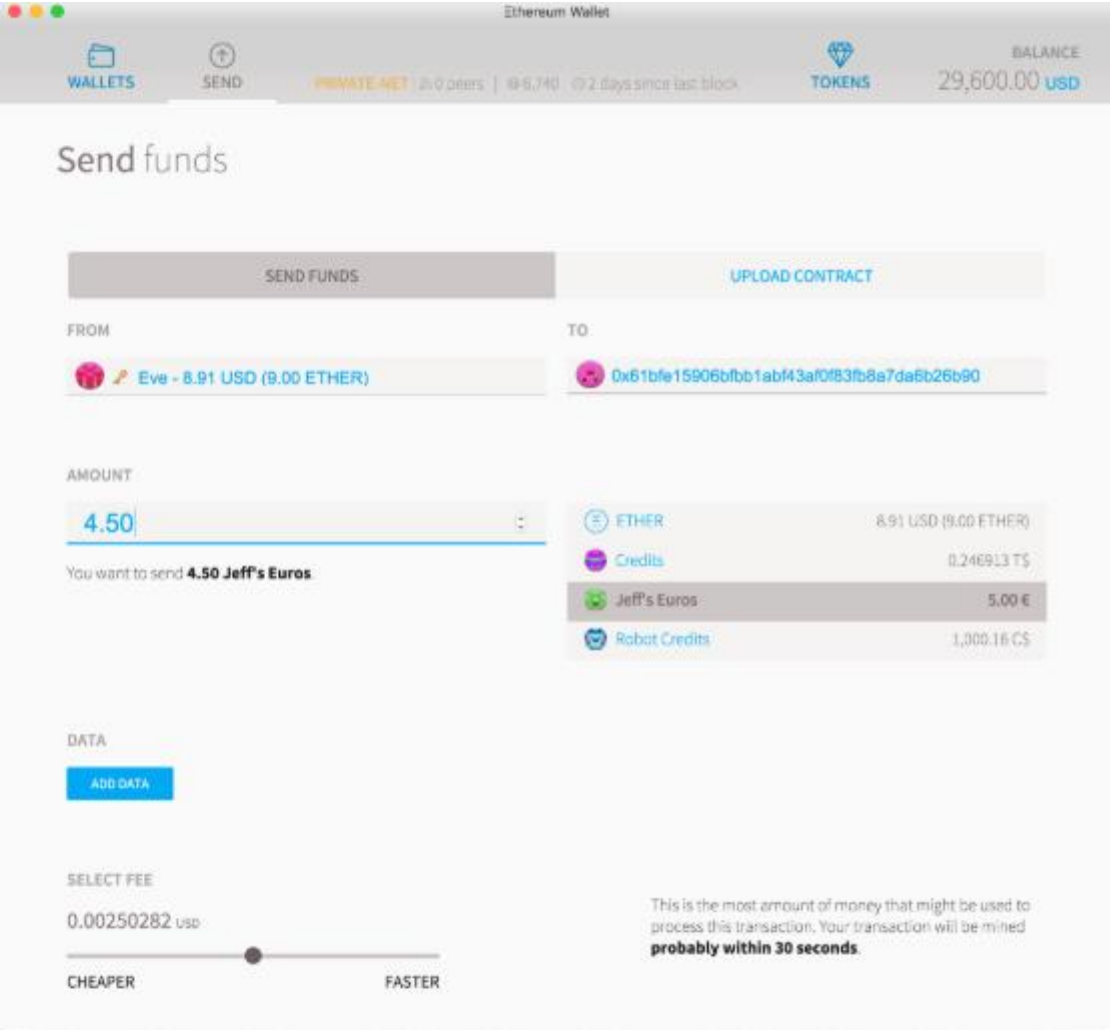

Figure 7 Ethereum Wallet

3.5.2 Hyperledger

Hyperledger is an umbrella project by the Linux Foundation, this project consists of open source blockchains and blockchain tools. The Hyperledger can be thought of as an open-source distributed ledger framework and code base. It aims to improve the way blockchain technology works by creating a cross-industry open standard platform. This means anyone who wishes can download the Hyperledger code base and begin making their own blockchain. The Hyperledger is also private and permissioned, this means that only those who have been given access can operate on the blockchain. The work of the Hyperledger community is important because they are the main group shepherding the blockchain industry into mainstream and commercial adaption. (Laurence, 2017) IBM is one company who is currently building blockchains on top of the Hyperledger code base, and according to Timo Koskinen IBM has, as of now, about 40% market share in the specific field, that means that they are market leaders. Some other participants in the Hyperledger project are

Intel, SAP, and AIRBUS. (Koskinen, 2019) (Cachin, 2016). IBM ran a project together with the S-Group to increase the traceability of a fish. The project was called Pike-perch radar which was based on IBM Blockchain technology. Customers in Finland could trace a fillet of pike or perch fish back to its home waters using a QR code on the package. (Lehikoinen, 2018)

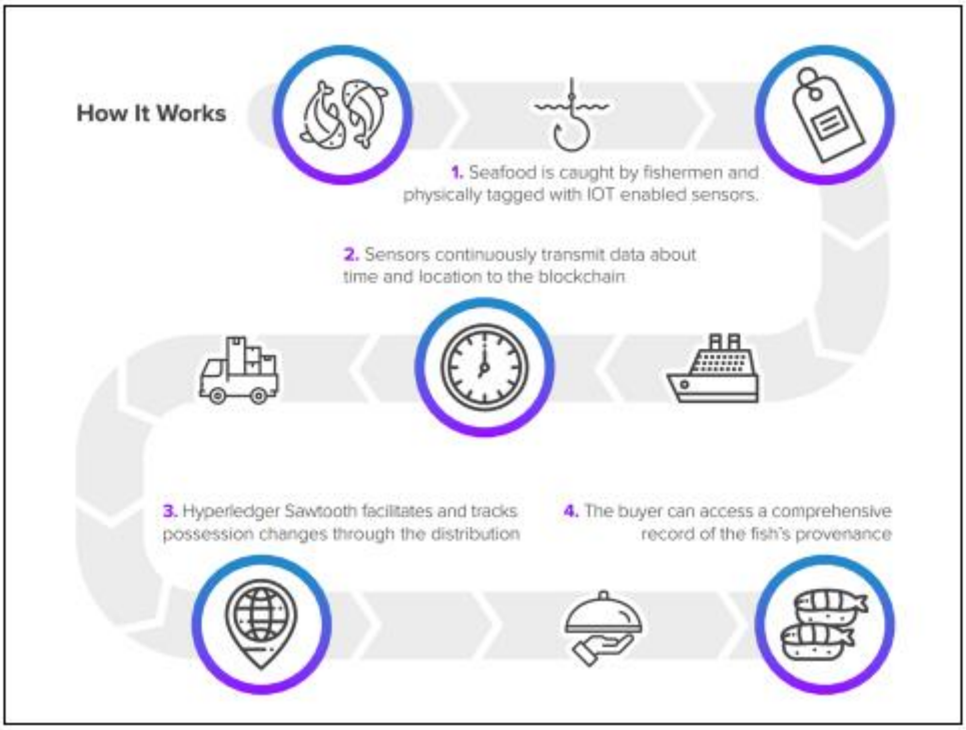

Figure 8 The traceability of a fish visualized

Hyperledger was created on the expectation that there will be many different Blockchain networks, all serving and providing for different goals. The Hyperledger Project uses “Turning complete”, which means that one can create applications on the Blockchain in many different programming languages. The Hyperledger Fabric permit many different uses of Blockchain, it, therefore, allows the creation of distinct levels of permission. The Hyperledger Fabric relies on Byzantine Fault Tolerant algorithms to secure consensus on the network, this differentiates it from Bitcoin which uses proof-of-work mining. (Kakavand, et al., 2016)

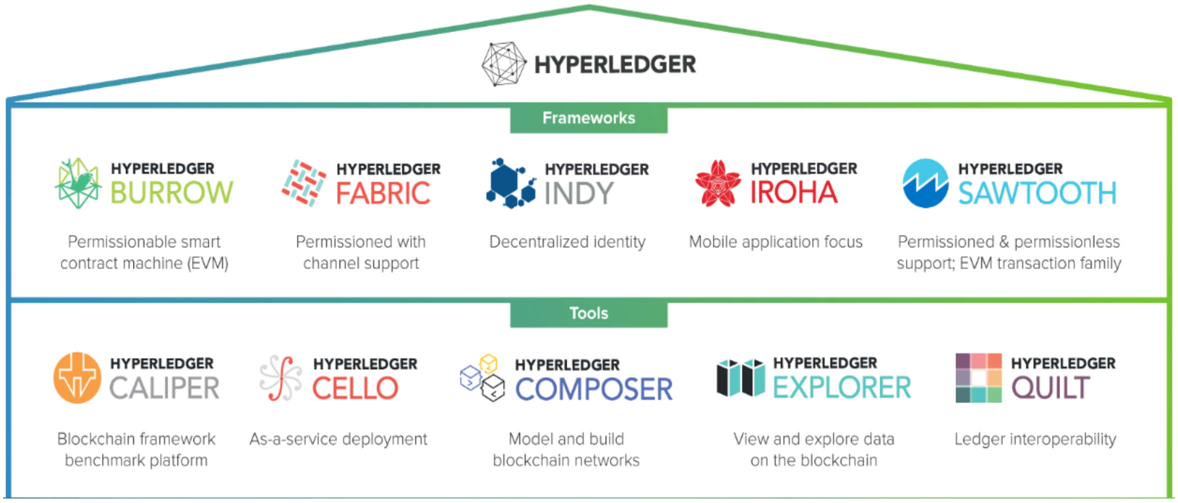

Figure 9 Hyperledger project greenhouse

3.5.3 Corda & Quorum

Corda is a Distributed Ledger Technology and is not a classic blockchain like Ethereum and bitcoin but more like Hyperledger. It is meant to be used only by businesses, for example, to ease the way transactions are done for financial institutions through keeping a shared ledger instead of every institution keeping their own books. Corda is a private/permissioned kind of DLT, the same as Hyperledger but different than Ethereum. The downside that comes with Ethereum and all other public blockchains is that every party using the blockchain must keep a local copy of the chain themselves so that app parties receive the update once a new block is added to the chain, the upside though is that this system is completely trustless. When a deal is made on Corda the data isn't put into a block with the deals of everyone else, instead, each deal is individual and can be sent to only those who need to know. Corda has partnered with for example Osuuspankki, Nordea and Toyota. (Corda, 2019)

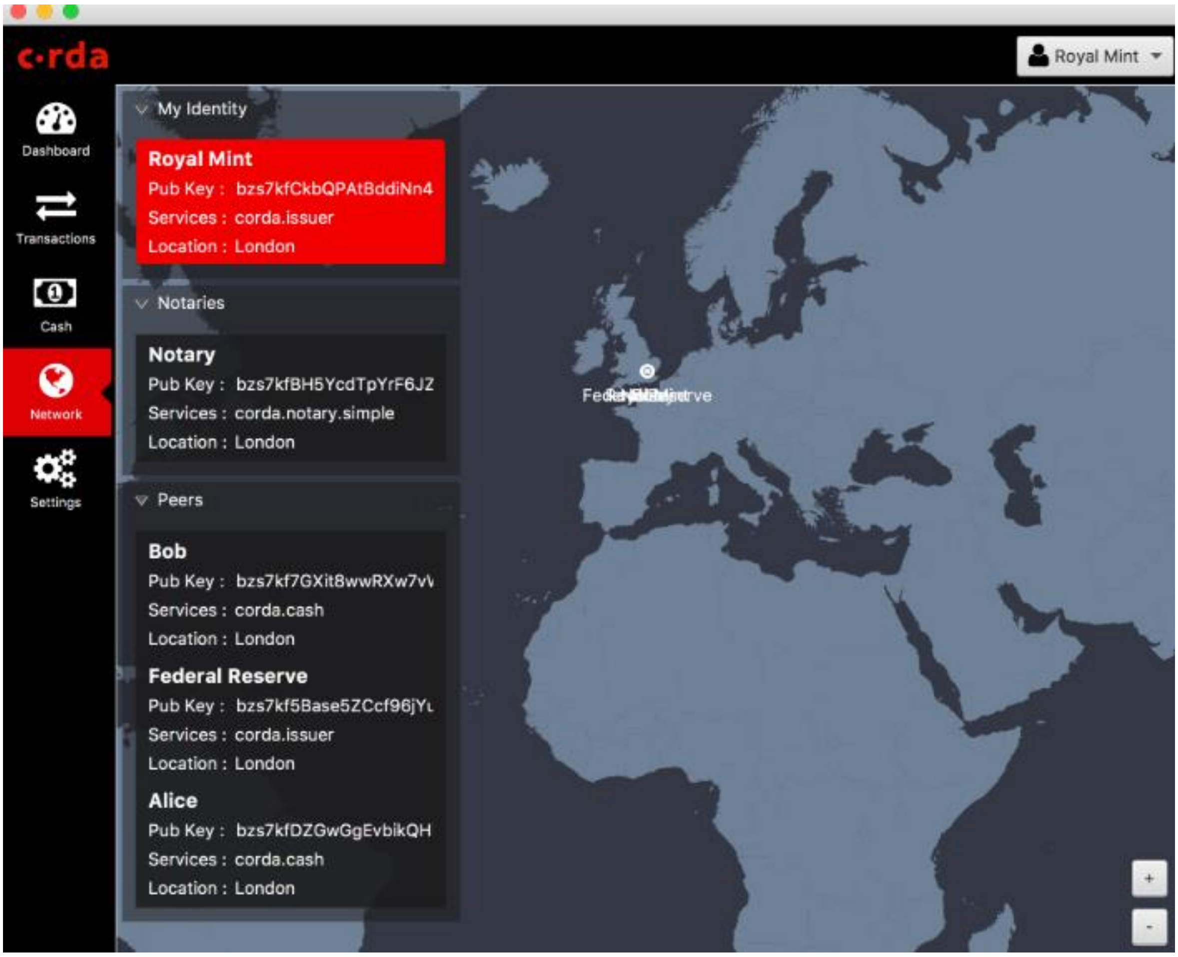

Figure 10 Corda User Interface

Quorum is an enterprise-ready distributed ledger and smart contract platform made by J.P.Morgan. Quorum is an Ethereum based DLT, the objective is to create a permissioned version of Ethereum that supports transactions and contract privacy. The banking world needs easy traceability and immutability, but they don't necessarily want to have all their transactions open to the public as it would be with a public blockchain. It was developed to clarify all the apprehension surrounding the use of blockchain as a part of the mainstream financial system. (J.P.Morgan, 2019)

3.5.4 Insolar & Shipchain

Insolar is another blockchain provider available, this provider is nowhere near the size of IBM and it is just a small startup originating from Russia. They are building their own blockchain from the ground up, they also provide BaaS, meaning they provide the blockchain to other companies. Apart from Hyperledger they also offer public blockchains, meaning anyone who wishes can contribute to it. Some of the examples of their partners are Valio and Unilever. (Insolar, 2018)

ShipChain is an end-to-end logistics platform, it is a fully integrated system across the entire supply chain, from the moment a shipment leaves the production facility, to the final delivery on the customer's doorstep. Every shipment is federated & validated in trustless, transparent blockchain contracts. Shipchain is operating on the public blockchain model with the Ethereum blockchain as a base. This means they build their blockchain on top of the Ethereum blockchain. This solution seems to be mainly focused on the shipping of goods, not tracing them before they enter and after they leave the shipping container. Maybe it would be able to modify though. (Shipchain, 2019)

3.5.5 Tradelens

Tradelens is a venture created by IBM and Maersk in order to make blockchain backed ports to reduce reliance on intermediaries, and therefore, overhead. The platform offers a more efficient, predictable and secure exchange of information, leading to better trust and collaboration across the global supply chain. The ecosystem consists of every organization in the end-to-end journey of a shipment. Tradelens can be divided into three primary layers, network, platform, and application & services. The network layer consists of all different stakeholders, these are shippers, ports, customs, brokers and more. The platform is essentially the way people interact with the blockchain, the platform is underpinned by Hyperledger Fabric. On top of these two layers is the application & services layer, this layer consists of the tools to customize the platform to each company needs by adding or removing certain applications. (Tradelens, 2019)

There are plenty of other services available but there is no need to list of all them. Some other ones that have not been included above is BlockVerify, IBM Watson, VeChain, WaltonChain, Amrosus & Everledger. (Quittem, 2018)

4 Methodology

This chapter will include the methods used to come up with the final results.

4.1 Research Approach

This work was ordered by Wärtsilä Field Services in the spring of 2019. Initially, a meeting was arranged with the supervisors from Wärtsilä during which the problem was described and the purpose defined, later a meeting with the supervisor from Novia was also arranged. One could explain the way this work was done through empirical research, that was the purpose. There are, according to (Jacbosen, 2002) basically two main concepts to evaluate in doing empirical research:

- New knowledge
- Description, explanation, and prediction.

New knowledge is defined by the author as “something we have not known before”. This knowledge is though often seen as revolutionizing because it challenges earlier established knowledge in a specific field. New knowledge may also be a phenomenon that has the goal of developing and improve already known and established knowledge. (Jacbosen, 2002)

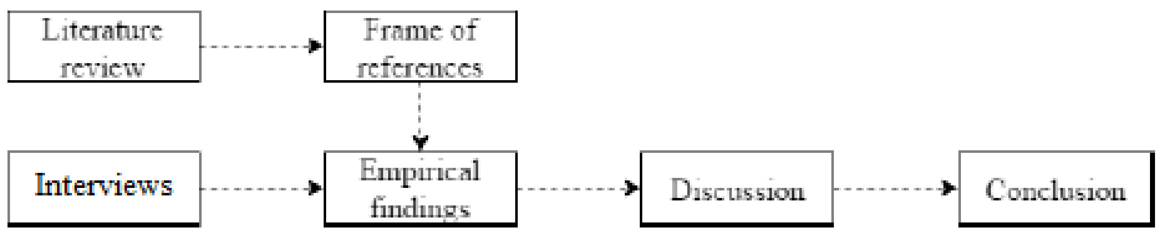

Figure 11 The method process

In Figure 11, the structure of the process is visualized, I started off with a literature review with studying relevant material from different fields. This was done to obtain a broader and deeper knowledge of the subject at hand, the literature review founded the base of the empirical study. After reviewing the literature and gaining the base knowledge needed, interviews were done. As many relevant people as possible within the timeframe was interviewed, this because the more people one interviews the better and more trustworthy the facts get, if several people state the same thing, the thing is more likely to be true. This means that the interviews were both qualitative and quantitive.

4.1.1 Methods

The methods that were chosen to be used in this Thesis work was interviews and doing theoretical research. The interviews were chosen because in order to get an understanding at the case at hand we needed to gather information from as many sources as possible because the problem is so complex and not easy to grasp it was quite the challenge in finding the right information from the right persons. Earlier cases have been done within Wärtsilä regarding the blockchain technology, but in that case, it was only with the purpose of fighting counterfeit spare parts, which is also partially involved in this thesis work. Interviews were done with people involved in the previous projects regarding blockchain technology, which was an idea that was presented to the Board of Management. The project was never really realized because of the complexity of the problem and since it was done in 2017 blockchain was not nearly as developed as it is today. There was also another case involving blockchain and remote service delivery that was done between Wärtsilä and TIETO back in 2016, back then the used blockchain solution was Ethereum, mainly because it was the only solution that somewhat filled the needs back then, this project was also never realized. Because this topic is so new the thesis was very theoretical, there were not that many old cases to look at that compared to this one. (Hautala, 2019) (Furlan, 2019)

Theoretical research was chosen as a study method because there was no other way since there is nothing that could be improved right away without first understanding the theoretical way that both blockchain and the current systems work. No tests could be done straight on top of the current systems because they are in use and I am no programmer. With external help though we managed to gather quite a bit of information and hands-on experience with different kinds of applications. The idea was just to gather information and try to figure out what was possible with this technology and if it could be applied to improve Wärtsiläs traceability issues, and that I think we accomplished quite well.

We chose to involve external parties because the information and expertise that we needed to gather in this thesis work were not available internally. Also, in order to get some information on how other companies have done the blockchain integration previously and how well they have succeeded we needed to involve external parties that have the experience needed for this type of work. Sooner or later external parties would have to be involved anyway since if this was to be executed and Wärtsilä actually was to proceed with implementing blockchain they could not do it on their own but would need external help and consulting to incorporate such a system into their supply chain.

4.2 Interviews

One of the important sources of information in a case study is the interviews. A case study is a research method used when one wants to get an in-depth, up-close and detailed examination of a subject of study. The interviews were mostly unstructured and was more set up like a chat with the purpose of the interviewer getting more knowledge on the different subjects discussed with the different parties. (Yin, 2009) Interviews were done both internally within Wärtsilä and externally. The information obtained from these interviews were either recorded on a mobile device or written down, to later be reviewed and the information analyzed. The interviews were either recorded or notes were taken by hand to later be able to review the material and information that was gathered from the meetings. The meetings were as much as possible set up face to face but when interviewing external parties and people who were not located in Vaasa the interviews were done mainly through Skype.

The persons we chose to interview was selected according to what fields we viewed as most relevant to this case, first of all, we needed to get some background into what the problem really was and what had already been done, for this we chose to interview internal experts within the traceability field and specifically those who had been involved in previous efforts in improving traceability. One representant from each of the currently available traceability systems was chosen, these systems are Maximo, Factory Traceability and WAMS Traceability, we also thought that the more the merrier in this case, since it is good to have many sources of information.

Mainly after the internal interviews but also during we did interviews with external blockchain experts and companies involved in the blockchain. We chose to do interviews with IBM since they had previously done and are as of now doing blockchain projects with various companies that shall not be named. IBM Blockchain is the global leader in improving trust and transparency across business networks by creating a new way for clients to share and secure data. IBM Blockchain now powers more than 500 client projects, with more than 85 active networks transforming supply chains, global shipping, and cross-border finance. IBM is a huge global company with over 370 thousand employees and for the year of 2018, the total net sales for IBM was USD 79.6 Billion. (IBM, 2018)

We also chose to interview TIETO for the simple reason that they have been previously involved in a blockchain project within Wärtsilä. TIETO is a leading Nordic software and services company that was founded in 1968 and its headquarters are located in Espoo.

TIETO has about 15000 employees and during the year of 2018 TIETOs net sales totaled EUR 1.59 Billion. TIETO has also developed other applications for Wärtsilä, for example, Smarthouse view which is an overview of the new Powergate 2 building that can be accessed online. (TIETO, 2018)

The questions that were generally asked during these interviews, of course, varied depending on what the subject of the meeting was and what person was interviewed. The general questions that were asked from internal parties and persons involved primarily with traceability were for example:

- How do current systems that are used work?
- What are the challenges with current systems?
- Have there been attempts to solve these challenges?

Some types of questions asked from external parties and those who are primarily involved in blockchain were:

- Have similar attempts been done with other companies to solve similar issues?
- What benefits does blockchain bring to this kind of case?
- Is blockchain easier to implement compared to centralized databases?
- What kind of issues could blockchain bring?

The interviewed persons were from Wärtsiläs side the General Manager of Process Development, Development Manager, General Manager of Sales Projects and Maintenance Manager, all of these are now or had previously been working with some kind of traceability systems or even blockchain.

And then there were external interviews from several different companies, from IBMs side we had several discussions with the Client Executive of Maritime and Logistics and the Chief Technology Officer of IBM Finland. With TIETO we had discussions with the Head of Blockchain Solutions and the Lead Enterprise Architect.

Totally there were eight people that in some way or another had an impact on this Thesis in the form of discussion or interviews.

5 Results

[CLASSIFIED]

6 Discussion

[CLASSIFIED]

7 References

Abubaker, H., Arthur, D., Anshuman, K. & Huei, L., 2017. Examining potential benefits and challenges associated with the Internet of Things integration in supply chains. *Journal of Manufacturing Technology Management*, pp. 1055-1085.

Andreas, A. & Gavin, W., 2018. *Mastering Ethereum: Building Smart Contracts and DApps.* s.l.:O'Reilly Media.

Bateman, A. H., 2015. Tracking the value of Traceability. *Supply chain management review,* pp. 8-10.

Behnke, R., 2018. *Here comes Blockchain-As-A-Service.* [Online]
Available at: https://medium.com/coinmonks/here-comes-blockchain-as-a-service-8cf187cc828f

Björknäs, U.-J., 2019. *Field Services*, Vaasa: Wärtsilä Internal.

Buterin, V., 2013. *What proof of stake is and why it matters.* [Online]
Available at: https://bitcoinmagazine.com/articles/what-proof-of-stake-is-and-why-it-matters-1377531463/

Cachin, C., 2016. *Architecture of the Hyperledger Blockchain Fabric,* Ruschlikon: IBM Research - Zurich.

Corda, 2019. *Corda.* [Online]
Available at: https://www.corda.net/
[Accessed 7 March 2019].

Deloitte, 2017. *Continuous interconnected supply chain using blockchain & Internet-of-Things in supply chain traceability,* Luxembourg: Deloitte.

Drescher, D., 2017. *Blockchain Basics.* Frankfurt: Apress.

Feng, T., 2017. A Supply Chain Traceability System for Food Safety Based on HACCP, Blockchain & Internet of Things. *Vienna University of Economics and Business*, pp. 1-6.

Furlan, S., 2019. *Fighting counterfeit spare parts through the use of blockchain.* [Interview] (4 March 2019).

Gao, J., Y.Zhu, E., Shim, S. & Chang, L., n.d. *Monitoring Software Components and Component-Based Software ,* San Jose: s.n.

Hansten, F., 2019. *DCV Factory Traceability & Digital Identification* [Interview] (25 February 2019).

Hautala, M., 2019. *Blockchain & Component traceability* [Interview] (5 March 2019).

Herbert, A. S., 1962. *The Architecture of Complexity,* s.l.: s.n.

Higginson, M., Nadeau, M.-C. & Rajgopal, K., 2019. *mckinsey&company.* [Online] Available at: https://www.mckinsey.com/industries/financial-services/our-insights/blockchains-occam-problem?cid=eml-web

Hyperledger, 2019. *Hyperledger fabric.* [Online]
Available at: https://hyperledger-fabric.readthedocs.io/en/release-1.4/
[Accessed 20 March 2019].

IBM, 2018. *Annual Report,* New York: IBM.

Insolar, 2018. *Presentation.* [Online]
Available at: https://insolar.io/uploads/Insolar%20Presentation.pdf

J.P.Morgan, 2019. *Quorum.* [Online]
Available at: https://www.jpmorgan.com/global/Quorum
[Accessed 8 March 2019].

Jacbosen, D. I., 2002. *Vad, hur och varför? - Om metodval i företagsekonomi och andra samhällsvetenskapliga ämnen,* Lund: Appia.

Jansson, F. & Petersen, O., 2017. *Blockchain Technology in Supply Chain Traceability Systems,* s.l.: Lund University.

Kakavand, H., Sevres, N. K. D. & Chilton, B., 2016. *The Blockchain Revolution : An Analysis Of Regulation And Technology Related to Distributed Ledger Technologies,* s.l.: s.n.

Karppinen, T., 2018. *Contract Management Tools.* [Online]
Available at:
https://wartsila.sharepoint.com/sites/compass/Operations/Life_cycle_support/Services_Contract_Management/CMT

Kolisko, L., 2018. *medium.* [Online]
Available at: https://medium.com/@lkolisko/in-depth-on-differences-between-public-private-and-permissioned-blockchains-aff762f0ca24
[Accessed 20 March 2019].

Koskinen, T., 2019. *Blockchains* [Interview] (11 February 2019).

Kshetri, N., 2018. Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management,* pp. 1-10.

Kulkarni, P. & Joshi, P., 2015. *Artificial Intelligence, Building Intelligent Systems.* Delhi: PHI Learning Private Limited.

Laurence, T., 2017. *Blockchain for dummies.* New Jersey: John Wiley & Sons .

Lehikoinen, T., 2018. *Fishing in Finland Means Food Traceability is On the Menu,* s.l.: IBM.

Lehtonen, M., 2018. *Spart Part Explorer to help identifying auxiliary spare parts,* Vaasa: Wärtsilä.

Matthews, K. R., Sapers, G. M. & Gerba, C. P., 2014. *The produce contamination problem,* San Diego: Elsevier.

Mengru, T., 2018. An exploratory study of Internet of Things (IoT) adoption intention in logistics and supply chain management. *The International Journal of Logistics Management,* pp. 131-151.

Mougayar, W., 2016. *The business blockchain.* New Jersey: John Wiley & Sons.

Quittem, B., 2018. *5 Blockchain Projects Revolutionizing The Supply Chain Management Industry.* [Online]
Available at: https://www.investinblockchain.com/supply-chain-blockchain-projects/

Ray, J., 2018. *Ethereum Introduction.* [Online]
Available at: https://github.com/ethereum/wiki/wiki/Ethereum-introduction

Rituparna, B., White, M. & Beloff, N., 2017. *A blockchain based peer-to-peer framework for exchanging leftover foreign currency.* London, UK: IEEE.

Sahdev, N. et al., 2019. *Blockchain for Business.* [Online]
Available at: https://courses.edx.org/courses/course-v1:LinuxFoundationX+LFS171x+3T2017/course/

Shipchain, 2019. *Vision.* [Online]
Available at: https://shipchain.io/vision.html

Singaram, M. & Jain, P., 2018. *Entrepreneur.* [Online]
Available at: https://www.entrepreneur.com/article/307454

Sundström, T., 2016. *Internet of Things En guide till sakernas internet.* s.l.:IIS.

Swan, M., 2015. *Blockchain, Blueprint for a new economy.* s.l.:O'Reilly Media Inc..

Tapscott, D. & Tapscott, A., 2016. *Blockchain Revolution.* New York: Penguin Random House LLC.

TIETO, 2018. *Annual Report.* [Online]
Available at: https://ar2018.tieto.com/media/pdf/annual-report-2018.pdf
[Accessed 12 March 2019].

Tradelens, 2019. *Solutions.* [Online]
Available at: https://www.tradelens.com/solution/

Twesige, R. L., 2015. *A simple explanation of Bitcoin and Block Chain technology,* s.l.: s.n.

Vidgren, S., 2019. *Carnival Traceability* [Interview] (27 February 2019).

Wärtsilä, 2019a. *This is Wärtsilä.* [Online]
Available at: https://www.wartsila.com/about

Wärtsilä, 2019b. *History of Wärtsilä.* [Online]
Available at: https://www.wartsila.com/about/history

Wärtsilä, 2019c. *Services.* [Online]
Available at: https://www.wartsila.com/services

Yin, R. K., 2009. *Case study research design and methods 2nd edition,* London: Sage Publications.

Zambrano, B., 2018. *Blockchain Explained: How Does Immutability Work?.* [Online]
Available at: https://www.verypossible.com/blog/blockchain-explained-how-does-immutability-work
[Accessed 13 March 2019].