Blockchains as a solution for traceability and transparency

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MASTER THESIS

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Abstract

Requirements from consumers and governments to produce more sustainable products have increased during recent years. Even if products are certified, one cannot make sure companies meet these requirements, since no chain of events can verify this exists. The transportation industry lacks certification and information on whether a product is transported in a sustainable way. The food industry, on the other hand, has integrated the use of certifications widely. However, the industry also requires traceability through the entire supply chain.

In this research, the authors study how traceability issues can be solved from the perspective of a fourth party logistics firm and how the transparency could be increased. Scholars argue that one way of solving traceability issues, and at the same time achieve transparency, could be to use the blockchain technology; a technology which stores data in chronological order, impossible to manipulate afterwards.

Therefore, the blockchain technology has been tested on a product's flow, from loading at a supplier, through a cross-docking terminal and a central warehouse, to receiving at a client's store. By integrating a blockchain to a smartphone application, enabling scanning of barcodes through the camera, and linking the information from the barcode to the blockchain, digital footprints between the parties could be created at each transaction. Additional information about the emission standards of the trucks were connected to the drivers, which was visualized by the blockchain together with the transported product.

To be able to implement the technology and successfully use it, three main challenges have to be overcome: cooperation between the involved parties, motivation for the user of the smartphone application, and a system integration between the different IT-systems.

The conclusions from the research are that the usage of blockchain technology is advantageous in order to achieve traceability. In addition, the technology enables all involved parties to check the product's entire history as well as its current location. Further, the technology creates transparency for all participants. Due to the irreversible technique of storing data, the blockchain technology creates a unique level of credibility, which contribute to a more sustainable industry. The information on the blockchain enables companies to strengthen the relationships with current customers and to attract new ones.

Keywords: Blockchain, Traceability, Transparency

Sammanfattning

Under de senare åren har konsumenter och myndigheter börjat ställa högre krav på att produkter är producerade på ett hållbart sätt. Om företagen faktiskt lever upp till dessa krav är något som konsumenter inte kan veta med säkerhet, även om vissa produkter är certifierade så finns det inte någon kedja av händelser som verifiera detta. I transportbranschen så saknas certifiering och information om en produkt transporterats på ett hållbart sätt. Livsmedelsbranschen har anammat certifieringar i stor utsträckning men där ställs det också krav på att livsmedelsprodukter ska kunna spåras genom alla led i försörjningskedjan.

Syftet med studien är att titta på hur spårningsbrister i transportkedjan kan lösas hos ett fjärdeparts logistikföretag samt hur transparens i kedjan ska uppnås. Ett alternativ för att lösa kravet på spårbarhet och samtidigt uppnå transparens är att använda blockkedjetekniken. En teknik som lagrar data i kronologisk ordning, omöjlig att ändra efteråt och som alla aktörer har en uppdaterad kopia av.

Blockkedjetekniken testades på en produkts flöde från upphämtning hos leverantör, via en omlastningsterminal och ett centrallager, till leverans och mottagning vid kundbutik. Genom att integrera en blockkedja till en smartphoneapplikation och låta kameran skanna streckkoder och koppla informationen till blockkedjan kunde digitala spår vid varje transaktion mellan aktörerna skapas. I studien kopplades också lastbilarnas koldioxidutsläppsklass till transportören, vilket sedan visualiseras på blockkedjan tillsammans med produkten som fraktas med lastbilarna.

För att tekniken ska kunna appliceras och användas framgångsrikt har framförallt tre utmaningar som måste övervinnas identifierats; samarbete mellan de inblandade aktörerna, motivering för användarna av smartphoneapplikationen samt systemintegrationer mellan de olika inblandade IT-systemen.

Slutsatsen är att blockkedjetekniken är fördelaktigt att använda för att uppnå kravet på spårbarhet. Tekniken möjliggör för varje aktör att kontrollera var produkten befinner sig för tillfället samt dess historik. Den skapar också transparens för alla aktörer som medverkar i blockkedjan. Detta skapar en unik trovärdighet eftersom den data som lagras på blockkedjan är omöjlig att ändra i efterhand, vilket bidrar till ett steg mot en mer hållbar bransch. Informationen på blockkedjan kan de anslutna företagen använda för att stärka banden med sina nuvarande kunder samt för att attrahera nya.

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The authors would like to thank our supervisor at LTH, Henrik Sternberg for the energy and commitment he has contributed with. A big thanks to the technicians for the collaboration with the development of the artefact.

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André Jeppsson Oskar Olsson

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ABBREVIATIONS

3PL	third party logistics
4PL	forth party logistics
BBD	best-before-date
Bring SCM	Bring SCM AB
CSR	corporate social responsibility
ERP	enterprise resource planning
FMS	fleet management system
GS1	global standards 1
GTIN	global trade item number
P2P	peer-to-peer
RFID	radio frequency identification
SSCC	serial shipping container code
TRU	traceable resource unit
TM	transport management
WMS	warehouse management system

1 INTRODUCTION

The first chapter introduces a 4PL company and describes the importance of traceability, the increasing demand of transparency and sustainability and the blockchain technology. These are the aspects that form the purpose and the three research questions. To make the study feasible, the delimitations are presented, and lastly, the outline of the thesis is visualized.

1.1 Background

The supply chain network consists of numerous parties; suppliers, intermediates, third party logistic (3PL), fourth party logistic (4PL) and customers (Mehmann & Teuteberg, 2016). A 4PL is a non-asset based integrator who manage clients' supply chains to create business value (Win, 2008). More actors within the chain create vast and complex supply chains. One part of the complexity is the truck transportation, which is the most common used way of transports (Caputo, Fratocchi, & Pelagagge, 2006). The transport industry consists of hauliers from whom a buyer bought the transport service, who in turn can use subcontractors to accomplish the transport (Sternberg, Germann, & Klaas-Wissing, 2013). The subcontractors might use additional subcontractors, resulting in multiple layers and leads to difficulties in terms of controlling the transport segment and its parties. It is to those lower layers that companies should give their full attention, since the pertaining parties often experience bad and unhealthy working conditions along with low salaries (Svensson, 2009), which causes unsustainability in the industry.

The sustainability awareness, not only from social aspects but also environmental, has grown during the last decade to become an important part of supply chain management (Gualandris, Klassen, Vachon, & Kalchschmidt, 2015). A combination of pressure from government and the public, forces companies to improve their sustainable practices (Sarkis, Zhu, & Lai, 2011). Nowadays, stakeholders interest in what a firm do in terms of sustainable practices (Gonzalez-Benito, Lannelongue, & Queiruga, 2011; Gray, 2013) and consumers demand more sustainable and transparent products (Trienekens, Wognum, Beulens, & van der Vorst, 2012). Information about environmental and social performance of suppliers and its products is sometimes available through different certifications (Gualandris et al., 2015), *fair trade* for instance, but there is no information or certification on how the transportation of an eco-friendly products is executed (Sternberg, 2016).

Regulations is one way to work proactively for a sustainable industry, but traceability can also affect the sustainability (Egels-Zanden, Hulthen, & Wulff, 2015). In terms of traceability, all type of food should be traceable through all stages of production, processing and distribution, where each party are responsible for tracing the food one step back and one step forward (European Parliament, 2002). This to secure that the complete history can be restored if needed, which is especially important if the food is contaminated. A traceability system must support both tracking and tracing, where tracking is used to keep record of the product at each stage, and tracing is the process to identify the origin of a product, i.e. reconstructing the history of the data recorded by the tracking process (Pizzuti & Mirabelli, 2015). By implementing a suitable traceability system, a company could obtain better control of the supply chain and in case of contaminated food, the speed of detecting it could be improved (Pizzuti & Mirabelli, 2015).

Related to traceability is transparency, since it for a logistic firm is the track and trace services that allow higher degree of visibility (Hultman & Axelsson, 2007). Doorey (2011) and Mol (2015) define transparency as disclosure of information. Besides the information sharing within the supply chain, there is an increased demand for transparency by other stakeholders, such as consumers and government (Carter & Rogers, 2008; Doorey, 2011). The potential benefits with being transparent is that it can create business opportunities (Svensson, 2009), improve (Carter & Rogers, 2008) and lead to a favorable reputation (Fombrun, 1996) for the firm. Another important aspect of transparency is the information asymmetry. The information asymmetry makes it impossible to choose the product that is believed to–yield greater value (Wognum, Bremmers, Trienekens, van der Vorst, & Bloemhof, 2011). Further, in terms of Corporate Social Responsibility (CSR), it is crucial to implement transparency in order to obtain a CSR policy that is sustainable, since a company that perform well in CSR cannot distinguish oneself from other competitors without transparency (Dubbink, Graafland, & van Liedekerke, 2008).

One technology that has been given much attention during the last few years, which can offer both traceability and transparency, is the blockchain technology (Yli-Huumo, Ko, Choi, Park, & Smolander, 2016). A technology that initially was invented to support the digital currency of Bitcoin (Nakamoto, 2008). The blockchain technology stores data in blocks, in chronological order, and due to a mathematical trapdoor (Brennan & Lunn, 2016), the data stored in the blocks is impossible to alter or remove (Nakamoto, 2008; Fanning & Centers, 2016). Copies of the chain of blocks, hence the term blockchain, and thereby the information, are distributed among the participants in the network (Tsai, Blower, Zhu, Yu, & Ieee, 2016). The copies of the blockchain are then updated when a new block of information is added to the chain (Swan, 2015). So far, research on blockchains has mainly been focused on digital currencies, and in particular Bitcoin (Yli-Huumo et al., 2016), but the blockchain technology is not fully explored (Lemieux, 2016) and it is said to be of future potential (Hull et al., 2016); especially as a recordkeeping technology (Lemieux, 2016). The irreversible data storing technology that blockchain enables has made the industry of food supply chain an interesting application area (Tian, 2016), where the technology could support traceability, and thereby achieving transparency (Hancock & Vaizey, 2016).

The aim of this study is to contribute to two different areas. Firstly, the field of tracking and tracing of goods, primarily in the food industry. This by exploring how blockchain technology could be applicable in the distribution part of a supply chain. Due to the increased demand of transparency from different stakeholders, our second intention of the study is to suggest a tool for managing transparency in the field of logistics by using blockchain technology.

1.2 Purpose and research questions

The purpose of the research is to study the real-world problem i.e. the traceability issues for the cooperative fourth party logistic (4PL) company. The company has a mismatch of the physical and digital flow, and the research intend to study if the blockchain technology is applicable to deal with this issue and thus obtain transparency.

Research question 1: What are the potential advantages and disadvantages for a 4PL company to use blockchain technology to deal with traceability and transparency?

Research question 2: What are the requirements for a 4PL to use an artefact, based on blockchain technology, to deal with traceability and transparency?

Research question 3: How can an artefact based on the blockchain technology affect traceability and transparency from the perspective of a 4PL company?

1.3 Delimitations

The focus of the research will be to follow one food product's flow from the point in time when it has been produced and is available at the supplier's warehouse facility, till it is received at the client's store. The flow is limited to be followed within the territory of Sweden. The manufacturing process of the product followed is not considered, since the focus is pointed towards the flow of the finished product. The picking processes are in shadow of the prioritized transfers between the holders in the supply chain, but is briefly touched in the research. Further, all types of transportation except from road transportation are excluded. The study does not cover the use of other than first hand contracted hauliers, i.e. no subcontractors are part of the study. Lastly, the 4PL collaboration partner gave restriction to only use barcode as a data capturing technique, therefore other techniques were not considered.

In order to avoid privacy and legal aspects, data that consider personal or other sensitive information is excluded.

The authors also made the decision to only focus on solutions that could be based on blockchain technology, since this is considered a technology of great potential by scholars.

1.4 Thesis outline

The thesis is divided into six chapters with following sub-chapters. Figure 1-1 visualizes the outline of the six chapters and the related sub-chapters. A brief description begins each chapter.

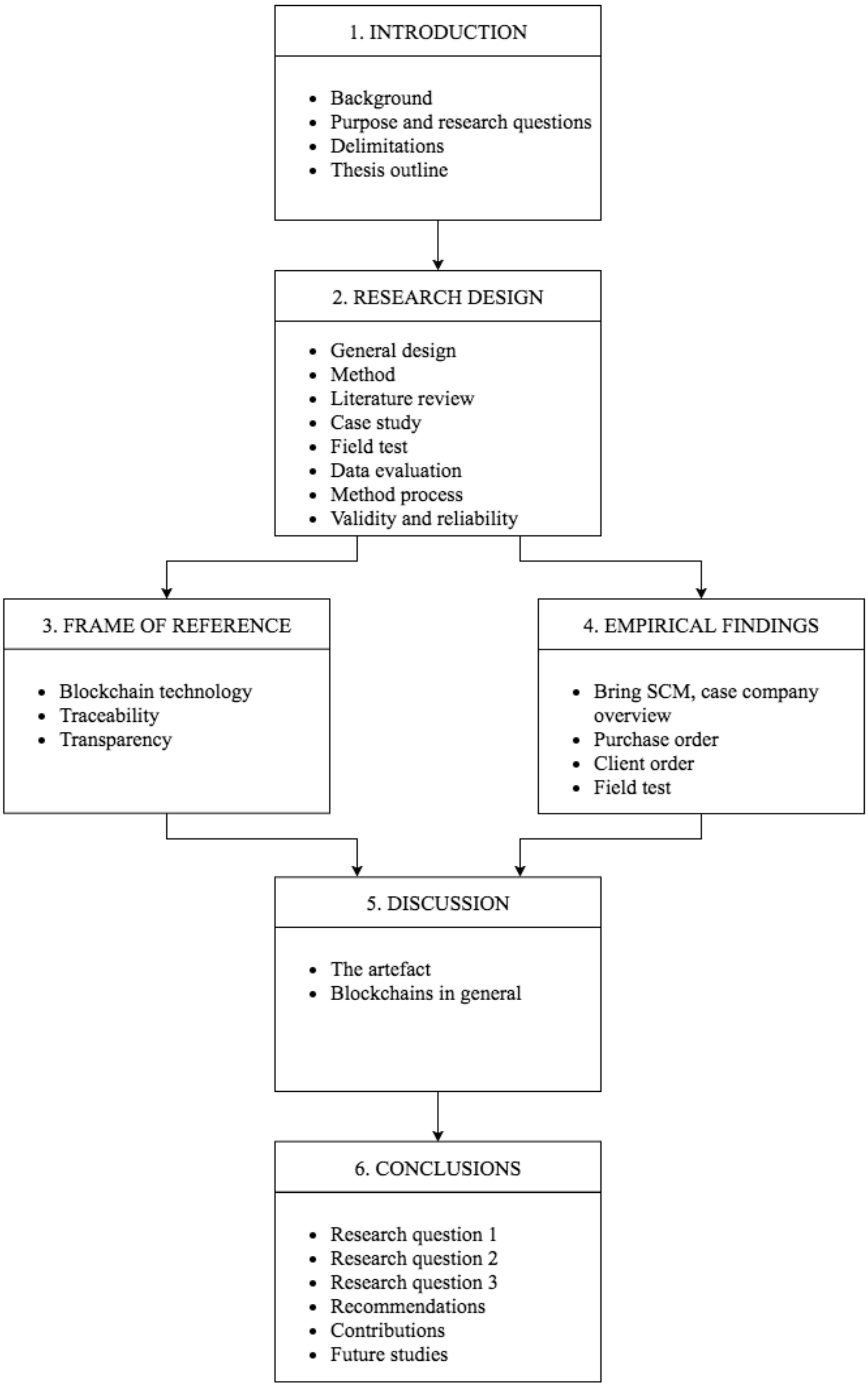

Figure 1-1, The thesis outline.

2 RESEARCH DESIGN

This chapter begins with a description of the general research design, followed by a description of the process of the literature review. The chapter continues with an elaboration of how information was gathered throughout the case study. Further, the execution of the field test is explained which is followed by a description of how the data was evaluated. Finally, the authors present how the validity and the reliability was formed in the research.

2.1 General design

The generic structure of engaged scholarship study by Mathiassen (2015) and the engaged scholarship framework by Van de Ven (2007), guided the authors through the research. The engaged scholarship is defined by (Van de Ven, 2007, p. 9) as:

> *"a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems. By involving others and leveraging their different kinds of knowledge, engaged scholarship can produce knowledge that is more penetrating and insightful than when scholars or practitioners work on the problem alone"*

The activities of the research design refer to predict what data to obtain if the model provides a good fit to the real world (Van de Ven, 2007). The figure of the used design is illustrated in Figure 2-1. The research question (RQ) is the center and has its point of origin in a real-world problem (P), both formulated and described in subchapter purpose and research questions. The real-world problem has a related area in the literature (A) and together they form the foundation of the research questions. To answer the research questions, empirical data should be collected based on a suitable method (M), from which the conceptual framework could be identified (F). Based on these, a contribution (C) is made to the framework, method, real-world problem and research area. Ideal is to accomplish a good research and contribute to both the real-world problem and theory (Van de Ven, 2007).

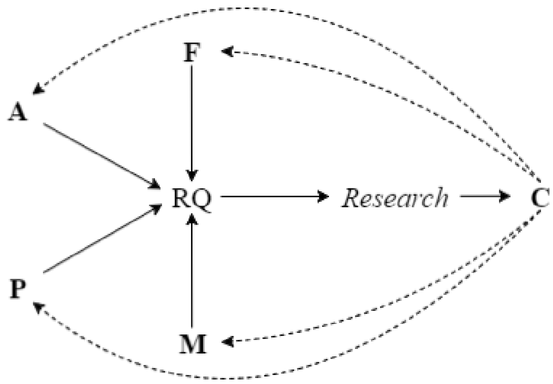

Figure 2-1, The engaged scholarship design by Mathiassen (2015)

According to Van de Ven (2007) engaged scholarship can be practiced in different forms, whereas design and evaluation research science is one form. The idea of the design science involves the development and evaluation of artefacts or programs to professional clients. The models that form the basis of the design and evaluation science are typically more general than the real-world problem faced.

2.2 Method

Along with the engaged scholarship design by Mathiassen (2015) empirical data should be collected based on a suitable method to answer the research questions. To determine what type of research design that is most suitable to use, Yin (2009) purposes three types of questions that should be answered. The first question that should be answered is what type of research questions the study applies to. The research question types can be organized as who, what, where, how and why questions. The second question is whether the study requires control of the behavior, where the researcher can manipulate the behavior and focus on a small isolated part. The third, and last, question is related to if the focus of the study is on current or historical events. Depending on the question, some methods are more suitable than others and the goal is to find the most advantageous one. Notable is, that even though the form of the research question is set, there is not always a sharp boundary between the different methods and overlaps among them exists, the goal is to avoid gross misfits (Yin, 2009). In Table 2-1, a summary of what type of method is suitable for which case.

Table 2-1, Relevant situations for different research methods by Yin (2009 48)

Method	Form of research question	Requires control of behavioral events	Focuses on contemporary events
Experiment	how, why?	yes	yes
Survey	who, what, where, how many, how much?	no	yes
Archival Analysis	who, what, where, how many, how much?	no	yes/no
History	how, why?	no	no
Case study	how, why?	no	yes

Even though the first two research questions are of *what* type, survey and archival methods are dismissed. This, since these methods are better suited when the goal is to describe an incidence of a phenomenon, or when it is to be predictive about the outcome (Yin, 2009). Historical method is dismissed since the study focuses on current events. The experimental method is preferably used when variables can be manipulated, directly, precisely and systematically (Yin, 2009), which is not the case in this research, therefore the experimental method is dismissed.

The research is guided by the engaged scholarship design, where one model can be design and evaluation science. The methods used when dealing with design and evaluation science are typically mathematical simulation modeling, case studies, natural field experiments and controlled experiments (Van de Ven, 2007). Since mathematical simulation modeling is not applicable for this study and the experimental method is dismissed, the case study is the most advantageous method to use in this research.

Another aspect that strengthens the choice of using a case study is the initial phase of the study, where an in depth investigation is needed (Frankel, Naslund, & Bolumole, 2005). A case study supports this need, since it is used when the understanding of a current situation from a real-world context is investigated (Yin, 2009).

Closely linked to the use of a case study is the qualitative approach, since it is preferable to use in situations where one wants to create a deeper understanding of a problem (Björklund & Paulsson, 2014). Typically, when using a qualitative approach the researcher makes several visits to observe the problem in its natural environment, asks questions and performs interviews (Kotzab, Müller, Reiner, & Seuring, 2005; Björklund & Paulsson, 2014).

The reasoning behind using a single case study rather than a multiple one is based on the book of Yin (2009), where it is stated that there are five different rationales to use a single case study approach; critical, rare, revelatory, representative or longitudinal case study. The critical case study is used when testing a well-formulated theory. Rare case studies, and revelatory case studies are used in special and previously inaccessible circumstances respectively. The representative case study is used when trying to capture the circumstances on a commonplace or everyday situation. And lastly, the longitudinal case study is used to study the same single case at several occasions. From the authors' perspective, a majority of the rationalities suits the given situation i.e. a single case study is better suited than a multiple one.

The second and the third research questions implies that an artefact must be designed and evaluated. The latter research question is of *how* type which is in line with the choice of a case study method, see Table 2-1. But, to support the development, realization and testing of an artefact, a field test was executed as an extension to the case study.

Referring to the reasoning above, a single case study, extended by a field test, is the most advantageous method to use in this research.

2.3 Literature review

The real-world problem has, according to Mathiassen (2015), an area in the literature that must be explored, and later contributed to. Therefore, a comprehensive literature study was conducted in an early phase of the thesis. By conducting a literature review a large amount of information can be accessed in a relatively short period of time (Björklund & Paulsson, 2014). The purpose of a literature review is to get a broader and deeper understanding of the studied subject and will lead to the frame of reference (Mathiassen, 2015). Another aspect of the review is that it will give the authors enough knowledge in order to identify and analyze potential gaps between reality and theory (Frankel et al., 2005).

The main database used to obtain the literature has been Web of Science. The reason behind only using Web of Science is that its articles originate from journals being subject to audits by independent editors and therefore excludes content that are not reliable, trustworthy or biased. There is a risk of not using additional search tools, for example Google Scholar, but since the database of Web of Science includes reviewed journals with large impact on science and technology it is considered to contain sufficient material to base the literature review on.

The literature review can be separated into three main parts were a keyword was used in each of the parts. Using only one keyword in the searches generated several results, and in order to reduce the number of hits the original keyword; blockchain, transparency and traceability, was combined with one or few additional words, see Table 2-2 for performed searches. When the number of hits was limited to a reasonable number the authors decided to read the abstract for each article. If the article encompassed the relevant field it was downloaded and sorted into an excel file. The authors then read through the article, summarized it and ranked it between 0-5, where 0 indicated low relevance and 5 high relevance. Throughout the reading other relevant articles were found and these were then categorized, summarized and ranked if they passed a journal reputation test. The conducting process is illustrated below in Figure 2-2.

Table 2-2, Used keywords

Keyword	Additional word(s)
Blockchain Distributed ledger	
Transparency	Supply chain Sustainability Information disclosure Traceability
Traceability Track and Trace Tracking and Tracing	Supply chain Logistics Food Transportation

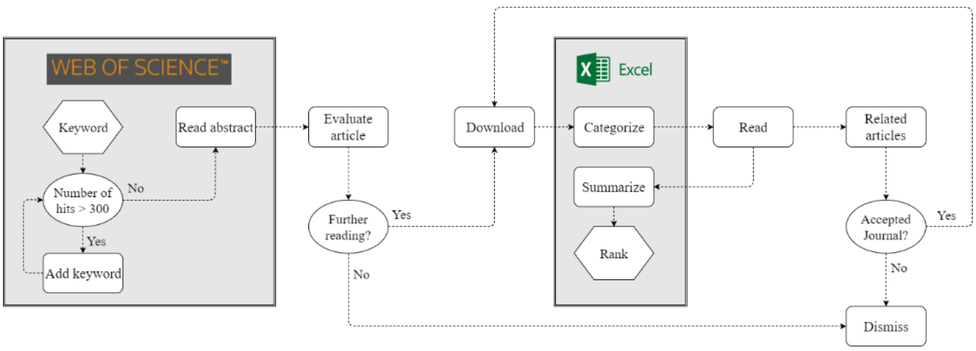

Figure 2-2, Process of the literature review.

During the literature review in the field of blockchain technology, indications arose of that the results in Web of Science were not enough. The number of published articles in the Web of Science core database were limited and therefore a decision was made to expand the accepted materials within the field of blockchain technology to also include conferences. Some companies in the mentioned field was also used due to the lag that published articles sometimes are facing. Therefore, the literature review also consists of white papers, government reports and company reports. Books, periodicals and other papers were used as a complement to the academicals journals, even though these sources were more critically reviewed.

To create a coherent text with a common thread, the last stage of the review took place directly after completion of the ranking procedure. By starting with the most relevant articles and then work the way down in the ranking list, the findings from the literature review began to form.

2.4 Case study

A case study was considered the most suitable method to use in the research. Bring SCM AB (Bring SCM) are offering management of clients' supply chains and related activities. Bring SCM does not have any assets, in terms of trucks or warehouses, but contracting 3PL providers to execute the transportation and warehousing services (Bring.se, 2017). Therefore, the authors chose Bring SCM as a representative case company in line with the definition of a 4 PL by (Win, 2008, p. 677)

> *"A 4PL is an independent, singularly accountable, non-asset based integrator of a clients supply and demand chains. The 4PL's role is to implement and manage a value creating business solution through control of time and place utilities and influence on form and possession utilities within the client organization. Performance and success of the 4PL's intervention is measured as a function of value creation within the client organization".*

2.4.1 **Scope**

The scope for the case study comprises the conduction of an investigation on the supply chain of one of Bring SCM's clients. The client operates globally but due to geographical reasons, limited time and resources, the scope of the study has been set to the domestic supply chain of Sweden. The starting point of the study has been set to the point in time when Bring SCM place an order, and the flow from the supplier to the delivery at the client's stores via the central warehouse in Helsingborg as the last part of the study.

To minimize the risk of a supplier backing out of the research, three suppliers were chosen at an early stage (Supplier A, B and C). For each supplier, one product (Product A, B, C) was chosen. Two of the suppliers (Supplier B & C) are located in southern Sweden and the third (Supplier A) in midwest Sweden. All three suppliers were contacted but two of them declined participation. The domestic flow between a supplier to the client's stores always goes via the central warehouse in Helsingborg. The differences are that orders from a supplier can be cross-docked before it reaches the central warehouse in Helsingborg, and the processes at the supplier can differ. Because of the similarities, it was decided to follow the flow of one product without jeopardizing the result. Therefore, the flow of Product A from Supplier A was studied.

The case study covers the physical flow from when the product is received from the production factory of Supplier A to their internal warehouse, and the last part of the flow is when the product is unloaded and received at the client's store. The digital flow is covered from the point when it is ordered by Bring SCM, and the last point is when it has been received at one of the client's stores.

2.4.2 Observations

To get an overview of the studied subject, an observation is often useful (Yin, 2009). An observation is not only important from an understanding point of view, but also in terms of quality (Kotzab et al., 2005). Even though it could be time consuming (Björklund & Paulsson, 2014), the current situation should be observed to get a clearer picture of how the processes within the chain are managed today. By observing, first-hand information is gathered which can develop relevant knowledge (Frankel et al., 2005). The observer can either just observe without any communication or observe, communicate and interact with the observed subjects (Malhotra, 2004).

From the basis of the above mentioned, observing the flow of Product A from Supplier A was required. First, the physical flow from the point in time when a product entered Supplier A's warehouse till it was loaded and transported by the haulier to a cross-docking warehouse in Gothenburg was observed. One of the authors went along with the driver between the warehouse of Supplier A to the cross-docking warehouse to observe the transportation part of the flow. The digital flow of the processes at Supplier A was also observed to get the whole picture of the processes.

The next step of Product A's journey was to make an observation at the central warehouse in Helsingborg, where a tour was held by a local foreman, with focus on the processes of the central warehouse related to the flow of Product A. At the observation, extra attention was paid to the loading and unloading processes. A second observation was made at the central warehouse to make sure that the processes from the first observation was interpreted correctly.

A final observation was made during the loading and transportation from the central warehouse to one of the client's stores, where the unloading took place. Extra attention was given to the transfers between the goods holders. As this observation was made the complete chain of the scope had been observed.

After the observations, the observed processes were drawn and reviewed together with the responsible person for each warehouse tours, respectively. This gave the authors the opportunity to ask questions and straighten out eventual misunderstandings.

2.4.3 **Interviews**

One of the important sources in a case study is the interviews (Yin, 2009). Depending on the circumstances and situation different kinds of interview techniques are suitable. Björklund and Paulsson (2014) describes three different types; structured, semi-structured and unstructured interviews. The first mentioned technique is based on beforehand prepared and known questions, where the interviewer follows a specific order. A semi-instructed interview is based on prepared questions but gives the interviewer the ability to ask additional questions when it is considered appropriate, and the last technique is more like a conversation without any prepared questions. Regardless of which type of interview held, they were submitted in the following order; preparation, execution, transcription and a follow-up.

The basic understanding from the perspective of Bring SCM was collected from several unstructured interviews with a transport coordinator and a warehouse coordinator at Bring SCM.

In the case of the visit at Supplier A, a semi-structured interview was conducted during the observation tour with the team leader. In combination with the observation, the interview aimed to get a complete understanding of the processes at Supplier A's warehouse. A semi-structured interview was also held with the truck driver during the transportation from Supplier A to the cross-docking terminal in Gothenburg.

During the two observations at the central warehouse the authors decided to conduct unstructured interviews and ask questions when appropriate. To link the processes between Bring SCM and the processes of the central warehouse in Helsingborg a warehouse coordinator at Bring SCM was interviewed in a semi-structured manner, which gave insights of the related processes.

2.5 Field test

The case study was extended with a field test which was supported by an artefact. The limited amount of time forced the authors to outsource the development of the artefact. The artefact was developed as an Android smartphone application where the backend was coded in Python by two technicians with over ten years of experience and with special skills in the field of blockchain technology. The design and the functionalities implemented in the smartphone application were based on the authors’ findings from the case study and the frame of reference. The field test consisted of two parts; a real-world test and a simulation based on real-world data.

2.5.1 **Scope**

The scope of the field test was to perform a test on the flow of Product A, and especially the transfers between holders of Product A. This, to see if it could be suitable to use an artefact, based on blockchain technology, to deal with traceability and transparency.

2.5.2 **Observations and interviews**

The idea was to perform the test in a participation observation way, which means that the observer participates (Björklund & Paulsson, 2014) or interact (Malhotra, 2004) to some extent. The used artefact was a beta version and at the point in time when the test was executed all functionalities were not in place. The first part of the chain, between Supplier A and the central warehouse in Helsingborg, was tested by using two Android smartphones where one of the employees of Supplier A was given a smartphone and the other smartphone was given to the driver. The authors and one of the technicians was first showing and explaining how to execute the transfer with the smartphone, then the employee of Supplier A and truck driver A completed the transfers of the orders containing Product A. The same procedure took place between truck driver A and truck driver B at the cross-docking warehouse in Gothenburg and later between truck driver B and an employee of the central warehouse.

Unstructured interviews (Björklund & Paulsson, 2014) were also held during a short amount of time after the testing at both locations, to get some thoughts of the application from future potential users.

2.6 Data evaluation

To be able to answer the first research question, a comparison between blockchain technology and an imaginary centralized system was made, which was mainly based on the learnings from the literature review and the field studies. These learnings contributed to which factors to evaluate and how to rank the factors when the technologies were compared. The comparison is visualized in a spider chart, which is a useful tool to identify gaps and differences (Björklund & Paulsson, 2014) between two systems.

To answer research questions two and three, learnings from the literature review, the case study and mainly the field test were combined and aiming to cover the related aspects of the research questions. The aspects that where found relevant are discussed in the *DISCUSSION* chapter and then summarized in the *CONCLUSIONS* chapter.

2.7 Method process

The literature review had its starting point in the real-world problem and formed the frame of reference. To obtain deeper knowledge a case study was executed which in combination with the literature review founded the base of the empirical study and the extended field test. Lastly, the discussion and conclusion were the results of combining the earlier phase of the study. The structure of the process is visualized in Figure 2-3.

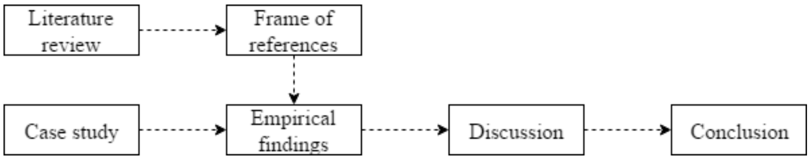

Figure 2-3, Method process.

2.8 Validity and Reliability

To ensure that the study has high credibility, Björklund and Paulsson (2014) and Yin (2009) describes the importance of validity and reliability. Validity implies to measure what the study really wants to measure (Björklund & Paulsson, 2014). Yin (2009) states that validity can be divided into two different types, internal and external, where the first one is inapplicable for explorative studies. External validity is an important part of an academic thesis and cannot be excluded (Björklund & Paulsson, 2014), and the target is to investigate if the findings could be generalized (Yin, 2009; Björklund & Paulsson, 2014). So, to make sure that no information would pass by unnoticed and ensure quality control during the case study, recordings and transcriptions were made of all interviews and observations. After the case study observations and the interviews, a transcript was created and reconnected with the involved ones, either by e-mail, telephone or both. By doing so the respondent has the possibility to point on misunderstandings and thereby strengthen the validity. To strengthen the external validity, a field test with the developed artefact, which was based on blockchain technology, was executed on the studied flow.

Reliability can be achieved by documenting the different procedures in such a way that that a later investigator could repeat the study all over again and arrive to the same findings and conclusions (Yin, 2009). To ensure reliability the authors created an in-depth documentation database where all data collected from the entire thesis were held. The in-depth database could be generalized as a tree structure with folders, where the content was divided into more folders and so forth. Even though a single case study was used, similar results could have been have achieved by using another 4PL company. This, since the studied 4PL company complies with the definition of a 4PL company.

A way to increase both reliability and validity is to use triangulation, which basically means that the studied object should be approached from different directions (Van de Ven, 2007; Yin, 2009; Björklund & Paulsson, 2014). In the study, the problem has been approached by doing a comprehensive literature review, followed up by observations and interviews from different actors in the studied flow. Lastly, and most importantly, a field test was performed. The field test gave the authors insights from the environment where the artefact could be used in the future. These insights were then compared with the results from previous studies.

By using triangulation one can avoid that the different methods used to study the phenomenon shares the same weaknesses (Kotzab et al., 2005), and avoid biases, especially in the case of the interviews.

3 FRAME OF REFERENCE

This chapter presents and defines the concepts used throughout the study. First, the blockchain technology, its usage and challenges are described. The blockchain part is followed by a traceability part after which the chapter ends with a section regarding transparency within supply chains.

3.1 Blockchain technology

3.1.1 Bitcoin

During the last years, published articles that has one or several points of contact with the blockchain technology or distributed ledger technology have increased heavily (Yli-Huumo et al., 2016). The reason behind the increase is the article published in 2008 by Nakamoto (2008) where the author introduced Bitcoin, a digital currency, to the public. The idea behind Bitcoin is the enabling of peer-to-peer (P2P) transactions without involvement of a third-party (Nakamoto, 2008; Tschorsch & Scheuermann, 2016). The backbone of Bitcoin is the blockchain technology, which can be described as a chain of hashes of digital signatures (Lemieux, 2016), that is public and transparent (Iansiti & Lakhani, 2017), distributed (Tsai et al., 2016), and runs on computers all over the world (Tapscott & Tapscott, 2016), i.e. it does not require any third-party organization (Weber et al., 2016; Yli-Huumo et al., 2016). All those peers, representing a computer, are known as nodes in the network and possess a copy of the ledger (Tsai et al., 2016). Each new transaction of a Bitcoin is written on a block, and is visible for all connected parties (Fanning & Centers, 2016). Then, when the transaction is reviewed and validated by the network, the block connects to its predecessor block (Yli-Huumo et al., 2016), and creates a chain of blocks (Swan, 2015). Importantly regarding these blocks is that they are added to the blockchain in a chronological order and cannot be removed (Fanning & Centers, 2016) or altered (Nakamoto, 2008). Essentially, the blockchain technology could be exemplified as a huge Google doc spreadsheet (Swan, 2016), which contains the whole history of all payments made with a Bitcoin (Lemieux, 2016).

3.1.2 The blocks and merkle trees

The content of a block in the case of Bitcoin is the block hash, the previous block hash, a nonce and the merkle root. The merkle root is a digital signature of all transaction that the block contains, and is used to save disk space (Lemieux, 2016). A block often consists of several transactions, where they are individually hashed and then combined with other transactions, and hashed again and so forth. Eventually, transactions are summarized in one single hash, called the merkle tree root, see Figure 3-1. Since the hashing output is unique and the block is referring to the previous block, it is impossible to change the content of one single transaction without interrupting the entire chain and thus produce a completely different hash history (Tsai et al., 2016). This means that the legitimacy of not only the reference to the previous block is confirmed, but all transactions ever made (Tschorsch & Scheuermann, 2016).

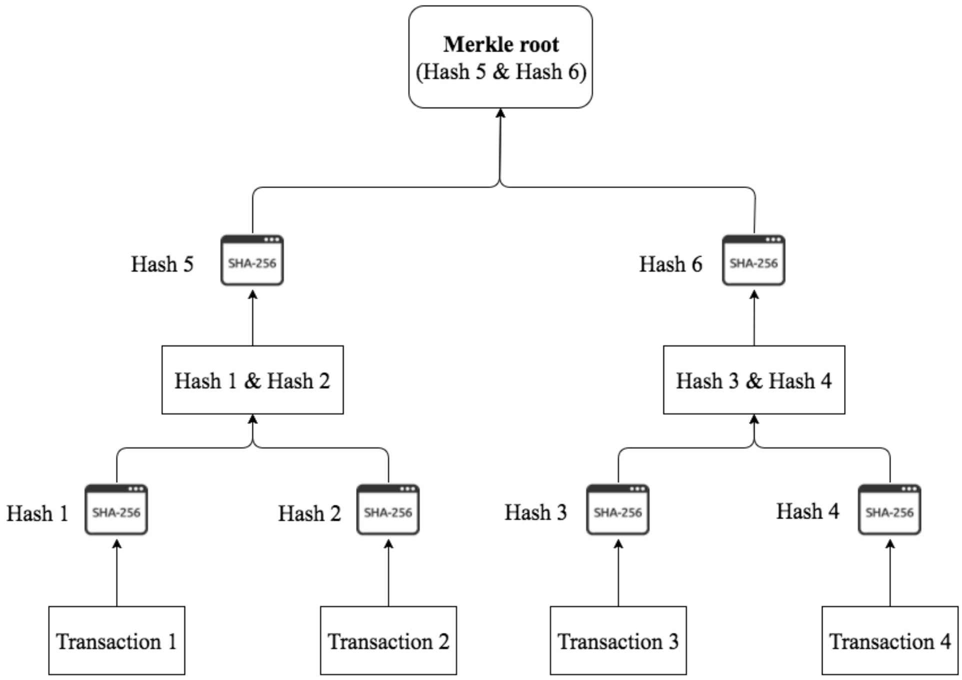

Figure 3-1, Hashed transactions and the merkle root.

3.1.3 Transaction process

To be able to execute a transaction from identity A to identity B one needs to have a public and private key, which are using encryption to maintain security (Tapscott & Tapscott, 2016), and are essentials for the authenticity. A metaphor that could be used to explain the private key is to look at it as a box where value can be stored.

This box does not have any lock and is open for anyone. The strength of the network of boxes is that one needs to know the location of the box to be able to access the content of it. The network contains 10^77 of those boxes, which can be compared with the amount of grain of sand on the earth that is 10^27 (Lovén, 2016). The public key can be described as an intermediate that proves that one has the private key without revealing it to the public. In the example in Figure 3-2 the P2P transaction process is illustrated by using the double key concept. The first one wants to do when preparing for sending, in this example a document, is to hash it. Once it is hashed the owner decrypt the hash-code by using his private key (Lemieux, 2016) (red key in Figure 3-2), and a unique digital signature, sometimes called a digital fingerprint of the shipment is created. The next step is to send the original document along with the public key (green key in Figure 3-2) and the digital signature to the recipient. Further, to evaluate if the sender is the legit owner, the recipient hash the document by using the same hashing algorithm as the sender did, in this case SHA-256, an algorithm that generates the exact same hash output if the input is the same. The digital signature is then decrypted by the supplied public key, and lastly a comparison of the two hashing codes is executed, and if they are identical the sender is the legit owner of the document (Swan, 2015). The mathematical complexity behind the hashing algorithm SHA-256 used by Bitcoin (Tschorsch & Scheuermann, 2016) makes the blockchain secure that going backwards to find the right input from a given hash, is a mathematical trapdoor (Brennan & Lunn, 2016). The level of complexity could be exemplified by hashing an E-book and then modify it by adding a space randomly in the E-book. This small modification would generate two completely different hashes. By using this technique, the sender does not need to trust the receiver and the receiver does not need to trust the sender (Weber et al., 2016).

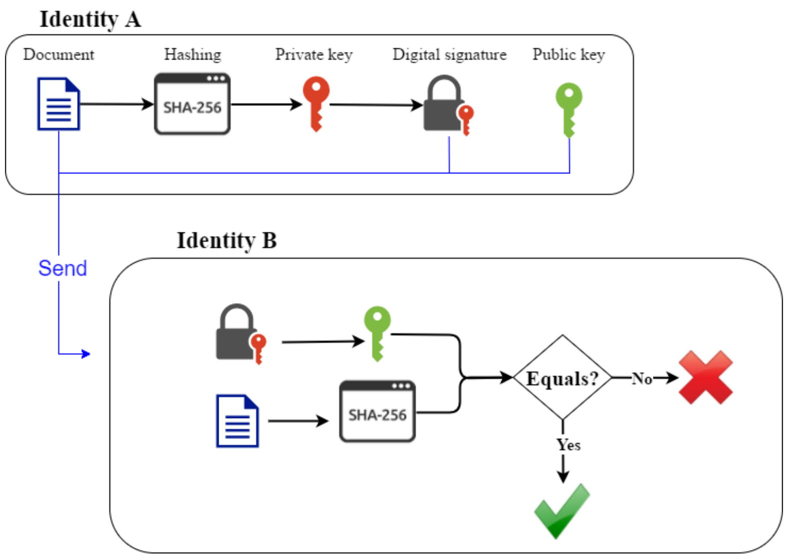

Figure 3-2, Blockchain transaction process.

3.1.4 **Validation process**

Regarding Bitcoin, there are two types of nodes in the bitcoin network, light and full weighted nodes. The light weighted are just participants in the network whereas the full weighted, also called miners are verifying the transactions, a process that is called mining or proof of work (Lemieux, 2016; Yli-Huumo et al., 2016). Once a new transaction is communicated to the network, i.e. passed the aforementioned *Transaction process*, the minors starts with creating a new block (Lemieux, 2016) and tries to find a valid candidate that fits the previous block (Fanning & Centers, 2016). This is called the proof-of-work and could be compared with solving a puzzle (Tschorsch & Scheuermann, 2016). By collecting the block hash, the hash of the previous block, a nonce and the merkle tree root of many other hashed transactions, and then hash them together repeatedly until the output hash begins with a leading number of zeroes (Lemieux, 2016) that matches a specific target value (Tschorsch & Scheuermann, 2016). Once a match, the miner broadcast the nonce together with the block, which can be verified by the other nodes (Lemieux, 2016; Tschorsch & Scheuermann, 2016). Then the block is added to the chain and its new identity is represented by the block hash. A reward in Bitcoins is given to the miner who finds the matching hash, i.e. verifying the correctness of the transactions (Tschorsch & Scheuermann, 2016; Yli-Huumo et al., 2016). This procedure is repeated continuously as more transactions enter the network (Weber et al., 2016). According to Swan (2015), a new block is added to the chain by a miner in a chronological order every ten minutes, which can be seen as the time it takes for an order to be verified. The only way one can control the transactions in the Bitcoin network is to have control of more than 50 percent of the total computer power in the network (Nakamoto, 2008; Lemieux, 2016). At that time one can decide which block that is the correct one to put onto the chain (Tschorsch & Scheuermann, 2016). Figure 3-3 illustrates the process, where the blockchain technology under the hood is the same regardless of the brand on the outside.

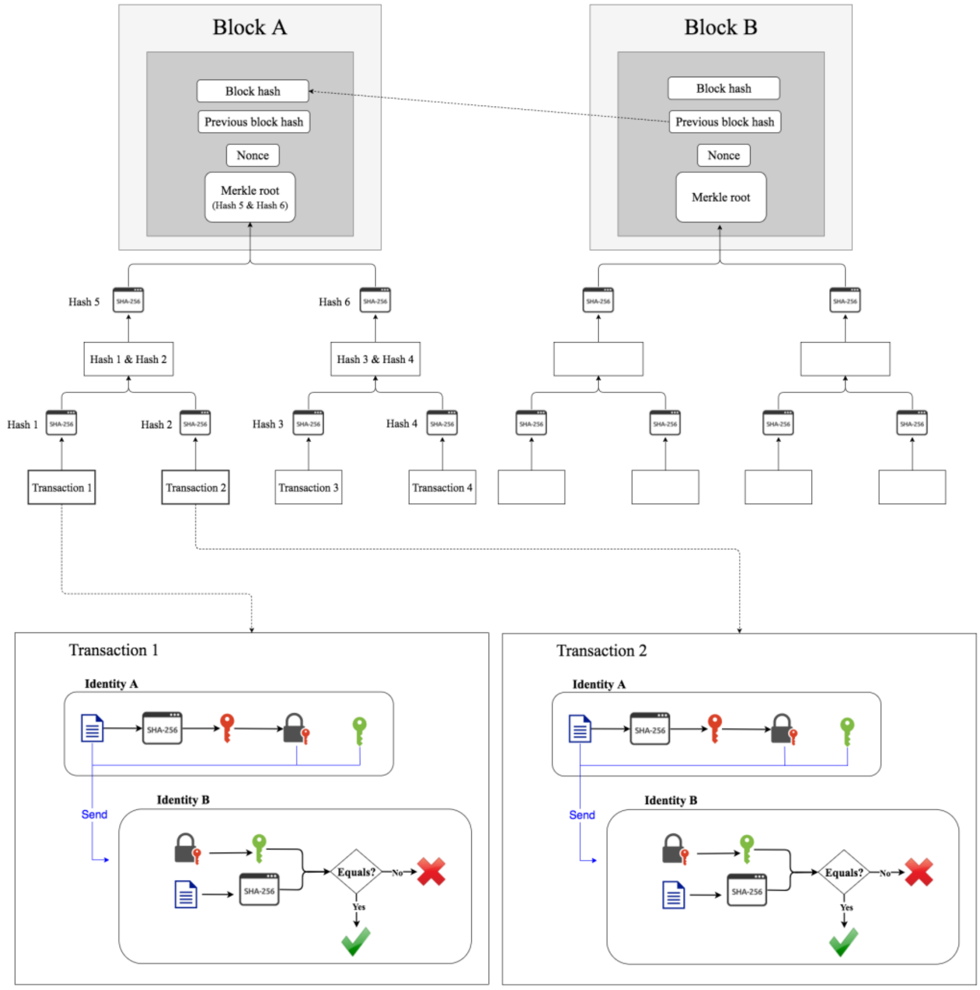

Figure 3-3, The blockchain under the hood.

3.1.5 **Different blockchains**

There are four types of ledgers, traditional (centralized), permissioned private, permissioned public and unpermissioned public (Brennan & Lunn, 2016; Tschorsch & Scheuermann, 2016). Except for the centralized ledger, the ledgers often denote as blockchains. The unpermissioned public ledger is used by the digital currency of Bitcoin and has no single owner. Permissioned ledger is a ledger where the participants are preselected and it is owned by one or many participants (Hancock & Vaizey, 2016).

The degree of centralization is depending on the type of ledger, as visualized in Figure 3-4. The unpermissioned ledger, like the Bitcoin blockchain, is the most decentralized type of ledger, followed by the permissioned public ledger, the permissioned private ledger and the centralized ledger (Brennan & Lunn, 2016; Hancock & Vaizey, 2016).

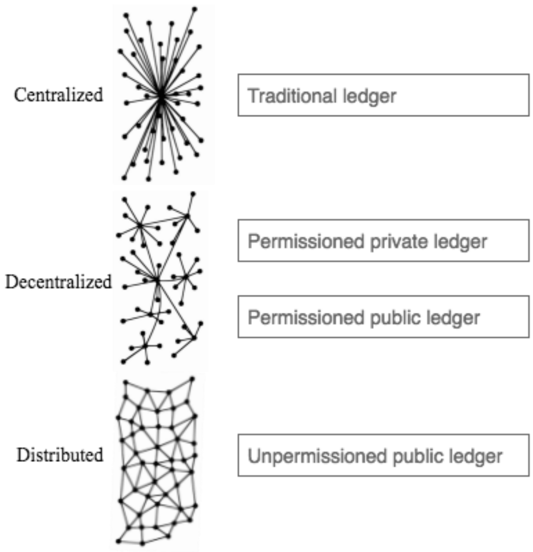

Figure 3-4, Different ledgers. A compilation from the sources Brennan and Lunn (2016) and Hancock and Vaizey (2016) made by the authors.

Which ledger type one wants to use depends on the circumstances. A guiding framework was addressed by (Brennan & Lunn, 2016; Hancock & Vaizey, 2016) to support the decision making. The framework is summarized in Figure 3-5 where three questions form the basis for the final decision; does it require shared access, could/should anyone participate, and who is controlling the ledger? Note that inter firm refers to sharing between two companies or more.

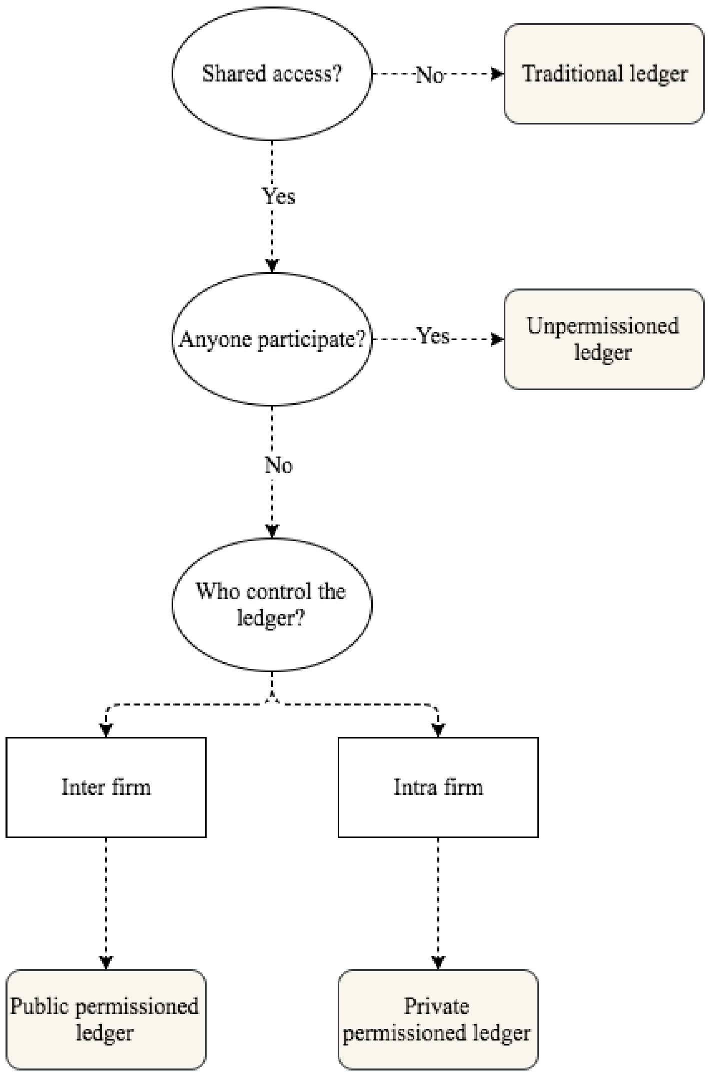

Figure 3-5, Which type of blockchain? An interpretation from the sources Hancock and Vaizey (2016) and Brennan and Lunn (2016), made by the authors.

3.1.6 Blockchain potential

The intention was first to use the blockchain technology in the financial sector (Azaria, Ekblaw, Vieira, & Lippman, 2016), but the technology has potential beyond that (Fanning & Centers, 2016; Mettler, 2016; Nguyen, 2016; Tschorsch & Scheuermann, 2016). One of those potential areas that was given attention was the area of food supply. In the article by Tian (2016) the author describe how to implement a traceability system, based on blockchain technology and radio frequency identification (RFID) technology in the agri-food supply chain. The article explains the entire agri-food chain, where information is gathered from every link in the chain “from-farm-to-fork”, which enables traceability to ensure quality and safety of the agri-food.

Provenance, a blockchain startup company is operating in the same field; tracking tuna from fisherman to end-customer by using blockchain technology along with smart tags, such as RFID (Provenance, 2016). Provenance also include social attributes onto the blockchain such as fishing methods and type of fishing boats.

Iansiti and Lakhani (2017) and Hull et al. (2016) point out that “smart contract” can be a well-suited application area for the blockchain technology. A smart contract is a distributed contract that executes based on specific conditions (Natoli & Gramoli, 2016). For instance, a company should transfer money to a supplier once a shipment is delivered. At delivery, the smart contract automatically triggers a payment to the supplier (Iansiti & Lakhani, 2017). Due to that smart contract is defined, regualated and executed by the code, the need for trust between parties can be disregarded (Swan, 2015)

Lemieux (2016) discusses the potential of using blockchain as a recordkeeping technology. Lemieux tries to separate the implementable part from the hype and actualize the blockchain technology to the reality. One argue that the blockchain technology could be the solution for recordkeeping problems connected to the land register system in Honduras. Another application area that also shed light over the record storing technology, is the paper by Sharples and Domingue (2016). The authors suggest that storing records of achievements and credits e.g. degrees and/or other certificates in a blockchain, which can be shared with employers and students, which could counteract counterfeiting of such documents.

Healthcare is another application area mentioned in positive terms (Mettler, 2016), where blockchain technology could be used to monitor productions processes of drugs and to be able to determine when and where the production of a product took place.

One of the startup companies is Hyperledger. The company has created a permissioned blockchain called Hyperledger fabric made for business (Hyperledger, 2016), which does not require the same type of mining (Swan, 2015) as the Bitcoin blockchain, since only the permissioned ones have access. The big difference from the Bitcoin blockchain is that Hyperledger fabric is universal and open source, which means it can be adapted to many different users (Hyperledger, 2016). Another difference is that the Hyperledger fabric bridges the gap between total transparency and privacy, e.g. all nodes that are participating in the network cannot see every transfer made, only the peers involved in the transaction could see it (Hyperledger, 2017). Lastly, Hyperledger fabric supports the use of smart contract (Hyperledger, 2017).

3.1.7 **Adoption of the blockchain technology**

Iansiti and Lakhani (2017) suggest that the adoption of the blockchain technology depends on the novelty and complexity. More novelty demands more effort to illuminate the users, and the complexity corresponds to the number of parties that need to cooperate around the technology. Bitcoin falls into the areas with low novelty and low complexity, which is the area that first adapts to the technology. On the contrary, areas with high novelty and high complexity is the area where the evolution will take longest time, but have greatest impact. Iansiti and Lakhani (2017) point at “smart contracts” as one of the most transformative blockchain applications in this area. They also address that areas with high novelty and low complexity are a natural step for companies, which has culminated into an increasing number of companies that invest in private blockchains. The same authors Iansiti and Lakhani (2017), believe that one low-risk approach could be to use blockchain technology internally for managing physical assets within firms.

3.1.8 **Challenges**

From the review, three main obstacles can be identified. Firstly, the immature technology behind blockchain which was addressed in the article regarding food products from “farm-to-fork” (Tian, 2016). Secondly Iansiti and Lakhani (2017) address the novelty problem, which boils down to reach a critical mass in order to understand the potential of the blockchain technology. The same authors also point out a last obstacle; the complexity. In order to reach out to many different parties one needs to collaborate to make the adoption and implementation of the blockchain technology fruitful.

If blockchain would provide new levels of efficiency for business collaboration then many would need to convert present collaboration processes into blockchain suited ones (Hull et al., 2016), which will require investments, and depending on the type of ledger one wants to implement the cost will vary. Cost and security goes hand in hand; a more secure ledger indicates higher cost and the other way around (Brennan & Lunn, 2016). Figure 3-6 explains the dependences.

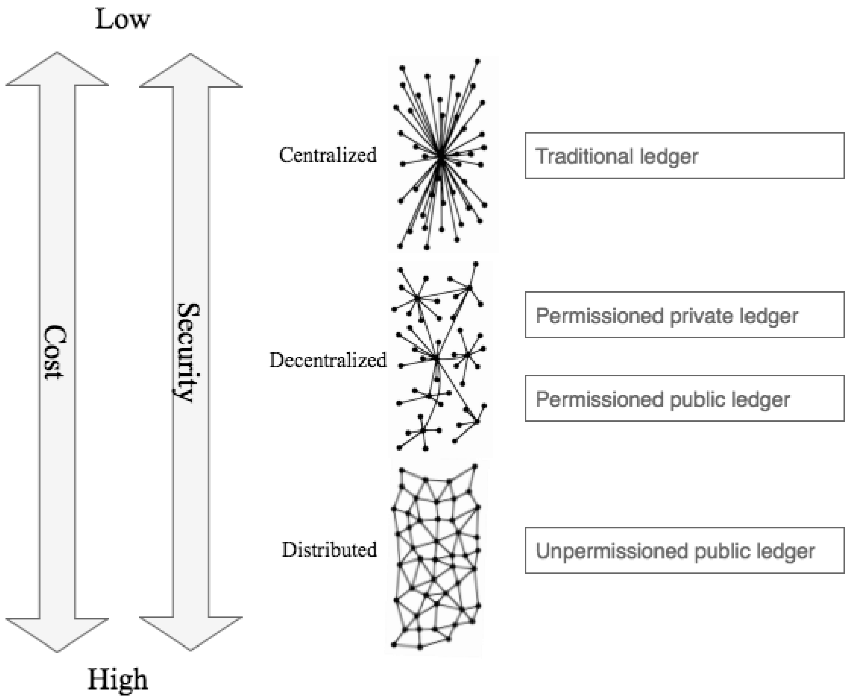

Figure 3-6, Cost vs. security of different ledger types.

3.1.9 Consensus

It is early days for the blockchain technology, and the potential is not yet fully explored (Lemieux, 2016). But there seems to be a consensus among scholars, the potential of the blockchain technology is significant (Hull et al., 2016). The blockchain technology is a suitable method to store data instead of in a centralized system (Zyskind, Nathan, Pentland, & Ieee, 2015). The technology can replace the third-party intermediate, it can power transparency in a way a centralized system cannot (Provenance, 2015; Tian, 2016). It can be used to monitor production processes (Mettler, 2016), used as a real-time tracking and tracing (Tian, 2016) and as a recordkeeping unit (Lemieux, 2016). The big question is when the technology will revolutionize businesses (Iansiti & Lakhani, 2017)? To make a comparison, Iansiti and Lakhani (2017) and Joichi, Narula, and Ali (2017) describes, in the case of Bitcoin blockchain, that it could be like e-mail was for the early Internet i.e. drove the development.

3.2 Traceability

3.2.1 Tracking and tracing

There is a lack of consistency in using the words tracking and tracing since these terms are used interchangeably, it is a source of confusion of the concepts (Bosona & Gebresenbet, 2013). Most definitions attempt to address it as the ability to follow the product's movement through the supply chain (Bosona & Gebresenbet, 2013). In the EU regulation (2002) the traceability requirements are defined as each actor should be able to trace the products' movement one step forward, and one step backwards. A traceability system must support both tracking and tracing (Kelepouris, Pramatari, & Doukidis, 2007; Bosona & Gebresenbet, 2013; Pizzuti & Mirabelli, 2015). The authors chose to relate to the definition of tracking and tracing by Pizzuti and Mirabelli (2015, pp. 17-18)

> *"Tracking is the informative process by which a product is followed along the supply chain keeping records at each stage [..]. Tracing is defined as the ability of reconstructing the history of a product, identifying its origin through the complexity of resources involved in its lifecycle."*

Moe (1998) distinguishes two core entities as fundamentals in a traceability system; *product* and *activity*. The entities are divided in essential descriptors which have to be included to obtain traceability (Moe, 1998). The *product entity* is divided into *type* and *amount*, and the *activity entity* is divided into *type* and *time*, this is illustrated in Figure 3-7. A criterion to be able to trace a unit is a traceable resource unit (TRU) (Aung & Chang, 2014). Three types of traceable units exist: *batch, trade unit* and *logistics unit* (Aung & Chang, 2014). A *batch unit* means a quantity going through the same process. A *trade unit* is the unit that is sent from one actor to the next actor in a supply chain, a bottle or a box for instance. The *logistic unit* is a type of a trade unit which group the trade units together before transportation or storage, a typical example is a pallet (Karlsen, Olsen, & Donnelly, 2010). The appearance of a TRU may change during time as a batch is split into several batches (Moe, 1998).

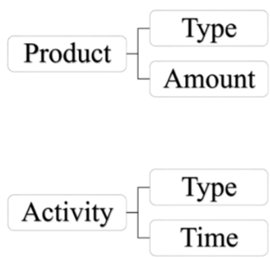

Figure 3-7, Core entities of a traceability system, inspired by Moe (1998)

Traceability can be divided in two categories; internal or external traceability (Moe, 1998; Thakur & Donnelly, 2010). Internal traceability means to track and trace unique products, components or units within a company's own organization (Moe, 1998; Karlsen et al., 2010). External traceability is the ability to track and trace unique units in the information flow linked to the physical movement of the goods between companies (Moe, 1998; Karlsen et al., 2010). To enable fast and precise tracing, traceability should address both internal and external traceability with clear connections between them (Bertolini, Bevilacqua, & Massini, 2006; Donnelly, Karlsen, & Dreyer, 2012; Hu, Zhang, Moga, & Neculita, 2013). External traceability requires that the partners in the supply chain have effective information connectivity between the information systems (Bosona & Gebresenbet, 2013). The external traceability is a consequence of the success of the internal traceability since each actor is responsible for collecting and communicating the information of their own processes and products. Which means, an internal traceability system is a prerequisite to enable full external traceability (Senneset, Foras, & Fremme, 2007). The external traceability is also highly dependent on the collaboration and coordination of the logistics processes and information sharing, between the companies, within the supply chain.

3.2.2 **Drivers for traceability**

There are several factors which motivates traceability in a food supply chain (Bosona & Gebresenbet, 2013; Aung & Chang, 2014). The drivers strive to, in combination, answer the questions who, what, when, where and why (Aung & Chang, 2014). These questions are also in line with the standard of Global Standards 1 (GS1), which is one of the most common used standards. It intends to describe the traceability processes, the related legislative and business needs (Aung & Chang, 2014). The drivers can be divided into the following categories; *safety and quality*, *social* and *economic*.

3.2.2.1 Safety and Quality

One of the major drivers for traceability systems is the safety and quality aspect (Bosona & Gebresenbet, 2013; Aung & Chang, 2014). Manos and Manikas (2010) and Rábade and Alfaro (2006) stresses that the initiatives behind food traceability is mainly connected to assure food quality and safety rather than logistics improvement issues. Food traceability has become an important issue during the last decades due to food crises as animal diseases, food counterfeiting and sustainability issues (Bertolini et al., 2006; Kelepouris et al., 2007; van Rijswijk, Frewer, Menozzi, & Faioli, 2008; Hong et al., 2011; Wognum et al., 2011; Salampasis, Tektonidis, & Kalogianni, 2012). New legislations which are introduced to address safety and quality concerns are important drivers for traceability (Bosona & Gebresenbet, 2013).

In a case where food has been discovered as contaminated it is of highest importance to find the source of the contamination as quickly as possible (Kher et al., 2010). A traceability system should include data concerning the type of food and ingredients, processes at all stages of the supply chain and the resources that have been used (Bosona & Gebresenbet, 2013). This to help the firm to trace the origin of food and ingredients of a product (Hayes, Sonesson, & Gjerde, 2005) and quickly isolate the source and reduce the impact. A precise traceability system enable faster identification of the problem and a faster solving of it (Golan et al., 2004). A traceability system can improve potential recall activities which enhance the security level and reduce the cost of the recall (Bosona & Gebresenbet, 2013).

A traceability system alone is not sufficient to achieve safety requirements in the supply chain, it should be seen as a complementary tool to quality and safety activities (Bosona & Gebresenbet, 2013). It can improve the quality of food since the workers' awareness are increased by the focus on data capturing and documentation processes (Donnelly & Olsen, 2012). Food quality and safety crises can cause crises in economic and marketing relations, both at national and international levels (Bosona & Gebresenbet, 2013). Investigations have shown that cases of food contamination and crises, except for the risk that some gets hurt, cost huge amount of money for the involved supply chain actors, government and the medical sector (Aung & Chang, 2014). Since food safety incidents often occur in media, consumers' confidence might suffer. One way to improve the confidence is through the traceability system (Canavari, Centonze, Hingley, & Spadoni, 2010; Kher et al., 2010; Bosona & Gebresenbet, 2013)

Some companies implement food traceability systems to stay in market by fulfilling the legislations of traceability Bosona and Gebresenbet (2013). Companies are pushed to invest in food traceability systems by political pressures to protect consumers and for companies to maintain market power (Bertolini et al., 2006; Heyder, Theuvsen, & Hollmann-Hespos, 2012; Resende & Hurley, 2012). There are mandatory food traceability laws by EU and the traceability data can be either mandatory or optional (Folinas, Manikas, & Manos, 2006). Mandatory data to trace are lot number, product ID, product description, supplier ID, quantity, unit of measure and buyer ID (Folinas et al., 2006).

3.2.2.2 Social

The consumers show an increased concern of the safety and properties of the food they eat. The available information of labels does not necessarily make the consumer more convinced about the food and there is an increasing need of more transparent information of the entire food supply chain (Aung & Chang, 2014). The consumers' satisfaction is related to the availability of adequate information which enable the customer to make an information based decision (Bosona & Gebresenbet, 2013). This type of information can be organized and communicated to consumers and stakeholders by using the traceability system. It is important that companies in food supply chains do not get satisfied by only following the regulations, instead they should strive to provide consumers with additional information about the products (Golan et al., 2004). Companies are motivated to invest in and implement food traceability systems to provide consumers with information to increase the consumers' confidence in food (Kher et al., 2010; Heyder et al., 2012; Hu et al., 2013). In recent years, consumers demands on transparent food supply chains have increased (Trienekens et al., 2012), and transparency is essential to preserve consumers' confidence in food (Beulens, Broens, Folstar, & Hofstede, 2005). One way to achieve confidence for the consumer, regarding the safety and quality of food is by using regulations and standards (Aung & Chang, 2014). Another possibility is to provide transparent track and trace information (Hong et al., 2011).

3.2.2.3 Economic

According to Bosona and Gebresenbet (2013) the economic benefits of traceability is not considered as one of the strongest drivers, due to the investment and resources it requires. Other drivers, such as better market access, product prices, potential funding were found (Donnelly & Olsen, 2012). Traceability information can be used as a marketing tool in terms of visualizing specific quality and safety standards (Liao, Chang, & Chang, 2011; Storoy, Thakur, & Olsen, 2013). In case of contaminated food, a traceability systems can limit the damage by quickly finding the contaminated source and protect the brand image (Mejia et al., 2010) and reduce the impact caused by media (Dabbene & Gay, 2011).

The efficiency of a supply chain can be improved through traceability by reducing logistics costs, providing information and enabling companies to manage their resources more efficiently (Regattieri, Gamberi, & Manzini, 2007; Hong et al., 2011; Karlsen, Dreyer, Olsen, & Elvevoll, 2013). The cooperation among the supply chain partners can be enhanced and technical and economic competences can be developed (Rábade & Alfaro, 2006; Dabbene & Gay, 2011). By integrating traceability and logistics activities, the supply chain could be improved through strengthened communication and information connectivity between the parties (Bosona & Gebresenbet, 2013).

Complex devices and systems are required to enable effective traceability, but the cost can put companies in doubt to invest in such a system. Emerging new and cheaper technologies motivates companies to integrate information of the supply chains all stages (Bosona & Gebresenbet, 2013).

3.2.3 **Requirements of a traceability system**

The characteristics of a traceability system differ among authors. Aung and Chang (2014) suggest three basic characteristics of a traceability system;

a) unique identification of units and batches of all products and ingredients,
b) information of when and where they are transferred,
c) linking the unit and the movements.

Salampasis et al. (2012) have similar key requirements, but add cost efficiency and user friendliness. Similar to the two mentioned scholars is Golan et al. (2004) who characterize a traceability system by its breadth (the amount of information), depth (how far downstream and upstream the system has information) and precision (the degree of assurance to pinpoint a particular movement).

The key factor for an effective and efficient traceability system is the linkage between the information and physical flow (Bosona & Gebresenbet, 2013). To be able to link the material flow with the information flow, packaging and labeling are requirements (Manos & Manikas, 2010).

A traceability system is complex and involves a variety of decision parameters. The involved parties have to decide on proper design parameters of what to include on product level to achieve an appropriate level of traceability (Dai, Ge, & Zhou, 2015). The decision of a traceability system also depends on structure of the supply chain, the relationships in the chain, the capacity and the quality (Manos & Manikas, 2010). A complete traceability system should be able to trace the product history through the whole food chain (Bosona & Gebresenbet, 2013). Regattieri et al. (2007) made a framework based on four fundamental pillars, which covering the factors a successful traceability system should be based on. The concept is illustrated in Figure 3-8 below, where the four pillars are; *product identification, data to trace, product routing* and *traceability tools.*

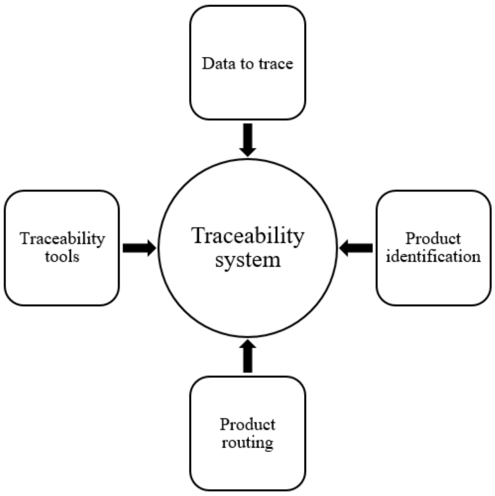

Figure 3-8, The four-pillar framework inspired by Regattieri et al. (2007).

The first pillar by Regattieri et al. (2007) is product identification which is fundamental. Since each entity must have a unique identification, a key concept is the TRU (Regattieri et al., 2007; Karlsen et al., 2010; Aung & Chang, 2014).

The second pillar by Regattieri et al. (2007) concerns the data to trace. One have to decide what kind of information the system must support and the confidentially levels of the information (Regattieri et al., 2007). The choice of what to trace depends on the capacities and capabilities of the involved actors (Manos & Manikas, 2010).

The next pillar by Regattieri et al. (2007) is product routing. A complete traceability system should cover the entire supply chain, from farm to end customer, including the manufacturing of the food (Folinas et al., 2006; Regattieri et al., 2007). The efficiency of a traceability system depends on its ability to track and trace the history through the whole chain (Folinas et al., 2006) and therefore, the manufacturing process is an important part to connect the components to the final product (Kher et al., 2010).

The last pillar by Regattieri et al. (2007) is the traceability tools. There exist a number of different technical solutions that can be used in a traceability system. Which tools to use should be decided by the requirements and the compatibility of the supply chain along with the cost of the traceability system (Regattieri et al., 2007). In order to quickly and automatically be able to identify a product, there are a couple of tools that can be used. The most common tools to capture data are paper record, barcodes, RFID and electronic systems (Manos & Manikas, 2010; Azuara, Tornos, & Salazar, 2012). Each labeling technique have some advantages and disadvantages and a company should consider using a combination of techniques (Lawson, 2009).

3.2.4 **Barriers and limitations for traceability systems**

Since many actors are involved, inter-organizational efforts are required to achieve food traceability (Sanfiel-Fumero, Ramos-Dominguez, & Oreja-Rodriguez, 2012). One of the most challenging parts with traceability systems is the lack of adequate standardized data and means of data exchange (Bosona & Gebresenbet, 2013; Aung & Chang, 2014). The standardization problem applies for both the information exchange between different actors and the systems in the food chain (Kher et al., 2010; Thakur & Donnelly, 2010). Traceability systems often get complicated due to variations and inconsistency in captured data, but also in terms of variations in data sharing among the partners, within the chain (Bosona & Gebresenbet, 2013). The lack of standardization creates compatibility problems as actors use different types of traceability techniques (Regattieri et al., 2007; Salampasis et al., 2012). To enable interoperability between information systems across the supply chain, and thereby achieve efficient traceability, global standards is inevitable (Aung & Chang, 2014).

The development and implementation of a traceability system is complicated and extensive (Kher et al., 2010; Bosona & Gebresenbet, 2013). This can lead to resistance of the implementation by some partners of the supply chain (Bosona &

Gebresenbet, 2013). Traceability systems require skilled personnel for development, implementation and management. Besides the technological capabilities of the employees, awareness, commitment and motivation are important and necessary factors for effective traceability (Donnelly et al., 2012). If the incentives are not aligned and the motivation to maintain the traceability system decrease for one party in the chain, the traceability system for the entire chain can be suffering in terms of the effectiveness and efficiency (Dai et al., 2015). Partners within a supply chain might not be willing to participate in traceability systems, which can be related to the lack of awareness of the benefits of such a system (Bosona & Gebresenbet, 2013).

A traceability system relies on the collected information and one must make sure that it has been collected and authenticated by robust mechanisms (Aung & Chang, 2014). Since each actor is responsible for collecting and communicating the information of their own processes and products, an internal traceability system is a prerequisite to enable traceability (Senneset et al., 2007). To enable successful tracking and tracing, motivated companies is a key factor (Donnelly et al., 2012).

3.3 Transparency

3.3.1 **Sustainable supply chain management**

The attention to incorporate sustainability in the supply chain management has grown over the last decades. A focus shift from a technical point of view, to also consider it from a business and policy perspective, first in environmental, and then, societal aspects, can be seen (Matos & Hall, 2007; Gualandris et al., 2015). Research on sustainable supply chain management (SSCM) has mainly focused on monitoring as a set of activities for sustainable operations and performance in supply chains (Vachon & Klassen, 2006; Awaysheh & Klassen, 2010). Seuring and Muller (2008) found that the environmental aspects have more developed discussions than the social aspects. Fritz, Schöggl, and Baumgartner (2017) conclude that the sustainability issues in supply chains is dominated by environmental, regulatory, and economic issues. The same author also emphasizes the need to better include social and governmental dimensions as well as the socio-economic factors in the SSCM.

Studies indicates that consumers are more aware of the ethical and social information that underlies a specific product (Trienekens et al., 2012). During the last years, the emphasis on greater transparency have increased (Sayogo et al., 2014) and Mol (2015) predicts that this development will continue leading to more comprehensive transparency in the future. Transparency is by Mol (2015) defined as disclosure of information, and is often related to the field of environmental and sustainability. The transparency area is high on public, political and researcher agenda. The growing emphasis of transparency can be traced to a broadening focus on shareholders' interests who have intensified efforts to protect workers right (Doorey, 2011) and consumers interests in sustainable products (Rahman & Post, 2012). External pressure from government, the public and NGOs force companies to integrate sustainability (Bowen, Cousins, Lamming, & Faruk, 2001; Linton, Klassen, & Jayaraman, 2007; Vachon & Klassen, 2007; Sarkis et al., 2011). Studies have shown that governmental pressures through laws and regulations drive companies to improve sustainable practices (Sarkis et al., 2011). The rising expectation of environmental and social sustainable products and processes form a normative pressure for companies to implement sustainable solutions (Sarkis et al., 2011). Actions from NGOs can damage the reputation of a company as the NGO holds the company responsible for environmental and social problems, also at earlier stages of the supply chain (Roberts, 2003). Carter and Rogers (2008) stresses that sustainable projects will be increasingly viable as the pressure from consumers demand greater transparency along supply chains. Firms must take a more holistic view of the costs and benefits that comes with social and environmental projects, and making it a part of the strategy instead of a burden (Matos & Hall, 2007). Beske-Janssen, Johnson, and Schaltegger (2015) points out transparency as a key for a successful sustainability assessment of supply chains. Sustainable products and supply chains aim to achieve cost savings, but also to increase sales and market opportunities by satisfying the consumers' needs (Rao & Holt, 2005; Sarkis et al., 2011).

Benefits that can be gained from social and environmental sustainable supply chain activities include reduced health and safety costs due to safer handling and better working conditions (Brown, 1996). Benefits from engaging in sustainable behavior can also be that the organization is more attractive to suppliers and customers (Scholder Ellen, Webb, & Mohr, 2006). It is also a way for a company to proactively work for future regulations and it may influence coming governmental regulations, which could lead to a competitive advantage for the company (Carter & Dresner, 2001). The sustainable actions should be concentrated around the issues dictated by highly salient stakeholders to reduce the gap between "what a firm does" and "what a firm should do" (Gonzalez-Benito et al., 2011; Gray, 2013). By aligning the stakeholders' perceptions and expectations, competitive advantage can be gained (Gualandris et al., 2015).

Sustainable monitoring includes activities such as gathering of supplier information, appraisal of environmental and social performance of suppliers and incoming goods (Gualandris et al., 2015). There are some limitations of the monitoring, it often tends to have a narrow focus of environmental and social indicators. A too narrow monitoring can overlook negative externalities that impact multiple stakeholders. The monitoring assumes that the information that are gathered through the chains are accurate and reliable (Gualandris et al., 2015). Seuring and Muller (2008) found that the environmental and social performances were order qualifiers to operate as a part of the supply chain, while the order winner in the long run is the economic performance. Stakeholders have different interests in environmental and social accounting (Edgley, Jones, & Solomon, 2010) and tend to have problems with clearly expressing their expectations and informational needs (Hall & Vredenburg, 2003). Seuring and Muller (2008) mention added complexity and coordination as some barriers which that must be overcome when implementing sustainable supply chains.

3.3.2 Information asymmetry

Consumers are becoming more conscious about the environment, and the society demands greater transparency and sustainable products (Rao & Holt, 2005; Singh, Sanchez, & del Bosque, 2008; Trienekens et al., 2012; Fritz et al., 2017). Often, some actors in a supply chain has more and better information than the other actors. The available information will affect the party with less information, making it hard, or impossible, to evaluate the quality of the information, which is referred to as information asymmetry (Akerlof, 1970; Mishra, Heide, & Cort, 1998; Sarkis et al., 2011). Due to the information asymmetry, companies may not be able to express the information underlying a product to the consumers (Sarkis et al., 2011). The information asymmetry prevent the customers from actively taking an ethical-based decision when purchasing a product (Giddens, Goutas, Leidner, & Sutanto, 2016), which put the customer in a position where one cannot choose the product that is believed to yield the greater value (Wognum et al., 2011). To reduce the information asymmetry, greater interactions are needed. The information asymmetry is not necessarily reduced by closer relationship, but the information sharing is critical when coordinating the supply chain (Sarkis et al., 2011).

One way to increase the available information, and thereby the awareness, is to provide information of the environmental impact and/or the social impact of a product (Giddens et al., 2016). This is often made by using third party certifications and labels, e.g. *Fairtrade*, aiming to reduce the information asymmetry of environmental and social impact and to guide consumer to differentiate between products (Sayogo et al., 2015). The increasing demand for sustainable products creates incentives for companies to change their production and supply chain processes (Sayogo et al., 2015). Today, there exist 465 ecolabels (Ecolabelindex, 2017) and limited information of what each certification or label means makes it difficult for the consumer to assess the meaning and credibility of the certification (Sayogo et al., 2015). An additional way to shed light over the environmental impact could be to look at emission standards for trucks. A standard that measure how well a truck performs regarding emissions. The emissions standard is ranked between Euro I-VI, where higher numerals is better than a lower in terms of emissions. A newly manufactured truck should have an emission standard of VI (Commission, 2011).

There is a challenge in making all data of certification, processes and products available in a trustable and useful way to the consumer (Sayogo et al., 2015). Companies use labels as an information instrument (Wognum et al., 2011) and the consumers need labels that are understandable, without overloading the information (Verbeke & Ward, 2006; Kimura et al., 2008; van Rijswijk et al., 2008). Kimura et al. (2008) pointed that providing too little information is not advisable either. One concern is when environmental improvements are dismissed, since the stakeholders' expectations are not aligned with the revealed information, as it is believed to only prettify the reality (Gualandris et al., 2015).

The objective of information disclosure is to help consumers make better choices (Sayogo et al., 2014), therefore, one must make sure that the data is relevant, accurate, reliable and available in an appropriate quantity (Wognum et al., 2011; Sayogo et al., 2015). Relevant information is a central aspect for earning trust among customers and shareholders (Tapscott & Tapscott, 2016). To reach high credibility the information must be unbiased, accurate, trustworthy and respond to the receiver's needs (Dando & Swift, 2003).

3.3.3 What to disclose

Since the external pressure from government regulations, best practice peers, non-governmental organizations, and "critical events", such as the collapsed garment factory in Bangladesh 2013 (Marshall, McCarthy, McGrath, & Harrigan, 2016), or unhealthy working conditions for foreign truck drivers (Conway, 2017), companies need to decide what information to disclose. The fundamental decision of what to disclosure is given by the expected response by the principal (Verrecchia, 2001). A weighed trade-off of the investment costs and the benefits of the disclosure as different investments are required to be able to share the information (Jira & Toffel, 2013). Studies found that supply chain partners are more likely to share information with each other in longstanding relationship which are built on trust and a shared vision (Li & Zhang, 2008). Sayogo et al. (2014) and Sayogo et al. (2015) found that companies are more willing to disclose information if the disclosure adds value to the relationship with the existing and potential consumers, and that privacy and proprietary information is not compromised. What information an actor in a supply chain decides to share depends on the breadth and depth of the information from the buyer (Jira & Toffel, 2013). The same information requested by more buyers indicates greater breadth of pressure and the depth tends to be more intense when the buyer has a plan of what the received information should be used for. The buyer typically has some problems with obtaining the information, unless it is not perceived as critical for the relationship (Jira & Toffel, 2013).

Influencing factors of information to disclose are what type of information that should be disclosed (Mol, 2015). All type of information disclosure and exchange are vital elements to improve sustainability (Wognum et al., 2011). Jira and Toffel

(2013) found that companies that already are obliged to gather information through regulations require less investments and are more likely to share the information. Since novel type of information is requested by the buyer, one have to determine whether the information is idiosyncratic or if it is a signal for new social movement (Jira & Toffel, 2013). There are different ways to pressure organizations to adopt new sustainable norms, for example activist groups who use media campaigns, shareholder resolutions, strikes and boycotts (Reid & Toffel, 2009). If it is interpreted as a new trend rather than just idiosyncratic more effort will be put since there are greater benefits to gain by sharing the information (Jira & Toffel, 2013). Since the importance of sustainability transparency grows, the drivers behind it will become stronger, and perhaps change. The sustainable factors increase in economic value and leading political importance (Mol, 2015).

According to Marshall et al. (2016) publicly commonly disclosed supply chain information is, provenance, environmental information and social information. Provenance means to disclose information about the components used in a product. Environmental information means the affection of the nature that a product has, whereas the social information could be anti-corruption information, working conditions, impact on local communities.

A successful disclosure strategy that Marshall et al. (2016) proposes is to first identify which type of information that could be disclosed and then, depending on how sensitive, risky and how valuable the information identified is to disclose, respond in a creative and meaningful way.

4 EMPIRICAL FINDINGS

This chapter presents the empirical findings from the observations and interview. First, a company overview is presented, which is followed by the processes of a purchase and client order. Lastly, the structure of the artefact and the field test is presented.

4.1 Bring SCM, case company overview

Bring SCM is a non-asset based 4PL provider who is managing their clients supply chains by contracting 3PL providers. The businesses are mainly focused on food logistics, both domestically and globally. The main services provided by Bring SCM are purchasing, transport planning and coordination, which is supported by financial services.

This study will focus on an international client, who is selling food, among other things, in their stores. The stores can be found in Europe, the Middle East, Asia, Africa, Australia and North America, where Europe is the largest market. The assortment includes frozen, chilled and ambient food products from almost 200 suppliers. The majority of the suppliers are located in Sweden, but only few are located outside Europe. Bring SCM is managing the supply chain to ensure availability of the products to the client's stores. To support the need of the client, Bring SCM has a central warehouse in Helsingborg and 16 distribution centers around the world, contracted by 3PL providers.

In the current situation, Bring SCM experience that there is a gap of information of the transports between the supplier and the central warehouse. If it is not asked specifically to the haulier, Bring SCM won't receive any status updates such as if an order has been loaded at the supplier. This causes problems, since it takes longer time to discover if an order would be late. Additionally, no information about the trucks, which transport the goods, are communicated to Bring SCM.

4.1.1 **Information systems**

There are several involved information systems to handle the client's requirements. In center of the systems is Bring SCM's enterprise resource planning (ERP) system.

All orders, both purchase orders and client orders (described more in detail in sub-chapter *4.2 Purchase order* and *4.3 Client order*), are handled in the ERP system.

Connected to Bring SCM's ERP system is a web portal where the client stores put their replenishment orders, which is automatically transferred to Bring SCM's ERP system. A transport management (TM) system is also connected to Bring SCMs ERPs system, see visualization in Figure 4-1 below. Information about all purchase orders are automatically sent to the TM system, which in turn, automatically send the bookings of the transports to the responsible haulier. The TM system is a link between Bring SCM's ERP system and the hauliers and it is used to simplify the communication between the parties. The TM system is also used as a tool to monitor the ordered transports by Bring SCM.

The warehouses have their own warehouse management systems (WMS) to support the handlings. These are all connected to Bring SCM's ERP system and when receiving and loading processes takes place, they are automatically updated in Bring SCM's ERP system.

Each supplier has their internal ERP systems, which are not automatically linked to Bring SCM's ERP system.

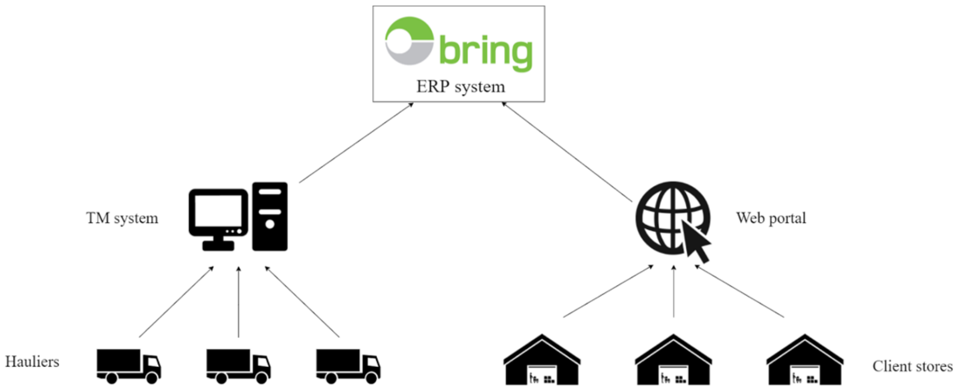

Figure 4-1, IT systems used.

4.2 Purchase order

The flow and the processes of a purchase order of Bring SCM to Supplier A is described in Figure 4-2. Starting with Bring SCM placing a purchase order, followed by the order preparation at Supplier A. Further, the order collection at Supplier A and the cross-docking procedure is explained. Lastly, the receiving process at the central warehouse is brought to the light. The description of the physical and the digital flow is elaborated in section *4.2.6 The physical and digital flow, purchase order*

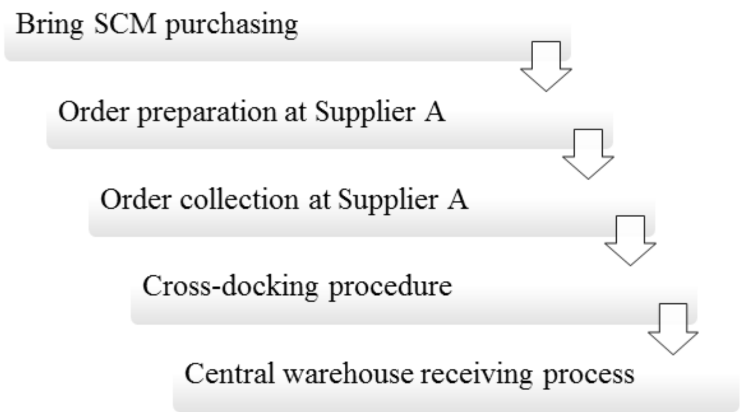

Figure 4-2, Overview of the purchase order processes

4.2.1 Bring SCM purchasing

The following description is visualized in Figure 4-3. First, a supply planner at Bring SCM evaluate replenishment proposals, which are generated automatically by the ERP system, for the specific product. If the supply planner finds it necessary to replenish the product, an order is placed in Bring SCM's ERP system. When the proposals have been controlled and approved by the supply planner the order is automatically sent by e-mail to the supplier. The e-mail includes order details, which consist of the products, price, quantity and planned pickup date. When the supplier has received the order, and controlled it, it is confirmed to Bring SCM by e-mail. The confirmation is responding to whether the requested products are available or not at the requested date. At Bring SCM the order availability is controlled. If there are deviations these are evaluated by the supply planner who must decide whether some products should be shipped at the requested date or if the complete order should be postponed. Then, the decision from the supply planner is communicated by e-mail or phone to the supplier. Otherwise, the entire order is confirmed in the ERP system.

When the order has been confirmed in Bring SCM's ERP system it is sent to the TM system. In the TM system, all confirmed purchase orders are logged. As an order has been logged, it is sent to the haulier automatically. The information sent to the haulier consist of supplier, pickup address, pallets, pallet spaces, weight, temperature and destination address. When the transport booking of an order has been sent to the haulier, it is confirmed automatically back to Bring SCM's ERP system. Then, it is up to the haulier to plan and carry out the transport in the most efficient manner. The transportations might include cross-docking, if it is used or not is not communicated to Bring SCM.

The haulier arranges the transport to be executed at the day it is planned and are responsible for the communication to the supplier, as when the truck will be there for loading. Information about when it should be loaded is not communicated to Bring SCM, it is assumed that the haulier collect the order during the day set in the transport booking. When an order has been loaded no status updates are sent to Bring SCM.–If Bring SCM wants to know if an order has been loaded or not at a supplier the haulier must be contacted by phone or email. Then, the transport planner at the haulier must call the truck driver to find out if the order has been loaded or not. To find out the status of an order several manual steps are required, but those steps are only made if an order has not been reported as delivered to the central warehouse when it was supposed to.

Before the arrival to the central warehouse in Helsingborg, the unloading times must be considered. This is made by an agreement between the hauliers' transport planners and a planner at the central warehouse. The planner at the central warehouse assign each truck with an unloading, resulting in an unloading list which is sent to Bring SCM by e-mail. The list is then used by Bring SCM to update statuses in their ERP system. Both the list and the updating procedure is made manually. This is the only status update Bring SCM receives about an order, but the unloading list is based on planning and what is supposed to be delivered.

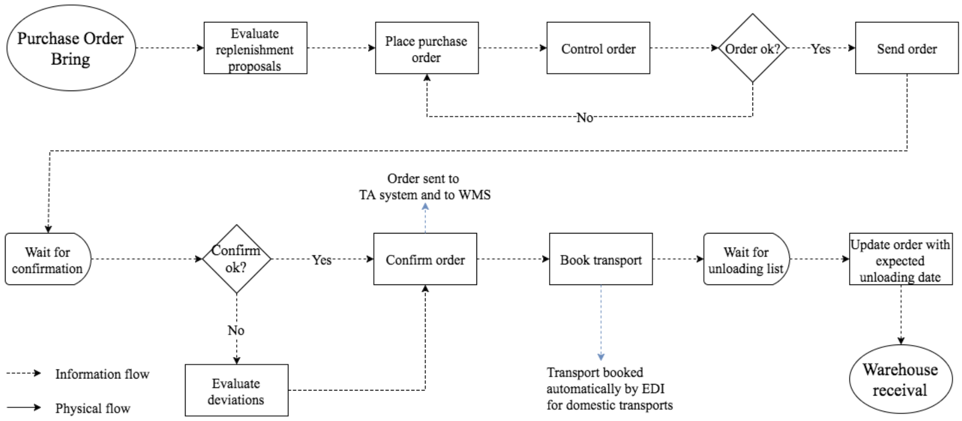

Figure 4-3, Flowchart of the processes of a purchase order by Bring SCM.

4.2.2 **Order preparation at Supplier A**

The scope of this case study has its starting point once Product A, which is a made-to-stock product, has been received at Supplier A's warehouse. How Product A are packed in boxes and placed on pallets can be seen in Figure 4-4.

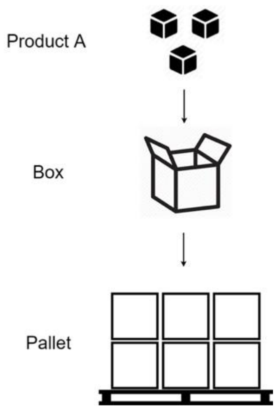

Figure 4-4, Product A packing procedure.

From the production process, each pallet is labelled according to the one-dimensional barcode (hereafter referred to as barcode) standard GS1-128 with three barcodes. Each pallet is assigned a serial shipping container code (SSCC) number, by the ERP system of Supplier A, which is a unique ID for each pallet. The SSCC number created by Supplier A will be used through the rest of the chain. The information written in text on a pallet label by Supplier A is the internal article number, a description of the product and a Global trade item number (GTIN). The number of cartons on a pallet, a batch reference and the best-before-date (BBD) are also written on the pallet label. The SSCC number, is also written in text, where the last digits is written on top of the label to simplify internal processes. The first of the three barcodes on the pallet label contains the GTIN, BBD and number of cartons on the pallet. The second barcode contains the batch number, whereas the last barcode, at the bottom of the pallet label, contain the SSCC number. An example of a pallet label is illustrated in Figure 4-5 below.

Figure 4-5, Example of a pallet label from Supplier A.

The factory where Product A is produced and the warehouse of Supplier A where it is stored, are located at two different locations. When the production factory has produced a certain amount of Product A they transport it to Supplier A without any specific notification. As the goods arrive to the warehouse, it is placed on the floor in the area of incoming goods. A forklift driver pick up the pallet and it is scanned by a fixed scanner in the front of the forklift. Once scanned, the WMS system is generating a vacant location in the pallet racks, where the pallet is placed.

When Supplier A receives an order from Bring SCM by e-mail, approximately two weeks before shipping, it is controlled and submitted into their ERP system. As it is registered in the ERP system, it is controlled whether the articles are available or not. The order is then confirmed to Bring SCM, either in full or with deviations. If products are missing, it is communicated to Bring SCM by e-mail. Bring SCM then decide how to handle the deviations and when to pick up the order. Based on the decision the order is scheduled for shipment on the agreed date. These steps where the order is handled in Supplier A's ERP system are described in the flowchart in Figure 4-6.

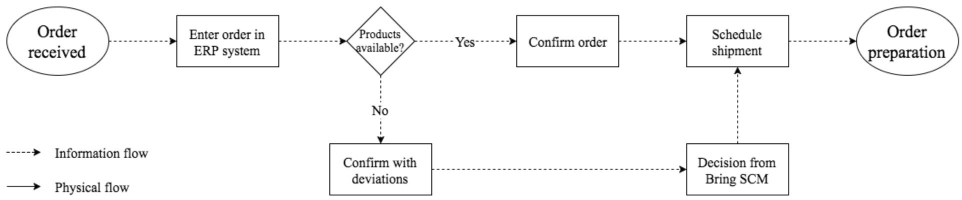

Figure 4-6, Flowchart of the order receiving process of Supplier A.

Two days before shipment of an order it is prepared in the ERP system. This means that each article is allocated with an available batch and a delivery number which is specific for Supplier A. An order can contain multiple pallets of a product and the products can have different batches on different pallets. As batches have been assigned to each product the order is assigned to a lane within the loading area where it should be placed once it has been picked. When the preparation is completed the picklist of the order and the address label is printed and put in a "waiting box" at the office at Supplier A.

To start the picking of an order a forklift driver go to the "waiting box" to collect the picklist. The delivery number of an order, which is written on the picklist, is submitted into the computer in the forklift. The information on the paper picklist is then compared with the information on the computer to check that it contains the same information. The printed picklist is used to minimize errors in the picking process.

The forklift driver follows the picklist, which direct the forklift driver to the shelf position where the pallet to pick is stored. Once a row on the picklist is picked, it is controlled and verified as the correct pallet by comparing the last three digits of the SSCC number on the computer with the three last digits of the SSCC number on the pallet label. To simplify this comparison the last seven digits of the SSCC number is written in large on top of the pallet label, as seen in Figure 4-5. The pallet is not scanned but it is confirmed by the driver by a given command on the computer in the forklift. Once the correct pallet is picked the driver head to the given lane where the pallets are placed until the transport arrive two days later. When the driver puts a pallet to the loading lane it is marked with a transport label, which can be seen below in Figure 4-7. The transport label states the order number, destination and loading date.

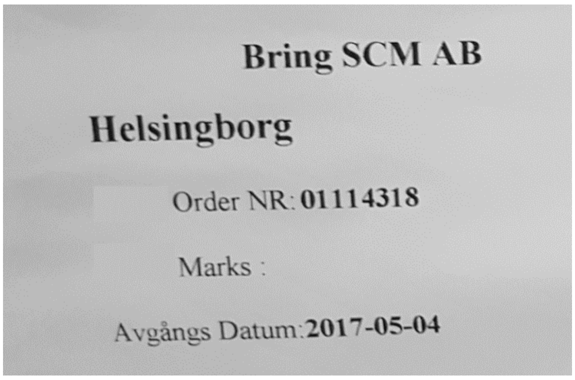

Figure 4-7, Example of a transport label from Supplier A.

When the picking of an order is finished the forklift driver report to the team leader who then print the freight documents. The printed freight documents are marked with an additional small label stating the loading date and loading day to easier distinguish between them. The freight documents are placed in different stacks based on the transport company. At this point, the order preparation is completed and it is ready to be collected by the truck driver who arrive two days later. The events at Supplier A are visualized below in Figure 4-8.

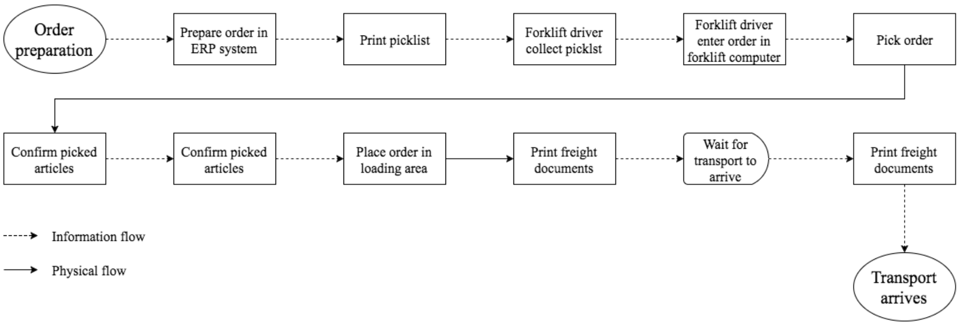

Figure 4-8, Flowchart of the order preparation process of Supplier A.

4.2.3 **Order collection at Supplier A**

The day before loading, the transport planner at the haulier send a list with the orders to load and a suggestion of a loading time to Supplier A. Once the loading time has been agreed upon the transport planner send the list with the orders to the truck driver who bring them on the loading day. The content of the list is all order numbers and in which order they should be loaded into the truck. The orders to load can be for multiple customers, i.e. not only for Bring SCM. Upon arrival at Supplier A, the truck driver announces the arrival at the office, collect the printed freight documents and compare them with the list in the smartphone, or the one in printed format. Then, the driver is directed to the loading gate by the team leader ~~at~~ employed by Supplier A.

The truck driver load the pallets of the orders, with a low lift pallet truck, assisted by the personnel of Supplier A, but depending on the situation the assistance varies. The correct order and number of pallets are identified by the truck driver by counting the pallets manually and compare the order number written on each pallet with the order number on the freight document. The freight document consists of four papers, whereas one part should, at completion of loading, be signed by the truck driver and be given to Supplier A. Supplier A store the signed freight document for at least for six months in the office. After signing the freight documents the loading procedure is completed and the truck driver transport the freight either to the cross-docking warehouse in Gothenburg or directly to the central warehouse in Helsingborg. The loading procedure is illustrated in Figure 4-9.

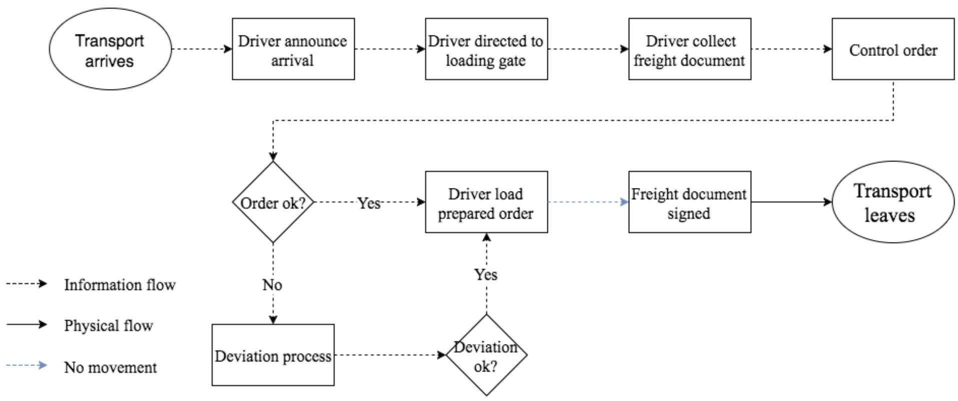

Figure 4-9, Flowchart of the loading procedure at Supplier A.

4.2.4 **Cross-docking procedure**

Shipments of Product A from Supplier A are made via a cross-docking warehouse in Gothenburg. Depending on the size and destination of the shipment, the procedure at the cross-docking warehouse varies. Almost every time it is one truck driver that drives from Supplier A to the cross-docking warehouse in Gothenburg and another truck driver who drives between the cross-docking warehouse and the central warehouse in Helsingborg. It should be noted that the shipments can contain orders to other customers with other destination than the orders from Bring SCM.

Three different scenarios are possible at the cross-docking warehouse. If the truck which will execute the transportation to the central warehouse in Helsingborg (truck B) is available for loading at arrival of the truck which transported the goods from Supplier A (truck A), it is loaded directly from truck A to truck B via the cross-docking terminal.

The second scenario is if truck B is not connected to the cross-docking warehouse at the time the goods is unloaded from truck A, the goods are unloaded and put in different lines in the cross-docking terminal. Depending on the destination, which is stated on a sheet of paper in the ceiling of the warehouse, the goods are placed in different lines. Then, the truck driver hands over the freight documents to the personnel at the cross-docking warehouse, and the personnel compare that the number of pallets in the row, designated by the final destination, is the same as in the freight document and the handover is completed.

Upon arrival of truck B, the truck driver collects a folder with the freight documents of the orders to be loaded. The correct rows with pallets are identified and the loading can start. The loading is made by the driver in collaboration with the cross-docking warehouse personnel. As the loading is completed the truck driver sign the copied freight document, which indicates that the correct pallets with the specific destination are loaded on the truck. The driver then brings the original freight documents to the central warehouse in Helsingborg.

The third scenario at the cross-docking terminal happens if the shipment from Supplier A is large and the trailer is full. Then, it is possible that the trailer is not unloaded at the cross-docking warehouse in Gothenburg. What the driver should do with the shipment is communicated to the driver by the haulier's transport planner. If the trailer should not be unloaded it is put next to terminal. The driver then enters the warehouse to hand over the freight documents to the personnel at the cross-docking warehouse who copy the documents. The copies are saved at the cross-docking warehouse while the original freight documents are given to truck driver B who will execute the transport from the cross-docking warehouse to the central warehouse.

Either way, unloading or loading, incoming or departing, no digital sign or status updating is communicated to Bring SCM. A summary of the procedure at the cross-docking warehouse in Gothenburg is visualized below in Figure 4-10.

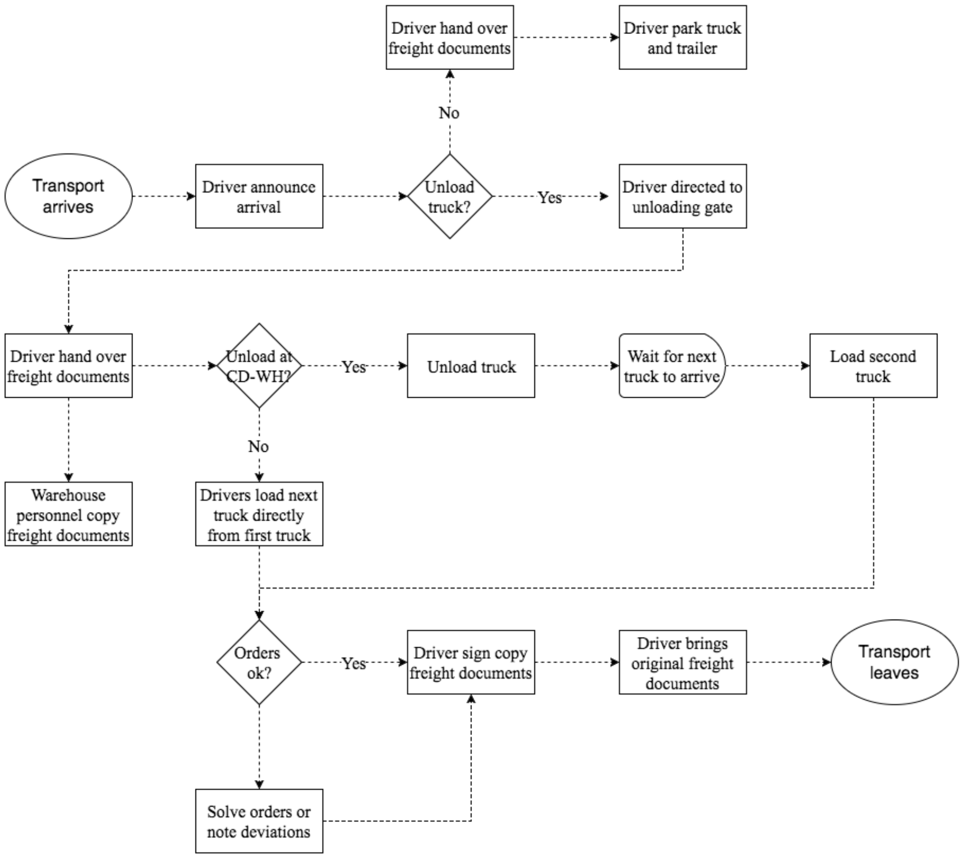

Figure 4-10, Flowchart of the cross-docking procedure in Gothenburg.

4.2.5 **Central warehouse receiving process**

When the driver arrives to the central warehouse in Helsingborg the arrival is announced and the driver is directed to one of the unloading gates. The driver then unload the pallets of the orders, assisted by the warehouse personnel, and put the pallets in a temporary storage area, within the central warehouse, close to the unloading gate. Once the pallets have been unloaded the order is controlled by the warehouse personnel, who compare the freight documents and the delivery notes from Supplier A. At this point in time, the pallets of an order are also scanned manually by the warehouse personnel who use a hand scanner. This is the first time the SSCC identity of an order are known and can be traced since it left Supplier A. When the control is completed and approved the freight documents are signed by the warehouse personnel and the truck driver. If deviations are found during the control these are reported to Bring SCM by e-mail or phone and noted on the freight document. Once the freight documents are signed the driver leaves.

If it is not possible to scan the barcode of a pallet from a supplier, as it is damaged or for other reasons cannot be scanned, a new pallet label is generated and printed through the WMS of the central warehouse. The printed label is attached to the pallet and replaces the damaged one. This printed label's SSCC number differ from the original SSCC number.

After the pallets have been controlled in the temporary storage area they are moved to the storage area by a forklift via a conveyor belt. When the pallets are moved by forklifts, they are scanned by a fixed scanner placed in the front of the forklift. When a pallet has been transferred by the conveyor belt it is collected by another truck and scanned in the same manner as described earlier, with a fixed scanner on the forklift. Once a pallet is scanned, the WMS finds a free storage position, to which the forklift driver is directed. The procedure is repeated until the complete order is put to storage, where they remain until they are requested by the client. Each pallet movement is registered in the WMS of the central warehouse with a time stamp and the person who moved it. Figure 4-11 illustrate the explained processes of the central warehouse.

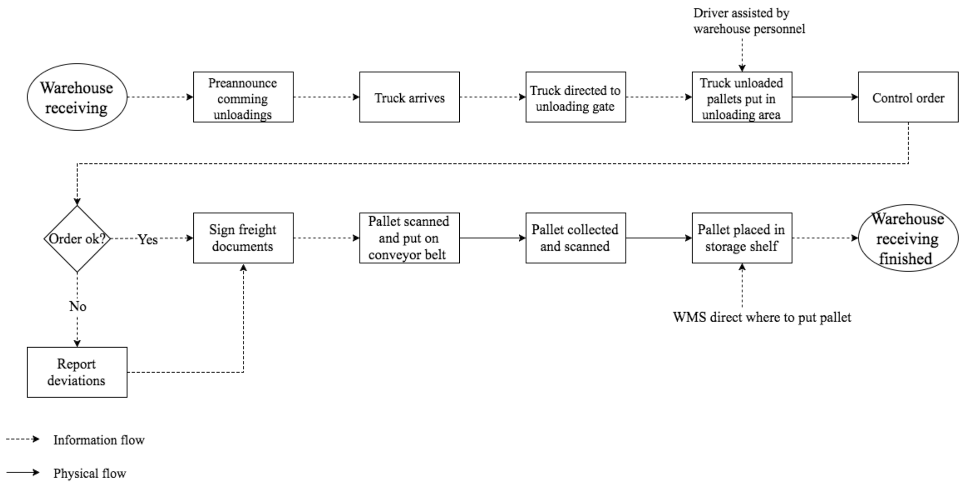

Figure 4-11, Flowchart of the receiving process of the central warehouse.

4.2.6 The physical and digital flow, purchase order

This section will put more emphasis on the information flow included in the processes and the statuses it contains, which is illustrated in Figure 4-13. Each process is numbered and referred to in the text within brackets.

The first step is that Bring SCM places a purchase order. When an order is approved in Bring SCM's ERP system it is automatically sent to Supplier A by e-mail, and the status in the ERP system is automatically updated to "order sent to supplier" (1). When Supplier A confirms the order by e-mail to Bring SCM (2) the status in Bring

SCM’s ERP system is manually updated to “order confirmed” (3). When the order is confirmed in Bring SCM’s ERP system the details of the order are automatically sent to the central warehouse’s WMS and to the TM system automatically (4). When the order has reached the TM system it is directly sent to the haulier (5). In conjunction with this, the TM system automatically send a status update to Bring SCM’s ERP system (6) with the status “transport booked”. For Product A, the above described events (1 - 6. in Figure 4-13) usually takes place approximately two weeks before the order is loaded.

A few days before loading of an order, the haulier and Supplier A agree on an approximate loading time, either by e-mail or phone, and confirm which orders to load (7). Once agreed, the haulier inform the cross-docking terminal in Gothenburg to prepare for the unloading and loading of the orders (8). The haulier and the central warehouse are facing the similar procedure; to agree upon an unloading time (9).

The next event is the order collection at Supplier A (10), where the processes of it is describe in section *Order collection at Supplier A*. At this point in time the digital information flow and the physical flow are mismatching, since no status updates are reported to either the haulier or Bring SCM. This means that the digital and the physical flow for an order will not match again until the order is received at the central warehouse in Helsingborg, see Figure 4-12. This lack of information is the studied real-world problem.

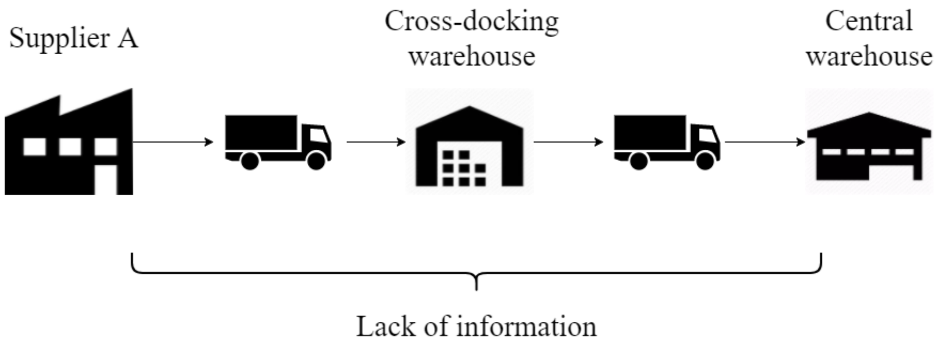

Figure 4-12, The real-world problem.

At the end of each day the central warehouse send an unloading list to Bring SCM (11) which is described in section *Bring SCM purchasing*. This list contains the following day’s unloading’s. Based on the unloading list, the orders are updated manually in Bring SCM’s ERP system with the status “expected arrival” (12).

As the order from Supplier A arrives to the central warehouse (13) it is scanned in conjunction with the unloading procedure, as described in section *Central warehouse receiving process*. Once the order has been scanned, the WMS system automatically send a status update to Bring SCM’s ERP system, with the information that order has been received (14). By this point in time the physical and the digital flow matches again.

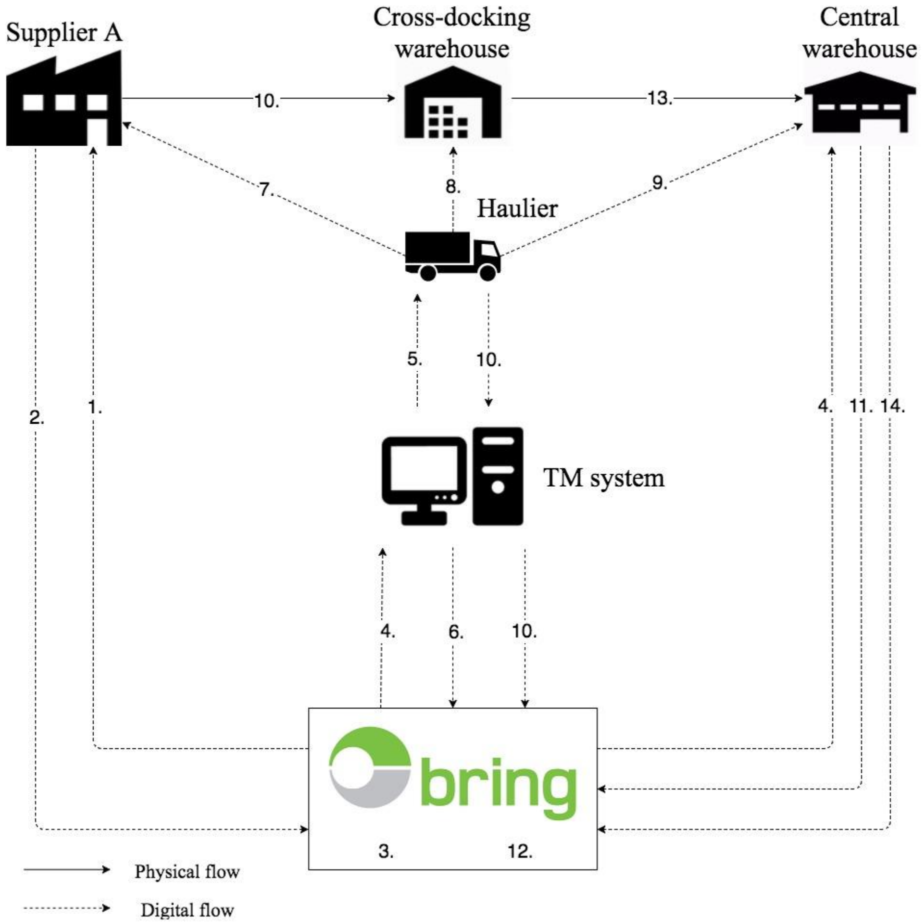

Figure 4-13, The digital and physical flow of a purchase order.

4.3 Client order

The flow and the processes of an order, from the client to delivery to one of the client's stores is described in the flowchart in Figure 4-14. The first step, where a client places an order, is followed by the picking process at the central warehouse in Helsingborg. When the picking process is completed, the order is transported to the client's store.

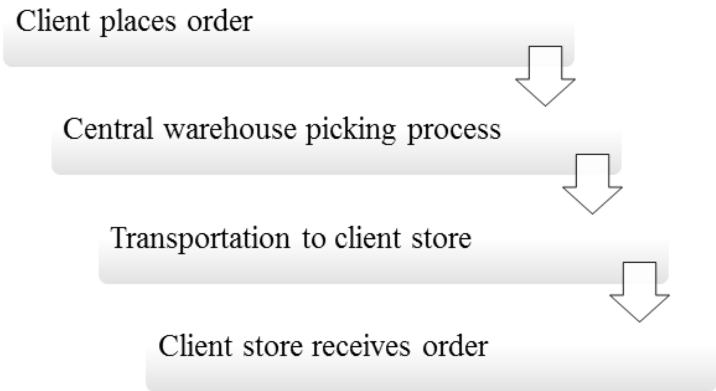

Figure 4-14, Overview of the client order processes.

4.3.1 **Client places order**

One or a few persons at the client's stores are responsible for the availability of the products and place replenishment orders to Bring SCM. This is made through a customer web portal, which is linked to Bring SCM's ERP system. When the order has been received by Bring SCM it is controlled to make sure that all ordered articles are available. If the articles are available it is sent without changes to the central warehouse's WMS. If some products are not available, and cannot be sent, these are removed before the order is confirmed to the central warehouse's WMS. The client's store is then notified that the non-available article will not be delivered. One or two days before loading, the order is sent to the warehouse and once they have received it, the picking process can start. The picking process is described in section *4.3.2 Central warehouse picking process*. The content of the orders, placed on a pallet, can be both homogenous or mixed ones. The administrative processes of a client order can be seen in the flowchart in Figure 4-15 below.

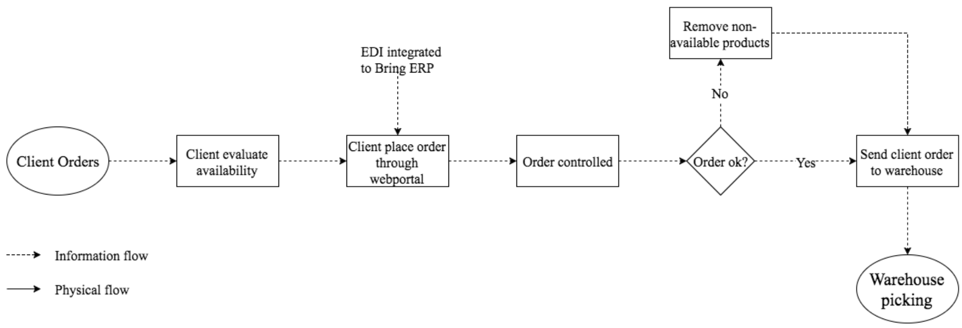

Figure 4-15, Explanation of the process when a client place an order

4.3.2 Central warehouse picking process

The clients' orders are received by the WMS of the central warehouse one or two days before loading. A warehouse employee controls the order before it is delegated to a picker as a picklist. There is a specific picking area within the central warehouse where one or a few pallets of each product is stored. The picker follows the picklist and verify that a certain article has been picked by scanning the barcode of the shelf position. Which product that is stored at a specific shelf position is available through the WMS. Once a pallet has been picked, it is wrapped in plastic and labeled with a unique SSCC number. Through the SSCC number it is possible to attain what have been picked on a specific pallet in the WMS. As the pallet is wrapped and labelled, it is put on a conveyor belt where it is scanned automatically. The pallet is then collected at the end of the conveyor belt and moved to a certain lane in the loading area, which depends on the destination of the order. The illustration of how a mixed product pallets looks like can be seen in Figure 4-16.

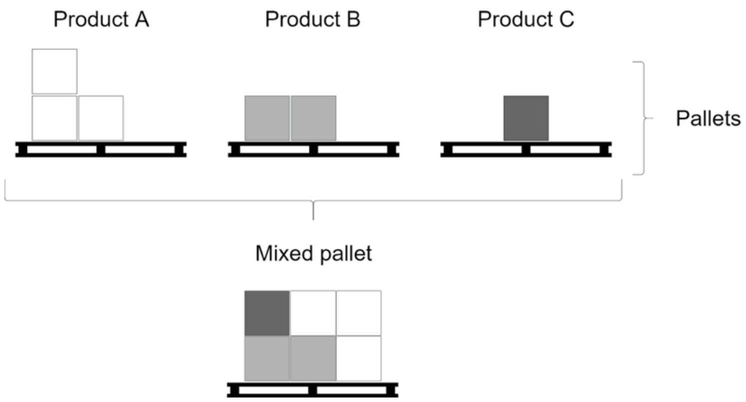

Figure 4-16, Mixed pallet illustration.

An order from the client does not necessarily only include mixed pallets, the client order might include homogeneous pallets as well. Homogenous pallets are picked directly from the storage position, a position which the computer in the forklift communicate to the driver. The pallets are picked and automatically scanned by the fixed scanner on the forklift, and then put in the lane at the loading area, where they are stored until next day when the truck arrives to collect the order. The picking process of the central warehouse in Helsingborg is visualized in Figure 4-17.

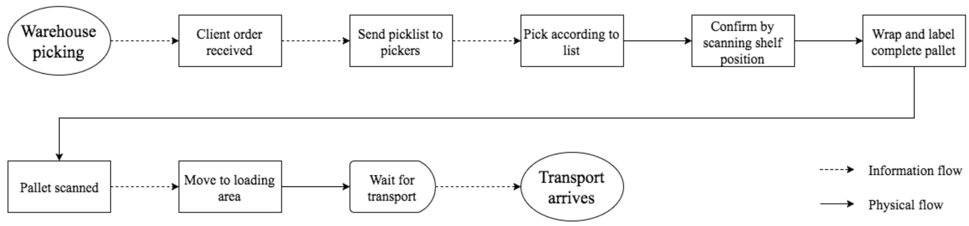

Figure 4-17, Flowchart of the picking process of the central warehouse.

4.3.3 Transportation to client store

The transportation of the goods to the client's store begins with a booking from Bring SCM the day before loading. When the truck arrives to the central warehouse in Helsingborg, the truck driver is directed to the loading gate, where the goods are stored temporarily. The next step is to control the order and check if it matches the printed freight documents, brought by the truck driver. The check is made by the driver and the central warehouse personnel. If there are deviations these are reported directly to Bring SCM and noted on the freight documents. When the order has been checked, the pallets are scanned as they are loaded on the truck. The driver is responsible for the loading, but is assisted by the central warehouse personnel, who is managing the pallet scanning's. The scanned pallets are reported to Bring SCM via the WMS of the central warehouse, which indicate that the order has been loaded. Once loaded, the freight documents are signed by the warehouse personnel and the driver, who then transport the goods to the client's store. The flowchart in Figure 4-18 illustrates the process.

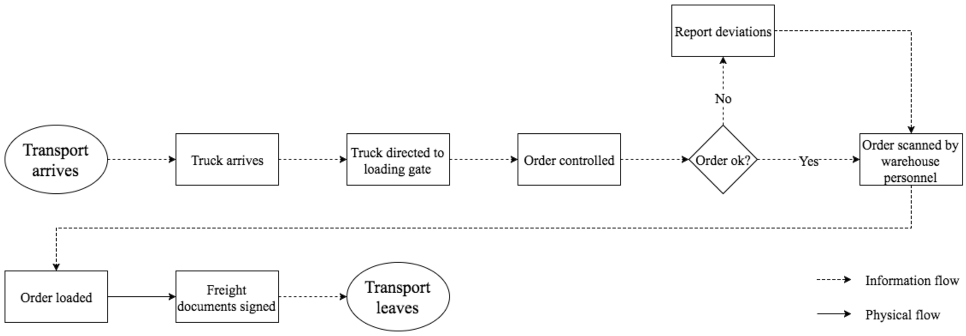

Figure 4-18, Flowchart of the loading processes at the central warehouse in Helsingborg

4.3.4 Client store receives order

When the truck arrives to the client store the driver is directed to an unloading gate. The driver unload the pallets and the order is controlled by the personnel at the client store. If there are deviations these are communicated to Bring SCM. When the goods have been received, it is reported to Bring SCM automatically between the systems. Once the unloading and controlling have been completed the freight documents are signed and the replenishment process is completed. Figure 4-19 illustrates the flow described.

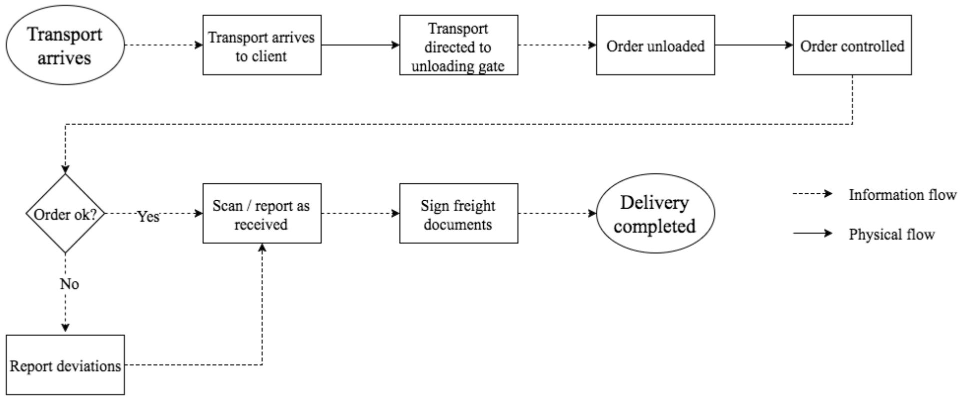

Figure 4-19, Flowchart of the order receiving processes at the client's store

4.3.5 Physical and digital flow, client’s order

The illustration of the physical and digital flow and each process is indicated with a number and visualized in Figure 4-20 below. When the client places an order in the web portal it is automatically sent to Bring SCM’s ERP system (1). After Bring SCM’s manual control it is sent to the central warehouse (2) and the status of the order is updated in Bring SCM’s ERP system. In connection with the previous step a preliminary transport booking is sent to the haulier, which consist of how many pallets the order contains, when it should be loaded and the destination of the order (3).

When the order has been picked, it is scanned before it is placed in the loading area in the central warehouse. As a pallet is scanned it is reported automatically to Bring SCM’s ERP system via the WMS of the central warehouse (4). When the order has been picked an updated, a transport booking with the number of pallets is sent to the haulier (5).

When the order is loaded, the pallets are scanned again, it is automatically reported to Bring SCM’s ERP system via the WMS of the central warehouse (6). When the loading of the order is completed, the truck driver transport the goods to the client (7). By the time when the order has been unloaded at the client’s store it is automatically reported to Bring SCM’s ERP system, where it is updated as “order delivered”.

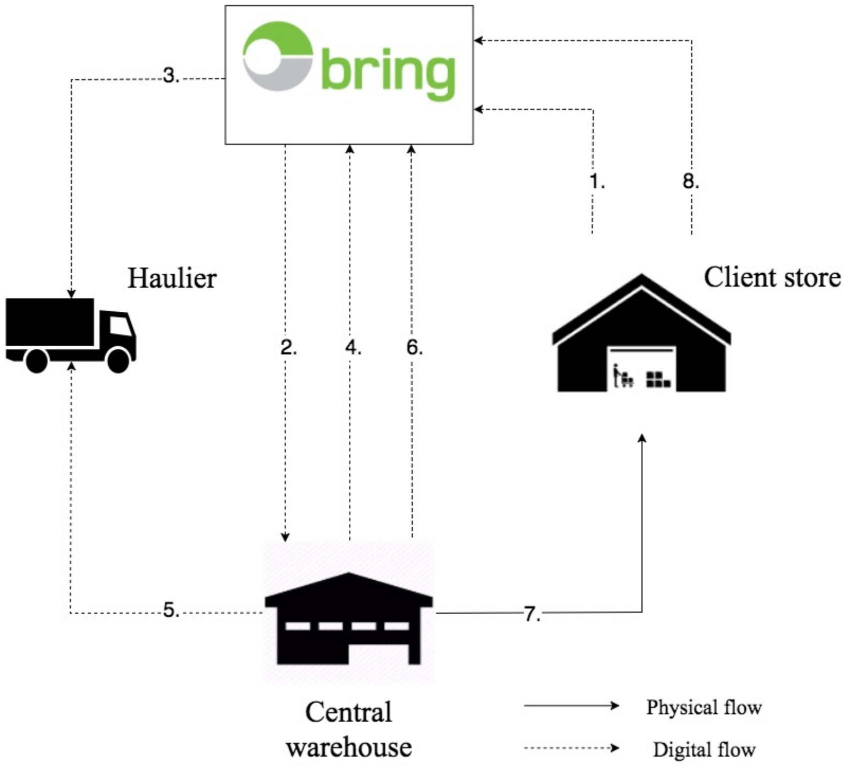

Figure 4-20, The digital and physical flow of a client order.

4.4 Field test

4.4.1 How to design the artefact

Before being able to perform a test with the artefact one must decide what data to trace, and how it should be traced. The four pillars, i.e. product identification, data to trace, product routing and traceability tools, by Regattieri et al. (2007) was used as a foundation of what to include in the artefact. As mentioned by Dai et al. (2015) and Manos and Manikas (2010) the decision of what to include in a traceability system is based on the balance between cost and the capacities and capabilities of the supply chain. The current capabilities were investigated through the case study, described more in detail in sub-chapter *4.2 Purchase order* and *4.3 Client order*, which gave insights of the current situation regarding the traceability issue, i.e. the real-world problem, for Bring SCM. The increasing demand of more sustainable and transparent products as mentioned by Rao and Holt (2005), Singh et al. (2008), Trienekens et al. (2012) and Fritz et al. (2017), was a major influence of what information to track and trace.

Given by the scope of the study, the product routing choice of the traceability system was limited. For a complete traceability system one wants to be able to trace a product already from the raw materials, but this was not possible in this research. The available flow ranges from when the product was available at the supplier, till it was delivered to the client store.

As mentioned by Regattieri et al. (2007), Salampasis et al. (2012), Bosona and Gebresenbet (2013) and Aung and Chang (2014) a unique identification is a key requirement of an efficient traceability system. It was decided to use the current product identification technology which is based on one-dimensional barcodes. Each pallet is labelled with product and batch information and a SSCC number, which is used as a unique identifier. Boxes and consumer packages have a barcode, but there is no unique identifier on this level of packages. Therefore, the smallest unit that can be uniquely identified and used as a TRU is a pallet.

The increasing demand of transparency influenced the authors to, in an earlier phase of the chain, being able to track and trace each pallet. Tracing each pallet uniquely from the supplier is also positive from the perspective of safety. Thereby, the time to trace eventual contaminated food could be reduced, which is of highest importance (Kher et al., 2010). The pallets were traced uniquely by connecting the SSCC number of each pallet to an order. By doing so, the pallets can be scanned one after another and manually connect them to an order. This is easy if it is a small order, but if it is an order in the size of a full truck and trailer it would require the truck driver to scan almost 100 pallets before loading. A very time consuming activity for the truck driver. The fact that the pallet label can include up to three barcodes where all must be scanned to retrieve the necessary information add even more time to the scanning. One solution could be to integrate the suppliers' ERP systems to the artefact and automatically transfer the SSCC identities of an order to the artefact when the pallets are prepared and picked. This type of system integration was chosen as the most suitable solution to use. In the field test a fictive database was created with information about the pallets and the products on them, which intended to work as the integration.

Additional to the information about pallets and orders, information about the truck used during the transportation was of importance for Bring SCM. The environmental question has, according to Rao and Holt (2005), Singh et al. (2008), Trienekens et al. (2012), Gualandris et al. (2015), Fritz et al. (2017) and for Bring SCM increased in importance. To measure the environmental performance of a truck, the emission standard was decided to be used as an indicator along with the travel times.

As mentioned by Wognum et al. (2011), Sayogo et al. (2015) and Tapscott and Tapscott (2016) the data must be relevant, accurate, reliable and of appropriate quantity to be credibility and trustworthy. Due to the data must be reliable and the future potential of blockchain technology (Fanning & Centers, 2016; Mettler, 2016; Nguyen, 2016; Tschorsch & Scheuermann, 2016; Iansiti & Lakhani, 2017; Joichi et al., 2017), it was early decided to find a traceability solution based on blockchains. The technology, is useful since it supports traceability and transparency (Tian, 2016) and can be used as a recordkeeping unit (Lemieux, 2016).

The framework by Brennan and Lunn (2016) and Hancock and Vaizey (2016) was used to evaluate which type of blockchain to use. Since our collaboration partner, Bring SCM, wants to have shared access but limit the access to approved participants, and at the same time, being able to influence the network to some extent, a permissioned public ledger was chosen as the most suitable blockchain to use. The blockchain technology could be implemented into the given situation by using Hyperledger fabric, which is adaptable to many different type of users and it is based on a permission ledger (Hyperledger, 2016). The positive effects that comes along with the use of the Hyperledger fabric is that it has no heavy mining activity to verify the transactions as the Bitcoin blockchain has (Swan, 2015). In the Bitcoin blockchain the mining activity takes approximately ten minutes to approve a transfer, which is not applicable when quick transfers between holders is needed. Another positive aspect with Hyperledger fabric is that it supports the use of smart contracts, which could be useful if one want to add, for instance, environmental, collective agreements or other factors to the blockchain, in the future. Therefore, the artefact was developed on an Android smartphone based on a permissioned public ledger supported by the blockchain of Hyperledger fabric, see Figure 4-21

Figure 4-21, The type of blockchain used.

To figure out how the goods should be transferred between different holders, the core identities of a traceability system by Moe (1998) was used, illustrated in Figure 3-7 in section *3.2.1 Tracking and tracing*. To adapt it to the current situation and all events that take place in the supply chain, the two core entities must be adjusted.

In the setup used, assets are moving between different identities. The assets, used in the artefact, are defined as box, pallet, order and truck. The identities are the different actors involved in the processes. Since the personal data must be kept personal the companies where the persons are employed was used, which are *supplier A*, *cross-docking warehouse*, *central warehouse*, *truck driver* and *client stores*. The assets and the identities can be seen Figure 4-22. Notice that, moving goods between identities others than a truck driver as an intermediate is restricted through the coding of the artefact. It is also of importance that a truck driver cannot pull or accept goods without already be connected to a truck, which also is solved by the coding.

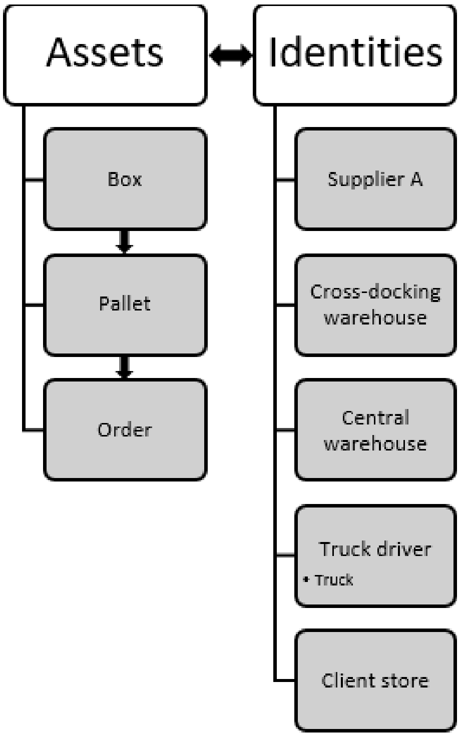

Figure 4-22, Used assets and identities.

4.4.2 **How the artefact works**

The smartphone application used in the research was a Beta version, where the back-end was programmed in Python and the front-end was programmed Hybrid. The application was developed by two technicians. The application works as an intermediate between the Hyperledger fabric blockchain and the barcodes on the pallets. The application scan barcodes via the smartphone camera and aggregate the data to the Hyperledger fabric blockchain. All information, such as order information and truck information, is retrieved from a fictive database.

The relation between identities and assets are the following: an asset can be aggregated to another asset and by doing so, larger assets can be created. This is not possible for the identities. The only identity that is special is the truck driver identity, to which it is possible to connect a truck and the emission standard of the truck. By building larger assets fewer transactions need to be approved and valuable time can be saved. When a transaction is executed the Hyperledger fabric blockchain stores the data in a chronological order, impossible to change afterwards.

When one wants to create an order, the boxes of an article is aggregated into a pallet with a unique SSCC number. The pallet also contains information about the batches of the boxes. The pallet or pallets are then aggregated into an order, and as a final step in the creation process, the order is transferred to Supplier A, which is the first possessor of the order in the field test.

When a truck driver login to the smartphone application, which should be made each new working day, the driver is forced to enter the license plate of the truck used. This, to get the information about the truck's emission standard, which in this test is retrieved from the fictive database, which in turn, was linked to the Swedish license plate register system, i.e. "Transportstyrelsen", where the information was gathered.

From the warehouses personnel perspective, an identity should be entered in the beginning of a working session or if the device changes user. In the test, it was decided not to use personal identification, instead it was keep on a company division level, Supplier A for instance.

Regarding the transfers between parties, the receiver of an order should always pull the assets from the current holder. This to avoid that the transfers are forced to another holder or transferred by mistake. An asset is pulled from the current holder when the new recipient scan the SSCC barcode on one of the pallets of an order and request transfer in the smartphone application. Since scanning of a pallet is required, it is unlikely that transfers are made by mistake. When a pallet has been scanned, the smartphone application retrieves the SSCC number of the pallet from the fictive database and finds the order to which it belongs. If one scan a pallet that is already connected to an order to which another pallet already has been scanned, the application notice that by replying: "*order already scanned, try scan again*". If the scanning is executed correctly, the order number is visualized on the interface of the smartphone application. In the next step, the receiver has to begin the transfer by requesting ownership of the order in the smartphone application. The current holder can either accept or reject the transfer in the smartphone application. Once the order is accepted the asset are moving from one identity to another. The transfer is not completed until it has been approved by the Hyperledger fabric blockchain, which is done instantly as the sender accepting the transfer.

In the test with the smartphone application it has been decided to exclude the internal handlings of the central warehouse. This, since the transfers between holders are of highest interest from the perspective of a 4PL company. To increase the reliability of a transfer it cannot be made between a supplier's facility to the central warehouse in Helsingborg, without using an intermediate truck driver. A transfer between truck drivers, without using an intermediate warehouse, is possible, since this is one of the occurrences when using a cross-docking warehouse. All those restrictions are handled through the coding of the artefact.

4.4.3 Artefact test execution

To perform the test two Android smartphones with the traceability application were used. Note that all transfers between different identities are initialized by the receiver of an order. Due to integrity reasons the license plates of the trucks, specific information and pictures on trucks and goods has been modified or blurred so the information from the test cannot be connected to the companies or products followed in the test.

The test of the artefact i.e. the smartphone application test was divided into two parts. The first part covered the flow of Product A, from loading at Supplier A till unloading at the central warehouse in Helsingborg. Three orders which consisted of four pallets in total were followed during the first part of the test. The second part covers the journey of a mixed pallet, containing Product A among other products, from loading at the central warehouse in Helsingborg till it was unloaded and received at the client store. The reason to divide the testing into two parts was that the central warehouse in Helsingborg stores Product A for a couple of weeks before it is shipped again. Therefore, the flow of the same identities of Product A could not be coherently followed without extending the research time heavily. Hence, the authors simulated the second part. The simulation was executed with real-world information, provided from the different actors in the chain. The results of the simulation versus follow the flow, would have been identical since the procedures from the first parts are similar to the second. The overall covered transfers can be seen in Figure 4-23.

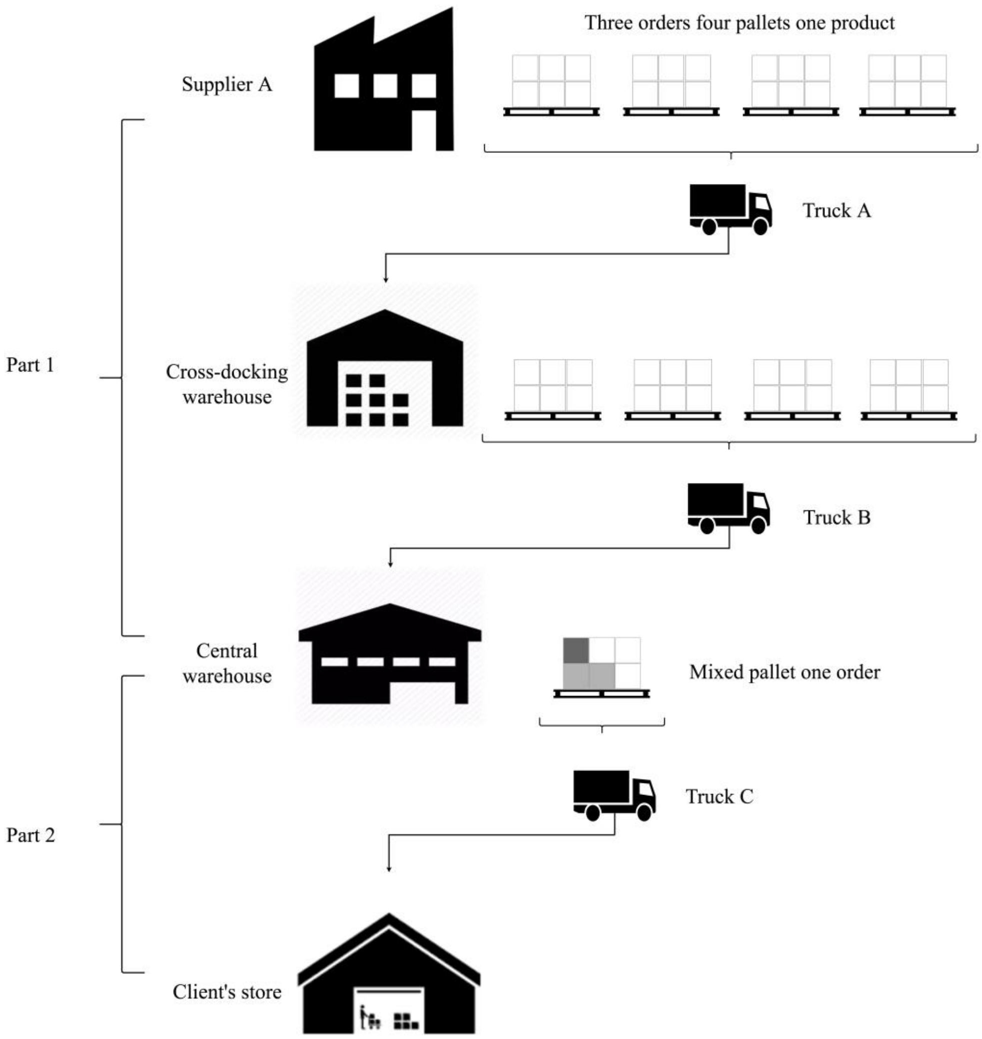

Figure 4-23, Test execution

4.4.3.1 Supplier A to truck driver A

Initially, one of the smartphones was logged in as a truck driver A identity, whereas the other one was logged in as a Supplier A identity. Before arrival of truck driver A to Supplier A, the authors prepared one of the smartphones by log in the identity of truck driver A and assigned him to the truck by typing in the license plate (ABC 123) of the truck into the smartphone application, see Figure 4-24.

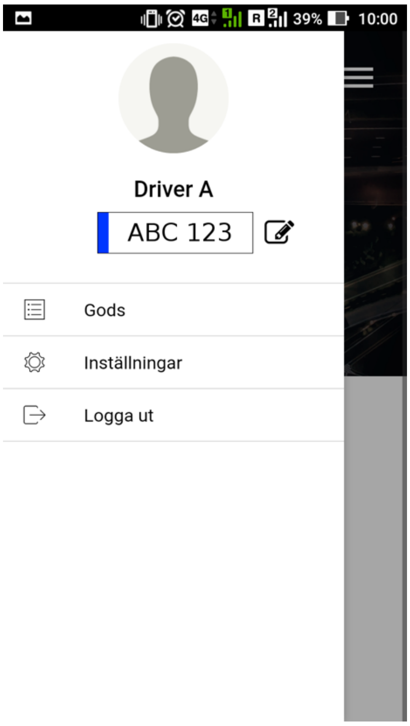

Figure 4-24, Driver login interface.

The fictive database retrieved the emission standard of the truck and connected it to the truck and driver. The license plate revealed that truck driver A drove a Scania with emission standard Euro IV. The other smartphone was logged in as the identity of Supplier A. Upon arrival to Supplier A, truck driver A collected the freight documents and controlled if the orders were undamaged and the quantities were correct. When truck driver A loaded the four pallets the authors made sure that the barcode of the SSCC number of one pallet of each order was scanned by the smartphone application in collaboration with truck driver A. The other smartphone, in possession of Supplier A, was accepting the transfer of the orders in collaboration with the authors. This procedure was executed for each order that were loaded on the truck. Screenshots from the smartphone application were taken of one of the transfers, which can be seen in Figure 4-25. The screenshots are visualizing the above described procedure where truck driver A scan and ask for transfer ("begär överlämning"), which can be seen in the left-hand side screenshot in Figure 4-25. When pushing the button "begär överlämning" a pop-up window occurs on the other smartphone, which states that driver A ask for transfer of goods with the specific order number, in this case 01114318. The current holder, i.e. Supplier A, is then pushing the button "info", which can be seen in the screenshot in the middle in Figure 4-25. Once the "info" button is pressed a new window pops up with the alternatives reject ("avvisa") or accept ("accept") the transfer, which can been seen in the right hand side screenshot in Figure 4-25.

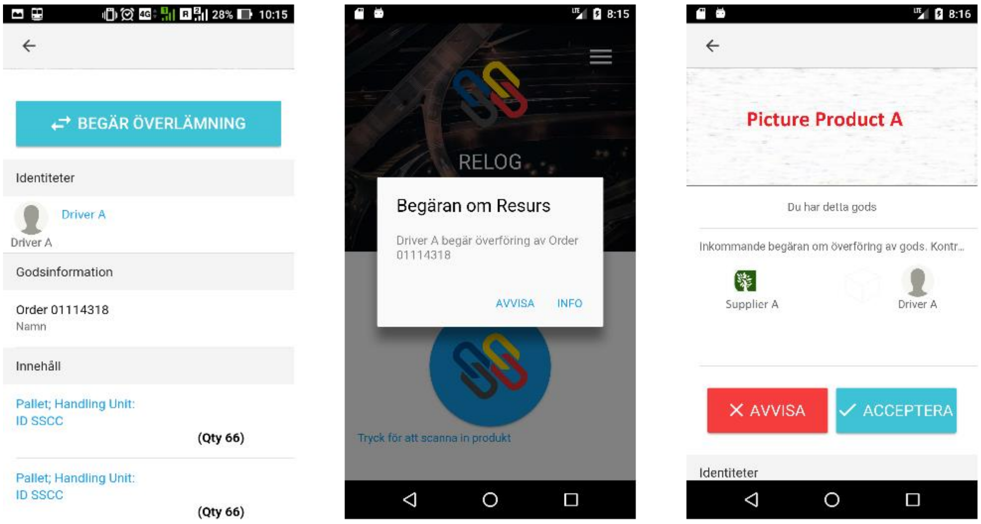

Figure 4-25, Transfer process in the smartphone application.

Once the transfer has been approved by the sender the first transfer of the order was completed and a digital signature was created and stored on the Hyperledger fabric blockchain. Truck driver A was, at this point in time, the holder of the three orders.

As the test was completed, questions about the artefact were asked to a person employed by Supplier A, who was involved in the transfer procedure. The response was overall positive, but there were some concerns that it should be time consuming to scan all pallets of an order as they are loaded. When it was explained that only one pallet of an order has to be scanned, the employee of Supplier A was more positive to use the application.

4.4.3.2 Cross-docking

The authors followed the truck's journey from Supplier A, with one intermediate stop for another customer than Bring SCM, before reaching the cross-docking warehouse in Gothenburg. Before arrival, the authors were informed that truck driver A would perform a cross-docking directly to the truck that would execute the transport to the central warehouse in Helsingborg. The smartphone used as the identity of Supplier A in the previous transaction was logged out and logged in as the identity of truck driver B, and the license plate of the truck was assigned to truck driver B. When the fictive database retrieved the license plate of the truck, it was clear that the Volvo truck used had the emission standard Euro VI.

The unloading from truck A to truck B was performed quickly, since the latter was waiting for the arrival of truck A. The authors made sure that the scan and transfer procedures were performed as planned, in collaboration with the truck drivers. Truck driver B initialized the transfer by scanning the SSCC barcode on one of the pallets, and pulled the order from truck driver A, by a click on the screen on the smartphone, in the same manner as the previous transfer. The text-box that asks for accepting or rejecting the order appeared on the screen of truck driver A's smartphone, and he accepted that the order was transfer to the new holder, i.e. truck driver B. This procedure was executed for all three orders. During the scanning of one of the barcodes some technical issues with the application occurred, which forced a reset of the application, but a second try was executed successful.

After the transfers questions were asked to truck driver B about his thoughts of the application. The response was that it must be fast and easy to use as there is no time to stand and wait, where indications were drawn to the application restart that was needed. Except for the concern about the time, the expressions were positive and the idea to transfer between the identities digitally, in this case the truck drivers, was appreciated.

It should be mentioned, that since the Beta version of the smartphone application was used, a transfer between truck driver A and truck driver B was infeasible without an intermediate transfer to the cross-docking warehouse.

4.4.3.3 Truck driver B to central warehouse

When the three orders that contained Product A were received at the central warehouse in Helsingborg the first part of the test was finished. This part was executed in the exact same manner as the previous transfers procedures. i.e. the recipient login and scan the order and ask for transfer in the smartphone application whereas the truck driver B accept or reject the transfer.

4.4.3.4 Central warehouse to truck driver C

The second, simulated part starts when truck driver C loads the orders at the central warehouse in Helsingborg. The simulation was made in an environment with copies of the real-world information. The available information was one mixed pallet, containing Product A among other products, transport label which consist of information about the destination, Bring SCM order number and a SSCC number written both in text and as a barcode. To simulate the process a fictive database was used which stated what was stored on the pallet, identically to the first part. This information was available through the central warehouse's WMS. When the SSCC barcode was scanned on the transport label on the pallet, the smartphone application recognized the content of the order since the SSCC numbers was connected to the order.

The truck information was also connected to the fictive database in the same manner as in the previous steps, where the information was based on real-world data from the haulier. This data was then retrieved from the database when the login of truck driver C was simulated. The license plate disclosed that the Scania truck used had emission standard Euro V. As truck driver C scanned the pallets barcode, information about the order was shown in the smartphone application and the driver then pulled the order from the central warehouse who, in the same manner as previous transfers, accept or reject the transfer.

4.4.3.5 Truck driver C to client store

This last part of the test, which also was simulated, covered the transport from the central warehouse in Helsingborg to the client's store. At arrival to the client store the client logged in and pull the order from truck driver C, a commitment that demand acceptance or rejection from truck driver C, like previous transfers. Once truck driver C accepted the order the entire flow from Supplier A to client store was covered.

4.4.3.6 Overview of the flow

It is possible, for a manager, during the transportation, to login and look exactly where the last transfer took place, at which time and by whom. One of the order's flow containing Product A can be seen in Figure 4-26.

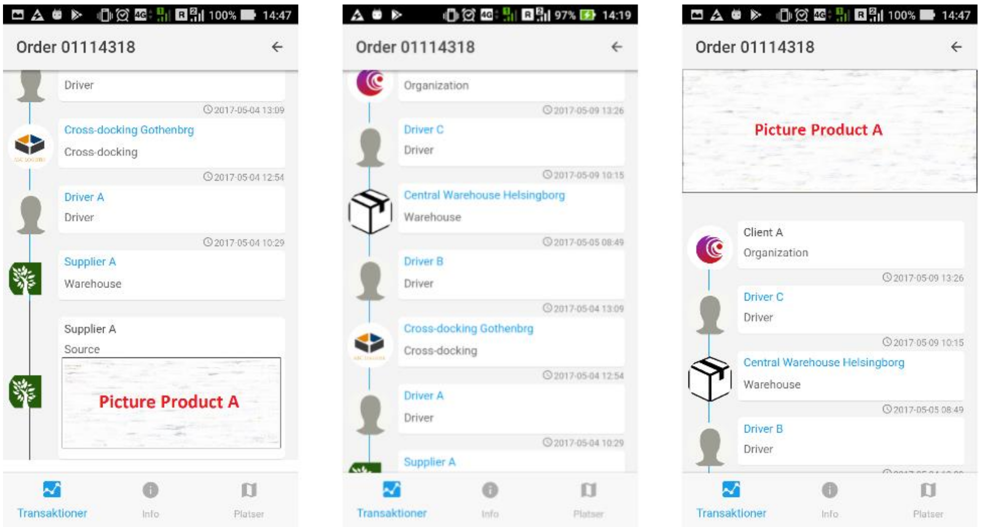

Figure 4-26, Order history from the smartphone application.

The fact that all transfers are stored on the Hyperledger fabric blockchain, free to access if participating in the blockchain, one can look up the history of a product and identify the entire chain with minimal workload. The emission standards that the trucks are using will, by using this setup, be transparent for every participant. By clicking on the different truck driver on the screen one can see the emission standard used including the travel time for each truck, see screenshots in Figure 4-27. For future setups, the collective agreement of the truck drivers is also visualized.

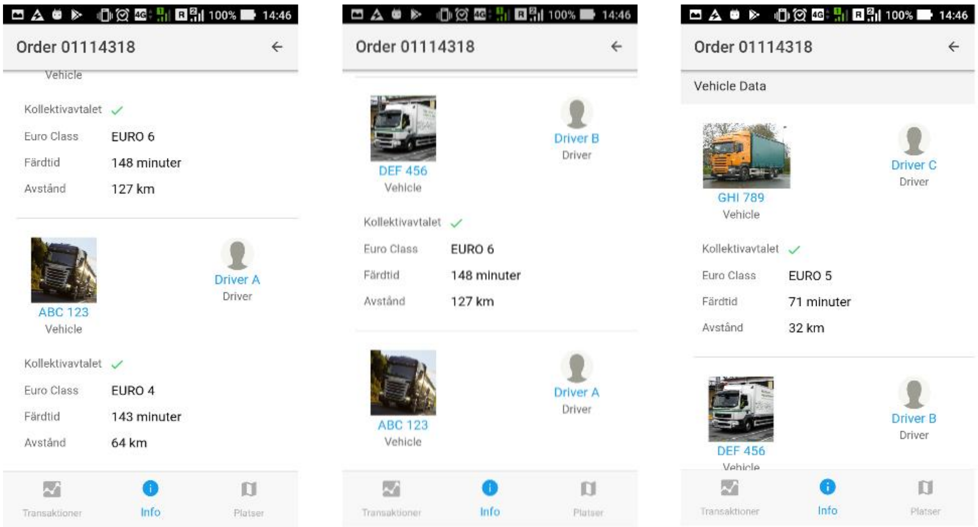

Figure 4-27, Transportation information from the smartphone application.

5 DISCUSSION

The discussion chapter forms the base of the conclusions. To be able to answer the research questions and thus solve the real-world problem, this chapter discuss the advantages and disadvantages of using a blockchain based solution, as well as the requirements and effects of using the artefact.

5.1 The artefact

When arguing about the use of blockchain technology, the type of ledger is irrelevant, unless it is not a traditional centralized ledger, since it is not based on blockchain technology. If it is not further pointed out, the blockchain intended is a permissioned ledger, more specific the Hyperledger fabric blockchain.

By implementing a traceability artefact as the one used in the field test, one will receive status updates of all transfers made of an order. The artefact will enable monitoring of the movements of an order and will put the companies who use the artefact in a position where full control of the goods is achieved. A result obtained since the digital and physical flow are matching, illustrated in Figure 5-1, which was not the case before. So, the real-world problem faced by Bring SCM can be solved by using the artefact.

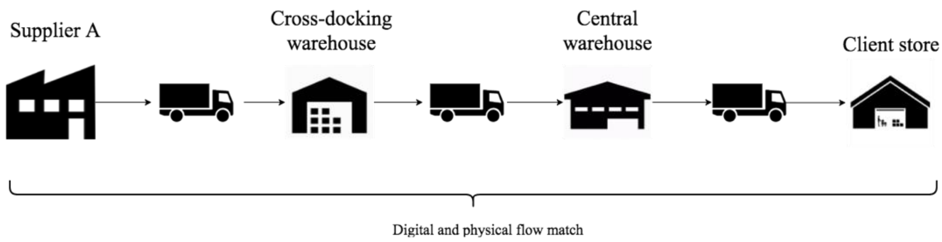

Figure 5-1, The digital and physical match.

By using the artefact one can in an earlier phase detect if an order will be delivered later than expected, which is an advantage. As it is today, Bring SCM will not be notified if an order is late or missing until someone at the supplier questioning why the goods was not loaded or delivered the day it was supposed. By the time the delay is discovered a few days could have passed, causing the order to be even more late.

To find out the reason about the delay, some investigation must be made. First, the responsible haulier must be contacted who then will investigate, internally, where the problems might be. It could be a planning mistake, some mistake by the truck driver or communication issues. As no digital footprint exist, one cannot exclude any of these reasons and many hours could be wasted before the hauliers return with a legit answer. Positive effect that comes along with shortening the time for delays by identifying the source of failure, is that the availability and service level towards the client could increase and lead to more satisfied clients.

If the artefact is used and every event is logged digitally, the required investigation process to locate an order can be reduced tremendously. The suggested blockchain solution do enable the timestamp of when an order was transferred between holders and who the current possessor of the goods is. Additional, the emission standards of all trucks used for transportation are visible by the blockchain. Since the information on the blockchain is accessible for the ones with permission, the required transparency is obtained.

It must be mentioned that the same traceability result could be achieved without the blockchain connected to the artefact. A traditional centralized system could achieve the same result, but it would not gain the benefits from the transparency, which the use of a blockchain connection brings.

5.1.1 Collaboration

To be able to implement and run a traceability artefact, based on blockchains, there are several requirements which must be fulfilled. As Sanfiel-Fumero et al. (2012) mention a traceability system requires a lot of effort in inter-organizational activities. During the observations, the complexity of traceability was obvious even though only one supplier and one product’s flow was studied. The complexity that was faced when tracing Product A from Supplier A to the central warehouse, like in the test, where four parties were involved, points on the obstacles but also the requirements.

In cases with other suppliers around the world there can be even more parties who are involved, which makes it even more complex. A first step must be to create acceptance of the artefact among the involved partners. Bosona and Gebresenbet (2013) and Kher et al. (2010) discuss that the implementation of a traceability system is complicated and extensive, which might create a resistance among the partners to participate and collaborate.

A key partner for a traceability solution in the studied part of a supply chain is the hauliers. It became obvious during the observations, since the truck drivers are involved in all the transfers between the different holders. Therefore, it requires motivation and incentives for the truck drivers to use the artefact, and it is of highest importance to be successful.

Another key stakeholder is the 3PL companies who handles the warehousing services. The warehouses are involved in both receiving of the purchase orders and the loading of client orders. Therefore, in order to achieve a physical and digital match of a product's flow, the 3PL companies are important actors.

5.1.2 Motivation

It is of highest importance that the involved parties are aware of the consequences and are motivated to participate to achieve a successful traceability, which are discussed by Donnelly et al. (2012), Bosona and Gebresenbet (2013) and Dai et al. (2015). It is enough that one part of the chain does not have enough incentives to participate and the traceability for the entire chain will be affected.

While executing the test of the smartphone application, it was clear that both the managers and the employees at Supplier A saw benefits of using a traceability tool based on a smartphone application. During the field test, it was obvious that truck driver A, who loaded the goods at Supplier A was not very interest in changing his working routines and use a smartphone application. During the test, there was a potential a risk that the scanning process would not been made without the authors monitoring the procedure. At the cross-docking warehouse in Gothenburg, truck Driver B was positive to the smartphone application but as truck Driver A's motivation to use the smartphone application was low the transfer between the drivers was suffering, even though it in the test was successful. As mentioned above, when one part is not motivated to participate or does not want to collaborate, the overall traceability will suffer. A potential reason to not participate in the use of such artefact, is that some party might see it as an extra burden and additional work without gaining any benefits of it, which is stressed by Bosona and Gebresenbet (2013). Add a situation where the different actors in the chain often already have a solution for the tracking and tracing of goods implemented. This means that a company have three options; replace the current system, run two systems or just simply use the current one. All options except for the last one would require much effort and investments from each actor, but it would also require a massive collaboration between the involved parties, since the systems of each party must interact with each other or the same system must be used. This is the case, regardless if a 4PL choosing to use a blockchain based solution or another centralized one.

Besides from the truck drivers who are the actual users of the artefact, there must be incentives for the planning personnel of the hauliers to use the artefact as well. If one cannot convince the hauliers to use the artefact, the possibility to succeed with the implementation will probably be lost.

5.1.3 Scanning

Since it was decided to track and trace each pallet uniquely from Supplier A to delivery at the client's stores, there was basically two solutions for getting the data into the blockchain via the smartphone application in a reasonable time frame. One solution was to scan each pallet individually during the loading process. It would be a massive increase in work for the truck drivers and it does not seem to be a good solution, both time and motivation-wise speaking. To avoid too many scanning procedures, a second solution was discussed; to integrate the artefact with the suppliers' ERP systems. For the test, a fictive database with information about the orders was created beforehand, to illustrate the later solution. To make the transfers between holders as simple as possible, the artefact was configured in a way that it was enough to scan one pallet of an order to get information about the entire order and thereby, being able to transfer it to the next holder. If the information from the order was found in the blockchain the smartphone application visualized the order that the pallet was connected to on the screen.

During the test, one of the transfers between truck Driver A and truck Driver B had some technical problems and the transfer took more than ten seconds to be approved which led to negative comments about the time it took to complete a transaction. The conclusions drawn from the test is, that the scanning must be simply and fast to perform, and the transfer between holders must be approved immediately, without technical issues. Therefore, the smartphone application must be user-friendly and reliable.

One disadvantages in the Beta version of the artefact is, if a shipment consists of several orders of few pallets, it would require a bigger impact on the current workload from the sender and recipient point of view, since many scanning procedures and transfers are needed, which takes time. On the other hand, if there are few orders with many pallets on it, the impact will be small, since fewer scanning procedures and transfers are needed.

Regarding the transactions, it became obvious, in the current setup, that a pallet of each order must be scanned and then immediately transferred, which is not optimal when loading multiple orders. A better solution would be to load the entire shipment at once and afterwards, ask for transfers and acceptance of the orders. Therefore, a feasible artefact should be able to save a scanning until the complete truck is loaded and then execute all transfers at once.

Pallet labels from Supplier A includes three barcodes and it is easy to, by mistake, scan the wrong barcode. It could lead to frustration, and unwillingness to use the equipment, among the personnel, especially in a stressful situation. General mistakes when using the artefact are most likely highest in the initial phase, due to the learning curve. Therefore, it is of importance that this initial phase is short, since the confidence for the artefact is on stake which could jeopardize the entire chain. The issue with scanning the wrong barcode can potentially be solved with picture recognition where the whole label is scanned with the smartphone camera which automatically could recognize the correct barcode. Due to different supplier use different types of pallet labels the artefact must be able to handle all type of barcodes. It should also be pointed out, that the pallet labels from the Supplier A followed the GS1-128 standard, which should be the case for all suppliers, but learned from the observations at the central warehouse in Helsingborg, this is not always the case. If a pallet label does not follow the standards and fulfill the requirements of a barcode it cannot be scanned at the central warehouse, which is problematic since a new pallet label, which following the standards, must be printed and attached. Therefore, the quality of the labels along the supply chain must be controlled and approved to avoid dysfunctionalities of the artefact.

5.1.4 System integrations

For a 4PL company who wants to use a traceability artefact, system integrations with the suppliers are a prerequisite to be able to identify each pallet of an order. To run the artefact on the rest of the chain requires critical collaboration and integration with the contracted 3PL.

Regattieri et al. (2007), Kher et al. (2010), Thakur and Donnelly (2010), Salampasis et al. (2012), Bosona and Gebresenbet (2013) and Aung and Chang (2014) discuss the absence of standards for traceability, both in the data and the data exchange. How much work it would require to setup system integrations with the suppliers has not been validated, but since regulations controls that an actor in a chain must be able to track a product one step upstream and one step downstream, the information exist, which means an integration is doable. Regarding Supplier A, all information about the sent pallets already exist in the ERP system, so a system integration would be possible. The problem is that each supplier often has their own setup of systems, which leads to requirements on the artefact to be able to connect with many different systems and data structures. From the case company's perspective, the majority of the suppliers of the client are large companies producing and delivering to larger wholesalers in respectively country and deliveries to markets outside the domestic are common. Therefore, it is most likely that well-developed ERP system are used by the suppliers. Though, one must consider that the suppliers probably have a great variety of ERP systems, which set the level of the requirement of the artefact.

System integrations can be challenging, due to sharing data between parties is a sensitive subject. By pointing at the importance of the information and the value it adds to the relationship, as discussed by Jira and Toffel (2013), Sayogo et al. (2014) and Sayogo et al. (2015), it is more likely that the wanted information can be shared between the parties, if one manage to do so.

In the handling process within the central warehouse in Helsingborg a system integration is needed. In the range of the test the authors did not consider the processes within the central warehouse. To be able to cover the entire flow it is essential to connect the last part of the chain, which must be seen as a requirement since the products are mixed before departure from the central warehouse to the client's stores. After the picking process in the central warehouse the WMS can state which products that are on a specific picked pallet and which pallet the products have been picked from. By connecting the products of a picked pallet's SSCC number with the SSCC number of the pallet from where the cartons were picked, the complete history of the distribution of a product can be retrieved.

Another aspect of the system integration from the perspective of Bring SCM, is that they have 16 distribution centers around the world where similar events like the ones in the central warehouse in Helsingborg occurs. Therefore, the same type of integration must be made in those warehouses, if the same solution should be used for all distribution centers.

The artefact must be integrated with the hauliers transportation system that are used to update when an order has been loaded or another event has happened. To change as few processes as possible and let the haulier work as before, without changing their routines, their work should be made in one interface. For a transport planner, the artefact should work as an invisible tool which update statuses of orders within the existing transportation system. Since the haulier is responsible for the cross-docking activity the artefact could also be used as a tool to update and monitor the stock levels at the cross-docking warehouse, which could be an advantage for the future.

Even though all parties are collaborating the lack of adequate and standardized data from the different actors is one of the most challenging part with a traceability system (Bosona & Gebresenbet, 2013; Aung & Chang, 2014). To enable interoperability between information system across the supply chain, and thereby achieve efficient traceability, global standards are almost inevitable (Aung & Chang, 2014) and should therefore be aimed to be fulfilled by all involved participants.

When assets are moving between identities, i.e. a transfer is made, the data output of the ERP systems and WMS might have to be adjusted to be integrated successfully. By putting additional integration where the suppliers or partners have to change their structure to fit the suggested solution is a source of failure. This puts great emphasis on the artefact to take care of all the adjustment of data structures and transform it to a structure where assets are aggregated to larger assets and then transferred between identities.

5.1.5 Additional information to trace

To get information about the emission standard the truck driver must enter the license plate of the truck when a new working session is started. This can be seen as an unnecessary step but to make sure that the information is reliable it is set to be made every day. There is still a risk that the truck driver enters a false license plate to make it “look good”. A solution where the truck driver take a picture of the license plate in the beginning of each working session, and enable the artefact to run a picture recognition process of the license plate to retrieve the information has been discussed, but not evaluated. Even the picture recognition solution does not make the solution hundred percent solid, since one can always use false plates or take pictures of another truck’s license plate. The authors are aware of this dishonestly, but the solution presented, to insert the license plate manually decreases the possibilities to cheat. A possibility for the future is to integrate the artefact with the fleet management system (FMS) of the used truck. An integration that would enable more valuable data than just the emission standard, but also another system integration that the artefact must support.

Due to sustainability are becoming more important (Singh et al., 2008; Gualandris et al., 2015; Fritz et al., 2017) the authors suggest that a 4PL firm monitor the emission standard connected to the trucks used in the supply chains. One way can be to demand that the hauliers should use a certain emission standard, otherwise they will not get the full payment. By doing so the 4PL could possibly reduce the number of unwanted transportations made, and thereby maintain and increase a good reputation. Controlling if a haulier sticks to the agreement can be achieved automatically in the future if one use a blockchain that supports smart contracts, which the Hyperledger fabric does. Depending on if the agreement is fulfilled, the smart contract can regulate the payments. For instance, if a transport is executed with truck with an emission standard with Euro V or Euro VI, as agreed upon, the smart contracts trigger a full payment. Otherwise, if a transportation is made with a truck with lower emission standard than Euro V, the smart contract automatically transfer another, beforehand decided, lower payment. This could also be used in marketing purpose by visualize the transparency enabled by the blockchain, that there is an awareness and responsibility that the transportations are executed in a sustainable way. In the future, the author see potential to connect the personal identity of the driver to the truck and add that to the blockchain. By doing so, one could probably, decrease the number of hauliers with social non-acceptable standards. One part of the application was if the driver of the truck has a collective agreement (“kollektivavtal”) which can be seen in Figure 4-27. Information like this would make the industry even more transparent than before, and something that scholars as Trienekens et al. (2012), Sayogo et al. (2015), Beske-Janssen et al. (2015) and Mol (2015) believes will be of important in the future, and affect the company using it in a positive way.

5.1.6 Alternatives to proposed solution

A possible solution is to track and trace goods on an order level instead of being able to identify each pallet of an order. By tracing goods on an order level, the system integration with the supplier would not be necessary and a huge amount of work could be saved. In a case like that, the suppliers would only be connected to the artefact by having a connected and permissioned artefact to use when orders should be transferred between the suppliers and a truck driver. This is a simplified way, which probably would be easier to implement, but also in terms of collaboration and motivation of the participants, since no extra system integration for the suppliers would be necessary.

The SSCC number of a pallet will, in a case where the supplier is not integrated, not be available for the rest of the chain until it is received at the central warehouse in Helsingborg, or one of the distribution center. As the pallets have been scanned the SSCC identities of the order can be retrieved from the WMS of the central warehouse, and through the artefact, be logged on the blockchain. The information about how an order has been handled and how it has been transported will still be available. By connecting the pallet identities at a later stage the trustworthy of the information is though, not as high as if the pallets are connected from the beginning. Relevant and trustworthy data are important as mentioned by Dando and Swift (2003), Wognum et al. (2011), Sayogo et al. (2015), which speaks against this type of solution.

Through the TM system it is possible to print freight documents which have a connection to Bring SCM's ERP system. These freight documents do not contain information on pallet level but addresses the weight and how many pallets the order should contain. A natural extension to the TM system and the freight documents is to enable digital freight documents in the artefact. The legal aspect of using digital freight documents has not been further investigated, but if the artefact has the freight documents digitally it would make the use of it more natural and useful for all parties in the chain.

The monitoring of the transportation of orders is made within the TM system by Bring SCM. Preferably, the artefact should be integrated so it could support the TM system with status updates. When a transfer has been completed between the supplier and the haulier, the status of the order should be updated in the TM system, and get the status "order collected". This is something that is possible both on pallet and order level.

The question if one should be able to identify each pallet uniquely or just on an order level does not affect the processes in a significant way, but it affect the implementation and configuration of the traceability artefact. To integrate the artefact with all suppliers would require massive efforts. To be able to identify each pallet uniquely already from the supplier is especially beneficial in case of contaminated food. It could also be beneficial if some pallets are lost during the way to the final destination, since it can easily be recognized through the SSCC number and faster taken care of. From a transparency perspective, more available information is better.

With the alternative solution, the pallets are identified through the SSCC number at the central warehouse in Helsingborg, and can be connected to the order on the blockchain. Still, it would be possible to see all movements and handlings of a pallet which resulting in a faster product recall if necessary.

5.2 Blockchains in general

One of the biggest challenges for implementing a blockchain system can, according to Iansiti and Lakhani (2017), be the complexity. Meaning that all actors in the chain must collaborate to adopt and implement the technology, to make it fruitful. Due to the immatureness of the blockchain technology, there is a lack of standards. The nearest one can come to a standardized system is blockchains like the Hyperledger fabric blockchain. A blockchain that is universal and adaptable so it suits a given type of situation (Hyperledger, 2016). To be able to agree upon which type of blockchain to use puts pressure on the parties involved in the chain. Something that, at this point in time, is a disadvantageous since the field of blockchain is moving fast and predict about the best blockchain type tomorrow is hard.

A big disadvantage regarding the blockchain technology is that few has successfully tried to implement the technology into the supply chain. If one has tried, a narrow flow has been studied, not the wider complexity that a supply chain typically has. Iansiti and Lakhani (2017) points on the novelty problem, as one of the obstacles to overcome to be successful with the blockchain technology. One of few blockchain that can be evaluated is the Bitcoin blockchain, which work as planned. A blockchain like the Bitcoin blockchain, where a transaction takes up to ten minutes to be verified by the miners, is not suitable for a supply chain, were time is highly valuable. The use of more universal blockchains, like the Hyperledger fabric, which is adaptable to certain types of business might be more useful to use in the supply chain for a 4PL, which is why it was used in the test. The lack of research on these types of adaptable blockchains is nearly total, which speaks for an immature technology. The executed field test points on the possibilities of the blockchain technology and it is doable but it requires motivations, collaborations and system integrations to work smoothly.

In case of the blockchain solution, there could be doubts towards the technology among parties within the supply chain. The reasons of the fear can be many, but one of the reasons can be related to safety. Some might believe that the blockchains are not safe and that secret information that have been shared in trust could be attained by anyone trying to gain access to the system. One can also argue that the distribution of data means that the control and ownership of it is lost.

To implement a blockchain solution, the involved parties must agree on what type of blockchain to use. The companies must ask themselves who should have access to the blockchain and being able to make transactions, which is strongly connected to the level of transparency that the involved ones want to offer.

A superior advantage, compared to the unpermissioned ledger, is that the Hyperledger fabric blockchain does not require mining activities in the same manner as the Bitcoin blockchain since the users have been given permission already. Several nodes (permissioned parties) must approve a transaction but it is made instantly which makes it more suitable to a traceability solution. The fact that permission is needed to use the blockchain, makes is easier to agree on the permissioned identities and what information to disclose, compared to use an unpermissioned ledger.

When choosing the type of ledger one should also think of the functionality of smart contracts, if it is something that is needed or not. Smart contracts put higher demands on the blockchain and the information, but can enable other business possibilities that would not be possible without the smart contracts.

The nature of blockchains makes it impossible to manipulate the data to look better afterwards. Once a transaction has been approved it cannot be changed without interrupting the rest of the blocks in the blockchain. If something goes wrong or is transferred by mistake it must be retransferred back again to get the right holder of the goods. Since it is not possible to manipulate the information afterwards a 4PL company can be confident that the information from the collaboration partners are reliable and trustworthy, even though there is no reason not to. Another positive effect that comes along using blockchain technology is that all with permission to the blockchain holds one copy of the ledger. Which means that if one party lose data of some reason, it will not affect the chain.

5.2.1 Blockchain as a traceability solution

Due to blockchain can store the history of all transactions ever made and it is easy to recreate the history and identify the origin of a product, the blockchain technology is fully supporting a traceability system in line with the definition stated by Pizzuti and Mirabelli (2015). The use of the blockchain as a traceability system is useful since the speed of detecting and identifying a certain product is done in a blink of an eye, even though the same result could be achieved in a well performing centralized system. The speed is of importance in general, but of great importance when dealing with food, especially if it is contaminated, when the source need to be identified quickly. Regarding a centralized system, information connectivity between the partners are required for an effective traceability system (Bosona & Gebresenbet, 2013) since one of the parties is the responsible for the data.

For the 4PL case company Bring SCM, the traceability is suffering due to lack of digital updates, but it cannot be assumed that this is the general case for a 4PL. In a blockchain system where the information is gathered and accessible for all parties connected, would have a shorter localization process of the goods if that is requested. So, identifying a product’s origin or history could be completed without further interaction between the parties which is an advantageous. Thereby, a 4PL could use the blockchain to track and trace goods as it is moving through the chain and at the same time fulfil the regulations which states that each part in the chain must be able to track and trace a product at least one step up and one down in the chain. Even though, a blockchain can fulfil traceability, distinguishing the differences in performance when using it in comparison with a centralized system is not possible. Therefore, the traceability functionalities that could be achieved by the blockchain solution could also be achieved by a traditional centralized system.

Beside that blockchains fulfil the requirements of a traceability system, it can also be used as a marketing tool. By pointing at the blockchain and visualize how the participants can control the goods (Liao et al., 2011; Storoy et al., 2013) and the total transparency (Iansiti & Lakhani, 2017) that the chain has, it is not unlikely that the company image and reputation could be improved (Fombrun, 1996; Carter & Rogers, 2008). This could also lead to increased loyalty among current customers (Pizzuti & Mirabelli, 2015), and the chain could also be used as an argument for attracting new customers (Svensson, 2009). This is major advantages that could affect any company using blockchain technology in a positive way. This, due to the possibility to distinguish oneself from competitors, by point on the transparency and the monitoring of the goods flow in the chain, could be done with ease. In the case of quickly finding the source, when dealing with contaminated food, the brand image of the company could also be protected (Mejia et al., 2010) and the negative impact caused by the media reduced (Dabbene & Gay, 2011).

To use blockchain technology as a record-keeping solution is promising but all the traceability activities can be executed similarly even though a traditional centralized database was used. The differences are not notable and of less importance when dealing with the artefact. If a 4PL company decide to use the artefact they might have slightly more influences of what to disclose but, once again, everyone must agree which affect the possibilities to be the key stakeholder in a situation where consensus must prevail.

The artefact, based on blockchains, enables an increased transparency and enable a 4PL firm to take a step towards a market leading position. In terms of Bring SCM, the solution enables control over the goods since it can be monitored in a way that was not possible before. Through the information about how the transportations are executed a more sustainable approach can be applied and communicated to customers which seems to be even more important in the future.

5.2.2 **Blockchains for improved transparency**

Transparency is one field that predicts to be of future value especially from the environmental and sustainability aspects (Mol, 2015). It is a field where the customers demand has increased the recent years (Trienekens et al., 2012), since the confidence, from a customer's perspective can be increased by transparency. Beske-Janssen et al. (2015) emphasize that to be able to assess the performance of a supply chain, transparency is the key. One could use a centralized system in order to be transparent by simply disclose information, but the blockchain technology is superior a centralized system in this case.

The strengths in the transparency of the blockchain lies in the trustworthiness as a transaction cannot be changed or manipulated afterwards, a trustworthiness that cannot be achieved by a centralized system, since it is impossible for an outsider to assess the trustworthiness of the disclosed information. The whole idea of blockchain is that the data stored chronologically are verified, and once verified it impossible to manipulate the data afterwards without changing the entire history of the blockchain. It means that once a transaction is made it is irreversible. It is important from the monitors e.g. a 4PLs' perspective, that the information is accurate and reliable (Gualandris et al., 2015), since the information about an order must be retrieved upon requested. Therefore, it is advantageous to use a blockchain technology over a centralized system in terms of trustworthiness.

The use of blockchain technology could supports the environmental aspects and the social aspects (Provenance, 2016) as well, which has been given much attention lately. This, due to blockchain technology supports traceability and transparency, which can be further developed with an integration of smart contracts. By using the blockchain technology and the functionality of smart contracts a 4PL company could limit the possibility that the hauliers using trucks that has an emission standard that is lower than agreed. It is possible to extend the blockchain to visualize collective agreements.

6 CONCLUSIONS

This chapter addresses the answers to the research questions, which is followed by recommendations and the contributions made. Lastly, the authors suggest areas for future studies.

6.1 Research question 1

> *What are the potential advantages and disadvantages for a 4PL company to use blockchain technology to deal with traceability and transparency?*

To be able to answer the first research question a spider chart was created, where the information covered in the DISCUSSION chapter, was boiled down into different factors; *traceability, transparency, trustworthy, maturity and future potential.* From the mentioned chapter and the authors' perception, the factors were scaled between one to five, where a higher number indicates better performance. A comparison between the blockchain technology and a non-blockchain based system, i.e. a centralized system, formed the grading.

Regarding the traceability, similar effects can be achieved by using either of the systems, which equals the grading of the two. The ability to track and trace products is good, which sets the grading to a four.

The blockchain types can be divided into permissioned public and permissioned private, and unpermissioned public ledgers, whereas the latter is fully accessible for anyone and the first two requires permission to access. Thus, the transparency can differ between the different type of blockchain systems, which sets the overall performance in terms of transparency of a blockchain solution to a four. The centralized system is set to two, lower than the blockchain solution, which is due to one party is controlling the information in such a system.

Even though blockchains can be permissioned or unpermissioned, the data on the blockchain is trustworthy. This is due to the advanced mathematical algorithm which makes data stored on the blocks impossible to alter afterwards. Therefore, the same trustworthiness achieved by a blockchain solution cannot be accomplished by a centralized system, which is the reason to the big difference and why the blockchain is graded to a five and the centralized system a two out of five.

Further, in terms of maturity there are challenges to overcome before a blockchain system can be comparable to a centralized system. Hence, the maturity is the only factor that is lower for a blockchain solution than a centralized one, which the author graded to two out of five whereas the centralized system was set to four.

Lastly, blockchain technology is said to be superior to the centralized system in terms of the potential of the future, which is mainly based on the trustworthiness and transparency it brings and the features, such as smart contracts, that are enabled. Thus, the future potential of the blockchain system is set to four and the centralized is set to two out of five.

The spider chart in Figure 6-1 visualize the above described factors. The maturity is the biggest disadvantage for a 4PL to use the blockchain technology to deal with traceability and transparency, whereas the most advantageous factor is the trustworthiness and transparency that the blockchain enable.

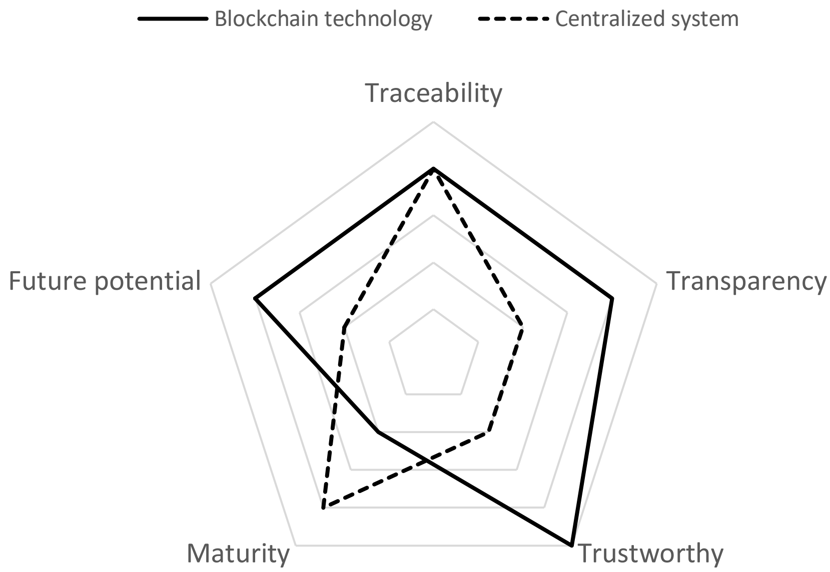

Figure 6-1, Spider chart of blockchain vs a centralized system.

6.2 Research question 2

> *What are the requirements for a 4PL to use an artefact, based on blockchain technology, to deal with traceability and transparency?*

The requirements of a traceability artefact boil down to a broad collaboration and motivation between all parties involved in the chain. Consensus among the different parties must prevail, no unclearness about what information to disclose could exist. To make the artefact work as desired, it also requires major integrations with current systems used across the chain. The artefact requires that the users in the chain are motivated to use it, otherwise it will fail.

6.3 Research question 3

> *How can an artefact based on the blockchain technology affect traceability and transparency from the perspective of a 4PL company?*

Regarding the traceability, a match between the digital and physical flow would be achieved. The artefact would not perform better in comparison to a decentralized system in terms of traceability, but the transparency achieved by the artefact is outstanding, since it is based on blockchains. The affection that a 4PL would experience are the effect of a trustworthy, transparent system that can be used as a tool to strengthen the brand image, reputation and attractiveness as the sustainable actions can be confirmed and visualized by the blockchain.

6.4 Recommendations

The blockchain technology can be beneficial and useful within the supply chain in order to achieve traceability and transparency, which the field test revealed. Even though the blockchain technology are not widely used in supply chains today, the authors' recommendation for a 4PL is to use an artefact similar to the one used in the test, to deal with traceability and transparency.

If it is decided to implement the suggested solution, it is recommended to do it step by step, starting in a small scale within Sweden and then increase the scale of the usage. A natural step would be to run a full implemented artefact with one supplier's flow, and then increase it to several suppliers' flow. Once the Swedish flows are covered it could be extended to non-domestic supplier, and in the same manner as the domestic flows, successively increase the usage.

6.5 Contributions

The authors want to point out the contributions made in this research, in line with the engaged scholarship design by Mathiassen (2015). There are few relevant articles in the field of logistics where the technology of blockchain are tested and evaluated in terms of traceability and transparency. In this research, the authors have succeeded with a contribution to this area as a blockchain based traceability artefact has been tested and evaluated, i.e. a contribution to the related area in the literature (A). A contribution is also made to the real-world problem (P), as the artefact has the possibility to solve the traceability and transparency problem for the case company. Further, the method used when evaluating the articles for the literature review is something that the authors wants to shed light over as a contribution to (M). Lastly, the authors manage to contribute to the framework (F), by using a unique frame on which to build the application. Since a contribution has been made to each field mentioned, a solid research has been completed.

6.6 Future studies

The blockchain technology has high potential and the future enable great possibilities. The executed test only consisted of a small number of orders and pallets and to better assess its technology and performance the artefact should be tested in larger scale with multiple suppliers. Due to the limited time, the full potential of the traceability artefact have not been reached. Several test iterations would have been beneficial to adjust the features of the artefact to fit the supply chain in the best possible way. More investigations about system integrations would also be necessary. Future studies could include the manufacturing process of a product and connect earlier phases of a product’s history, already from harvesting of the raw material, to enable better traceability and transparency. A potential future study would also be to move to the next part of the chain, i.e. to the end customers, and offer the ability to find out the history of the product one wishes to buy.

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